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Research Article

Contribution of Saddle Height on Knee Injury in Recreational Cyclists – A Literature Review

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Abstract

Introduction: Cycling is a popular activity that offers both health benefits and practical use as a means of transportation. Despite its advantages, many cyclists experience knee pain, often due to improper saddle height. Saddle height plays a critical role in determining the biomechanics of the lower limb during pedaling. Ensuring correct saddle positioning may help reduce strain on the knee joint, improve efficiency, and prevent overuse injuries.

Aim and Objective: The purpose of this review is to evaluate the impact of saddle height on knee joint stress and the associated risk of injury in adult cyclists between the ages of 20 and 35.

Methodology: A structured literature search was conducted using the keywords related to knee injury, saddle height, and cycling. Research databases, including PubMed, Google Scholar, Cochrane Library, and Scopus, were searched for studies published between 2016 and 2025. Relevant studies were selected based on their focus on saddle height adjustment and knee biomechanics in adult cyclists.

Results: A total of 168 articles were initially identified, from which 18 were selected for final review after applying the inclusion criteria. The selected studies consistently demonstrated a connection between saddle height and knee joint loading patterns. Improper saddle height, whether too low or too high, was associated with altered pedaling mechanics. A low saddle height increased compressive forces on the front of the knee, especially at the patellofemoral joint. Conversely, a high saddle position was linked to excessive knee extension and potential strain on the iliotibial band. These biomechanical imbalances can contribute to the development of chronic knee pain and overuse injuries in cyclists.

Conclusion: Adjusting the saddle height appropriately can enhance pedaling efficiency and significantly reduce stress on the knee joint. Understanding the biomechanical influence of saddle position is important for injury prevention and for promoting long-term musculoskeletal health in cyclists.

Clinical Relevance: Saddle height adjustment using methods such as the knee flexion angle approach, targeting an angle between 25 and 30 degrees, can help minimize injury risk and improve cycling performance. This review supports the integration of biomechanical assessment in bike fitting practices for injury prevention.

Keywords: Cycling; Saddle Height; Knee Pain; Injury Prevention; Biomechanics

Introduction

Cycling is widely recognized for its cardiovascular and musculoskeletal benefits, making it a popular activity among recreational populations. However, improper bike setup—particularly saddle height—has been consistently associated with increased risk of overuse injuries, especially at the knee joint [1]. Electromyographic studies have shown that variations in saddle height can alter the activation patterns of key muscles such as the rectus femoris, biceps femoris, and gastrocnemius, which may disrupt lower limb coordination and contribute to injury development [1].

Even minor adjustments in saddle height, such as a 2% increase, have been found to significantly influence joint kinematics, pressure distribution, and perceived comfort in elite cyclists, highlighting the sensitivity of the musculoskeletal system to positional changes [2]. Furthermore, research in recumbent cycling has shown that the biomechanical impact of saddle height becomes amplified at higher workloads, particularly increasing frontal and sagittal plane knee forces under elevated saddle conditions [3].

An umbrella review compiling systematic data emphasized that higher saddle heights reduce tibiofemoral shear forces, which is biomechanically favourable, but often at the expense of rider comfort, suggesting a trade-off between joint protection and subjective tolerance [4]. Additionally, changes in saddle height can alter pelvic tilt and alignment, affect the entire kinetic chain and modify lower limb movement patterns—thereby indirectly influencing knee mechanics [5].

Systematic synthesis of prior findings confirms that incorrect saddle positioning is linked to increased muscle imbalance and joint loading, reinforcing its role in knee overuse injuries and the need for evidence-based fitting practices [6]. Longitudinal studies on professional bike fitting show that proper saddle height calibration using motion capture systems can alleviate knee pain, reduce fatigue, and enhance rider comfort, even among non-elite cyclists [7].

Age-specific research on older cyclists also reveals that low saddle positions limiting knee extension can significantly increase knee extension moments, thus elevating sagittal plane stress on the joint [8]. Biomechanical modelling supports these outcomes by demonstrating that the lowest joint stress occurs when riders cycle at their self-selected saddle height, while lower-than-optimal settings lead to increased patellofemoral and tibiofemoral forces [9].

