OPEN ACCESS

Journal of Science & Cycling
Breakthroughs in Cycling & Triathlon Sciences

Conference Abstract

Science and Cycling Conference, Lille 2025

Injuries Caused by Poor Biomechanical Fit in Cycling: A Narrative Review

Asier Castilla Pikaza [1] and Jon Iriberri [2]

Received: 1 March 2025 **Accepted:** 13 March 2025 **Published:** 22 December 2025

[1] Fundacion Ciclista Euskadi

[2] Visma-Leaseabike Cycling Team

Correspondence

Jon Iriberri

Visma-Leaseabike Cycling Team

jon.iriberri@teamvismaleaseabike.com

Abstract

In cycling, an understanding of biomechanics is indispensable for the prevention of injuries, more specifically overuse injuries, which occur due to continuous pedaling on a poorly adjusted or inappropriate bicycle. This work has been developed in the form of a systematic review, examining current evidence related to the main injuries of biomechanical origin in cycling and the maladjustments that cause them. To this end, different scientific article databases (EHU Liburutegia, PubMed, Google Scholar) have been reviewed to collate the information gathered on the subject. After imposing certain standards of quality and recency of the information, inclusion and exclusion criteria were established, and 38 articles were considered appropriate for this review. Most of the studies deal with the most common overuse injuries, knee and low back injuries, although throughout the review we have also managed to classify several injuries occurring to other parts of the body: neck, shoulders, arm, hands, hips, buttocks, perineum, genitalia, Achilles tendon and feet. The aim of this review is to provide, with a summary table, a systematic overview of the scientific evidence of cycling injuries with biomechanical origin. There have been certain limitations to this review, particularly regarding the lack of studies on certain injuries.

Keywords

Injury; Cycling; Overuse; Biomechanics

1 Introduction

The health benefits of cycling are undeniable (Kotler et al., 2016). However, cycling is one of the most injury-prone sports (Silberman, 2013), and more than half of these injuries are nontraumatic overuse injuries (Silberman, 2013; Bini & Di Alencar, 2014). A significant factor contributing to these overuse injuries is poor bicycle fit (Bini et al., 2011; Asplund et al., 2004; Silberman, 2013; Dettori & Norvell, 2006; Visentini & Clarsen, 2016; Kotler et al., 2016; Callaghan, 2005). These injuries often occur during training rather than competition (De Bernardo et al., 2012), as they are often caused by monotonous load and maintaining static postures for prolonged periods (Visentini & Clarsen, 2016). A poorly adjusted posture over long periods can be harmful. Sometimes, we tend to think that the most comfortable posture is ideal, and while some studies suggest this may be true for certain parameters, such as knee flexion (Priego Quesada et al., 2016), more recent studies indicate that comfort alone cannot guide us, as the body tends to adapt to harmful postures, regardless of comfort (Bini & Hunter, 2023).

Among the most common biomechanically related injuries are knee injuries (Bini & Di Alencar, 2014; Bini et al., 2011; Asplund et al., 2004; Clarsen et al., 2010; Silberman, 2013; Piotrowska et al., 2017; Dettori & Norvell, 2006; Bini & Hunter, 2023). Knee injuries have been reported to occur in approximately 25% of people (Brayle et al., 2003; Bini et al., 2011), and in cyclists, this figure rises to 40-60% (Bini et al., 2011; Asplund et al., 2004), which is considerably high. Additionally, one study suggests that women are more prone to knee injuries (Dettori & Norvell, 2006).

Other common injuries include lower back pain, which is frequently reported in cyclists (Bini & Di Alencar, 2014), although studies on the epidemiology of lower back pain in cyclists are limited (Marsden et al., 2010; Piotrowska et al., 2017). One study found that lower back pain was the most common injury among professional cyclists and, along with knee injuries, is the leading cause of stopping training and competition in high-level cyclists (Clarsen et al., 2010).

Neck and shoulder pain are also common, often grouped together, as cyclists complain of pain in areas that cross both sets of joints (such as the trapezius and levator scapulae muscles). These pains usually develop over time, and are often due to muscular and physiological factors rather than biomechanical ones (Dettori & Norvell, 2006).

In 1895, Simpson reported the first recorded nontraumatic cycling injury, describing a long-distance cyclist with cubital neuritis (Dettori & Norvell, 2006), as hand injuries can also occur in cycling. Buttock injuries are also common, although many of these are not caused by poor biomechanics but rather by incorrect use of the bicycle, and reports of symptoms decreased as cycling continued (Dettori & Norvell, 2006; Kotler et al., 2016). Numbness is also sometimes reported in the perineum, which can lead to erectile dysfunction. Cyclists are thought to be more prone to this condition, although there is controversy over this claim (Dettori & Norvell, 2006).

Injuries in the upper leg (hip and thigh) and lower leg (calf, ankle, and foot) are less common in cycling, although relatively common cases such as Achilles tendinopathy can occur (Dettori & Norvell, 2006; Kotler et al., 2016). In addition to the mentioned injuries, there are others which will be discussed throughout this review.

The aim of this work is to compile an evidenced record of all common biomechanically related injuries in cycling. Additionally, it aims to identify the biomechanical causes behind these injuries, which may be relevant for active biomechanics to understand the necessary bicycle adjustments required when encountering a specific injury.

2 Methodology

2.1 Data Search Strategy - Inclusion and Exclusion Criteria

Articles, reviews, and relevant studies were searched in different databases (EHU Liburutegia, PubMed, Google Scholar, ResearchGate) using the keywords: "injury," "cycling," "overuse," "biomechanics." Specific injuries such as "knee pain," "low back pain," "ulnar neuropathy," and "endofibrosis" were also searched. The results were filtered based on the following inclusion and exclusion criteria (Table 1).

