Review Article

The Impact of Bicycle Configuration on Cycling Biomechanics: A Brief Narrative Review

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This brief narrative review examined the effects of bicycle configuration on cycling biomechanics, with particular emphasis on saddle height, saddle fore–aft position, and frame geometry. Relevant peer-reviewed studies that experimentally manipulated bicycle settings and assessed biomechanical outcomes were identified and narratively synthesized. The available evidence indicates that saddle height has the clearest influence on lower-limb kinematics, particularly at the knee and hip, and may also affect joint loading, pedal-force effectiveness, and mechanical efficiency. Lower saddle positions generally increase knee flexion and may increase local knee loading, whereas higher positions promote greater lower-limb extension, although their effects on metabolic economy are not consistent. Saddle fore–aft position primarily alters the distribution of mechanical work between the hip and knee, with a more rearward position generally increasing hip contribution and force effectiveness, but potentially increasing loading of posterior and lateral soft-tissue structures. Changes in frame geometry appear to have smaller effects on global biomechanical outcomes, although they may modify muscle activation and movement strategy. Overall, bicycle configuration should not be optimized according to a single biomechanical criterion. Rather, bike fitting should balance performance, comfort, metabolic demands, and potential injury risk, while accounting for the cyclist's anthropometry, mobility, experience, and specific goals.

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1. Introduction

The impact of bicycle set-up on cycling biomechanics is complex because cycling involves repetitive movement within a closed kinetic chain[1][2], in which even small adjustments to bicycle geometry may alter the functioning of the locomotor system[3]. Cyclists may perform up to 5,000 pedal revolutions per hour, resulting in substantial cumulative loading, and overuse injuries are common in cycling[4]. Suboptimal cycling position is considered one possible contributing factor[5]. Achieving an appropriate balance among mechanical efficiency, aerodynamics, comfort, and injury prevention therefore requires adapting the bicycle to the individual, a process commonly known as bike fitting[6][7]. Bike fitting involves assessing the cyclist's physical characteristics and performance and progressively adjusting the bicycle to their goals and needs[8]. Common adjustments include saddle height and fore–aft position, handlebar position, and frame-related parameters[9].

1.1. Bicycle adjustments

The most commonly discussed variable in the literature is saddle height[10], defined as the distance between the centre of the crankset axis and the upper surface of the saddle[11]. Its biomechanical effect is commonly assessed using the knee angle when the pedal is at the lowest point of the pedal stroke[12]. Two well-established approaches are commonly used to determine saddle height[3]. The Hamley method recommends a saddle height equal to 109% of inseam length, whereas the Holmes method recommends a position that produces a knee angle of 25–35° at the lowest point of the pedal stroke[13].

The horizontal position of the saddle can also be adjusted and is commonly expressed as the horizontal distance between the centre of the crankset axis and the rear of the saddle[14]. A greater setback indicates that the saddle is positioned further rearwards[15]. Saddle setback primarily affects force and work effectiveness, as well as lower-limb joint angles and ranges of motion[14][16].

An individual's position on a bicycle is also influenced by bicycle type (e.g. time trial, road, or mountain bicycle)[17]. Differences in frame geometry may be particularly relevant for cyclists who regularly alternate between road and mountain bicycles during training[18]. Time trial bicycles have a distinct geometry that facilitates a more aggressive aerodynamic position to reduce air resistance[19]. An important parameter is the seat tube angle, which is typically less than 75° on road bicycles and permits a relatively stable, rearward position. In contrast, triathlon bicycles often use a steeper seat tube angle, shifting the rider's centre of gravity forward. This setting alters lower-limb kinematics and may facilitate the transition from cycling to running[20].

1.2. Biomechanical variables

In biomechanical analysis, we distinguish between kinematic parameters, which describe the geometry and course of motion without taking into account its causes, and kinetic parameters, which describe internal and external forces, power and torques[21]. Among the important kinetic indicators is the force effectiveness index, which represents the ratio between the effective tangential force acting perpendicular to the crank and generating torque and the total resultant force applied to the pedals[10][16]. Knee extension and abduction moments are also frequently assessed[9]. The knee extension moment is generated in the sagittal plane, primarily by the knee extensor muscles, to overcome pedal resistance. During cycling, this moment is greatest in the propulsive phase (0–180° of crank rotation), peaking at approximately 90°[22].