Studies focused on rehabilitation contexts further highlight that optimal saddle height contributes to improved knee stability and smoother joint movement, reinforcing its preventive and therapeutic importance [10]. Similarly, biomechanical testing among recreational cyclists shows that excessively low saddle positions increase adduction, flexion, and abduction moments, directly intensifying knee joint stress [11].

Finally, the interaction between saddle height and pedal-shoe interface must also be considered, as misaligned cleats or improper foot placement can exacerbate the effects of poor saddle setup, increase tibiofemoral stress and compromise joint integrity [12].

Purpose of the study

This review aims to examine the role of saddle height in the development of knee pain among cyclists. It seeks to explore biomechanical evidence and clinical insights to understand how saddle position influences lower limb function and injury patterns.

Significance of the study

An improved understanding of the relationship between saddle height and knee pain can guide injury prevention strategies and improve bike fitting practices. This knowledge is valuable for athletes, clinicians, coaches, and physiotherapists seeking to enhance rider comfort, efficiency, and long-term musculoskeletal health.

Materials and Methods

Review of literature

- Article 1; BioMed Engineering Online (2024) conducted a study that analyzed muscle activation patterns under varying saddle heights and workloads using electromyography. The researchers observed notable changes in the recruitment of the rectus femoris, biceps femoris, and gastrocnemius muscles, suggesting that improper saddle height may disrupt joint mechanics and increase the risk of long-term knee issues [1].

- Article 2; Ferrer-Roca., *et al*. (2023) examined elite cyclists and assessed the impact of small incremental changes in saddle height on joint kinematics, saddle pressure distribution, and rider comfort. The study found that even a 2% increase in saddle height led to greater knee extension and reduced comfort, highlighting the delicate balance between mechanical efficiency and subjective rider experience [2].
- Article 3; Lu., *et al*. (2023) investigated the interaction between saddle position and workload in recumbent cycling. Their findings indicated that increased workloads amplified the biomechanical effects of saddle height, especially under elevated saddle positions. These were associated with significant changes in frontal and sagittal plane knee forces, underscoring the compounded influence of intensity and posture on joint loading [3].
- Article 4; The MDPI Umbrella Review (2023) compiled data from multiple systematic reviews to assess the musculoskeletal effects of cycling posture, with a focus on saddle height. The collective findings indicated that higher saddle heights consistently reduce tibiofemoral shear forces. However, such positions may also result in increased discomfort, emphasizing the trade-off between biomechanical efficiency and subjective tolerance [4].
- Article 5; The MDPI Saddle Pressure Review (2023) focused on how saddle height adjustments influence pressure distribution and pelvic alignment. The review found that changes in saddle height affect pelvic tilt, which in turn modifies lower limb movement patterns. Though the study primarily addressed perineal comfort, the implications for knee biomechanics were evident through altered kinetic chain behaviour [5].
- Article 6; Bini and Priego-Quesada (2022) performed a systematic review that synthesized previous findings on the biomechanical impact of saddle height. They concluded that incorrect saddle height contributes to altered muscle activation patterns and increased knee joint stress, potentially leading to overuse injuries. The review emphasized the need for standardized methods in determining optimal saddle height [6].
- Article 7; Scot., *et al*. (2022) carried out an observational study analyzing the long-term effects of professional bike fitting, particularly saddle height adjustments, on knee pain and rider comfort. Utilizing 3D motion capture for fitting and longitudinal monitoring, the study documented improved rider comfort, reduced fatigue, and decreased knee pain following proper saddle height calibration [7].
- Article 8; Hummer., *et al*. (2021) focused on older cyclists to determine how different knee extension angles — resulting from altered saddle heights — affect knee joint biomechanics. Their results showed that a saddle height resulting in only 20° of knee extension led to a significant increase in knee extension moment, although abduction moments remained unchanged. This suggests that lower saddle settings predominantly influence sagittal plane loading [8].
- Article 9; Bini., *et al*. (2021) explored the influence of saddle height on compressive and shear forces at the knee using motion capture and biomechanical modeling. Their study revealed that the lowest joint loading occurred at the cyclist's self-selected, preferred saddle height. When the saddle was positioned lower than optimal, both patellofemoral and tibiofemoral shear forces increased, emphasizing the critical role of appropriate saddle height in minimizing joint stress [9].
- Article 10; BMC Musculoskeletal Disorders (2021) conducted a rehabilitation-focused study using 3D biomechanical analysis to assess knee joint stability across varying saddle heights. The study found that optimal saddle height promotes consistent knee motion and reduces joint strain, underlining its significance in injury prevention and rehabilitation [10].
- Article 11; Wang., *et al*. (2020) conducted a biomechanical study on 20 healthy recreational cyclists to examine the impact of different saddle heights on knee joint loading. Their findings indicated that a lower saddle position significantly increased knee adduction, flexion, and abduction moments. Conversely, higher saddle positions mitigated these forces, suggesting that suboptimal, low saddle settings may heighten the risk of knee injury due to increased joint stress [11].
- Article 12; Bini., *et al*. (2010) offered a broader biomechanical perspective by examining the interaction between saddle height and the shoe–pedal interface. The study demonstrated that variations in foot placement and pedal mechanics can amplify the adverse effects of incorrect saddle height. Misaligned cleats or inappropriate pedal resistance altered force vectors during the pedal stroke, increasing tibiofemoral joint stress. This underscores the necessity of a holistic approach to bike fitting [12].