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Peer-reviewed publications published in English	Non-peer reviewed publications
Study population of competitive road cyclists and trained road cyclists	Opinion pieces
Provide empirical evidence	Pre-2000 studies
Addressing biomechanical injuries and pain in cyclists related to the biomechanics and/or physiology of positional changes in cycling	Papers not available in English Recreational untrained cyclists
Related to pain when cycling	Non-relevant articles (handcycling, recycling, BMX…)

3 Results

The initial search yielded a total of 9,368 results across all databases. After applying the inclusion and exclusion criteria, 38 articles were deemed suitable for this review.

4 Discussion

4.1 Knee Injuries

One of the main reasons for the prevalence of knee injuries in cyclists is the relationship between forces and knee joint kinematics (Bini et al., 2011). In general, studies have shown that cyclists with knee pain exhibit greater knee adduction and ankle dorsiflexion, as well as differences in the activation of the hamstrings and quadriceps muscles (Bini & Flores Bini, 2018). Several possible knee injuries can occur:

4.1.1 Anterior Knee Pain

Anterior knee pain can be caused by various injuries, mostly the following: patellofemoral pain syndrome, chondromalacia, quadriceps tendinitis, patellar tendinitis, and occasionally prepatellar bursitis (Asplund et al., 2004; Kotler et al., 2016). The reasons for these injuries are varied. Common causes are that the saddle is too low (Burt, 2014; Asplund et al., 2004; Brayle et al., 2003; Silberman, 2013; Kotler et al., 2016; Dettori & Norvell, 2006; Callaghan, 2005; Guanziroli et al., 2020), or too far forward, or both, leading to excessive patellofemoral loading throughout the pedaling cycle (Burt, 2014; Asplund et al., 2004; Silberman, 2013; Dettori & Norvell, 2006; Guanziroli et al., 2020; Kotler et al., 2016).

Regarding saddle setback, a recent study indicated that moving it forward does not significantly modify the forces on the patella, while moving it backward increases them to a greater extent (Menard et al., 2020), although more studies are needed to verify these conclusions. In any case, changes in patellar forces are partly due to changes in flexion angle that occur when the saddle is displaced (Bini et al., 2014). When the saddle is low, the knee operates in hyperflexion, increasing patellar compression on the femur (Asplund et al., 2004; Bini et al., 2011). Additionally, excessively long crank arms can also cause hyperflexion, and low cadence can exacerbate this injury (Burt, 2014; Silberman, 2013; Guanziroli et al., 2020; Dettori & Norvell, 2006; Sanner & O'Halloran, 2000; Kotler et al., 2016).

Improper cleat position or excessive float can force the cyclist to pedal with poor biomechanics, also increasing patellar forces. Cleats with excessive internal or external rotation can cause exaggerated tibial rotation, placing more stress on the anterior knee (Asplund et al., 2004; Dettori & Norvell, 2006; Sanner & O'Halloran, 2000). Cleats placed too far forward are also problematic (Burt, 2014). Certain physiological or pedaling characteristics, such as knee valgus caused by a pronated foot, can alter the Q-factor, which can be harmful (Sanner & O'Halloran, 2000; Guanziroli et al., 2020; Kotler et al., 2016; Gregersen et al., 2006; Bini & Flores Bini, 2018). In relation to this, insoles or foot support can also play a role (Kotler et al., 2016; Guanziroli et al., 2020). One study concluded that foot eversion can be beneficial in preventing or improving patellofemoral pain syndrome in cycling (Gregersen et al., 2006). Pain in the anterior cruciate ligament can be caused by a high saddle (Callaghan, 2005).

Regarding anterior knee pain and patellar tendinitis, Brayle et al. (2003) analyzed several parameters that could influence it. These include maximum and minimum tibial adduction, tibial adduction velocities, knee flexion, and ankle dorsiflexion. Significant differences were found in the point of maximum adduction and minimum dorsiflexion, indicating greater dorsiflexion and abduction in symptomatic cyclists. This supported previous research that found differences in leg movement patterns in the coronal plane between cyclists with and without a history of injury. However, this did not provide a solid basis for linking it to anterior knee pain or patellar tendinitis. The point where a significant difference occurred was in a phase of the pedaling cycle where a knee flexor moment was found, suggesting that, as previously mentioned, a low saddle is the cause of these injuries. However, a literature review justifies patellar tendinitis with a high saddle (Dettori & Norvell, 2006).

To prevent the knee injuries listed above, which are caused by saddle height, Bini et al. (2011) propose setting saddle height using the knee flexion angle method of 25°-30° or 150° (rear angle) (see image of angles in section 7) (Silberman, 2013). A small variation of 3% does not interfere with knee joint forces (Tamborindeguy & Bini, 2011). Another study attempted to determine whether modifying shoe stiffness could prevent certain knee injuries, but the results were not significant as it seemed to work in some subjects but not others (Fletcher et al., 2019). Additionally, clipless pedals produce higher and more evenly distributed pressures across the foot compared to toeclip pedals. This may have implications for their use in preventing and/or treating overuse injuries in the knee and foot (Davis et al., 2011).