Gatti et al.[23] presented the typical kinematics of the lower-limb joints during a single pedalling cycle. For the hip joint, average minimum flexion of 36.7° ± 8.1°, maximum flexion of 73.7° ± 8.8°, and range of motion (ROM) of 37.0° ± 6.4° were reported. In the knee joint, the minimum flexion was 30.2° ± 5.9°, the maximum flexion was 105.2° ± 8.6°, and the ROM was 75.0° ± 6.8°. For the ankle, the authors reported a minimum dorsiflexion of -7.7° ± 5.8°, a maximum dorsiflexion of 18.3° ± 4.6°, and a ROM of 26.0° ± 5.5°. These results indicate that the greatest range of motion is present in the knee joint, followed by the hip and ankle.

Bicycle set-up should account for the individual's anthropometry and movement patterns[13]. Bike fitting is regarded as an important means of optimizing performance and comfort and potentially reducing excessive mechanical loading[24]. Raising the saddle alters the distribution of mechanical work across the joints and may increase the contribution of the hip relative to the knee[10]. Even small changes in saddle height can influence gross cycling efficiency and lower-limb kinematics[12].

The aim of this review was to synthesize the available evidence on the effects of bicycle configuration on cycling biomechanics. Specifically, we examined how saddle height, saddle fore–aft position, seat tube angle, and frame geometry influence lower-limb kinematics, joint kinetics, pedal-force effectiveness, muscle activation, and the distribution of mechanical work across the lower-limb joints. Particular attention was given to whether these adjustments have consistent implications for cycling performance, comfort, and potential injury risk.

2. Methods

Between 12 February 2026 and 2 March 2026, a structured search of the scientific literature was conducted in PubMed and ScienceDirect using the following search string: ("bike fitting" OR "cycling fit" OR "saddle height") AND (biomechanics OR kinematics) AND cycling.

The identified records were exported to Zotero, and duplicates were removed using its automated duplicate-detection function. Titles were then screened manually, and records that did not meet the eligibility criteria were excluded. The final selection was determined after assessment of the available full texts.

Studies that met the following criteria were included in the review:

- published in peer-reviewed scientific journals,
- with full text in English,
- included adult cyclists and/or triathletes with no reported acute injuries and experience in competitive cycling,
- manipulated at least one bicycle adjustment and compared at least two settings,
- were conducted under controlled laboratory or ergometer conditions,
- reported at least one biomechanical outcome (e.g. kinematics, kinetics, force or work effectiveness, joint loading, compression forces, or joint mechanical work) using standardized measures or calculations.

Randomized controlled and cohort studies were considered. The following information was extracted from each article: author, year of publication, participant characteristics, bicycle adjustment, biomechanical outcomes, and main findings. The included studies were synthesized narratively without quantitative pooling or meta-analysis and were compared according to study design, bicycle configuration, and outcome measures. Additional relevant publications were used to provide context and support the interpretation of the findings.

3. Results

The search of the two databases yielded 490 records. The study-selection process is summarized in Figure 1. Following the initial review, 20 duplicates and five non-English records were removed. A further 398 records were excluded after title screening because they were not relevant to the topic of the review.

