Can electric mountain bikes keep you just as active and healthy as traditional mountain bikes?

¿Pueden las bicicletas de montaña eléctricas mantenerte igual de activo y saludable que las bicicletas de montaña tradicionales?

Authors

Juan Carlos Redondo-Castán [1]
José María Izquierdo-Velasco [2]
Miguel Ramírez-Giménez [2]
Silvia Sedano-Campo [3]

[1] University of León (Spain)
[2] University of Valladolid (Spain)
[3] European University Miguel de Cervantes University (Spain)

Corresponding author:
Juan Carlos Redondo Castán
jc.castan@unileon.es

Received: 15-10-25
Accepted: 29-12-25

How to cite in APA

Redondo Castán, J. C., Izquierdo Velasco, J. M., Ramírez Jiménez, M., & Sedano Campo, S. (2026). Can electric mountain bikes keep you just as active and healthy as traditional mountain bikes? *Retos, 76*, 563-575. https://doi.org/10.47197/retos.v76.117884

Abstract

Introduction: The use of electric mountain bikes has increased interest in their contribution to physical activity and health, although evidence under real-world conditions remains limited.
Objective: This study explored whether the transition from a conventional mountain bike to an electric mountain bike allowed the maintenance of health-related exercise intensities in a recreational cyclist under different assistance modes.
Methodology: A longitudinal single-participant study was conducted over sixteen weeks. Four conditions were compared: a conventional mountain bike and an electric mountain bike with three assistance configurations. Heart rate, speed, power output, cadence, slope, perceived exertion, and training load indices were recorded during twenty-eight outdoor rides covering seven hundred and seventy-eight kilometres.
Results: Physiological differences were observed across conditions. In this participant, lower assistance and constrained modes were associated with moderate-to-vigorous intensities and reduced momentary physiological load compared with conventional cycling. On steeper slopes, some assisted modes reached relative intensities close to functional threshold power.
Discussion: These patterns were consistent with previous studies describing meaningful physiological responses when assistance was regulated and highlighted the influence of terrain and assistance selection.
Conclusions: This exploratory study suggests that electric mountain biking may allow some users to sustain health-relevant exercise intensities under specific conditions.

Keywords

Cardiorespiratory response; exercise intensity; electric mountain bike (eMTB); physical activity; training load.

Resumen

Introducción: El uso de bicicletas eléctricas de montaña ha aumentado el interés por su contribución a la actividad física y la salud, pero la evidencia en condiciones reales es limitada.
Objetivo: Se exploró si la transición de bicicleta de montaña convencional a bicicleta eléctrica de montaña permitió mantener intensidades saludables en un ciclista recreativo bajo distintas asistencias.
Metodología: Se realizó un estudio longitudinal de caso único durante dieciséis semanas. Se compararon cuatro condiciones: bicicleta convencional y bicicleta eléctrica con tres configuraciones de asistencia. Se registraron frecuencia cardíaca, velocidad, potencia, cadencia, pendiente, percepción del esfuerzo e índices de carga en veintiocho salidas reales (setecientos setenta y ocho kilómetros).
Resultados: Se observaron diferencias fisiológicas entre condiciones. En este participante, modos de menor asistencia y el modo restringido se asociaron con intensidades moderadas a vigorosas y menor carga fisiológica momentánea que la bicicleta convencional. En pendientes pronunciadas, algunos modos asistidos alcanzaron intensidades relativas próximas al umbral funcional de potencia.
Discusión: Los patrones fueron coherentes con estudios previos que describieron respuestas relevantes cuando la asistencia se reguló, y mostraron la influencia del terreno y del modo.
Conclusiones: Este estudio exploratorio sugiere que algunos usuarios pueden sostener intensidades saludables con bicicleta eléctrica en condiciones específicas.

Palabras clave

Actividad física; bicicleta de montaña eléctrica (eMTB); carga de entrenamiento; intensidad del ejercicio; respuesta cardiorrespiratoria.

Introduction

Current guidelines recommend that adults (aged 18-64 years) accumulate 150 to 300 minutes of moderate-intensity physical activity (PA), 75 to 150 minutes of vigorous-intensity PA, or an equivalent combination of both each week, along with to muscle-strengthening activities at least twice a week (Bull et al., 2020; Services, 2018). Additionally, the UK National Institute of Health and Care Excellence (NICE) (Kelly et al., 2010) supports the idea that increasing the amount of walking or cycling may enhance overall PA levels, leading to health benefits. It could be essential to provide opportunities for everyone, including individuals with impairments, to participate in and enjoy the outdoor environment (Nolan et al., 2018).

The benefits of physical activity for healthy aging extend beyond those who have maintained an active lifestyle throughout adulthood. In fact, longitudinal data demonstrate that initiating physical activity in late adulthood can also lead to significant improvements in health and wellbeing (Hamer et al., 2014; Szychowska & Drygas, 2022). Engaging in regular physical activity during later years not only helps reduce the risk of chronic diseases but also enhances mental health and improves overall quality of life (Anderson & Durstine, 2019).

Cycling is a widely practiced sport at both competitive and recreational levels, and it is one of the most popular amateur sports in Europe (Ferrucci et al., 2021). According to Ferrucci et al. (2021), amateur cyclists represent one of the largest segments of active sport participants, accounting for approximately 30–35% of regular recreational athletes in several European countries. Large-scale surveys of European mountain bikers, such as that conducted by Campbell et al. (2021) with 3,780 participants from 28 nations, confirm that mountain biking has consolidated as a major outdoor activity motivated by physical fitness, nature experience, and social engagement. In line with these findings, Garrosa-Martín et al. (2023) reported that mountain biking now represents nearly half of all off-road cycling practice, highlighting its exponential growth during the past two decades. More recently, the use of electrically assisted mountain bikes (eMTBs) has expanded rapidly, with market data showing annual increases exceeding 20% and a progressive shift in user demographics toward older or less performance-oriented riders (Kuwaczka et al., 2023). This evolution illustrates how eMTBs are reshaping participation patterns and broadening accessibility within the mountain biking community. Beyond Europe, similar trends have been reported globally. In North America, survey data show a rapid increase in electric bicycle adoption among adults, including older recreational riders seeking accessible forms of outdoor physical activity (MacArthur et al., 2018). In China, where e-bikes represent one of the fastest-growing modes of active mobility, recent studies have highlighted their contribution to both utilitarian and recreational physical activity, with substantial uptake across diverse age groups (Cherry et al., 2016). These international patterns reinforce the broader relevance of evaluating how eMTBs may support health-promoting physical activity across populations beyond Europe.

