FITNESS · TRAINING · PHYSICAL THERAPY

The eMTB and the Analog Mountain Bike

An Evidence-Based Comparison for Riders, Coaches, and Clinicians

What the research says about exercise intensity, cardiorespiratory fitness, structured training, injury, and rehabilitation

Prepared for TGI Cycling

June 2026

Contents

1. Executive Summary

The electric mountain bike (eMTB) is often framed as a shortcut, a way to get the fun of mountain biking without the work. The evidence tells a more interesting story. Across the exercise-physiology literature, riding an eMTB is not 'cheating' the workout; it is a different, and in many cases complementary, training stimulus. It shifts where effort lands, who can access the sport, and how a given body absorbs load over a week, a season, or during recovery from injury.

This paper synthesizes peer-reviewed research across several fronts. Regarding muscle activation and biomechanics, assistance does not turn any muscle off; it lowers the peak pedal force the legs must produce while allowing the rider to maintain a joint-friendly cadence, which is mechanically favorable for protecting the knee, though it is a limitation if the goal is maximal strength. On fitness, controlled studies find that eMTB riding keeps riders in genuinely vigorous territory: in a Brigham Young University pilot, average heart rate on the eMTB was 94% of the analog figure, with both bikes placing riders in the upper half of the vigorous-intensity zone. In training, the eMTB's value is less about any single ride and more about a weekly structure that enables true recovery rides, higher frequency, and more descents per hour of skill practice, while protecting the hard days that drive adaptation. On physical therapy and rehabilitation, adjustable assistance becomes a graded-exposure tool: load can be dialed to the exact tolerance of a healing knee, a recovering cardiac patient, or a deconditioned beginner, and increased as capacity returns. On weight, handling, and injury, eMTBs are heavier and faster, but the first dedicated injury studies find on-trail injury severity comparable to analog mountain biking, with weight not emerging as a clear crash factor. On the head-to-head question, neither bike is universally 'better'; the right choice depends on the rider's goal, physiology, terrain, and health status.

The overarching finding for retailers is that the eMTB broadens the market for genuine physical activity rather than diluting it. It brings in people who could not otherwise ride, older adults, those returning from injury, mixed-ability partners and families, and time-pressed riders, and it gives already-fit athletes a legitimate tool for recovery, volume, and skills. Sold honestly, with the physiology explained, it is as much a health product as a recreational one.

Note on scope: this document summarizes published research and is intended for general education. It is not medical advice. Anyone returning to riding after injury, surgery, or a cardiac event should train under the guidance of their physician or physical therapist.

2. How Pedal Assistance Changes the Workout

A mid-drive motor multiplies the rider's pedaling input rather than replacing it. On a Class 1 / EU pedelec system, the motor assists only while the rider pedals and cuts out at 20 mph (US) or 25 km/h (EU), so the rider always contributes work. What changes is the relationship between effort and outcome: for a given leg power output, the bike goes faster, climbs steeper grades, and covers more ground. Riders can, and studies show they do, choose to convert that assistance partly into less effort and partly into more distance, elevation, and speed.

This is why the intuitive assumption ('a motor means no exercise') is wrong. The motor lowers the floor of required effort but does not lower the ceiling, and riders self-select an intensity that, for most people on most terrain, remains firmly in the moderate-to-vigorous range. The sections below quantify this.

3. Muscle Activation and Pedaling Biomechanics

Beneath the heart-rate numbers lies a mechanical question: what are the legs actually doing on an assisted bike? Cycling biomechanics is well characterized. During the pedal stroke, the gluteals initiate the downstroke, the quadriceps (vastus lateralis and medialis) extend the knee through the power phase, the point most riders associate with peak force, especially when climbing, and the hamstrings and calf muscles contribute through the back and bottom of the stroke. The same muscles fire on an eMTB; assistance does not switch any muscle group off. What it changes is the magnitude and timing of the force each muscle must produce.

The key variable is the force–cadence operating point. Unassisted climbing forces a rider into high pedal forces at low cadence, the 'grind ', which is exactly the combination that loads the knee joint most heavily and fatigues the quadriceps fastest. A mid-drive motor lets the rider maintain a comfortable, higher cadence while the motor supplies part of the torque, so peak pedal force (and the corresponding knee-extensor and patellofemoral load) drops even though the legs keep working. In effect, assistance decouples 'keeping the legs turning' from 'producing very high joint forces.' That is a mechanically favorable trade for anyone protecting a joint, and it is the biomechanical basis for the rehabilitation uses discussed later.