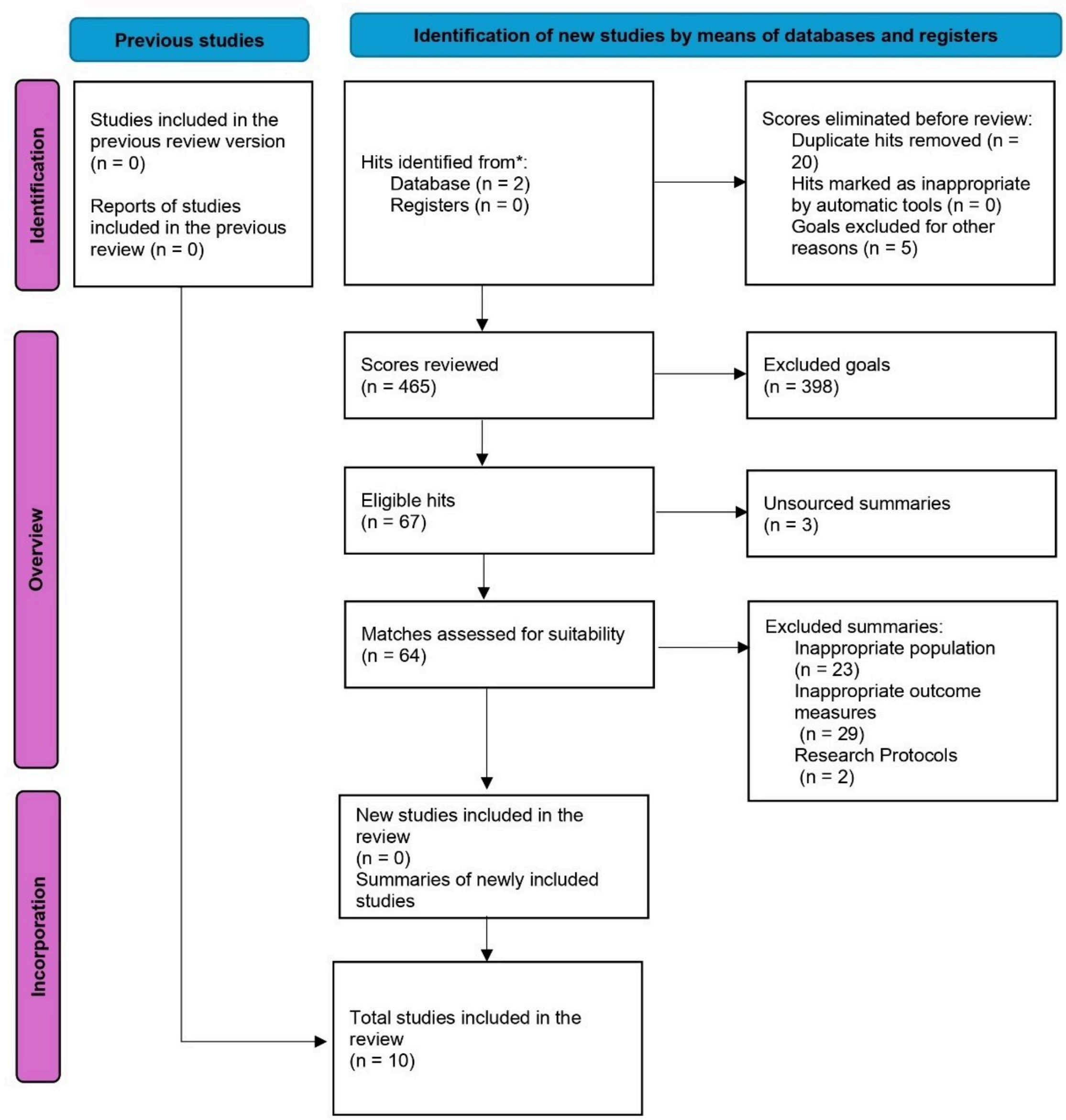

Figure 1. The PRISMA flowchart.

This left 67 potentially relevant articles for more detailed assessment. Three reports were excluded because the full text could not be accessed, leaving 64 records for abstract assessment. Based on the eligibility criteria, 29 studies were excluded because of an ineligible population, 23 because they did not directly examine biomechanical outcomes, and two because they presented only research protocols or theoretical models. Ten studies were included in the final review, and their key characteristics are presented in Table 1.

The included studies had relatively small samples, ranging from 10 to 34 participants, with 163 participants across all studies. Only two studies included women; the remaining studies included men only. Participant age ranged from 18 to 60 years.

Four studies[1][2][10][12][9] investigated saddle height by varying the vertical distance between the saddle and pedals using fixed distances, percentages of leg length to the greater trochanter, or knee flexion angle. Outcomes included lower-limb joint angles and ranges of motion, pedal forces and force effectiveness, knee moments, muscle activity, and joint mechanical work. Overall, saddle height influenced hip and knee kinematics, while lower settings tended to increase knee flexion and may reduce force effectiveness. The available findings suggest that no single setting simultaneously optimizes all biomechanical and physiological outcomes.