4.1.2 Medial Knee Pain

Medial knee pain is usually caused by pes anserine bursitis or medial plica syndrome, and the biomechanical causes of these injuries are often related to increased tension due to an improperly adjusted saddle height; either too high or too low (Burt, 2014; Asplund et al., 2004). It can also occur when the fore-aft position of the saddle is incorrect, or the cleat position (toes pointing too far outward) increases internal tibial rotation (Asplund et al., 2004; Burt, 2014; Guanziroli et al., 2020). Other biomechanical factors include improper cleat placement, excessive or insufficient cleat float, and having the feet too far apart (Silberman, 2013; Burt, 2014; Guanziroli et al., 2020). Riding long distances without cleats and clipless pedals can also be harmful (Guanziroli et al., 2020).

4.1.3 *Lateral Knee Pain*

Iliotibial band syndrome is the main cause of lateral knee pain, although biceps femoris tendinopathy can also occur to a lesser extent. Biomechanically, this pain can be caused by incorrect cleat position (toes pointing inward, heel outward), which leads to a pedaling technique that aggravates hip extension-adduction and/or knee extension-internal rotation (Menard et al., 2020; Guanziroli et al., 2020; Dettori & Norvell, 2006; Sanner & O'Halloran, 2000; Kotler et al., 2016; Burt, 2014). Additionally, a saddle that is too high can cause knee extension beyond 150°, which can irritate the distal ITB (Burt, 2014; Guanziroli et al., 2020; Asplund et al., 2004; Menard et al., 2020; Dettori & Norvell, 2006; Sanner & O'Halloran, 2000; Kotler et al., 2016; Callaghan, 2005). Also, saddles that are too far back can cause excessive forward reach for the pedal, which also stretches the ITB (Asplund et al., 2004; Menard et al., 2020; Dettori & Norvell, 2006; Sanner & O'Halloran, 2000; Kotler et al., 2016; Callaghan, 2005). The study by Farrell et al. (2003) confirms that a saddle that is too high is a cause of Iliotibial band syndrome, and also rules out the force applied to the pedal as a direct cause. An alternative to moving the saddle forward, if not possible, could be to bring the handlebars closer, as a more upright position relaxes the muscles involved (Sanner & O'Halloran, 2000).

Additionally, excessive or insufficient pedal float and worn cleats, as well as having the feet too close together, can also lead to this injury (Silberman, 2013; Burt, 2014). If the pedals are too close together relative to the individual's iliac crest width (Q-factor), this area can also be overloaded, leading to injuries (Kotler et al., 2016). Burt (2014) adds that a low saddle or having feet too far apart (too large a Q-factor) can also cause this pain. Guanziroli et al. (2020) confirms that pedals with too much float can also damage the lateral side of the knee.

4.1.4 *Posterior Knee Pain*

Posterior knee pain is most often attributed to biceps femoris tendinitis or, less frequently, medial hamstring tendinosis. Biomechanical causes can include saddles that are too high or too far back, as they can stress the biceps tendon (Guanziroli et al., 2020; Kotler et al., 2016; Silberman, 2013; Burt, 2014; Asplund et al., 2004; Callaghan, 2005). Excessive internal rotation of the cleats can also increase tension (Asplund et al., 2004; Kotler et al., 2016). This excessive rotation can also be caused by excessive foot float (Silberman, 2013; Guanziroli et al., 2020). A reach that is too long and a saddle shape that blocks or could block pelvic rotation are also factors to consider (Guanziroli et al., 2020).

4.2 Lower Back Injuries

Among the lower back injuries that can occur in cycling are lumbar discogenic pain and radiculopathy. The cyclist's position on the bicycle places the spine in a nonphysiological flexed position for prolonged periods. This unnatural spinal position can place excessive strain on the spine, increasing the likelihood of developing lower back pain (Marsden et al., 2010; Srinivasan et al., 2007; Piotrowska et al., 2017). One of the key parameters that can cause lower back pain is excessive flexion (Burt, 2014; Silberman, 2013; Van Hoof et al., 2012; Marsden et al., 2010; Visentini & Clarsen, 2016; Kotler et al., 2016), as greater lumbar flexion increases the chances of pain. Ironically, individuals often adopt a poorly-adapted posture that stresses their painsensitive tissues to the maximum without being aware of it (Burnett et al., 2004; Van Hoof et al., 2012). This excessive flexion is caused by a reach that is too long (Guanziroli et al., 2020; Burt, 2014; Kotler et al., 2016; Marsden et al., 2010; Silberman, 2013; Dettori & Norvell, 2006; Sanner &

O'Halloran, 2000) or by handlebars that are too low or too far forward (excessive drop) (Guanziroli et al., 2020; Burt, 2014; Kotler et al., 2016; Silberman, 2013; Sanner & O'Halloran, 2000; Streisfeld et al., 2017). The reach distance can be adjusted by modifying the stem length, saddle setback, and handlebar height. However, there is currently no scientific consensus on what constitutes an appropriate reach, and further research is needed (Marsden et al., 2010). Silberman (2013) proposes a reach that causes a trunk twist of 60° when gripping the top of the handlebars and 45° when gripping the drops, although this may be too general, as flexion tolerance depends more on physiological factors than biomechanical ones (Piotrowska et al., 2017; Srinivasan et al., 2007).

Aside from reach, another factor that can directly influence back flexion is the saddle angle. An excessive upward tilt of the saddle forces the pelvis to rotate more, increasing tension on the lumbar spine ligaments (Burt, 2014; Kotler et al., 2016; Marsden et al., 2010; Dettori & Norvell, 2006; Guanziroli et al., 2020). Sitting on the saddle behind the ischial tuberosities can also cause back pain due to the aforementioned pelvic rotation (Guanziroli et al., 2020). Additionally, a saddle that is too high, causing hyperextension, can overload the back muscles, leading to injury (Sanner & O'Halloran, 2000). The type of saddle can also influence this pain; for example, a saddle that blocks pelvic rotation due to its shape can contribute to discomfort (Burt, 2014).