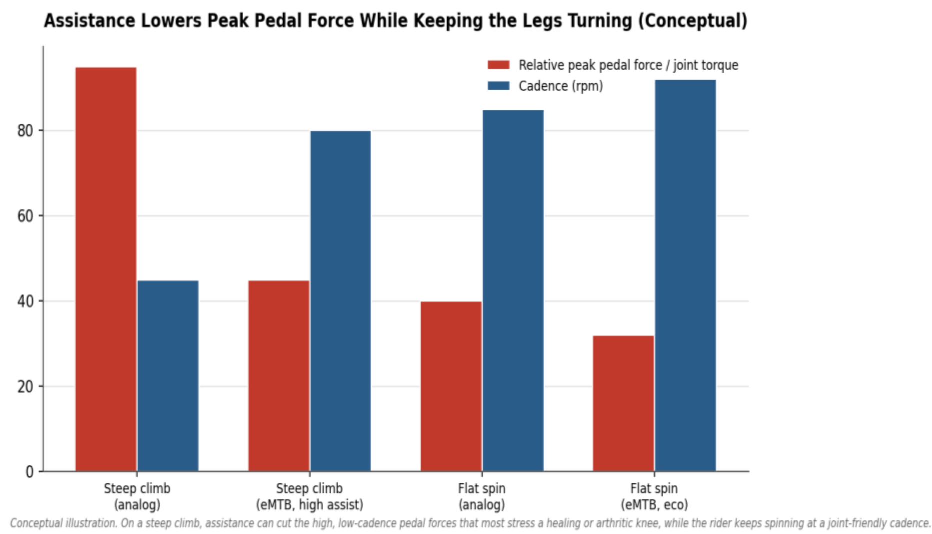

Figure 1. Conceptual force–cadence trade-off. On a steep climb, assistance cuts the high, low-cadence pedal forces that most stress the knee while the rider keeps spinning at a joint-friendly cadence.

Two honest caveats. First, there is not yet a large body of eMTB-specific electromyography (EMG) research directly measuring muscle activation on the trail; the picture above is based on established cycling biomechanics and the known physics of load-sharing, not on a definitive eMTB EMG trial. Second, lower peak force benefits joint protection and endurance but limits pure strength stimulus: if the training goal is maximal leg strength or the specific muscular endurance for sustained hard climbing, reducing pedal force works against that goal. As with the fitness data, the assisted bike is not universally 'better' or 'worse '; it shifts the mechanical demand, and whether that shift helps depends on the rider's objective.

4. Fitness: Exercise Intensity and Cardiorespiratory Benefit

4.1 Intensity on the trail

The most-cited controlled comparison is a Brigham Young University pilot study (JMIR Formative Research, 2019). Experienced mountain bikers rode a 6-mile loop with roughly 700 feet of climbing on both a conventional MTB and an eMTB. Average heart rate was 154.8 bpm on the analog bike and 144.9 bpm on the eMTB, a difference of about 10 bpm, meaning the eMTB heart rate was 94% of the conventional figure. Both rides placed participants in the upper half of the vigorous-intensity zone (roughly 70–85% of estimated maximum heart rate). Riders finished the loop about 12–13 minutes faster on the eMTB yet still logged a vigorous cardiovascular effort.

A striking secondary finding was perceptual: despite working at 94% of their analog heart rate, participants believed the eMTB was far easier and that their heart rate was 'considerably lower.' In other words, the eMTB delivered a hidden workout, high physiological effort with low perceived exertion. That gap has a practical upside (people exercise harder than they realize and enjoy it more) and a caution (perceived ease can lead riders to underestimate their actual cardiac load).