Horizontal saddle displacement was investigated in four studies[14][25][16][15]. Outcomes included force and work effectiveness, joint power, ITB loading, and pelvic tilt. Rearward saddle positions generally increased hip contribution and altered force effectiveness but could also increase ITB-related compression.

Devys et al.[18] and Bisi et al.[20] examined the effects of frame type and seat tube angle. They compared force effectiveness between road and mountain bicycles and assessed changes in muscle activation associated with seat tube angle. Frame geometry had relatively small effects on global kinematics but influenced selected muscle-activation patterns and specific joint motions.

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Author, year	Population	Dimension, setting	Outcome measures	Key findings
[16]	11 well-trained cyclists 8.3 ± 2.1 years of experience in competitive cycling 31.2 ± 7.1 years, 66.2 ± 8.3 kg, 177.1 ± 8.2 cm Average weekly training volume 4.1 ± 1.3 hours	6 different saddle positions: recommended, 10% further back, 10% further back with height adjustment (reduced seat height), 10% further forward, 10% further forward with height adjustment (increased seat height) and their preferred position	Force Efficiency Index Work Efficiency Index	Sitting further back reduced total work by 5% cumulatively, increased the work efficiency index (84.2 ± 3.7 vs. 82.0 ± 4.7%), and increased the force efficiency index (41.7 ± 2.9 vs. 39.9 ± 3.7 and 36.9 ± 0.7%).
[10]	12 cyclists and 12 triathletes with competitive experience Cyclists: 36 ± 14 years old, 77 ± 14 kg, 179 ± 5 cm, Weekly training volume 9 ± 5 hours or 180 ± 22 km Triathletes: 42 ± 8 years old, 74 ± 16 kg, 176 ± 10 cm, Weekly training volume 6 ± 2	4 different positions based on the extent of knee flexion when the foot is at its lowest point: preferential position, high position (-10° flexion), low position (+10° flexion), theoretical optimum (25° flexion)	Pedal force, efficiency index, average angle, range of motion and mechanical work of the hip, knee and ankle.	A 5% increase in saddle height increased the efficiency index of cyclists by 7%. At low and preferential heights, knee angles were 11–15% higher and hip angles were 6–8% lower compared to higher and optimal positions. Triathletes have 9% higher ROM at the preferred height.

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Author, year	Population	Dimension, setting	Outcome measures	Key findings
	hours or 112 ± 56 km			
[9]	14 recreational cyclists 57.14 ± 6.37 years, 1.76 ± 0.10 m, 82.60 ± 17.68 kg, BMI: 26.41 ± 3.61 kg/m²	3 different saddle heights: 20, 30 and 40° knee flexion when the foot is in the lowest position	Knee abduction moment; knee extension moment and joint sagittal torque; muscle activity of m. vastus medialis, m. vastus lateralis, m. biceps femoris, m. semitendinosus; pedal reaction force; range of motion of the knee	The internal abduction moment of the knee did not change with changes in seat height. Lowering the seat from 40° to 30° and 20° of knee flexion reduced the knee extension moment. The increase in workload, however, increased both the abduction and extension torque of the knee,
[1][2]	11 cyclists and 11 triathletes with competitive experience 41 ± 11 years, 74 ± 14 kg, weekly training volume 8 ± 4 h,	4 different positions according to the degree of knee flexion when the foot is at its lowest point: preferred position, high position (-10° flexion), low position (+10° flexion), theoretical optimum (25° knee flexion)	Pedal forces (isolated to tangential force on the crank) and calculated force efficiency.	Force resultant was lowest at the highest position (156 ± 35 N) and highest at the lowest position (163 ± 36 N). Force efficiency was highest at higher (57 ± 6%) and optimal setting (56 ± 7%) compared to preferred and low (54%).
[20]	10 male triathletes with competitive experience and in the training process at the	Seat tube angle of 73.5° and 78° at power outputs of 230 and 300 W.	Activation of m. soleus, m. gastrocnemius, all heads of m. quadriceps, mm. glutei, m. biceps femoris and m. tibialis anterior; ranges of	Changing the tube angle showed no significant effects on kinematics, muscle activation, and the ability to generate muscle power.