Procedure

We searched several electric databases like pub med, google scholar, science direct, Scopus, Cochrane library PEDro and published papers from 2020 to 2024. For further relevant studies, we manually reviewed references from the collections. A total of 113 records were screened from the databases, from which 5 duplicate were removed. After careful scrutinizing based on the inclusion criteria, 82 articles were removed. A total of 9 articles were included based on the critical appraisal skills programme (CASP) ≥ 7.

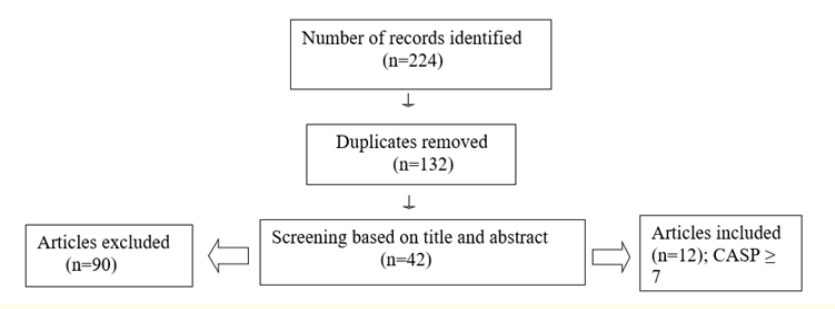

Figure 1

Results and Discussion

The reviewed literature consistently demonstrated a strong relationship between saddle height and knee joint biomechanics in cyclists. Across multiple studies, variations in saddle height were shown to influence joint angles, muscle activation, force distribution, and overall cycling efficiency.

Lower saddle heights were associated with increased knee flexion angles during the pedal cycle, which in turn elevated patellofemoral compressive forces and contributed to anterior knee pain. This pattern was reported in several biomechanical investigations, confirming that excessive knee flexion leads to greater joint loading and potential overuse injuries. Conversely, excessively high saddle positions were found to increase posterior knee extension and pelvic rocking, often resulting in strain to the hamstring muscles and lower back.

Electromyographic data across studies indicated that saddle height changes significantly altered the activation levels of major muscle groups, particularly the quadriceps, hamstrings, and gastrocnemius. These changes were directly linked to joint loading variations and could impact both performance and injury risk. Motion capture and kinetic analyses further supported that even slight deviations from an optimal saddle height led to noticeable changes in pedaling mechanics, including increased shear and compressive forces at the tibiofemoral and patellofemoral joints.

Several studies employing 3D modeling and parametric mapping techniques revealed that there is an optimal range of saddle height that minimizes joint stress while maintaining effective muscle function. Riders positioned within this range exhibited more efficient pedaling mechanics, consistent joint movement, and lower reports of discomfort or pain.

Longitudinal studies focusing on bike fitting interventions also confirmed that precision in saddle height adjustment significantly reduced knee pain and improved rider comfort over time. In addition, systematic and narrative reviews provided conclusive evidence that improper saddle height disrupts biomechanical symmetry, contributing to the onset and persistence of cycling-related knee injuries.