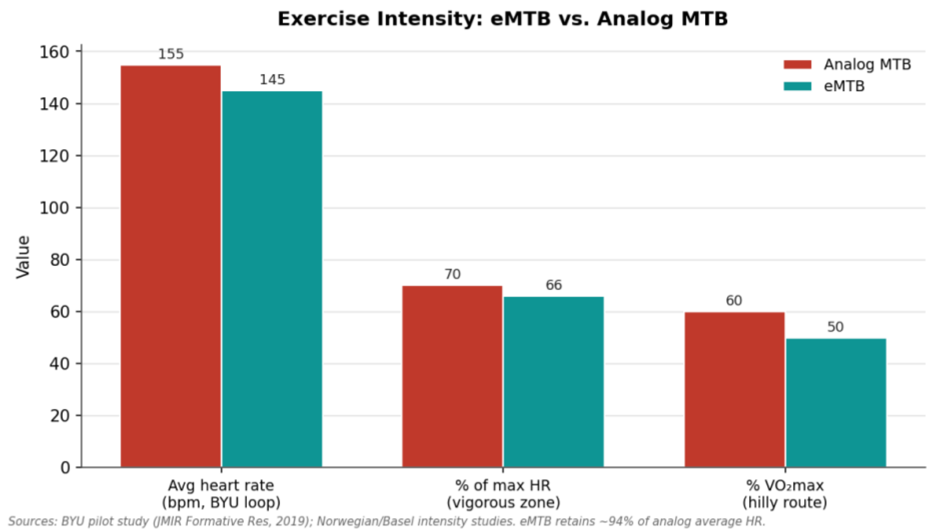

Figure 2. Exercise-intensity markers on eMTB versus analog MTB. The eMTB maintains roughly 94% of the average heart rate, keeping riders in the vigorous zone.

4.2 Time spent in moderate-to-vigorous activity

Public health guidance centers on minutes of moderate-to-vigorous physical activity (MVPA). Studies comparing e-bikes and conventional bikes consistently find that although e-cyclists spend somewhat fewer minutes at the very top of the intensity range, the overwhelming majority of ride time, typically 92–99%, still qualifies as MVPA. In a Norwegian comparison on a hilly route, riders logged about 26% fewer MVPA minutes and 35% fewer vigorous minutes on the e-bike but still spent nearly all of their (shorter) ride in the MVPA band. The e-bike trades a little peak intensity for a large gain in accessibility and, often, ride frequency.

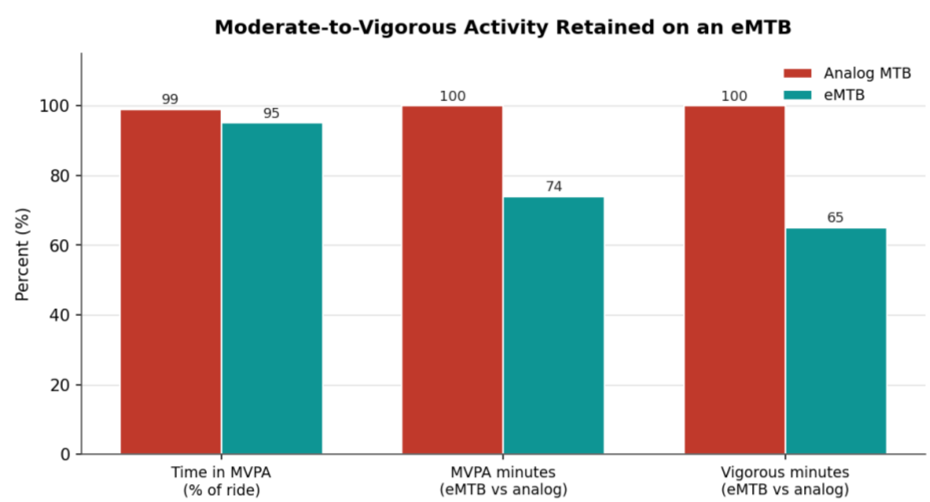

Figure 3. Both bikes keep riders in MVPA for nearly the entire ride; the eMTB logs somewhat fewer high-intensity minutes per loop.

4.3 Measurable fitness gains over time

Does that translate into real cardiorespiratory improvement? A four-week randomized controlled trial in Basel (Höchsmann et al., 2018) assigned overweight, previously sedentary adults to commute by e-bike or conventional bike. VO_2peak, the gold-standard measure of aerobic fitness, rose in both groups: +3.6 mL/kg/min in the e-bike group and +2.2 mL/kg/min in the conventional-bike group, a difference that was not statistically significant. The e-bike group posted the larger mean gain because assistance let them ride farther, climb more, and, crucially, stick with the program. The authors concluded that e-bikes can improve fitness comparably to conventional bikes, despite the assist, precisely because they enable higher speeds, greater elevation gains, and better adherence.

