WHITE PAPER

Clipless vs. Flat Pedals in Mountain Biking

Performance, Biomechanics, and the Physiology of Float and Freedom

A practical and evidence-based guide for riders and fitters

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Executive Summary

The choice between clipless and flat pedals is one of mountain biking's most persistent debates, and much of the disagreement stems from a single overstated claim: that clipping in delivers a large efficiency advantage by letting a rider "pull up" on the pedal. **The evidence does not support a large efficiency gap.** Across controlled testing, the two systems are far closer than marketing suggests, and the real decision turns on control, safety, skill development, terrain, and individual biomechanics rather than raw wattage.

This paper examines both systems through three lenses: measured performance, rider skill and safety, and physiology. The physiological section addresses the two mechanisms riders care about most: *float*, the small rotational freedom engineered into clipless systems to protect the knee, and the *unconstrained freedom* of a flat platform, where the foot can reposition continuously. Understanding how each interacts with the knee, ankle, and pedal stroke is the key to a recommendation that fits the rider rather than the trend.

Key Takeaways

Question	What the evidence indicates
Efficiency (steady effort)	No meaningful difference at submaximal intensity; the "pull-up" contributes little net power
Power (sprint / short climb)	Clipless shows a modest edge (~10% in short all-out efforts), mostly from foot stability, not pulling up
Control & foot security	Clipless keeps feet planted on rough ground; quality flats + shoes get closer than assumed
Safety & bailing	Flats allow instant dabs and clean bailouts; clipless requires trained unclip reflex
Skill development	Flats expose technique flaws and build cleaner pedaling and body mechanics
Knee health	Float and correct cleat setup reduce rotational strain; flats self-select a natural angle

Figure ES-1. Summary of clipless vs. flat considerations. The efficiency question is largely settled; the meaningful differences are in control, safety, skill, and joint mechanics.

1. The Two Systems Defined

The terminology is famously counterintuitive. **Clipless** pedals use a cleat bolted to the sole of the shoe that locks into a spring-loaded retention mechanism, so named because they replaced the older toe-clip cages. The rider engages by stepping down and disengages by rotating the heel outward. The mountain bike standard is the two-bolt system (e.g., Shimano SPD and compatible designs), chosen for its mud-shedding recessed cleat and walkability.

Flat pedals, also called platform pedals, present a wide, usually concave metal or composite body studded with replaceable traction pins. Grip comes entirely from the interaction between those pins and a soft, dedicated rubber outsole; there is no mechanical attachment. The foot rests on the platform and can be lifted, slid, or repositioned at any instant.

1.1 A Note on Retention as a Spectrum

It helps to think of foot retention as a continuum rather than a binary. A pinned platform with a purpose-built flat-pedal shoe already provides substantial retention. Modern aggressive shoes interlock with pins so firmly that lateral and fore-aft movement is minimal. Clipless simply adds a positive mechanical lock. Hybrid pedals (a clip mechanism set into a small platform) occupy the middle, offering a supportive cage around the cleat for downhill and enduro use.

2. Performance: Separating Evidence from Folklore

2.1 The Efficiency Myth

The most repeated claim, that clipless pedals are 20–30% more efficient, has no support in the biomechanics literature. It derives from a misreading of the pedal stroke: because a clipped-in rider *can* apply force on the upstroke, it was assumed they routinely do, adding "free" power. In practice, most riders do not meaningfully pull up during sustained pedaling; the trailing leg largely unweights rather than actively lifts, and the net contribution to power is small.

Controlled work supports this. A frequently cited 2008 study in the *International Journal of Sports Medicine* found that a clipless system did not change mechanical efficiency, pedaling mechanics, or muscle activity during submaximal cycling. Stationary-bike testing has likewise found that flat pedals with trainers are as efficient as clipped-in shoes at lower intensities. The practical conclusion: for steady climbing and endurance riding, the efficiency difference is negligible.

2.2 Where Clipless Does Help: Power and Stability

The advantage appears at the extremes. Outdoor sprint testing has shown clipless shoes raising maximum sprint power by roughly 16% over trainers on flats, with toe-clips landing in between. Independent power-meter testing on climbs found clipless to be modestly faster (on the order of tens of seconds over a ~15–27-minute climb) at matched heart rate. **Crucially, the mechanism is foot stability, not pulling up:** a locked foot cannot be bounced out of position, so every downstroke lands on a stable platform and force is delivered through the optimal part of the foot. On flats, at very high cadence or over chatter, the pedal can momentarily unload the foot, costing a fraction of each stroke.

2.3 Summary of the Performance Trade-offs

Dimension	Clipless	Flat
Steady-state efficiency	No meaningful advantage	Equivalent
Max sprint / burst power	Modest edge (~10–16% in tests)	Slightly lower peak
Foot stability on chatter	Excellent, foot cannot displace	Good with sticky shoes; can bounce
High-cadence spin	More secure	Foot can lift off if technique lapses
Repositioning mid-trail	Not possible without unclipping	Instant and continuous

Figure 2. Performance comparison. The measured gaps are smaller than commonly claimed and concentrate in maximal efforts, driven by foot stability rather than upstroke power.