Users who replace a conventional bicycle trip with an electric-assisted bicycle (e-bike) typically experience a relative reduction in the minutes spent in moderate-to-vigorous physical activity (MVPA), as e-bikes require less physical effort than traditional bicycles. However, this does not imply that e-bike riding fails to provide meaningful activity. Langford et al. (2017) showed that, although e-bikes reduce the energetic cost compared with conventional cycling, they still enable riders to achieve moderate levels of physical activity and can even elicit vigorous intensities on hilly terrain. Furthermore, in hilly environments, e-bikes are expected to enable riders to achieve vigorous-intensity PA during uphill segments (Langford et al., 2017). This is likely to result in an increase in neotenous behaviour, therefore, as more, and younger, riders could experience the thrills of riding without requiring exceptional fitness (Taylor et al., 2023).

From a public health perspective, it will be important to advocate for an empirical approach when assessing both user-group challenges and the health benefits of this technology (Chaney et al., 2019). Previous studies (Berntsen et al., 2017; Langford et al., 2017) have found that e-bikes are faster and have lower exercise intensity compared to conventional bicycles. Moreover, the option to choose a mountain bike (MTB) or eMTB bike for mountain biking appears to create the conditions that enhance rider comfort, controlling the pace and duration of the ride, while being able to plan the route length and difficulty level (Ostrowski et al., 2023). The literature on physical activity associated with the use of an eMTB in recreational activities, however, is both limited and inconsistent.

Despite these advances, limited evidence exists on how eMTB assistance modes influence physiological responses during real-world mountain biking. In particular, little is known about how heart rate, power output and exercise intensity change when a recreational rider transitions between MTB and different eMTB support modes across varied outdoor terrain. This represents an important knowledge gap, given that assistance level, slope and technical difficulty can substantially alter the physical demands of riding.

Given the emerging nature of electrically assisted mountain biking research and the complexity of real-world riding conditions, exploratory case-based approaches can provide valuable initial insight into physiological responses that may not be readily captured in larger experimental designs. A physiological comparison between MTB and eMTB is therefore warranted. Although several studies have examined e-bike use in commuting or laboratory contexts, reporting lower heart-rate responses and energy expenditure compared with conventional cycling (Blanco Herrera & Almeida Cunha Arantes, 2002; Katsanos & Moffatt, 2005), far fewer investigations have analysed how different motor-assistance settings affect physiological indicators such as heart rate, power output and training load during prolonged outdoor rides. Existing work in recreational cyclists suggests that the interaction between slope, terrain variability and assistance mode can substantially influence exercise intensity and perceived effort (Karsten et al., 2021; López-Miñarro & Rodríguez, 2010). Understanding these differences is essential for interpreting how eMTBs may influence exercise load, rider experience and the potential to meet physical activity recommendations. Recent work within the active transportation field has emphasised that cycling, both conventional and electrically assisted, can contribute meaningfully to daily moderate-intensity physical activity, reinforcing its relevance for public health initiatives (Sáez Padilla et al., 2022; Vásquez-Gómez et al., 2025). Moreover, recent analyses of public bicycle-sharing systems indicate that older adults can be active and frequent users of cycling-based mobility services (Pans Sancho et al., 2023), supporting the idea that electrically assisted bicycles may facilitate engagement in outdoor physical activity among groups who might otherwise face functional or motivational barriers.

Therefore, the current exploratory study aimed to address these gaps by examining how the transition from a conventional mountain bike (MTB) to an electric mountain bike (eMTB) affects the ability to maintain equivalent levels of physical activity in a single recreational rider. Specifically, the study compared cardiorespiratory, metabolic, and psychological responses under four recreational mountain biking conditions (MTB, ECO_eMTB, FREE_eMTB, and C_eMTB). Given the single-participant design, the hypotheses were formulated cautiously and refer specifically to this individual. We expected that (1) eMTB riding would allow the participant to maintain moderate-to-vigorous physical activity levels comparable to those achieved with conventional MTB use, as reflected by heart rate (HR) and power output (PO); (2) higher levels of electric assistance (FREE_eMTB and C_eMTB) would reduce HR and PO values compared with MTB; and (3) when rides were performed at matched perceived exertion (RPE), training load indices (TRIMP and TSS) would remain within comparable ranges across conditions.

By testing these hypotheses, the study sought to clarify whether eMTBs can sustain exercise intensities that meet health-related physical activity recommendations and thus represent a feasible alternative for maintaining cardiorespiratory and metabolic benefits during recreational cycling.

Method

Participants

A non-competitive level male cyclist who regularly engages in recreational physical activity with a very low asymmetry index (4%) (Carpes et al., 2010) voluntarily participated in the study. Participant characteristics are outlined in Table 1. He had been using an MTB for the past 3 years, an average of 2 times per week with at least 150 minutes per time. According to Simons et al. (2009) the subject was habitually active, in good health, and had been using a conventional mountain bike (MTB) for the past three years, meeting current physical activity recommendations. The participant's profile is consistent with the demographic of European recreational mountain bikers aged 40–60 years, one of the fastest-growing groups adopting eMTBs (Campbell et al., 2021; Kuwaczka et al., 2023). However, this correspondence is descriptive and does not imply representativeness. This age segment is typically characterized by high motivation to maintain health and fitness while moderating physical strain, aligning well with the purpose of transitioning from MTB to eMTB use.

Before data collection, he underwent familiarization sessions with the electric-assisted mountain bike (eMTB) to ensure safe and consistent use during the study. Prior to testing, and after receiving a full explanation of the nature and purpose of the study, the subject provided written informed consent. In addition, the participant reported not having suffered any sports-related injury, surgery or rehabilitation during the 12 months prior to the start of the study. The research project was conducted in accordance with the Declaration of Helsinki and was approved by the university's ethics committee.