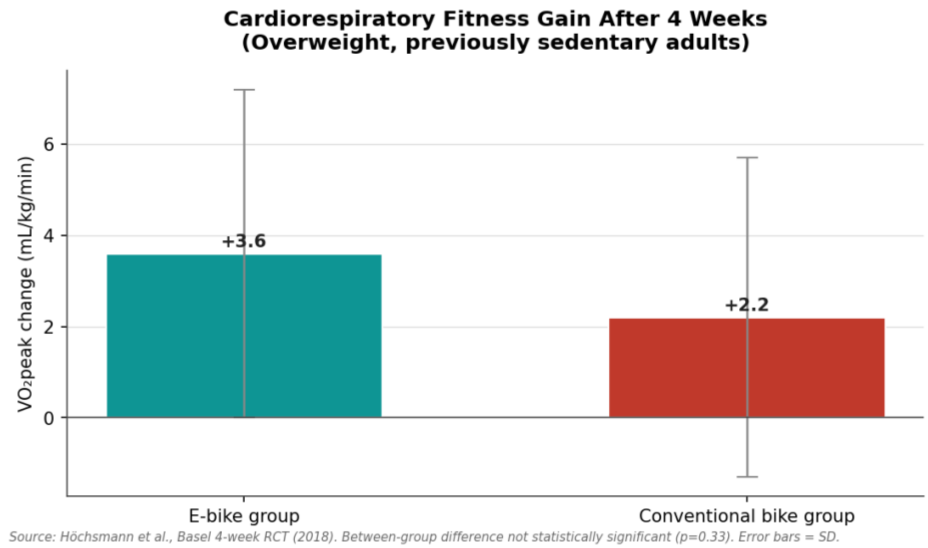

Figure 4. VO_2peak improved in both groups after four weeks; the e-bike group's mean gain was at least as large as the conventional group's.

Adherence plays a crucial role in this literature. The most effective training stimulus is the one an individual consistently completes. Since eMTBs reduce the fear of daunting climbs, the risk of being dropped, and post-ride fatigue, they increase the likelihood of completing rides. For someone sedentary or out of shape, a vigorous eMTB session repeated three times weekly is more beneficial than a tough traditional ride abandoned after just two attempts.

5. Training: Structuring Load, Recovery, and Skill

For riders already training with intent, whether racing enduro, chasing personal records, or simply improving, the eMTB is best understood not as a replacement for the analog bike but as a second tool that reshapes the training week. Its advantages are structural.

5.1 Genuine recovery rides

Endurance-training theory is increasingly 'polarized': most volume should be genuinely easy, a smaller share genuinely hard, and little in the fatiguing middle. The problem for mountain bikers is terrain on real trails. Even an 'easy' ride includes climbs that spike the rider out of the recovery zone, so true low-load recovery rides are hard to execute. A pedal-assist bike solves this directly: the motor flattens the climbs, letting a rider keep effort low enough for actual recovery (easy enough to breathe through the nose, per the classic coaching cue) while still getting outside, moving the legs, and practicing on dirt. This lets athletes ride on days they would otherwise need to rest, adding easy volume without adding fatigue.

5.2 Frequency, volume, and the protected hard day

Because the eMTB reduces the recovery cost of any given ride, it raises the ceiling on how often a rider can train. More sessions per week mean more skill exposure, more time in nature, and more cumulative aerobic work without the overtraining risk that piling on analog rides would create. The complementary model many coaches now recommend is simple: keep the genuinely hard interval and threshold sessions on the analog bike (or in assist-off / eco mode), and use assistance to add frequency, recovery, and volume around them. The chart below illustrates the concept.