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Author, year	Population	Dimension, setting	Outcome measures	Key findings
	time of the study 32 ± 8 years old, 1.75 ± 0.02 m, 70 ± 6 kg		motion in the hip, knee and ankle.	With a greater angle, there was reduced activation of m. gastrocnemius and m. biceps femoris.
[25]	10 cyclists and 4 triathletes with competitive experience; 9 men 69.1 ± 4.6 kg, 5 women 61.1 ± 5.2 kg, 28.2 ± 7.5 years, Right dominant lower-limb	4 horizontal seat positions: Preferred position, saddle as far back as possible, middle position (+5 cm forward), front position (+10 cm forward)	Joint power (calculated as the scalar product of torques and angular velocities) and normalized to body weight.	Power in the knee increased in forward position (0.88 ± 0.05 W/kg). Hip power peaked when moving the saddle backwards (1.28 ± 0.03 W/kg). Peak knee power occurs when moving saddle forward, 18.2 ± 3.1° later than in the preferential position.
[18]	10 amateur-level mountain bikers with experience in national-level competitions 18.8 ± 2.2 years; 177.3 ± 5.4 cm; 64.9 ± 3.9 kg	2 different cycling frames: road and off-road (mountain)	peak of effective force, corresponding to the pedal arm angle, overall and instantaneous efficiency index	Despite the differences in geometry, the frame type did not affect the biomechanical parameters, significant changes occurred only between different power levels, and not between the frames.
[15]	10 trained cyclists 30.9 ± 8.6 years, 1.75 ± 0.05 m, 65.2 ± 8.3 kg	3 different seat settings: standardised saddle height and rearward adjustment based on anthropometric measurements, rearward	Ranges of motion in the hip, knee and ankle, ITB load, loading rate and ITB-LFE (lateral epicondyle of	A 6 cm difference in saddle position resulted in a 7% difference in the maximum knee extension angle, which is lower

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Author, year	Population	Dimension, setting	Outcome measures	Key findings
		(10% further back) and forward (10% further forward)	the femur) compression force.	when moving backwards (37.5 ± 11.8°) than when it is moved forward (39.9 ± 10.5°). Saddle position did not affect the ITB stretch (0.53 ± 0.03 m). The compressive force is greater when the seat is moved backwards (5.05 ± 1.85%) than when moving forward.
[12]	14 trained cyclists 32.6 ± 5.6 years; 72.5 ± 9.3 kg; 1.76 ± 0.05 m; BMI 23.4 ± 2.0 kg/m² 8 ± 5 years of experience in competitive cycling, Weekly training volume 15.7 ± 5.0 hours	3 saddle height settings: preferential, 2% higher and 2% lower	Ranges of motion in the hip, knee and ankle, overall efficiency, power output.	A higher saddle reduced gross efficiency to 19.9% and increased oxygen consumption to 43.8 $mL{\cdot}kg^{-1}min^{-1}$. Raising the saddle increased hip (4°), knee (7°) and ankle (8°) extension and increases the ROM. Gross efficiency differed by 0.8%

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Author, year	Population	Dimension, setting	Outcome measures	Key findings
[14]	34 recreational road cyclists, 20 men: 30 ± 8 years old, 1.7 ± 0.1m, 69.3 ± 6.5 kg; 14 women: 35 ± 10 years, 1.6 ± 0.1m, 60.3 ± 6.4 kg	3 saddle position settings: preferred, 10% rearward and 10% forward; 2 intensities: VT1 (first ventilatory threshold) and VT2 (second ventilatory threshold)	Ranges of motion in the hip, knee and ankle, pelvic tilt	Subjective effort increased at VT2 (12.3 – 13.1), decreased comfort when moving the seat rearwards (7.2 – 7.4) compared to preferred and moving forward. Rearward saddle positioning increased hip flexion and extension, ankle plantar flexion and lateral knee deviation when moving the seat rearwards.

Table 1. Summary of study characteristics and main findings.

4. Discussion

The aim of this review was to examine the influence of bicycle adjustments on biomechanical responses during cycling, focusing on kinematic and kinetic variables and performance-related indicators. The reviewed evidence indicates that bicycle settings influence lower-limb joint kinematics, particularly at the knee and hip, and the distribution of mechanical work across the joints [10][12]. Kinetic outcomes, such as force effectiveness and knee moments, also vary, although findings are less consistent and depend on the specific adjustment and testing conditions [9][16]. Frame geometry appears to have a smaller influence on global biomechanical indicators but may affect muscle activation and movement strategy [20][18].