4.3 Neck and Shoulder Injuries

Excessive cervical extension (or hyperextension of the cervical spine) caused by handlebars that are too low or too far forward (excessive reach and/or drop) can promote neck pain (Guanziroli et al., 2020; Silberman, 2013; Dettori & Norvell, 2006; Kotler et al., 2016). Additionally, riding in an aerodynamic position, seated on the nose of the saddle, can also lead to neck and shoulder pain (Dettori & Norvell, 2006). Prolonged riding in this aerodynamic position (gripping the lower part of the handlebars) or using aerobars can cause neck pain, and handlebars that are too narrow relative to shoulder width can cause shoulder pain (Burt, 2014). Furthermore, it has been confirmed that shoulder cramps and myofascial pain can occur if the handlebars are too far from the saddle (Bini & Di Alencar, 2014).

4.4 Lower Leg and Foot Injuries

4.4.1 Achilles Tendinopathy

Achilles tendinopathy can occur due to a saddle that is too high (excessive stretch) (Kotler et al., 2016; Silberman, 2013; Burt, 2014) or too low (excessive heel push to generate more power) (Silberman, 2013; Dettori & Norvell, 2006; Sanner & O'Halloran, 2000; Guanziroli et al., 2020; Burt, 2014; Kotler et al., 2016). Other contributing factors include a saddle that is too far back, cleats that are too far forward, or improperly-positioned cleats (toes pointing inward). Shoes with soles that are too soft can also contribute to this tendinopathy (Guanziroli et al., 2020; Kotler et al., 2016; Burt, 2014).

4.4.2 Plantar Fasciitis

A low saddle can create overload on the plantar fascia, leading to plantar fasciitis (Dettori & Norvell, 2006).

4.4.3 Metatarsalgia

Using cycling shoes that are too tight can cause metatarsalgia (Dettori & Norvell, 2006; Kotler et al., 2016).

4.4.4 Plantar Neuropathy and Morton's Neuroma

Burning feet, "hot foot," numbness, or pain are frequent complaints resulting from the compression of the interdigital plantar nerves due to a fixed cleat-pedal interface and rigid, narrow cycling shoes (Silberman, 2013; Sanner

& O'Halloran, 2000; Kotler et al., 2016). Cleats that are too far forward can also contribute to these symptoms (Guanziroli et al., 2020). Symptoms can be alleviated by adjusting the cleat position (usually moving it backward), wearing shoes with a wider toe box, loosening shoe straps, or using wider pedals (Silberman, 2013; Kotler et al., 2016). Additionally, insufficient float can also cause these neuropathies (Kotler et al., 2016; Guanziroli et al., 2020). Shoes play an important role; not only are very narrow shoes harmful, but shoes that are too small or too large can also cause numbness or cramps in the feet (Burt, 2014).

4.5 Hand and Arms Injuries

4.5.1 Ulnar - Medial Neuropathy / Carpal Tunnel Syndrome and HandForearm Pain

This occurs due to compression of the nerves passing through Guyon's canal, often caused by handlebars that are too low or too far forward (excessive reach and drop), insufficient padding (on gloves or handlebars), or excessive downward tilt of the saddle (Guanziroli et al., 2020; Burt, 2014; Kotler et al., 2016; Silberman, 2013; Patterson et al., 2003; Dettori & Norvell, 2006). Regarding insufficient padding, Akuthota et al. (2005) conducted a study on 28 adults and found no significant differences that could pinpoint the exact cause of this neuropathy, suggesting that more studies are needed. Other factors that can cause hand and forearm pain include brake levers that are too far forward (Burt, 2014) and wrist hyperextension (Guanziroli et al., 2020).

4.5.2 Arm Injuries

Prolonged use of aerobars can cause compression of the brachial nerves (Bini & Di Alencar, 2014). Additionally, excessive reach, drop, and a forward-tilted saddle can overload and cause elbow pain, as can handlebars that are too narrow relative to shoulder width (Burt, 2014).

4.6 Hip, Buttock and Perineum Injuries

No discussion of cycling-related injuries would be complete without mentioning injuries that occur at the contact point between the cyclist and the saddle, particularly with regard to the position and forward tilt of the ischial tuberosities and pubic rami. The width of the ischial tuberosities can be measured and, alongside pelvic shape and overall bike fit, influences saddle choice. A more forward position with weight on the pubic rami is compatible with a narrower saddle, while an upright position with weight on the ischial tuberosities requires a wider saddle. Saddles vary in width, shape, tilt, cutout, and material. There are specific saddles for women, based on observed sexual differences in saddle load distribution. Optimizing overall bike fit (not just saddle changes) will affect weight distribution, aiming to minimize discomfort (Kotler et al., 2016). Studies indicate that saddle width is crucial in preventing genitourinary tract dysfunction, and the distance between the ischial tuberosities could be an important anthropometric parameter for determining the optimal saddle for each cyclist (Bini & Di Alencar, 2014).

4.6.1 Cutaneous Injuries in the Gluteal-Perineal Region

These are generally caused by friction or moisture but can also occur due to biomechanical factors such as saddle height and tilt, reach, handlebar height, and saddle type (Guanziroli et al., 2020; Silberman, 2013). Dettori (2006) notes that insufficient padding or a saddle that is too narrow can cause chafing or myofascial pain in this area (Kotler et al., 2016). The saddle should be wide enough to support the ischial tuberosities, and a slight downward tilt is recommended, though caution is advised due to any limitations of the specific saddle model (Spears et al., 2003; Guanziroli et al., 2020).