Table 1. Participant characteristics.

Sex	Male
Age (y)	57.4
Height (cm)	169.2
Body mass (kg)	70.4
BMI (Weight/height^2)	24.6
FCmax	186
FTP (W)	212.4
FTP (W·kg^{-1})	3.01
Pmean (W)‡	602.5
Pmean (W·kg^{-1})‡	8.56
Ppeak (W)‡	771
Ppeak (W·kg^{-1})‡	10.95

BMI = body mass index; FTP = functional threshold; Pmean = average power output during 30-second Wingate test; Ppeak = peak power output during 30-second Wingate test.

Experimental design

A longitudinal single-participant design was used to explore the transition from conventional MTB to eMTB riding under four recreational conditions. The aim was to compare the physical, cardiorespiratory, metabolic and perceptual responses across conditions in this participant, and to examine whether certain eMTB modes might allow him to sustain exercise intensities similar to those achieved with conventional MTB riding. These conditions focused on the use of a regular mountain bike (MTB) without assistance or an electric mountain bike (eMTB).

Depending on the type of mechanical assistance selected, the eMTB condition was divided into three experimental modes: ECO_eMTB, FREE_eMTB, and C_eMTB. In the ECO_eMTB condition, the participant rode exclusively using the ECO assistance mode, which provided approximately 60% motor support. In the FREE_eMTB condition, the participant was free to select among any of the four manufacturer-provided assistance modes (ECO, TOUR+, eMTB, and TURBO) according to the terrain and perceived effort. In the C_eMTB condition, the participant could also choose from all four assistance modes but was instructed to maintain the same cycling speed as recorded in the MTB condition. According to the manufacturer's specifications, the eMTB motor (maximum torque of 80 Nm) adjusts assistance proportionally to the cyclist's applied power, with the four available modes offering incremental support levels: ECO (≈60% assistance), TOUR+ (dynamic support between ECO and eMTB), eMTB (≈240% assistance), and TURBO (≈340% assistance).

Following a familiarization period, laboratory tests, and a specific range of physical performance assessments, the participant cycled 778 kilometers over a 16-week period (between March and June), distributed across 28 rides on 7 distinct tracks, each completed 4 times. The sequence of conditions followed a partially randomised structure: ECO_eMTB and FREE_eMTB were performed in random order across repetitions, whereas MTB was always performed before C_eMTB to provide a speed reference for the constrained mode. This structure is now explicitly acknowledged as a limitation because it may have introduced partial order effects. The recovery period between rides was always at least 72 hours.

It is important to note that the present study followed a single-participant longitudinal design, which allowed for strict control of environmental and procedural conditions but inherently limits the generalizability of the findings. The methodological approach used here is therefore best understood as an intensive within-subject analysis rather than an inferential design. All laboratory and field procedures, measurement instruments, and statistical analyses were selected to maximize internal consistency and accuracy within this framework. Consequently, the results should be interpreted in light of these methodological characteristics.

Given the 16-week duration and total training volume (778 km), the possibility of progressive physiological adaptation cannot be fully excluded. This is now explicitly acknowledged as a limitation, as such adaptations may have affected inter-condition comparisons.

Testing procedures

The MTB test sessions were conducted on a mountain bike (Specialized, Stumpjumper 15 Alloy) with 29-inch wheels, weighing 16.57 kg. The eMTB test sessions, on the other hand, were conducted on a mountain bike (Orbea, WILD FS M-LTD 21) with 29-inch wheels, weighing 22,5 kg. Both bikes were fitted with VCT pedals connected to Garmin power control. The tire (Maxxis Minion DH R II 29x2.40'') pressure was set to 24 PSI, and the chain was well-lubricated. The riding position was standardized, and the participant was instructed to remain seated throughout the entire ride, consistently wearing the same mountain biking shoes. According to the manufacturer's specifications, the motor power of the eMTB used (with a maximum torque of 80 Nm) is proportional to the power applied by the cyclist. The eMTB offers four assistance modes: ECO, providing 60% assistance; TOUR+, with dynamic assistance that automatically shifts between ECO and TURBO modes; e-MTB, offering direct assistance of 240%; and TURBO, with direct assistance of 340%.

In the Garmin VCT vector power meter (VCT, Olathe, USA), power output (PO) is measured at the pedals where force is applied. The VCT records the slight deflection of the pedal spindle throughout the entire pedal stroke, as well as the 2D force vectors. This data is used to calculate power. The force sensors are housed in both pedals, allowing independent power measurement from each leg and report the total VCT power output (POVCT), considering the left-right leg balance. According to Bouillod et al (2017) validity and reliability of the VCT was investigated in the laboratory during a sub-maximal 30-min continuous test, with an SRM power meter (SRM, Schoberer Rad Messtechnich, Julich, Germany) as a gold standard. Before each test, the SRM and the VCT were "calibrated" according to the manufacturer's recommendations, i.e. the zero-power offset was reset, although the setting of the zero offset does not substitute for a standardized calibration. Prior to each field session, the VCT system was zero-offset reset according to manufacturer recommendations to minimise drift and ensure consistency across rides. The SRM power output (POSRM), the POVTC, the velocity, and the pedaling cadence were stored every 1 s. There was no significant difference ($p = 0.195$) between the mean POSRM and POVTC during the 30-min continuous tests (157.4 ± 3.6 vs. 155.0 ± 3.97W, respectively) and the mean CV was 1.5% and 1.9% for POSRM and POVTC, respectively.

Following the method used by Karsten et al. (2021), functional threshold power (FTP) was estimated from a single 20 min time trial (TT). The TT commenced with a 5-minute warm-up at 100 W. Throughout the 20 min TT, participants were allowed to self-pace, with elapsed time feedback provided. Heart rate (HR) was monitored continuously, and the rate of perceived exertion (RPE) (Robertson et al., 2004) was recorded immediately after completing the trial. HR within 10 beats of the age-predicted maximum and RPE values above 18 were taken as indicators of a maximal effort and accepted as a successful test. FTP was then calculated as 95% of the 20-minute maximal measured PO (20MMP) recorded during the TT. Based on the data obtained, training zones were calculated according to the methodology proposed by Allen et al. (2019). Additionally, five cardiorespiratory workload zones were defined using heart rate (HR) values, following the framework established by Blanco and Almeida (2002).

