

FATIGUE AND WHAT IT TAKES, IN ORDER

What Goes *First*

Fatigue does not degrade a delivery evenly. Some things fall, some hold, and one thing goes up. Velocity drops about a quarter mph an inning while elbow load climbs after the third, which means the pitcher is throwing softer and paying more at exactly the moment he feels least dangerous.

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The sixth inning is a different athlete throwing a different delivery. **The gun says he is doing less. The elbow says he is doing more.**

Both are true, and the gap between them is the whole management problem. A fatigued pitcher loses the mechanical qualities that spread force over time before he loses the ability to produce force at all, so the load per pitch rises while the output falls. Nothing in what he feels reports that, and nothing in what the radar reports it either.

The order things fail in

Measured across a simulated game. Two cautions before you use these: the velocity and torque figures come from **11 pitchers with a mean age of 17.6** throwing 90 pitches, and the other rows come from separate small studies. The directions are consistent across the literature. The exact numbers are not settled.

WHAT A FULL OUTING DOES, PER INNING		
WHAT	CHANGE	WHAT IT MEANS
Velocity	falls about 0.28 mph per inning	The first thing anyone notices, and the least informative. It is the output falling, not the cause.
Hip to shoulder separation	decreases across the game	The loading mechanism for the trunk degrades. Holding the chest closed against a rotating pelvis is active work and it gets abandoned.
Scap load at foot contact	about 21° falling to 19° 16 high school pitchers	The elbow sits less far behind the shoulder line as the outing goes on, so the arm has less runway. The lower half gives up before the arm does.

WHAT	CHANGE	WHAT IT MEANS
Maximum layback	about 181° to 172° across a game 7 major league pitchers	Range falls while the arm keeps being asked for the same thing. Note the sample is tiny, so treat the direction as the finding rather than the number.
Medial elbow torque	rises after inning three about 0.84 Nm per inning	The finding that should change how outings are managed. Load goes up while velocity goes down. The trade gets worse every inning after the third.
Shoulder external rotation and total motion	increase after pitching	Measured acutely, the shoulder gets looser. That is tissue laxity, not improvement, and it is the window in which the joint is least protected.

Why load rises while output falls

The arm keeps working and the delivery stops helping it

Read the table as a single story. Separation collapses, so the trunk delivers less rotation. The arm speed holds, because the arm is still trying. The difference between what the trunk used to supply and what the arm still produces is made up at the elbow.

That is the same mechanism as every mechanical fault in this library, arriving through fatigue instead of through habit. A pitcher in the sixth inning is producing a version of *Nothing Left to Turn* and *Push or Whip* that he did not have in the first.

Which also explains why it starts after the third. It is not that the tissue suddenly weakens at a threshold. It is that the mechanical qualities holding the delivery together degrade gradually, and somewhere around there the arm has to start covering the gap.

Rate goes before strength

He loses speed of force production before he loses force

Fatigue degrades how *fast* a muscle produces force well before it degrades how much it can produce. That ordering matters because the delivery runs on rate rather than on maximum: contact to release is roughly 0.15 seconds and reaching peak force takes around 0.3.

So the quality the block depends on is the quality fatigue takes first. A front leg that covered its ground in the first inning has less to cover it with in the sixth, the block slides later, and the trunk gets less. That is the mechanical route by which separation and slot both drift.

It also has a training consequence: **every quality in this library needs to be tested tired, not just fresh.** A pitcher who passes a screen rested and fails it fatigued has the problem, because fatigued is the state the pitching happens in by the fifth.

Why asking how he feels does not work

WHAT HE REPORTS

Effort tracks velocity

The athlete's sense of how hard he is throwing follows the number on the gun, and the gun is falling. He genuinely feels like he is doing less, because in the only terms he has access to, he is.

Reduced effort throwing shows the same disconnect from the other direction: **75 to 80 percent effort produced 80 to 95 percent of full effort elbow load**, and high schoolers asked for 50 percent still produced 75 percent of maximum torque.

WHAT IS HAPPENING

Load tracks mechanics

Elbow torque is set by positions and timings, and those are degrading. The load is going up on a curve the athlete has no sensory access to at all.

Which is why **throw count and accumulated load are the management tools** and perceived effort is not. Not because athletes are unreliable reporters, but because the thing they can report is not the thing that is happening.

What to watch for

All of these are visible without a lab, and all of them are more useful than asking how he feels.

VIDEO Compare inning one to inning five Same camera, same angle, foot contact frame. Belt line, chest orientation and arm elevation drift in ways that are obvious side by side and invisible pitch to pitch.	VIDEO The finish gets shorter A follow through that is full early and abbreviated late is the deceleration system running out. It also shortens the runway just as the load is peaking.	BALL FLIGHT Release height creeping down The arm slot drift, made measurable. Roughly three quarters of a degree an inning turns into a real change in approach angle across a start.
RADAR The trend, not the peak Velocity falling on a slope is expected. Falling faster than usual for that athlete is the signal, and it is only visible if you track it by inning.	VIDEO The lower half quiets down first Hip hiking deepens, the block softens, the landing drifts open. The lower half is doing the active work, so it is where the abandonment starts.	NEXT DAY Where he is sore Back of the shoulder and glutes is expected. Side, low back, or front of the upper arm means the compensations took over and stayed.

What to do about it

MANAGE

Count throws, not percentages

The single clearest practical conclusion in this document.

- **Throw count and cumulative load** as the tools, since perceived effort does not track the bill
- Treat **innings four onward** as a different exposure rather than more of the same
- Stop counting reduced effort work as rest. It has a place for skill and command, not for recovery
- The acute laxity window after pitching is a reason to be careful about what gets loaded immediately afterward

TRAIN

Build the qualities fatigue takes first

Rate of force production and eccentric capacity are what degrade, so they are what to build reserve in.

- **Rate work** — jumps, bounds, drop jumps, rotational med ball at full intent, low reps and full rest
- **Eccentric and isometric capacity** in the front leg and the back of the shoulder, since both are brakes
- **Aerobic and repeat effort capacity**, which is what determines how quickly rate degrades in the first place
- Program rate work as quality. It collapses the moment the reps become fatiguing, which defeats the purpose

TEST

Screen tired as well as fresh

Half of what matters only appears under fatigue, and that is the condition most of the pitching happens in.

- Single leg stance and pelvic control after a workload, not before
- External rotation strength fatigued, since deceleration failure is a fatigue event
- Grip strength late in a session against fresh
- Late outing video as a routine capture rather than an occasional one

Sources

Values come from simulated game protocols with small samples, several of them adolescent, and vary by study, athlete and level. Treat the directions as reliable and the magnitudes as indicative only.

- Manifestations of muscle fatigue in baseball pitchers: a systematic review
- Effect of fatigue on medial elbow torque in baseball pitchers
- Wolf, Kinney, Waterman, Bullock, Nicholson — Differences in Pitching Kinetics and Kinematics During Various Effort Level Pitching
- Fleisig et al. — Kinematic Parameters Associated With Elbow Varus Torque in Elite Adult Baseball Pitchers
- Bullock, Nicholson et al. — Baseball pitching biomechanics in relation to pain, injury, and surgery
- NSCA — CSCS program design, rate of force development and fatigue
- Force velocity curve and rate of force development
- ASMI — The Clinician's Guide to Baseball Pitching Biomechanics

Softer and more expensive at the same time. That is the only sentence in this document that has to be remembered.