4.6.2 Perineal Vasculopathy/Neuropathy, Medial Gluteal Nerve Entrapment, Ischial Bursitis, Proximal Hamstring Tendinitis

According to Dettori (2006), these injuries can occur due to a saddle that is too narrow, insufficiently padded, or tilted upward, as well as excessive weight on the saddle relative to the handlebars. A handlebar that is higher than the saddle can also contribute to these injuries (Guanziroli et al., 2020; Kotler et al., 2016). Very short saddles, in some individuals, can trigger these injuries (Silberman, 2013; Dettori & Norvell, 2006), although these studies are not significant and may simply be coincidental. Dettori (2006) suggests that insufficient padding, an excessively high saddle, and excessive weight on the saddle can cause medial gluteal nerve entrapment. A saddle with an inappropriate shape (usually too narrow), excessive upward tilt, or a cutout nose can cause genital injuries (Kotler et al., 2016). While cutout saddles are sometimes considered harmful, Bini and Di Alencar (2014) argue that using a saddle with a relief cutout can reduce perineal pressure. However, this type of saddle may not provide satisfactory results compared to a conventional saddle. More studies are needed to determine whether shorter saddles are inherently harmful or if the injury results from poor posture.

Focusing on pudendal nerve entrapment, this condition is related to prolonged cycling, causing pain, burning, and numbness, sometimes accompanied by sexual dysfunction, impotence, or urinary incontinence. Compression, friction, and nerve stretching are involved. To address this issue, it is recommended to alternate between seated and standing pedaling and to check certain biomechanical parameters. A saddle that is excessively high, narrow, tilted upward or downward, or handlebars that are too far forward and/or low can increase compression. Ergonomic saddles with a split design, cutout nose, or central relief have been designed to reduce compression (Silberman, 2013; Leibovitch & Mor, 2005; Guanziroli et al., 2020). The cause of both genital numbness and erectile dysfunction (which occurs in 24% of older cyclists who ride more than 400 km per week, according to Guanziroli et al., 2020) appears to be pudendal nerve compression during pedaling. Excessive pressure causes transient hypoxia of the nerve, and the duration of compression seems more relevant than the intensity of the pressure itself. Several studies in the literature show that excessive pressure on the anterior region of the saddle is harmful to erectile tissues compared to pressures recorded in the posterior region. Therefore, reducing compression load on soft tissues is the primary goal in the development of bicycle saddle geometries (Vicari et al., 2023). A cross-sectional survey study hypothesizes that constant genital numbness in women, due to saddle pressure, could influence female sexual dysfunction (Greenberg et al., 2019). Saddles that effectively reduce or distribute perineal pressure, such as those with a two-cheek design, V-slot, split design, central cutout, inflatable air cushion, or those tailored to individual anatomy, are recommended (Leibovitch & Mor, 2005).

4.6.3 Iliac Artery Endofibrosis and Kinking

Progressive deformation or stenosis of the iliac artery can reduce blood flow to the lower limb and negatively affect performance. The extreme aerodynamic position often used by competitive cyclists causes hyperflexion at the hip joint and can lead to repetitive stretching and deformation of the iliac arteries, stimulating antifibrotic changes. Cyclists should be advised to raise the handlebars or move the saddle forward to minimize hip flexion. Pulling the pedals upward should also be avoided to reduce psoas hypertrophy.

However, these basic measures often do not alleviate symptoms and, while acceptable for recreational cyclists, may not be realistic for professional athletes (Peach et al., 2012).

4.6.4 Trochanteric Tendonitis/Bursitis, Iliopsoas Tendonitis, and Gluteal Tendinopathy

A saddle that is too high can cause inflammation of the nerve inserting into the trochanter and the iliopsoas tendon (Sanner & O'Halloran, 2000; Dettori & Norvell, 2006; Guanziroli et al., 2020; Kotler et al., 2016). A low saddle increases dorsiflexion and can also inflame the iliopsoas tendon (Dettori & Norvell, 2006; Guanziroli et al., 2020). Gluteal tendinitis can also be caused by a high saddle (Kotler et al., 2016). Other biomechanical factors that can influence these hip injuries include excessive hip adduction, improper cleat alignment (toes pointing inward), excessively long crank arms, and spending too much time in very low aerodynamic positions (Guanziroli et al., 2020).

4.6.5 Hip Pain and Vascular Issues

Incorrect cleat alignment (toes pointing inward), insufficient cleat float, excessively long crank arms, and an overly aggressive aerodynamic position (using aerobars) can cause hip pain (Kotler et al., 2016). Additionally, a hip angle that is too closed (due to a low back angle), long crank arms (increasing hip flexion), cleats placed too far forward, and a low or backward-positioned saddle can contribute to vascular problems and hip joint pain (Burt, 2014).

5 Summary Tables of Injuries

5.1 Tables Proposed in the Consulted Bibliography

Table 2. Adapted from Asplund et al., 2004

Fitting	Injury
Saddle too high	Knee extension that irritates the ITB, stress on biceps tendon, patellofemoral loading, hips stressed by rocking while pedaling, posterior knee pain
Saddle too low	Stress on patellar and quadriceps tendons
Saddle too far forward	Stress on anterior knee from pedaling in hyperflexed position
Saddle too far back	ITB stretch from excessive forward reach for pedal, stress on biceps tendon
Crank arms too long	Increased forces on the entire knee; patellar tendon and quadriceps tendon are most affected
Internally rotated cleats	Patellar tendinosis, tibial rotation stress on anterior knee
Externally rotated cleats	Medial knee stress

Table 3. Adapted from Silberman, 2013

Injury	Fitting issue
Neck pain	Excessive cervical extension Handlebars too low or far forward
Hand neuropathy	Too much pressure on handlebars, too little padding Handlebars too low
Low back pain	Excessive flexion or reach Handlebars too low or too far forward
Achilles tendinopathy	Saddle height too high (excessive stretch) Saddle height too low (excessive pushing heel down to generate more power)
Foot neuropathy	Cleat position Irregular sole Shoes too tight
Perineal numbness	Saddle too high Tilt angle excessively up or down

Table 4.