Discussion

The findings of this review underscore the critical role saddle height plays in influencing knee biomechanics, particularly in recreational cyclists who may lack professional fitting guidance.

Variations in saddle height were found to significantly affect lower limb muscle recruitment, with changes in rectus femoris, biceps femoris, and gastrocnemius activation patterns likely disrupting normal movement mechanics and contributing to injury risk [1]. These neuromuscular imbalances, if persistent, could lead to cumulative joint stress and chronic conditions such as patellofemoral pain syndrome or tendinopathies.

Notably, even minimal changes in saddle height can result in meaningful alterations in joint motion and rider perception. Ferrer-Roca., *et al*. found that a 2% increase in saddle height increased knee extension and reduced comfort, suggesting that recreational cyclists, who often rely on subjective comfort alone, may unknowingly adopt risky positions [2]. The interaction between saddle position and workload further complicates the issue. As demonstrated by Lu., *et al*. higher workloads amplify the adverse effects of improper saddle height, especially under elevated positions where both frontal and sagittal plane forces increase significantly [3].

The broader implications of these mechanical adjustments are evident in umbrella reviews, which consistently report that higher saddle heights reduce tibiofemoral shear forces, a desirable biomechanical outcome. However, this comes with the caveat of decreased comfort, indicating a delicate balance between protective joint loading and user tolerance [4]. In addition, saddle height-induced changes in pelvic tilt have downstream effects on the kinetic chain, modifying lower limb movement and further impacting knee joint dynamics [5].

Such complex interactions emphasize the importance of evidence-based saddle height determination. As noted by Bini and Priego-Quesada, non-standardized fitting practices contribute to elevated joint stress and altered muscle activation, increasing the risk of overuse injuries [6]. This is particularly relevant for recreational cyclists who typically do not undergo formal biomechanical assessments. Observational studies on professional bike fitting illustrate that when saddle height is correctly adjusted, improvements in knee pain, fatigue, and comfort are observed over time [7].

In age-diverse populations, especially older adults, saddle height also has unique biomechanical implications. Hummer., *et al*. demonstrated that low saddle positions limiting knee extension led to increased extension moments, disproportionately loading the sagittal plane and potentially accelerating joint degeneration in aging cyclists [8]. Furthermore, modelling studies confirm that the lowest knee stress occurs at self-selected saddle heights, with both patellofemoral and tibiofemoral loads increasing under suboptimal settings [9].

Rehabilitation-oriented evidence supports these conclusions by highlighting that optimal saddle positioning contributes to consistent, stable knee motion, reducing injury recurrence and enhancing recovery outcomes [10]. For recreational cyclists, this becomes particularly significant, as poor fit is often overlooked during self-guided training or commuting routines. Experimental data show that low saddle positions elevate knee adduction, flexion, and abduction moments, biomechanical markers known to contribute to medial and anterior knee pain [11].

Lastly, it is essential to consider the influence of the shoe–pedal interface, as improper foot placement or cleat alignment can intensify the stress caused by incorrect saddle height. Bini., *et al*. emphasized that even with a correct saddle position, misaligned pedal mechanics can alter force vectors and increase tibiofemoral joint strain, underscoring the need for a holistic approach to bike fitting [12].

Conclusion

This review highlights the significant role saddle height plays in influencing knee joint biomechanics and the development of overuse injuries in cyclists. Optimal saddle height not only enhances pedaling efficiency but also reduces mechanical stress on the knee, thereby minimizing the risk of injury.

Given these findings of the review, accurate saddle height adjustment should be a fundamental component of any professional bike fitting protocol. For athletes, coaches, physiotherapists, and sports medicine practitioners, understanding the biomechanical consequences of saddle height is essential for injury prevention, performance optimization, and long-term musculoskeletal health.

Future research should continue to explore individual variability in response to saddle height adjustments and integrate other

contributing factors such as rider posture, cleat alignment, and flexibility. A personalized, data-driven approach to bike fitting may offer the most effective strategy for mitigating knee pain and enhancing cycling outcomes.

Conflict of Interest

No conflict of interest.

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