3. Control, Safety, and Skill Development

3.1 The Case for Clipless on the Trail

- **Foot security on rough terrain.** Feet stay put through rock gardens, roots, drops, and hard braking, so the rider can focus on line choice rather than foot placement.
- **Confidence pedaling through chunder.** There is no fear of a foot bouncing off mid-stroke on a technical climb, which helps maintain momentum.
- **Consistency.** The foot returns to exactly the same spot every time, giving a repeatable, optimized position.
- **Clearance.** Smaller bodies reduce pedal strikes on rocks compared with large platforms.

3.2 The Case for Flats on the Trail

- **Instant bailout.** The foot can leave the pedal without thought, the decisive advantage in crashes, awkward stalls, and low-speed technical failures. This is why most downhill and freeride riders, as well as many coaches, favor flats.
- **Free dabs and repositioning.** A quick foot-down in a corner or a mid-move adjustment is effortless, valuable when learning or riding unfamiliar, slippery, or exposed terrain.
- **Technique feedback.** Flats punish sloppy inputs; if your feet fly off a jump lip or over braking bumps, your body position or timing is wrong. Riders forced to keep their feet planted through skill, not a clip, tend to develop cleaner mechanics that carry over to clipless.
- **Off-the-bike mobility.** Walking, hiking, and biking sections, as well as coaching on foot, are easier in flat-pedal shoes.

3.3 A Common Misconception About Pulling Out in a Crash

A frequent worry is being "trapped" in clipless pedals during a crash. Properly adjusted release tension and practiced technique make unclipping close to automatic, and most experienced riders disengage reflexively. That said, the reflex must be trained: the failure mode is a slow, low-speed tip-over in which a novice forgets to twist. For riders early in their journey, or those returning after a scare, this learning curve is a genuine consideration, and an argument for starting on flats.

4. The Physiology of Float in Clipless Systems

4.1 What Float Is

Float is the small amount of rotational (and, in some systems, lateral) movement the cleat permits while the foot remains engaged, typically expressed in degrees, with common options around 0°, ±4.5°, and ±6°. **Float exists to solve a biomechanical problem:** the human leg does not track in a perfectly flat plane during the pedal stroke. The knee, though it likes to behave like a hinge, naturally rotates and translates slightly as the hip, knee, and ankle move through their ranges. Locking the foot at a fixed angle forces the joint to accommodate any mismatch, and that mismatch manifests as torsional load on the knee.

4.2 Why Float Protects the Knee

The dominant overuse injury in cycling is patellofemoral pain, anterior knee pain around or behind the kneecap, driven by a combination of patellofemoral joint compression, frontal-plane knee motion, and rotational (torsional) forces at the joint. When a fixed cleat holds the foot at an angle that does not match the rider's natural rotation, the resulting torque is transmitted up to the knee, aggravating patellar tracking.

Float mitigates this by letting the foot self-align. Research on floating systems has shown that they reduce the applied moments at the foot–pedal interface without compromising power transmission, which, in turn, should reduce torque at the knee. The clinical literature reflects this: increasing cleat float (alongside appropriate saddle height) is a standard recommendation for reducing patellofemoral joint stress. **The key nuance:** most riders need float when the leg is unloaded rather than during the power phase, and float chiefly provides a margin for error against imperfect cleat alignment, fatigue, and day-to-day anatomical variation (foot pronation, leg-length differences, hip mobility).

4.3 Float Is Not a Substitute for Cleat Setup

An important caveat runs through the biomechanics literature: the root cause of clipless knee pain is usually sub-optimal cleat position, not the mere fact of being fixed to the pedal. Float buys tolerance, but it cannot rescue a badly angled or poorly placed cleat. A rider who dials in cleat angle to match their natural foot orientation may need less float; a rider unwilling or unable to fine-tune setup is safer with more. This is the central argument for a professional bike fit for anyone riding clipless with any history of knee, hip, or ankle discomfort.

Float amount	Typical rider	Trade-off
Zero / minimal	Elite sprinters with dialed fit	Maximum stability; demands precise cleat setup
Moderate (±4.5°)	Most riders	Balance of stability, comfort, injury prevention
High (±6°+)	History of knee issues; imperfect fit	Most forgiving: slight loss of "connected" feel

Figure 3. Float selection. When in doubt, err on the side of more float: the injury-prevention margin outweighs the small loss of stability for most riders.

5. The Physiology of Freedom on Flat Pedals

5.1 Continuous, Unconstrained Self-Alignment

Where clipless engineers a few degrees of protective float, a flat pedal offers effectively unlimited float in every direction; the foot is never locked, so it continuously finds its own angle, fore-aft position, and medial-lateral placement. For the knee, this means rotational mismatches are simply never imposed: the foot rotates freely to whatever the joint prefers at each moment of the stroke. Riders with anatomical asymmetries, prior injuries, or cleat-setup sensitivity often find flats eliminate a source of knee strain outright, because there is no fixed reference angle to fight.