Knee Area	Contributing Position
Anterior	Seat too low / Seat too far forward / Cranks too long / Big gears, low rpm
Medial	Cleats: toe point out / Excessive or no float / Feet too far apart
Lateral	Cleats: toe point in / Excessive or no float / Feet too narrow
Posterior	Saddle too high / Saddle too far back / Excessive float

Table 5. Adapted from Dettori, et al., 2006

Area	Injury	Fitting issue	Prevention Strategies	Strategies Tested?
Knee	Patellofemoral inflammation	Saddle too low and/or too far forward Pronated foot Cleat rotated Gears too high	Proper saddle adjustment Orthotics Cleat adjustment Gear down, especially early in season	No
Knee	Patella tendinitis	Saddle too high Gears too high	Use floating pedal system Proper saddle adjustment	No
Knee	Iliotibial band inflammation	Saddle too high Saddle too far back Cleat internally rotated	Avoid excessive hills Proper saddle adjustment Cleat adjustment	No
Neck / shoulder	Foramen encroachment	Handlebar reach too long Aero-position Riding in the drop position	Raise handlebars Use upright bars Move saddle closer to handlebars	No
Neck / shoulder	Facet compression / Myofascial pain	Same as encroachment	Same as encroachment	No
Hand / wrist	Ulnar nerve compression	Handlebar reach too long Supporting too much body weight with arms Not enough padding on bars	Raise handlebars Reduce stem length Change hand position often Wear padded gloves Reduce weight supported by arms	No
Buttock	Median nerve compression / Saddle soreness / Chafing / Ulceration	Same as ulnar nerve / Narrow saddle / Not enough padding on saddle / Sweating	Same as ulnar nerve Wider saddle Padded shorts/saddle Stand to cycle periodically Powder, antiperspirant	No

Table 6.

Site of Injury	Possible Condition	Possible Mechanisms	Prevention Strategies	Strategies Tested?
Perineum	Numbness	Narrow saddle	Wider saddle	Yes [43,44]
Perineum	Numbness	Not enough padding on saddle	Padded shorts/saddle	No
Perineum	Numbness	Saddle nose tilted up	Tilt saddle nose down	No
Perineum	Numbness	Handlebars higher than saddle	Use cut-out saddle	No
Perineum	ED	Same as numbness	Same as numbness	Same as numbness
Back	Lumbar strain	Improper stem/top tube length	Proper adjustment of the cyclist foreaft position	No
Back	Lumbar strain	Leg length discrepancy	Correct leg length discrepancy with shim	No
Upper leg / hip	Trochanteric tendonitis/bursitis	Saddle too high	Adjust saddle to prevent fascia lata against trochanter	Yes [18]
Lower leg / foot	Iliopsoas tendonitis	Saddle too high	Adjust saddle height	No
	Achilles tendonitis	Saddle too low	Adjust to prevent excessive ankle dorsiflexion	No
	Plantar fasciitis	Saddle too low	Adjust saddle height	No
	Metatarsalgia	Shoes too tight	Proper shoe fit	

Table 7. Adapted from Callaghan, 2005

Autor	Bike Problem	Body Problem
Asplund & St Pierre (2004)	Saddle too high	ITB pain, PF loading, posterior knee pain
Holmes et al. (1993)	Saddle too high (>30° knee flexion)	ITB pain
Holmes et al. (1994)	Saddle too high	ITB pain, biceps femoris tendonitis
Timmer (1991)	Saddle too high	ACL strain
Farrell et al. (2003)	Saddle too high	ITB pain
Burke & Pruitt (1996)	Saddle too high	Posterior knee pain
Fleming et al. (1998)	Saddle too high	Increased ACL strain
McLean & Blanch (1993)	Saddle too high	Increased extensor torque
Kronisch (1998)[1]	Saddle too high	Hamstrings tendonitis, PES anserine bursitis, patellar tendonitis, PFJ pain, ITB pain, quadriceps tendonitis
Holmes et al. (1991)	Saddle too high	Posterior capsule strain, biceps femoris strain
Burke & Pruitt (1996)	Saddle too low	Anterior knee pain
Mellion (1991)	Saddle too low	Patellofemoral pain
Sanner & O'Halloran (2000)	Saddle too low	Patellofemoral pain
Salai et al. (1999)	Saddle tilted anterior/posterior	Low back pain