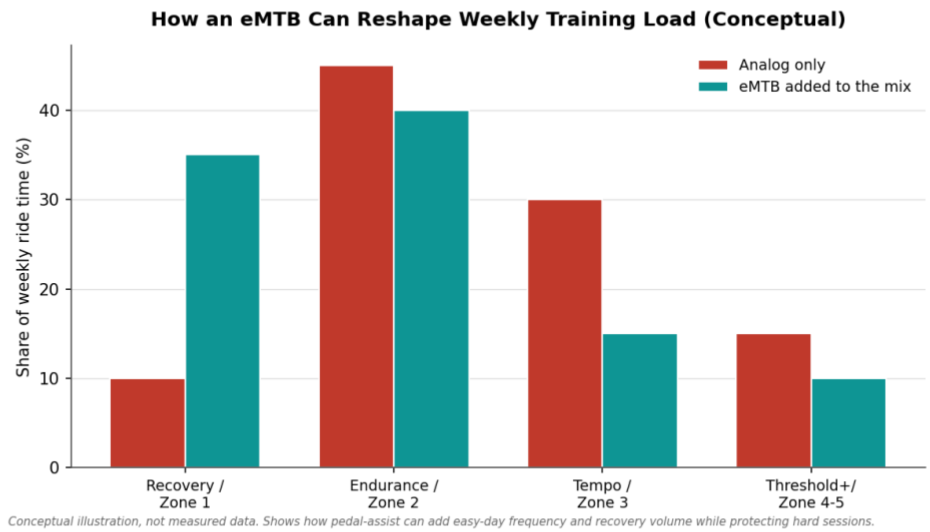

Figure 5. Conceptual weekly-load reshaping: an eMTB can expand easy/recovery volume and frequency while the hard sessions stay protected. Illustrative, not measured data.

5.3 Skill development and descending practice

Downhill and technical skills improve with repetition, but on an analog bike, each descent must be earned with a long climb, so a skills session yields only a handful of runs before the legs are cooked. An eMTB shortens the climb, multiplying the number of quality descents per session and letting riders practice cornering, line choice, and technical features while fresh rather than exhausted. For developing riders, this is a meaningful accelerant; fatigue is where technique degrades, and crashes happen, so more reps in a fresher state led to faster, arguably safer, learning.

5.4 Where the analog bike still wins for training

None of this makes the analog bike obsolete for the committed athlete. Maximal aerobic development, the specific muscular and metabolic demands of sustained unassisted climbing, and race-specific preparation for non-assisted events all require riding without a motor. Power-to-weight, sustained threshold capacity, and the mental resilience of grinding out a long climb are built by doing exactly that. The honest framing is that the two bikes train overlapping but distinct qualities, and a serious rider benefits from owning the distinction rather than treating either bike as a total substitute.

6. Physical Therapy, Rehabilitation, and Special Populations

Cycling has long been a staple of rehabilitation because it is low-impact, joint-friendly, and easily graded. The eMTB extends those virtues by adding a variable that stationary rehab equipment struggles to match outdoors: continuously adjustable assistance. That makes it a powerful graded-exposure tool, the therapeutic principle of reintroducing load in controlled, progressive doses that stay within a healing tissue's tolerance.

6.1 Adjustable load as a clinical dial

On a mid-drive eMTB, assistance can be tuned mode-by-mode and, on modern systems, fine-tuned in an app. In rehabilitation terms, this is a load dial. A patient recovering from knee surgery can begin with maximum assistance so the quadriceps and joint experience only a fraction of the normal pedaling load, then reduce assistance week by week as strength and confidence return, providing an outdoor analogue to the progressive cycling protocols used in supervised rehab. The same dial lets a clinician keep a patient within a target heart-rate window (important after a cardiac event) by offloading climbs that would otherwise spike intensity uncontrollably.

6.2 Cardiac and cardiometabolic rehabilitation

The cardiorespiratory evidence in Section 3 is directly relevant here. Because e-bikes reliably produce moderate-intensity activity while allowing the rider to cap peak exertion, they align well with the intensity targets used in cardiac and cardiometabolic rehabilitation, where the goal is regular, controllable aerobic work rather than maximal effort. The Basel RCT population, overweight, sedentary adults, is essentially a primary-prevention cardiometabolic group, and the e-bike improved their VO_2peak while remaining something they continued to do. For patients whose barrier is that conventional exercise feels too hard or daunting, assisted cycling can be the on-ramp that makes adherence to rehabilitation realistic.

6.3 Joint health, osteoarthritis, and return from injury

For riders with knee or hip osteoarthritis, the clinical consensus favors regular low-impact aerobic exercise and lower-limb strengthening to reduce pain and preserve function; cycling is a mainstay because it loads the joint through a smooth range without impact. An eMTB lets an osteoarthritic or post-operative rider control the peak torque their joints must produce. The assistance absorbs the high-force, low-cadence 'mashing' that aggravates a sore knee while still delivering the aerobic and quadriceps-activating benefits of pedaling. In a return-to-sport context, the same graded-load logic applies: an athlete rebuilding after an ACL reconstruction or a long layoff can resume trail riding at a fraction of the physiological and mechanical load, then progressively remove assistance as tissue tolerance and confidence rebuild.