5.2 The Trade-off: Freedom Costs a Reference Position

That same freedom has a cost. Without a fixed cleat, the foot has no automatic "home," so consistency depends on the rider actively landmarking a repeatable position and staying engaged with the pedal. Good technique on flats is not passive; it involves consciously driving the feet into the platform (a heels-down, weighted stance) to generate grip over rough terrain. This is why platform shape matters: a concave body and sticky shoe help the foot find and hold a consistent spot, reducing the mental load of foot management.

5.3 Effects on Pedaling Dynamics

The two systems shape the pedal stroke differently:

- **Force application.** On flats, propulsion is dominated by the downstroke (roughly the 1–5 o'clock sector); riders cannot rely on any upstroke pull, so efficient flat pedaling emphasizes a rounded, well-timed push and active foot pressure. Clipless allows a marginally smoother transition across the top and bottom of the stroke, though the upstroke contribution remains small.
- **Ankle strategy.** Flats encourage a natural, mobile ankle that adjusts angle to maintain pin contact; this can build a more dynamic, terrain-reactive lower-leg technique. Clipless fixes the fore-aft foot position, standardizing the ankle's reference point but limiting spontaneous adjustment.
- **Muscle recruitment.** Because flats reward keeping the foot driven onto the platform, riders often report more engagement of the posterior chain and calf for stability. The literature does not show a large, consistent difference in gross muscle activation at submaximal effort, but the demand for active foot control is real and is part of why flats are used as a coaching tool.

5.4 Freedom and Skill Transfer

The unconstrained platform is a feedback device. Because nothing holds the foot but technique, flats reveal exactly when a rider's body position, timing, or pressure control breaks down, information a clip masks by holding the foot regardless. Many coaches therefore prescribe flats during skill acquisition (cornering, jumping, manualing) so that the clean mechanics learned there transfer to whatever system the rider ultimately races.

6. Matching the System to the Rider

There is no universally correct answer; the right choice is contextual. The framework below synthesizes the performance, safety, and physiological evidence into practical guidance.

Rider / context	Leaning	Rationale
New to MTB	Flats	Safety, confidence, and technique feedback while learning to bail
XC racing / long climbs	Clipless	Foot security and marginal power gains matter over sustained efforts
Downhill / freeride	Flats (or hybrid)	Instant bailout and repositioning outweigh small power loss
Enduro / aggressive trail	Either / hybrid	Personal preference: many run clipless with platform-caged pedals
History of knee pain	Flats or high-float clipless	Eliminate or minimize imposed rotational strain; get a bike fit
Skill development phase	Flats	Expose and correct mechanics that a clip would hide

Figure 4. A decision framework. Terrain, experience, goals, and knee history matter more than the efficiency question that dominates most debates.

6.1 Practical Recommendations

- **Start on flats, then decide.** Even riders who ultimately race clipped in benefit from a flat-pedal foundation.
- **Invest in the shoe, not just the pedal.** A dedicated stiff-soled, sticky-rubber shoe transforms both systems; a soft gym shoe undermines either.
- **If clipless, get a fit and choose float honestly.** Match the cleat angle to your natural stance and err on the side of more float if setup or knees are uncertain.
- **Consider seasonal or discipline switching.** Many riders run flats for skills, jumps, and steep days, and clipless for XC and big-mileage rides; there is no rule requiring a single system.

7. Conclusion

The clipless-versus-flat debate has been distorted by an efficiency claim that the evidence does not support. Once that myth is set aside, the decision becomes clearer and more personal. **Clipless pedals offer foot security and a modest edge in maximal efforts, with float engineered to protect the knee from rotational strain, provided the cleats are set up correctly. Flat pedals offer instant safety, unconstrained self-alignment that can spare sensitive knees entirely, and honest feedback that builds better technique.**

For the rider, the most useful reframing is this: float and freedom are two answers to the same physiological question, how to let the lower limb move the way it naturally wants to while still delivering power to the pedal. Clipless gives a bounded, repeatable version of that freedom; flats give an unbounded, self-managed version. The best system is the one whose trade-offs match the rider's terrain, goals, skill stage, and joints. Many riders are best served by owning both.

Notes on sources. This paper synthesizes peer-reviewed biomechanics and sports-medicine research, clinical physiotherapy guidance, standards and coaching literature, and independent field testing. Where controlled data is limited (notably on real-world muscle activation and flat-pedal technique), claims are presented as directional and are flagged as such. Individual anatomy varies; riders with persistent pain should consult a physiotherapist or professional bike fitter.

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Note: Several entries are secondary field tests or coaching sources rather than peer-reviewed studies; they are included where controlled data is sparse and are identified as such. Exact study citations (e.g., Mornieux 2008) should be verified against the original journal before formal publication. This paper is an educational outlook and does not constitute medical or bike-fit advice.