Table 8. Adapted from Kotler et al., 2016

Injury / Pain	Equipment contributions
Anterior knee pain (Patellofemoral pain, patellar/quadriceps tendinopathy)	Saddle too low / Saddle too anterior / Crank length too long Foot pronation / Inadequate shoe support
Distal ITB syndrome	Saddle too high / Saddle too posterior / Cleats toed-in / Pedal position too narrow
Biceps femoris tendinopathy	Saddle too high / Saddle too posterior / Cleats toed-in
Low back pain (Lumbar discogenic pain/radiculopathy)	Saddle-bar drop / Excessive lumbar flexion (handlebar reach/drop) / Posterior pelvic tilt (saddle nose-up)
Neck pain (Cervical radiculopathy, facetmediated pain, myofascial pain)	Excessive reach to handlebars / Low handlebar position (saddle-bar drop)
Achilles tendinopathy	Saddle too high/posterior (may also occur if too low) / Cleat position too anterior / Cleats toed-in / Shoes too soft / Lack of support
Foot numbness/pain (Metatarsalgia, interdigital neuralgia)	Improper cleat placement (usually anterior) / Ill-fitting shoes / Lack of pedal float
Hand numbness (Ulnar neuropathy, carpal tunnel syndrome)	Too much weight on hands / Lack of cushioning (bars/gloves) / Handlebars too low/forward / Saddle tilted nose-down
Buttock pain (Ischial bursitis, proximal hamstring tendinopathy, saddle sores)	Inappropriate saddle shape (typically too narrow) / Lack of saddle padding / Saddle too high / Excessive seat weight / Lack of padding/lubrication
Genital pain / numbness (Pudendal neuralgia)	Inappropriate saddle type (too narrow) / Excessive saddle tilt (often nose-up) / Improper weight distribution (saddle vs. bars) / Handlebars too high / Lack of saddle cut-out
Lateral hip pain (Trochanteric bursitis, gluteal tendinopathy)	Saddle too high
Hip joint pain	Improper cleat alignment (toed-in) / Insufficient cleat float Cranks too long / Aero position too low/aggressive

Table 9. Adapted from Bini & Di Alencar, 2014

Body Site	Type of Injury	Advocated Mechanism	Strength of Evidence
Knee	Chondromalacia patellae	Saddle too low or with excessive anterior projection (anterior knee injuries)	4 [11], 5 [224], 5 [230], 2a [41], 4 [231], 2b [3, 30]
Knee	Tendinitis patellae	(See above)	(Not separately specified)
Knee	Iliotibial band friction	(See below)	(Not separately specified)
Knee	Hamstrings tendinopathies	Saddle too high or excessively posterior projection (iliotibial and hamstrings injuries)	[Evidence not specified in original]
Upper Back	Cramps	Handlebars too far away from the saddle	5 [224]
Upper Back	Myofascial pain	(Not specified)	(Not specified)
Upper Back	Compression of brachial nerves	Use of aerobars	[Evidence not specified]
Hands/Wrists	Compression of the ulnar nerve	Long rides	2b [225]
Buttocks	Pudendal nerve compression	Too narrow saddle	2a [7]
Buttocks	Reduced oxygen supply (perineal artery)	Prolonged seated riding	[Evidence not specified]
Low Back	Compression of posterior nerve roots	Handlebars too far away from the saddle	5 [224], 2b [162]
Low Back	Overload on sacrum promontorium (anterior)	Excessive incline for the anterior portion of the saddle	[Evidence not specified]

Table 10. Adapted from Burt, 2014

Source	Cause	Solution
Overworked Shoulders / elbows / hands	Too much reach	Reduce reach to relax elbows/shoulders
	Too much drop	Raise handlebars to reduce weight on hands/elbows
	Saddle tilted forward	Level saddle to reduce pelvis tipping forward
Hand / forearm pain	Hand position too wide/narrow	Adjust to fit shoulder width
	Hoods too far forward	Move around handlebars
	Narrow girth of bars	Double bar tape for vibration reduction and better grip
Hips – pain / vascular	Too closed hip angle – low torso/back angle	Adjust reach/drop to relax back angle, open hip
	Crank length too long	Reduce to open hip
	Cleats too far forward	Adjust – closes hip on back stroke
	Leg length difference	Lower longer leg saddle height
	Saddle too low	Raise to open hip
	Saddle too far back	Move forward to open angle
Front [anterior] pain	Saddle too low	Raise saddle to optimal knee angle
	Saddle too far forward	Move backwards
	Cranks too long	Shorten
	Cleats too far forward	Move rearwards
Inside [medial] pain	Saddle too low	Raise saddle to optimal knee angle
	Saddle too high	Lower saddle to optimal knee angle
	Cleat position	Reflect walking style – heels drop in on pedals
	Excessive float	Dial float off, check for worn cleats/pedals
	Stance width too wide (feet too far apart)	Reduce stance width – move cleats in, change spindle length
Outside [lateral] pain	Saddle too high	Lower saddle to optimal knee angle
	Saddle too low	Raise saddle to optimal knee angle
	Cleat positioning	Reflect walking style – heels drop in on pedals
	Excessive float	Dial float off, check for worn cleats/pedals
	Stance width too wide (feet too far apart)	Increase stance width – move cleats out, change spindle length
Back [posterior] pain	Saddle too high	Lower saddle to optimal knee angle
	Saddle too far back	Move forward
	Reach too far	Relax/shorten reach to allow pelvis rotation
	Saddle shape	Change if blocking pelvic rotation
Foot pain / numbness	Cycling shoes too tight	Loosen straps – feet swell cycling
	Ball of foot pain	Remove inside or change size to accommodate
	Waterfalling – pain on outside of foot	Move cleat – follow guidelines Move cleat in, consider longer spindles
Foot cramping	Shoes too small	Change size
	Shoes too big (toes overwork for stability)	Change size
Achilles pain	Saddle too high	Reduce – stop foot overreaching
	Saddle too low	Increase – stop heel-down pedalling
	Sustained hill climbing	Avoid until settled or move cleat backwards
	Cleat position too far forward	Move cleat backward to reduce Achilles load
Lower back pain	Torso/back angle too low – too much reach	Reduce reach – shorten stem, move saddle forward if knee not compromised
	Torso/back angle too low – too much drop	Raise handlebars, drop saddle if knee angle allows
	Both above	Shorten stem, raise handlebars, drop saddle, move forward if knee allows
	Leg Length Difference	Adjust saddle height for long leg, build up shorter leg
	Saddle Choice	Saddle blocking pelvic rotation – try different shapes
	Saddle tilt	Nose up saddles force pelvis back, increasing flexion/strain on lower back