Measurements

The parameters measured during the tests were, heart rate (HR), cycling speed (CS), power output (PO), pedaling cadence (PC), slope (SLP), rate of perceived exertion (RPE), TRaining IMPulse (TRIMP) and Training Stress Score (TSS).

A Garmin Edge 1030 bicycle counter (Cardiosport, Waterlooville, Hampshire, UK), paired with a hub-mounted and properly calibrated Garmin Bluetooth Ant+2 speed sensor, was used to measure cycling speed (CS), slope (SLP), distance and altitude. A Garmin HRM Pro sensor worn on the subject's chest, paired with the Garmin Edge 1030 bicycle counter, was used to measure physical exertion as measured by heart rate (HR). A VCT power meter Garmin Vector paired with the Garmin Edge 1030 bicycle counter was used to measure power output (PO) and pedaling cadence (PC).

The data recorded after each ride was saved in the Garmin Connect software cloud, from where it was further exported to a file with a ".csv" extension. This file contained detailed ride information with a 1-

second recording interval and was analyzed within a MS Excel spreadsheet in order to calculate TRIMP (Edwards, 1994), TSS (Allen et al., 2019) and normalized power (NP) (Allen et al., 2019).

Several contextual variables, such as ambient temperature, wind conditions, surface characteristics, and day-to-day fatigue, were not explicitly controlled or modelled in the analysis. Given the exploratory and single-participant nature of the study, these factors were considered part of the ecological variability inherent to real-world outdoor cycling. Their potential influence on the recorded physiological responses is therefore acknowledged as a limitation and should be addressed in future multi-participant or controlled designs.

Data analysis

Given the single-participant design, the data were analysed descriptively rather than inferentially. For each condition (MTB, ECO_eMTB, FREE_eMTB and C_eMTB), mean and standard deviation values were calculated for HR, PO, NP, CS, PC, SLP, RPE, TRIMP and TSS. Graphical comparisons were performed to visualise intra-individual variability across modes. No inferential statistics (e.g., ANOVA, significance testing) were applied, as these procedures require inter-individual variance and independent sampling assumptions that are not met in N-of-1 designs.

Results

The general characteristics of the exercise-related parameters measured under each of the different conditions investigated are shown in Table 2. The initial descriptive analysis revealed that 98% of the recorded route data fell within a slope range of ±12.5%. Consequently, this filter was applied to all subsequent analyses to exclude outliers that could potentially bias the results.

Table 2. General characteristics of mtb and emtb mountain bike tracks and modes

Mode	Tracks	km	Climb	RPE	Time	Temp
MTB	7	26,6±10	2,631±138	7	100±37	19.8±1.3
ECO_ eMTB	7	27,1±10	2,715±132	7	85±27	20.3±2.1
FREE_eMTB	7	26,1±9.6	2,583±134	7	79±32	21.6±2.2
C_eMTB	7	26,3±9.7	2,633±136	5.2±0.3	99±26	21.8±1.9
TOTAL	28	736.27	10,562		2,535	

Climb= meters climbed, rpe = perceived exertion, time = minutes per track, temp = temperatures (media and sd), mtb = mountain bike; emtb = electrical mtb; eco_emtb = eco support; free_emtb = free support, c_emtb free support at the same pace as the mtb condition.

Table 3 summarises mean and standard deviation values for all variables across modes, while Table 4 presents average power output values across slope categories. These descriptive comparisons allow for an examination of how assistance levels were associated with changes in cardiac, metabolic and mechanical demands in this participant.

Table 3. Descriptive summary of physiological and mechanical variables across MTB and eMTB modes (single participant)

Modes	Normalized power (w)	Heart rate (ppm)	Speed (km/h)	Trimp	Tss	Rate
MTB (n = 40,251)	110,34±101,65	135.87±21.97	16.43±6.56	744	97,1	53.9±36.7
ECO_eMTB (n = 37,166)	108.11±88.21	138,92±18,69	18.50±6.25	758	65.9	66.4±34.1
FREE_eMTB (n = 34,313)	121.47±90.35	139.52±17.56	21,30±5,90	698	90.3	66,9±33,9
C_eMTB (n = 39,460)	92.49±81.58	116.67±19.09	16.1±6.01	460	66.1	58.9±32

MTB = mountain bike; eMTB = electrical MTB; ECO_eMTB = eco support; FREE_eMTB = free support, C_eMTB free support at the same pace as the MTB condition; TRIMP =TRaining IMPulse; TSS = Training Stress Score; RATE = Pedaling Rate; All values correspond to repeated measurements obtained from a single participant across multiple rides. The term "n" does not refer to the number of participants.

Across conditions, normalized power (NP), heart rate (HR), and cycling speed (CS) varied according to assistance mode. When averaged across all rides and terrain conditions, higher assistance modes

(FREE_eMTB and C_eMTB) were generally associated with lower NP and HR values compared with conventional MTB. In contrast, NP and HR during ECO_eMTB remained within ranges typically associated with moderate-to-vigorous intensities, although these values varied depending on terrain characteristics. These patterns are reflected in the mean values shown in Table 3.

Pedalling cadence also varied across conditions, with MTB displaying the lowest average cadence and FREE_eMTB and C_eMTB tending toward higher values. ECO_eMTB and FREE_eMTB displayed similar cadence patterns, consistent with their comparable assistance profiles.