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4.1. Kinematics of the lower-limb joints

Kinematic variables such as angles and ranges of motion (ROM) in the hip, knee, and ankle represent one of the most frequently studied outcomes in the analysed studies. Research reports significant changes in kinematics following changes in bicycle set-up [10][14][12].

Configurations that allow greater lower-limb extension, including some rearward saddle positions, can alter knee and hip extension [12]. Encarnación-Martínez et al.[14] reported that a more rearward saddle position increased hip motion, ankle plantar flexion, and lateral knee deviation. Menard et al.[15] also observed greater ITB-related compression with a rearward saddle, suggesting increased loading of structures implicated in iliotibial band symptoms.

Changes in range of motion are also observed when saddle height is manipulated. Lower and preferred saddle heights generally produce greater knee flexion and less hip extension. At the preferred saddle height, triathletes exhibited a smaller hip angle and greater range of motion than cyclists [10]. Further lowering the saddle may reduce the total range of motion of the lower-limb [9].

These changes may result from altered musculotendinous lengths and joint moment arms. A greater range of motion may facilitate mechanical work production but may also increase loading of passive joint structures [21]. This may be particularly relevant at the knee, where greater flexion can increase patellofemoral loading and alter ITB-related compression [14][15].

In contrast to manipulations of saddle height and fore–aft position, Bisi et al.[20] did not detect significant kinematic changes when seat tube angle was altered, suggesting that not all configuration changes affect movement to the same extent. This may reflect the relative robustness of the basic cycling movement pattern and the ability of the neuromuscular system to maintain broadly stable kinematics despite changes in external conditions [26].

4.2. Joint kinetics and torques

Kinetic variables, such as knee torque and pedal forces, are crucial for understanding the loads acting on the musculoskeletal system. Compared to kinematics, the findings in this area are less consistent, indicating a greater complexity of these parameters [9].

The maximum knee extension moment may decrease in positions that permit greater knee extension [9]. This may reduce the knee extensor demand during parts of the propulsive phase. At the same time,

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increasing workload raises both knee extension and abduction moments, indicating that joint kinetics are strongly dependent on cycling intensity [27]. Knee abduction moment did not differ across the saddle-height conditions examined by Hummer et al.[9], suggesting that this outcome may be less sensitive to saddle-height adjustment than sagittal-plane knee kinetics.

4.3. Force and work efficiency index

The force and work effectiveness indices are commonly used indicators of pedalling technique because they describe how effectively pedal forces contribute to crank propulsion [10][16]. Pedal-force analyses indicate that resultant forces may be highest in configurations that increase knee flexion [1]. Although such a settings may increase total mechanical loading of the lower-limb, they do not necessarily improve the transfer of force to the crank.

Several studies reported improved force or work effectiveness in configurations that increased hip contribution. Menard et al.[16] observed higher force and work effectiveness in more rearward positions, while Bini et al.[10] reported higher force effectiveness with greater lower-limb extension.

Biomechanically, these findings may reflect changes in the contribution of the hip extensors and in the direction of force application to the pedal. A greater tangential component of pedal force contributes more directly to crank torque and therefore increases force effectiveness [21].

Nevertheless, findings are not fully consistent. Ferrer-Roca et al.[12] showed that a mechanically favourable configuration does not necessarily improve metabolic efficiency, as oxygen consumption may increase despite changes in gross efficiency. This distinction between mechanical and metabolic optimization is important [28]. In practical terms, bicycle configuration should therefore be evaluated using multiple outcomes rather than a single measure of effectiveness or efficiency [29].

4.4. Distribution of mechanical work across the joints

Another important aspect of cycling biomechanics is the distribution of mechanical work among the hip, knee, and ankle. The relative contributions of these joints vary with cycling position [10][25].

Greater hip contribution has been associated with improved force effectiveness and altered knee demand [10]. Hayot et al.[25] found that hip power increased when the saddle was moved rearwards, whereas knee power increased in the preferred and more forward positions. These changes suggest that the neuromuscular system redistributes mechanical work across the joints in response to altered task constraints.