Two clinical cautions belong alongside this optimism. First, mountain biking, whether assisted or not, carries an inherent crash risk on technical terrain, which is a different consideration from the controlled loading of pedaling; return-to-sport decisions must weigh terrain and handling, not just pedaling load. Second, the 'hidden workout' effect means patients may reach genuinely high cardiac intensities while feeling comfortable, so heart-rate monitoring (rather than perceived exertion alone) is prudent for anyone with a cardiac history.

6.4 Widening access: older adults, mixed-ability, and the deconditioned

Perhaps the eMTB's greatest health contribution is simply who it lets ride. Older adults, people carrying extra weight, those with chronic conditions, and beginners intimidated by fitness demands can all access trails that an analog bike would keep out of reach. It also equalizes mixed-ability groups: a stronger and a weaker rider, or a parent and child, can ride together, with the assistance balancing the difference, which sustains the social connection that itself predicts long-term exercise adherence. Activity that happens is worth more than activity that is theoretically superior but never undertaken.

7. Weight, Handling, and Injury Risk

Any honest account of eMTB fitness has to address the flip side of the ledger: these bikes are heavier and faster, and that combination raises reasonable questions about crash and injury risk. The engineering reality is that a full-power eMTB with a large battery typically weighs 20–27 kg, roughly 7–12 kg more than a comparable analog trail bike. That extra mass, most of it centered low in the frame, changes how the bike behaves and how it interacts with the higher average speeds and greater distances the motor makes possible.

7.1 How weight changes handling

The added mass cuts both ways. The low, central battery weight lowers the center of gravity and can make an eMTB feel planted and stable at speed, which some riders find confidence-inspiring. But the same mass increases rotational inertia: the bike is slower to change direction, harder to lift or reposition over technical features, and carries more momentum into corners and obstacles. When a heavy bike begins to fall or slide, there is more energy to arrest, so low-speed technical mistakes that a rider would simply dab out on a light bike can be harder to recover from. Braking demands increase with greater mass and speed, leading to longer stopping distances and more heat in the brakes during sustained descents. These are learnable characteristics, not disqualifying ones, but they mean that an eMTB rewards a deliberate transition rather than assuming that skills transfer one-to-one from a light bike.

7.2 What the injury data actually show

Here, the evidence is more reassuring than intuition. The first dedicated study of eMTB injuries (Ruddick, Trease & Pearson, published 2026) found that the heavier weight of eMTBs was not a clear contributing factor in any of the reported accidents, and that injury severity was comparable to traditional mountain biking. A separate eMTB injury profile (Journal of Science and Medicine in Sport, 2023) similarly found that the injury mix, mostly superficial skin injuries and limb fractures, most often on descents, closely mirrored non-assisted MTB, with the one notable difference being a somewhat higher share of chest/thorax trauma. In both datasets, most injuries were minor, and many were self-managed.

This contrasts with the e-ROAD-bike literature, which has repeatedly found more severe injuries and higher hospitalization rates among e-bike riders than among conventional cyclists. Crucially, that difference is largely explained by rider age, not the bikes themselves: emergency-department studies show that e-road-bike casualties are substantially older (median ~60–67 years versus the mid-40s for conventional bikes), and older riders sustain more severe injuries in equivalent crashes. When researchers controlled for age, much of the severity gap narrowed. The lesson for eMTB is that the demographic the bike attracts, including older and returning riders, matters as much as the machine, and that protective equipment and skills progression matter most for exactly those riders.