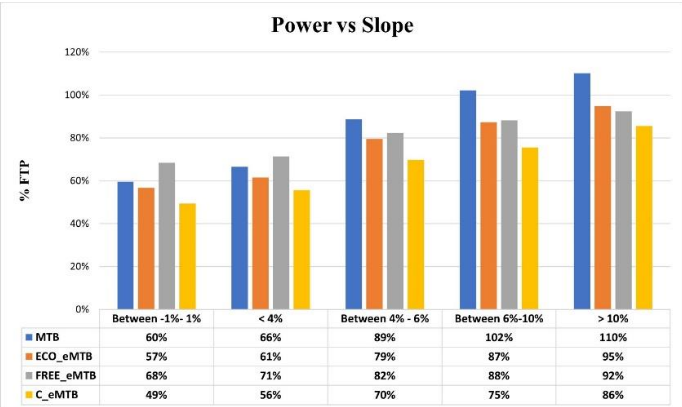
Table 4. Normalized power values across terrain slope categories and assistance modes (single participant).

Modes	Normalized power (w)			
	Slope ± 1%	Slope -1%- 4%	Slope 4%- 7%	Slope > 7%
MTB	89.0±84.5	104.7±87.9	174.0±90.3	209.9±99.2
ECO_eMTB	97.9±74.2	107.5±75.2	158.2±75.8	186.4±77.7
FREE_eMTB	119.9±82.8	128.1±79.8	162.7±73.3	181.6±73.5
C_eMTB	77.5±71.1	90.9±71.1	138.6±70.5	166.6±70.4

MTB = mountain bike; eMTB = electrical MTB; ECO_eMTB = eco support; FREE_eMTB = free support, C_eMTB free support at the same pace as the MTB condition.

Terrain slope was a key factor influencing associated with variations in mechanical and physiological responses. As shown in Table 4, absolute power output increased with slope across all modes, although the magnitude of this increase differed by assistance level. In terms of absolute power, MTB elicited the highest values across gradients, while ECO_eMTB and FREE_eMTB showed intermediate responses and C_eMTB the lowest. In contrast, when intensity was expressed relative to the participant's functional threshold power (%FTP), the ECO_eMTB and FREE_eMTB modes reached the highest proportional intensities on slopes greater than 7%, whereas C_eMTB was associated with lower relative demand. Figure 1 illustrates these slope-dependent patterns.

Figure 1. Percentage of functional threshold power (%FTP) relative to terrain slope for the different assistance modes



MTB = mountain bike; eMTB = electrical MTB; ECO_eMTB = eco support; FREE_eMTB = free support, C_eMTB free support at the same pace as the MTB condition.

Analysis of time spent within FTP and FTHR zones during each condition (Figure 2) showed distinct but partially overlapping distributions of exercise intensity across modes when rides were performed at similar perceived exertion (RPE). ECO_eMTB and FREE_eMTB were associated with a slightly higher proportion of time spent in moderate-intensity zones (e.g., zone 3), whereas C_eMTB tended to concentrate time in lower-intensity zones. MTB showed the highest proportion of time in zones associated with vigorous intensity. These patterns describe how exercise intensity was distributed across assistance modes for this participant under comparable perceptual effort.

Figure 2. Percentage of time per functional threshold heart rate (FTHR) and percentage of time per functional threshold power (FTP).

MTB = mountain bike; eMTB = electrical MTB; ECO_eMTB = eco support; FREE_eMTB = free support, C_eMTB free support at the same pace as the MTB condition. Table associated with the figure presents percentage of time per zone for MTB mode and the percentage differences for the various electric assistance modes (eMTB) compared to the MTB mode. Difference = ± 4% ( ), difference ≥ 4,1% (and difference ≤ - 4,1% ( )

Overall, the descriptive patterns observed in this participant were consistent with the expected influence of assistance level on physiological demand across assistance levels. Electric assistance was associated with lower instantaneous load, although the ECO and C_eMTB modes still allowed this rider to sustain intensities comparable to those reached with conventional MTB riding under certain terrain conditions. In contrast, the FREE mode tended to produce lower NP and HR values, reflecting reduced effort in this specific case. The combined role of slope and assistance level describes how effort distribution varied across modes during recreational mountain biking. These observations provide preliminary insight into how eMTB use may influence the intensity profile of outdoor rides in this participant, although confirmation in broader samples is required.

Discussion

The purpose of this study was to examine whether the transition from using a conventional mountain bike (MTB) to an electric mountain bike (eMTB) allows for the maintenance of equivalent physical activity levels. In accordance with our hypotheses, the results suggest that, in this participant, eMTB use was associated with moderate-to-vigorous exercise intensities, particularly when operating in ECO mode and, under specific terrain conditions, in the constrained C_eMTB mode. These conditions produced mean heart rate (HR) and normalized power (NP) values within ranges comparable to those recorded during conventional MTB rides, indicating the possibility that this participant may maintain health-related physical activity levels while reducing physiological strain. Furthermore, the influence of assistance level on exercise intensity was consistent with our second hypothesis: higher levels of motor support significantly reduced HR and PO values, especially under steeper slope conditions. Finally, consistent with our third hypothesis, comparable training load indices (TRIMP and TSS) were observed between MTB and eMTB rides when performed at equivalent perceived exertion (RPE), indicating that overall workload can be preserved for this participant despite mechanical assistance. Together, these findings provide preliminary insight suggesting that the ECO and C_eMTB modes may help sustain intensity ranges that, in this participant and under specific terrain conditions, overlapped with those observed during MTB use, whereas the FREE mode resulted in substantially lower physiological demand. Further research involving larger and more diverse samples is needed to verify these patterns. These observations align with recent findings in the active-transportation literature, where electrically assisted and conventional cycling have been associated with meaningful levels of physical activity and cardiorespiratory engagement (Vásquez-Gómez et al., 2025).