This adaptability of the neuromuscular system may help explain why cyclists respond differently to changes in bicycle configuration. The distribution of mechanical work across the lower-limb joints is influenced by factors such as muscle capacity, joint mobility, and neuromuscular coordination [30]. Positions that increase hip contribution may be more suitable for cyclists who can effectively generate and sustain hip-extensor work, whereas more flexed configurations may shift a greater proportion of the mechanical demand towards the knee extensors [10][16]. However, the available evidence does not establish clear cyclist characteristics that predict the optimal configuration for a given individual. The stability of the movement pattern despite changes in position further suggests that an optimal position represents a compromise among biomechanical, metabolic, and neuromuscular factors, supporting an individualized approach to bike fitting. Increased loading of a particular joint or tissue may also be relevant to overuse symptoms, although direct inferences regarding injury risk cannot be made from the available biomechanical studies.

4.5. Muscle activation

Muscle activation has been addressed in a limited number of studies but provides insight into how cyclists adapt to changes in position and mechanical conditions. Changes in bicycle geometry and cyclist position may affect the timing and magnitude of muscle activation without necessarily altering overall mechanical performance or power output [20].

Key muscle groups, including the quadriceps, biceps femoris, gluteal muscles, gastrocnemius, and soleus, work synergistically, with their activation adapting to the mechanical demands of pedalling [31]. Bisi et al. [20] found that a smaller seat tube angle, corresponding to a more rearward position, was associated with differences in gastrocnemius and biceps femoris activation. Such redistribution of muscle activity may allow the neuromuscular system to accommodate altered mechanical conditions without substantial changes in total mechanical output.

In addition to cyclist position, cadence and power output influence muscle activation. Higher cadences may increase the contribution of hip flexors and reduce the relative mechanical demand on the knee extensors [32][33]. These adaptations may be particularly relevant in inexperienced cyclists, whose movement patterns tend to be more variable [34][30].

4.6. Biomechanical responses in untrained populations

The included studies primarily involved trained or recreational cyclists, limiting the generalizability of the findings to untrained populations. Bini et al.[34] provided complementary evidence from individuals without cycling experience by examining the effects of saddle height, cadence, and workload on joint kinematics and kinetics. Their findings indicated greater variability in biomechanical responses among inexperienced cyclists.

Changes in saddle height may produce greater variability in knee and hip kinematics in inexperienced than in trained cyclists. Greater variability in knee angles throughout the pedalling cycle may reflect less stable motor coordination and a less established movement pattern. Thus, cycling kinematics are influenced not only by mechanical configuration but also by task familiarity and motor learning.

Inexperienced riders may also generate less effective pedal forces, reflected in a lower force effectiveness index. This may result from less favourable alignment of the resultant pedal force with the tangential direction, producing a greater proportion of non-propulsive force[21]. Bicycle configuration may partly compensate for these constraints; for example, shorter cranks reduce the required hip and knee ranges of motion and may improve cycling economy in novice cyclists[35]. Certain configurations may nevertheless increase knee moments and therefore mechanical demand on the joint.

Cadence also influences kinematics and kinetics in inexperienced cyclists. Higher cadence may reduce some joint moments but simultaneously increases coordination demands. Inexperienced cyclists may therefore find it more difficult to adapt to particular cadence and workload combinations, contributing to greater between-individual variability[34].

These findings indicate that the influence of bicycle set-up in beginners is closely intertwined with motor learning. Whereas trained cyclists may show relatively predictable biomechanical responses to configuration changes, inexperienced cyclists exhibit greater variability in neuromuscular control and movement stability, particularly under fatigue[36]. In practice, bicycle configuration for beginners should therefore account not only for biomechanical criteria but also for movement familiarity, comfort, and the gradual acquisition of a stable pedalling pattern.

4.7. Biomechanics and efficiency in time trial position

The time trial position illustrates how biomechanical adjustments interact with aerodynamic requirements, because changes in trunk and pelvic position influence cyclists' kinematic and physiological responses[37][29]. This position involves greater forward trunk inclination and a more closed hip angle, potentially affecting muscle activation and the distribution of joint work. The ability to maintain the position is also influenced by individual anthropometry and mobility[8]. At the kinetic level, changes in trunk and pelvic angles may alter pedal coordination and redistribute mechanical work across the joints[29].