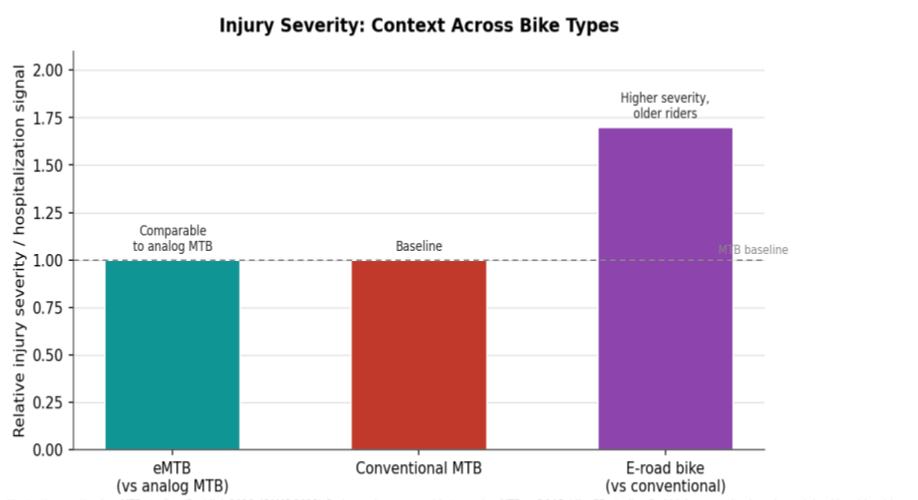

Figure 6. Injury-severity context. Dedicated eMTB studies find severity comparable to analog MTB; the elevated severity seen in e-road-bike data is largely attributable to older rider age, not the bike.

7.3 Practical risk management

The constructive takeaway is that eMTB risk is manageable and largely overlaps with ordinary mountain-bike risk, provided a few things are respected. Speed is the dominant severity driver on descents for any mountain bike, so the eMTB's ability to arrive at features faster and fresher, the same trait that makes it great for skills practice, deserves respect. Because most serious MTB injuries happen going downhill and involve the upper body, head, and increasingly the trunk, appropriate protective equipment (a quality helmet, knee protection, and body/chest protection for technical terrain) is well supported by the injury data. And because the eMTB brings in newer and returning riders, a graduated progression, matching trail difficulty to genuine skill, not to how easily the motor gets you to the top, is the single most effective risk control a shop can coach.

For the retailer, this reframes the heavier bike not as a hazard to downplay but as a fitting opportunity: the rider most likely to buy an eMTB (older, returning, or new to the sport) is also the rider who benefits most from a proper safety-gear setup and a candid conversation about handling differences and trail selection.

8. eMTB vs. Analog MTB: Choosing by Goal

The comparison resists a single winner because the two bikes optimize for different things. The table below summarizes the evidence-based trade-offs across the dimensions this paper has covered.

Dimension	Analog MTB	eMTB
Exercise intensity (same loop)	Higher average HR; more vigorous minutes	~94% of analog HR; still vigorous, fewer peak minutes
Perceived exertion	Matches actual effort	Feels easier than it is ('hidden workout')
Cardiorespiratory gains	Proven	Comparable in trials; often better adherence
Recovery rides	Hard on real terrain	Enables true low-load recovery
Session frequency / volume	Limited by fatigue	Higher; lower recovery cost
Skill / descending reps	Few per session	Many; practice while fresh
Max aerobic & race-specific prep	Superior	Not a substitute
Peak pedal / joint force	Higher (esp. climbing)	Lower; assistance shares torque
Rehab / graded load	Fixed by terrain	Adjustable 'load dial'
Access (older, injured, mixed-ability)	Limited	Broad
Weight & handling	Lighter, more agile	Heavier; planted but more momentum
Injury severity (on trails)	Baseline	Comparable to analog MTB

Summary of evidence-based trade-offs discussed in Sections 3–7. 'Vigorous' and 'MVPA' follow standard heart-rate-zone definitions.

8.1 Rider profiles

- Fitness-focused beginner or returning rider: eMTB as primary. It delivers vigorous, health-building activity with low perceived exertion and high adherence, the workout that actually gets repeated.
- Competitive/performance athlete: analog as primary, eMTB as a training tool. Hard sessions and race-specific prep remain unassisted; the eMTB adds recovery rides, frequency, and descending reps.
- Rehab, cardiac, osteoarthritis, or post-injury: eMTB under clinical guidance. The adjustable load dial and capped intensity make a graded return to activity feasible outdoors.
- Older adults, mixed-ability groups, families: eMTB for access and togetherness, keeping people riding and riding together for longer.
- Time-pressed rider: either leaning eMTB. More elevation and distance per available hour at genuine MVPA.