The present results revealed significant differences in power output and exercise intensity between the MTB and eMTB conditions. While electric assistance reduced power demand, the ECO_eMTB mode showed differences that were not substantial enough in this participant to indicate a drastic reduction in physical effort compared with the MTB condition. In contrast, the FREE_eMTB mode resulted in a clearly lower physiological demand in this participant, particularly when assistance was freely selected across terrain, as reflected in both NP and HR values. In this participant, the observed responses were consistent with the direction of our first hypothesis and resembled patterns reported in previous studies indicating that e-bikes can elicit moderate levels of energy expenditure (Berntsen et al., 2017; Langford et al., 2017). However, given the single-participant design, these similarities should be interpreted cautiously. The most notable decrease in power output occurred in the C_eMTB condition, where the participant maintained MTB speed with electrical assistance, indicating that, in this participant, motor support substantially reduces energy demand when pace is held constant. Moreover, HR data were consistent with our second hypothesis, showing a clear reduction in cardiorespiratory load under high assistance levels (Berntsen et al., 2017; Chaney et al., 2019). This adaptive reduction in HR may be relevant for older adults or those with cardiorespiratory limitations, although this remains speculative beyond this participant and aligns with findings by Mitterwallner et al. (2021) regarding the accessibility of eMTBs on challenging terrain.

On slopes greater than 7%, the ECO and FREE modes sustained higher relative intensities (87% and 86% of FTP, respectively) than the MTB mode, which achieved 82% of FTP on moderate gradients (4–7%). These data indicate that, under demanding terrain, certain eMTB configurations, particularly ECO mode and, in specific situations, FREE mode, may at times reach vigorous-intensity thresholds in this participant. (Berntsen et al., 2017; Langford et al., 2017). However, this interpretation should be approached cautiously given the single-participant design, and further research is required to determine whether similar patterns occur in broader samples. This is consistent with the view that eMTBs may lower physical barriers to participation while still providing meaningful exercise stimuli, although more extensive studies are needed to substantiate this (Chaney et al., 2019; Mitterwallner et al., 2021). Such findings are particularly relevant from a public health perspective: eMTBs could encourage more individuals, including older adults or those with limited fitness, to engage in outdoor recreation, enhancing overall health and wellbeing (Hamer et al., 2014; Szychowska & Drygas, 2022). Nevertheless, achieving comparable training effects requires continuous monitoring of the functional threshold power (%FTP), as subjective perception of effort may be unreliable for inexperienced riders.

Regarding training load quantification, our findings partially contrasted with those of Wallace et al. (2014). While the highest TRIMP was recorded in the ECO_eMTB mode, the highest TSS occurred in the MTB condition. This divergence likely reflects the instability of HR-based load estimation during variable-effort cycling (Foster et al., 2005), emphasizing that power-based metrics provide a more consistent assessment of training load (Robinson et al., 2011). This observation aligns with the exploratory aims of the present study and underscores the potential relevance of integrating power-output monitoring systems into eMTBs for improving the description of training load in both research and applied settings. Moreover, the strong alignment between RPE and HR observed in this study is consistent with earlier research (Muyor et al., 2015; Perez-Landaluce et al., 2002), confirming RPE as a useful tool for monitoring effort in MTB (Katsanos & Moffatt, 2005). However, given that RPE reliability depends on prior familiarization (López-Miñarro & Rodríguez, 2010), novice riders may still require objective feedback (e.g., %FTP) to ensure adequate load management. This interpretation is consistent with recent analyses in active-mobility research showing that cycling behaviour and effort regulation vary substantially across users and contexts (Sáez Padilla et al., 2022), reinforcing the importance of monitoring both internal and external load when evaluating assisted cycling.

The influence of terrain slope was also consistent with well-established principles of cycling physiology: gradient strongly modulates effort intensity. At slopes below 4%, the ECO and FREE eMTB modes occasionally elicited higher effort than MTB due to differences in inertia and cadence. Between 4% and 7% gradients, intensity tended to decline as motor assistance contributed proportionally more to propulsion. However, on slopes steeper than 7%, effort increased again in ECO and FREE modes, reaching higher relative intensities than in the MTB condition (Richard Davison et al., 2000). Although these results come from a single-participant design, they illustrate the biomechanical complexity of eMTB performance and justify further multi-participant research.

In addition, single-participant designs have been widely used and validated in exercise science when the aim is to obtain detailed, repeated, and ecologically valid physiological data under tightly controlled conditions. Previous research has demonstrated that single-case approaches can provide rigorous and sensitive insights into individual responses to exercise stimuli (Backman & Harris, 1999; Barker et al., 2013). Similar methodological frameworks have been applied in endurance sports and cycling performance research, where N-of-1 longitudinal data have been used to track temporal adaptations and physiological regulation in real-world contexts (Rønnestad et al., 2019). These studies support the relevance and methodological legitimacy of using an intensive single-participant design in the present work, although such designs inherently limit generalisability and reinforce the need for future investigations with larger and more heterogeneous samples.

Although the single-participant design allowed for tight control of conditions and a detailed characterization of physiological responses, this methodological approach naturally limits the generalizability of the findings. Future research should include participants with more diverse characteristics—such as different ages, sex, fitness levels, cycling experience, and familiarity with eMTBs—to explore potential inter-individual variability. Incorporating heterogeneous samples would broaden the applicability of the results and help determine whether similar patterns of effort regulation and physical activity intensity are observed across a wider range of riders.

The analysis of FTP and FTHR zones provided further descriptive information. While eMTB modes, particularly ECO and FREE, reduced overall power output, they maintained time in moderate-to-high intensity zones comparable to MTB (Sanders et al., 2020). This suggests that eMTB cycling may offer exercise stimuli conducive to cardiovascular adaptation for this participant, even with partial mechanical support (Ostrowski et al., 2023). The capacity to tailor assistance dynamically enables cyclists to regulate effort precisely, potentially improving exercise adherence and long-term cardiovascular outcomes (Berntsen et al., 2017; Langford et al., 2017). Additionally, integrating power output reporting in eMTBs could enhance the accuracy of training load estimation for cyclists, addressing discrepancies observed in HR-based load estimation (Robinson et al., 2011; Wallace et al., 2014).

Importantly, these findings should not be interpreted as evidence of equivalence between MTB and eMTB modalities, but rather as descriptive patterns observed within a single rider under specific assistance and terrain conditions. Rather than indicating equivalence or demonstrating general effects, the present findings suggest that effort distribution varied systematically with assistance level and terrain in this individual. Future research should expand on these findings by exploring inter-individual variability, long-term adaptation, and psychological factors influencing eMTB use across different terrains and user profiles (Ostrowski et al., 2023).