Under practical time trial conditions, aerodynamic advantages may outweigh some biomechanical compromises because aerodynamic drag is a major determinant of cycling speed. A reduction in frontal area may therefore improve performance even when the position is not biomechanically optimal[37][29]. The optimal time trial position represents a compromise between reducing drag and maintaining sustainable power output[17][38].

In practical terms, the time trial position should be individualized according to anthropometry, mobility, performance demands, comfort, and the cyclist's biomechanical responses[8]. An overly aggressive position may reduce sustainable power or increase local mechanical loading, whereas a more open position may improve comfort and power production but increase aerodynamic drag. The final configuration should therefore balance aerodynamic, biomechanical, and physiological considerations[37][38].

4.8. Practical implications

Based on the reviewed literature, bicycle adjustments appear to influence biomechanical responses during cycling to different degrees depending on the type of modification. Saddle height is among the most influential parameters because it alters lower-limb joint kinematics and, consequently, the mechanical demands placed on the knee, hip, and ankle. Although certain saddle-height ranges may be associated with more favorable indicators of mechanical efficiency, no universally optimal position can be identified. The most appropriate setting depends on the cyclist and on the distinction between mechanical and metabolic efficiency.

Saddle fore–aft position also affects pedalling strategy and the distribution of mechanical work across the lower-limb joints. Moving the saddle rearwards generally increases hip contribution and may improve force effectiveness by promoting a more favourable tangential application of force to the pedal. However, these potential benefits must be considered alongside possible increases in loading of posterior and lateral soft-tissue structures. Conversely, a more forward saddle position may increase knee flexion and shift a greater proportion of the mechanical demand towards the knee joint.

Compared with saddle adjustments, changes in frame geometry generally have a smaller effect on global biomechanical indicators such as joint angles and torques. Nevertheless, frame geometry is not biomechanically irrelevant, as it may modify body posture, muscle activation, and movement strategy.

Overall, optimal bicycle configuration should be considered an individualized compromise among biomechanical, metabolic, aerodynamic, and neuromuscular factors. This supports a holistic approach to bike fitting that accounts for performance, comfort, and the management of mechanical loading rather than relying on a single universal setting.

The findings should be interpreted in view of the limited number and small sample sizes of the included studies, the predominance of male and experienced cyclists, and the focused search strategy. Accordingly, this review provides a structured narrative overview rather than an exhaustive synthesis of all bicycle-configuration research.

5. Conclusion

The reviewed evidence indicates that bicycle adjustments influence cycling biomechanics, particularly lower-limb joint kinematics and the distribution of mechanical work across the joints. Saddle height appears to be especially relevant to knee and hip kinematics, whereas saddle fore–aft position primarily alters the relative contributions of the hip and knee. Effects on joint kinetics, force effectiveness, metabolic efficiency, and muscle activation are less consistent and appear to depend on the specific adjustment, workload, and characteristics of the cyclist. Frame geometry generally has smaller effects than saddle adjustments, although it may still influence posture and muscle-recruitment strategies. Overall, an optimal bicycle configuration cannot be defined by a single universal setting and should instead be individualized according to anthropometry, mobility, cycling experience, performance demands, and comfort. Further studies with larger and more diverse samples, particularly women and novice cyclists, are needed.

Statements and Declarations

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Potential Competing Interests

The authors declare no potential competing interests.

Ethics

Ethics approval was not required because the manuscript is a literature review.

Author Contributions

N.K.: Conceptualization, Methodology, Investigation, Data Curation, Writing – Original Draft, Visualization. Ž.K.: Conceptualization, Methodology, Supervision, Validation, Writing – Review & Editing. Both authors approved the final version of the manuscript.

Data Availability

All data analysed in this review were obtained from the published studies cited in the manuscript. The study-selection records and extracted data are available from the corresponding author upon reasonable request.

Use of Generative AI

ChatGPT (OpenAI) was used to support English-language editing and improve the clarity of selected passages. The authors reviewed and verified all generated or revised content and take full responsibility for the manuscript.

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