9. Conclusions

The research converges on a conclusion that should reassure riders and retailers alike: the eMTB is a legitimate instrument for fitness, training, and rehabilitation, not a shortcut. It keeps riders in the vigorous zone at roughly 94% of analog heart rate, produces cardiorespiratory gains comparable to conventional cycling in controlled trials, and, through adjustable assistance, becomes a uniquely flexible tool for structuring training load and graded rehabilitation. Its perceptual signature (hard work that feels easy) is both its greatest strength for adherence and the reason to monitor real intensity rather than trusting feel alone.

The strategic takeaway is that an eMTB sale is often a health outcome: it brings new people into vigorous activity, keeps injured and older riders moving, and gives athletes a smarter way to manage a season. The analog bike remains the purest tool for maximal aerobic development and race-specific preparation, and the most satisfying choice for many riders. The two are complements, not rivals. A shop that can explain the physiology honestly and match the bike to the rider's goal and health status offers something more valuable than a transaction: informed guidance that keeps customers healthy, riding, and loyal.

10. References

Peterson, S. J., & Prins, P. J., et al. (2019). Pedal-Assist Mountain Bikes: A Pilot Study Comparison of the Exercise Response, Perceptions, and Beliefs of Experienced Mountain Bikers. JMIR Formative Research, 3(3), e13643. (BYU pilot; eMTB HR = 94% of analog, both vigorous.)

Höchsmann, C., et al. (2018). Effect of E-Bike Versus Bike Commuting on Cardiorespiratory Fitness in Overweight Adults: A 4-Week Randomized Pilot Study. Clinical Journal of Sport Medicine. (VO_2peak +3.6 e-bike vs +2.2 bike; n.s.)

Bourne, J. E., et al. (2018/2020). E-bikes, physical activity and health: systematic review evidence on MVPA and moderate-intensity attainment during e-cycling.

Berntsen, S., et al. Norwegian comparison of E-bike versus conventional bicycle: exercise intensity, trip duration, and time in MVPA on hilly and flat routes. (Lower intensity but 92–99% of time in MVPA.)

Physical effort and pace of MTB and eMTB bicycles (2023). Comparative field study of heart-rate response and pace, MTB vs eMTB. Journal of Physical Education and Sport.

Can electric mountain bikes keep you just as active and healthy as traditional mountain bikes? (2026). Physiological comparison across assistance modes (FTHR/FTP time-in-zone).

World Health Organization. (2020). Guidelines on physical activity and sedentary behaviour (150–300 min/week moderate, or 75–150 min vigorous).

Fransen, M., et al. (Cochrane). Exercise for osteoarthritis of the knee/hip: low-impact aerobic exercise and lower-limb strengthening reduce pain and improve function.

Mountain Biking Australia. (2020). Skills: Training with e-MTBs — practical coaching perspective on recovery rides and ride frequency.

Watanabe, K., et al. (2016). Quadriceps and hamstring muscle activity during cycling as measured with intramuscular electromyography. European Journal of Applied Physiology, 116, 1897–1907. (Pedal-stroke muscle-activation timing.)

Physiopedia. Cycling Biomechanics — phase-by-phase lower-limb muscle recruitment during the pedal stroke.

Ruddick, G., Trease, L., & Pearson, S. (2026). Epidemiology of Electronic Mountain Biking Injuries: An Unexplored Emerging Extreme Sport. Wilderness & Environmental Medicine. (eMTB weight not a clear injury factor; severity comparable to analog MTB.)

Braybrook, P., et al. (2023). Epidemiology of electronic mountain biking injuries. Journal of Science and Medicine in Sport. (eMTB injury profile mirrors non-e MTB; higher share of chest trauma.)

Bicycle-related injuries in the emergency department: a comparison between E-bikes and conventional bicycles (2020, Netherlands); and Increased injury severity and hospitalization following e-bike crashes (2022, Switzerland). (E-ROAD-bike severity elevated, largely explained by older rider age.)

American Association of Cardiovascular and Pulmonary Rehabilitation. Guidelines for cardiac rehabilitation (moderate-intensity, heart-rate-guided aerobic prescription).

This white paper is an educational synthesis of publicly available research, compiled for general information. It is not medical advice. Individuals with injuries or cardiovascular, metabolic, or musculoskeletal conditions should consult a physician or physical therapist before beginning or changing an exercise program. Study details may be summarized; consult the primary sources for full methods and limitations.