Conclusions

This single-participant study offers preliminary insight into how electric mountain bikes (eMTBs) may influence exercise intensity and physiological responses under real-world conditions. In this case, eMTB use (particularly in the ECO and C_eMTB modes) allowed the rider to sustain moderate-to-vigorous intensity levels on certain terrain segments, while reducing momentary physiological strain compared with conventional MTB riding. These observations resemble patterns reported in previous exploratory studies, although they should not be generalized beyond this participant.

The differences observed across modes in power output, heart rate, and cycling speed indicate how assistance levels may influence effort distribution for this individual. At the same time, the variability between modes highlights that the physiological demands of eMTB riding depend strongly on individual behaviour, assistance selection, and terrain, and may not follow uniform trends across riders.

From a training perspective, the findings suggest that power-based metrics could help riders regulate effort when alternating between MTB and eMTB, although this possibility requires confirmation in larger samples. Subjective measures such as RPE may assist with effort monitoring, but their reliability likely depends on adequate familiarization.

Overall, these findings should be interpreted as exploratory, describing the responses of a single experienced rider rather than indicating population-level effects. Future research including larger and more diverse samples—varying in age, cycling experience, fitness levels, and riding contexts—is needed to examine whether similar patterns emerge across riders and to clarify the potential role of eMTBs in supporting health-promoting physical activity.

Data availability statement

Supplemental data for this article can be accessed online at https://doi.org/10.57760/sciencedb.19823.

Financing

No funding was received.

References

Allen, H., Coggan, A. R., & McGregor, S. (2019). Training and racing with a power meter. VeloPress.

Anderson, E., & Durstine, J. L. (2019). Physical activity, exercise, and chronic diseases: A brief review. Sports medicine and health science, 1(1), 3-10.

Backman, C. L., & Harris, S. R. (1999). Case studies, single-subject research, and n of 1 randomized trials: Comparisons and Contrasts: 1. American journal of physical medicine & rehabilitation, 78(2), 170-176.

Barker, J. B., Mellalieu, S. D., McCarthy, P. J., Jones, M. V., & Moran, A. (2013). A review of single-case research in sport psychology 1997–2012: Research trends and future directions. Journal of Applied Sport Psychology, 25(1), 4-32. https://doi.org/10.1080/10413200.2012.709579

Berntsen, S., Malnes, L., Langåker, A., & Bere, E. (2017). Physical activity when riding an electric assisted bicycle. International journal of behavioral nutrition and physical activity, 14, 1-7. https://doi.org/10.1186/s12966-017-0513-z

Blanco Herrera, J., & Almeida Cunha Arantes, A. (2002). Determination of training zones by two different methods. Arch. med. deporte, 445-448.

Bouillod, A., Pinot, J., Soto-Romero, G., Bertucci, W., & Grappe, F. (2017). Validity, sensitivity, reproducibility, and robustness of the PowerTap, Stages, and Garmin Vector power meters in comparison with the SRM device. International Journal of Sports Physiology and Performance, 12(8), 1023-1030. https://doi.org/10.1123/ijspp.2016-0436

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G.,…Chou, R. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. British journal of sports medicine, 54(24), 1451-1462. https://doi.org/10.1136/bjsports-2020-102955

Campbell, T., Kirkwood, L., McLean, G., Torsius, M., & Florida-James, G. (2021). Trail use, motivations, and environmental attitudes of 3780 European mountain bikers: What is sustainable? International Journal of Environmental Research and Public Health, 18(24), 12971. https://doi.org/10.3390/ijerph182412971

Carpes, F. P., Mota, C. B., & Faria, I. E. (2010). On the bilateral asymmetry during running and cycling–A review considering leg preference. Physical therapy in sport, 11(4), 136-142.

Chaney, R. A., Hall, P. C., Crowder, A. R., Crookston, B. T., & West, J. H. (2019). Mountain biker attitudes and perceptions of eMTBs (electric-mountain bikes). Sport Sciences for Health, 15(3), 577-583. https://doi.org/10.1007/s11332-019-00555-z

Cherry, C. R., Yang, H., Jones, L. R., & He, M. (2016). Dynamics of electric bike ownership and use in Kunming, China. Transport Policy, 45, 127-135.

Edwards, S. (1994). The heart rate monitor book. In: LWW.

Ferrucci, L., Forlani, F., & Picciotti, A. (2021). Sports consumption behavior: Discovering typologies of amateur cyclists. Polish Journal of Sport and Tourism, 28(4), 26-31.

Foster, C., Hoyos, J., Earnest, C., & Lucia, A. (2005). Regulation of energy expenditure during prolonged athletic competition. Medicine & Science in Sports & Exercise, 37(4), 670-675.

Garrosa-Martín, G., Muniesa, C. A., Molina-Martín, J. J., & Diez-Vega, I. (2023). Low Back Pain in Cycling. Are There Differences between Road and Mountain Biking? International Journal of Environmental Research and Public Health, 20(5), 3791. https://doi.org/10.3390/ijerph20053791

Hamer, M., Lavoie, K. L., & Bacon, S. L. (2014). Taking up physical activity in later life and healthy ageing: the English longitudinal study of ageing. British journal of sports medicine, 48(3), 239-243.

Karsten, B., Petrigna, L., Klose, A., Bianco, A., Townsend, N., & Triska, C. (2021). Relationship between the critical power test and a 20-min functional threshold power test in cycling. Frontiers in physiology, 11, 613151. https://doi.org/10.3389/fphys.2020.613151

Katsanos, C. S., & Moffatt, R. J. (2005). Reliability of heart rate responses at given ratings of perceived exertion in cycling and walking. Research quarterly for exercise and sport, 76(4), 433.

Kelly, M., Morgan, A., Ellis, S., Younger, T., Huntley, J., & Swann, C. (2010). Evidence based public health: a review of the experience of the National Institute of Health and Clinical Excellence (NICE) of developing public health guidance in England. Social science & medicine, 71(6), 1056-1062. https://doi.org/10.1016/j.socscimed.2010.06.032

Kuwaczka, L. F., Mitterwallner, V., Audorff, V., & Steinbauer, M. J. (2023). Ecological impacts of (electrically assisted) mountain biking. Global Ecology and Conservation, 44, e02475. https://doi.org/10.1016/j.gecco.2023.e02475

Langford, B. C., Cherry, C. R., Bassett Jr, D. R., Fitzhugh, E. C., & Dhakal, N. (2017). Comparing physical activity of pedal-assist electric bikes with walking and conventional bicycles. Journal of Transport & Health, 6, 463-473. https://doi.org/10.1016/j.jth.2017.06.002

López-Miñarro, P., & Rodríguez, J. M. (2010). Heart rate and overall ratings of perceived exertion during Spinning® cycle indoor session in novice adults. Science & Sports, 25(5), 238-244.

MacArthur, J., Cherry, C. R., Harpool, M., & Scheppke, D. (2018). A North American survey of electric bicycle owners.

Mitterwallner, V., Steinbauer, M. J., Besold, A., Dreitz, A., Karl, M., Wachsmuth, N.,…Audorff, V. (2021). Electrically assisted mountain biking: Riding faster, higher, farther in natural mountain systems. Journal of Outdoor Recreation and Tourism, 36, 100448. https://doi.org/10.1016/j.jort.2021.100448

Muyor, J. M., Vaquero-Cristóbal, R., Alacid, F., & López-Miñarro, P. A. (2015). Rating of perceived exertion as a tool to control intensity in indoor cycling activity. Revista de psicología del deporte, 24(1), 45-52.

Nolan, K., Shearn, P., Gholitabar, M., & Richardson, J. (2018). NICE public health guidance update. In: Oxford University Press.

Ostrowski, A., Stanula, A., AMBROŻY, T., RYDZIK, Ł., Skaliy, A., Skalski, D.,…Mulyk, K. (2023). Physical effort and pace of MTB and eMTB bicycles on mountain trails-a case study. Journal of Physical Education & Sport, 23(7).

Pans Sancho, M. À., Antón González, L., & Villarrasa Sapiña, I. (2023). Análisis de edades, género y nivel socioeconómico del tiempo de uso del sistema de bicicletas compartidas de València (España).

Perez-Landaluce, J., Fernández-García, B., Rodríguez-Alonso, M., García-Herrero, F., García-Zapico, P., Patterson, A., & Terrados, N. (2002). Physiological differences and rating of perceived exertion (RPE) in professional, amateur and young cyclists. Journal of sports medicine and physical fitness, 42(4), 389-395.

Richard Davison, R., Swan, D., Coleman, D., & Bird, S. (2000). Correlates of simulated hill climb cycling performance. Journal of sports sciences, 18(2), 105-110.

Robertson, R. J., Goss, F. L., Dube, J., Rutkowski, J., Dupain, M., Brennan, C., & Andreacci, J. (2004). Validation of the adult OMNI scale of perceived exertion for cycle ergometer exercise. Medicine & Science in Sports & Exercise, 36(1), 102-108.

Robinson, M. E., Plasschaert, J., & Kisaalita, N. R. (2011). Effects of high intensity training by heart rate or power in recreational cyclists. Journal of sports science & medicine, 10(3), 498.

Rønnestad, B. R., Hansen, J., Stensløkken, L., Joyner, M. J., & Lundby, C. (2019). Case studies in physiology: temporal changes in determinants of aerobic performance in individual going from alpine skier to world junior champion time trial cyclist. Journal of Applied Physiology, 127(2), 306-311. https://doi.org/10.1152/japplphysiol.00798.2018

Sanders, D., Taylor, R. J., Myers, T., & Akubat, I. (2020). A field-based cycling test to assess predictors of endurance performance and establishing training zones. The Journal of Strength & Conditioning Research, 34(12), 3482-3488. https://doi.org/10.1519/JSC.0000000000001910

Services, U. D. o. H. a. H. (2018). 2018 Physical activity guidelines advisory committee scientific report.

Simons, M., Van Es, E., & Hendriksen, I. (2009). Electrically assisted cycling: a new mode for meeting physical activity guidelines? Medicine & Science in Sports & Exercise, 41(11), 2097-2102. https://doi.org/10.1249/MSS.0b013e3181a6aaa4

Szychowska, A., & Drygas, W. (2022). Physical activity as a determinant of successful aging: a narrative review article. Aging clinical and experimental research, 34(6), 1209-1214. https://doi.org/10.1007/s40520-021-02037-0

Sáez Padilla, J., Cantonero Cobos, J. M., Moreno Sánchez, E., Molina López, J., & Tornero Quiñones, I. (2022). Beneficios y barreras del desplazamiento activo hacia el centro escolar: una revisión sistemática (Benefits and barriers of active commuting to the school center: a systematic review). *Retos*, *43*, 572-578. https://doi.org/10.47197/retos.v43i0.89075

Taylor, S., Burrow, C., & Button, S. (2023). Challenging hegemonic velocipedic modality in the great outdoors: The seemingly inexorable rise of the electric mountain bike. Journal of Outdoor Recreation and Tourism, 43, 100684. https://doi.org/https://doi.org/10.1016/j.jort.2023.100684

Vásquez-Gómez, J. A., Cigarroa, I., Faúndez-Casanova, C., Álvarez, C., Villouta, P. L., & Castillo-Retamal, M. (2025). Necesidad de transporte activo para la mejora de la salud cardiorrespiratoria: análisis de encuesta poblacional en Chile. Retos, 66, 339-348. https://doi.org/10.47197/retos.v66.110851

Wallace, L. K., Slattery, K. M., & Coutts, A. J. (2014). A comparison of methods for quantifying training load: relationships between modelled and actual training responses. Eur J Appl Physiol, 114(1), 11-20. https://doi.org/10.1007/s00421-013-2745-1.

Authors and translators' details:

Juan Carlos Redondo Castán	jc.castan@unileon.es	Author
José María Izquierdo Velasco	josemaria.izquierdo@uva.es	Author
Miguel Ramírez Giménez	miguel.ramirez.jimenez@uva.es	Author
Silvia Sedano Campo	ssedano@uemc.es	Author