Table 11. Adapted from Guanziroli et al., 2020

Location	Symptoms	Factors	Bike fitting correction/treatment
Neck	Pain	Cervical spine hyperextension / Prolonged riding in drops or aero bars / Excessive reach to handlebars / Low handlebars position	Riding more upright and with shorter reach / Raising stem height / Raising handlebars / Rest / NSAID medications / Stretching
Low back	Pain	Sitting behind ischial tuberosities / Excessive lumbar flexion due to handlebars reach / Saddle too low or back / Posterior pelvic tilt due to upright saddle position	Riding more upright and with shorter reach / Raising stem height / Shortening stem length / NSAID medications / Stretching
Hand	Pain/numbness Deep palmar branch of the ulnar nerve Compression through the Guyon's canal Median nerve	Wrist hyperextension / Wrist compression change / High pressure on handlebars / Insufficient padding / Excessive reach and/or low handlebar position / Downhill cycling or riding on rough ground / Tight grip on handlebars in bumpy terrain (because of fear)	Padded gloves or handlebars / Changing hand position and grip / Raising stem height / Raising handlebars / Shorter stem / Time off cycling
Buttock / perineum	Pain/numbness/impotence Furuncles and folliculitis Dorsal branch of the pudendal nerve compression	Insufficient position change / Increased pressure over the perineum / Indoor cycling / Handlebars too high / Saddle too high / Saddle too narrow / Saddle nose up / Improper weight distribution / Low cadence / Friction from the saddle / Prolonged sitting	Frequent position change and standing on the saddle / Using a cut-out saddle / Wider saddle / Saddle nose down / Adjusting handlebars height and stem / Changing hand/saddle weight ratio / Limiting time in aero bar / Using cream or lubricant / Time off cycling / NSAID medications
Hip / greater trochanter	Pain Greater trochanteric pain syndrome (proximal TBS) Trochanteric bursitis External snapping hip	Longer riding / Saddle too high / Excessive hip abduction while riding / Prolonged riding in drops / Improper cleat alignment / Cranks too long / Already nose position too low / Excessive mileage	Standing on the bike while riding / Lowering saddle height / Ensuring toe-heel alignment / Adjusting cleat alignment / NSAID / Time-off the cycling / Stretching
Knee anterior	Pain Patellar tendinopathy Patellofemoral pain syndrome Chondromalacia patella Patellar poor tracking	Saddle too low or too forward / Climbing / Big gears with low / RPM / Cranks too long / Inadequate foot support / Muscular imbalances within quadriceps muscles / Problems with alignment of the legs / Patella alta	Raising saddle height / Moving the saddle back / Spinning more / Strengthening quads / Proper alignment and support / Physical therapy / Reducing training load
Knee medial	Pain MCL bursitis Medial plica syndrome Pes anserine syndrome Medial meniscus tear	Improper cleat alignment (toed-out) / Floating pedals / Feet too far apart / Twisting off pedal (toe clip)	Adjusting cleat alignment / Moving cleats closer / Shortening pedal spindle / NSAIDs / Cortisone injection
Knee lateral	Pain Iliotibial band syndrome (ITBS) Biceps femoris tendinopathy	Improper cleat alignment / Floating pedals / Feet too narrow/ Rapid mileage increase / Big gears on hills	Adjusting cleat position / Limit float / Widen stance / Massage, stretching / NSAIDs / Cortisone injection / Surgery (if needed)
Knee posterior	Pain Biceps femoris tendinopathy	Saddle too high or too far back / Floating pedals	Lower saddle / Move saddle forward / Limit float
Ankle / foot	Pain/numbness Achilles tendinopathy Plantar neuropathy Morton's neuroma	Plantar/dorsiflexion due to saddle height / Shoes too tight or soft / Improper cleat alignment / Lack of float	Change shoes/ Adjust cleats / Float adjustment / Stretching / Footwear check / Possible surgery (Morton)

5.2 Own Macro Table

Table 12. Summary of the discussion

Location of Pain	Injury	Biomechanical Cause
Knee	Anterior pain (patellofemoral pain syndrome, chondromalacia, quadriceps tendonitis, patellar tendonitis, and occasionally prepatellar bursitis)	Low saddle, Forward saddle, Long cranks, Cleats with excessive external or internal rotation, Cleats with a lot of floatation, Forward cleats, Pronator foot (knee valgus, increase in Q Factor), High saddle (affects the anterior cruciate ligament especially), NON-automatic pedals.
	Medial pain (anserine foot bursitis or midpatellar plica syndrome)	High or low saddle, Forward or backward saddle, Excessively rotated cleats (toes pointing outwards), Excessive or non-existent floating of the cleats, Feet too far apart, NOT automatic pedals.
	Lateral pain (iliotibial band syndrome or biceps femoris tendinopathy)	High saddle, Backward saddle, Low saddle, Over-rotated cleats (toes pointing inwards), Excessive or non-existent floating of the cleats, Feet too close together or too far apart.
	Posterior pain (biceps femoris tendonitis or, less commonly, medial hamstring tendinosis)	High saddle, Backward saddle, Saddle shaped to block pelvic rotation, Cleats with excessive external or internal rotation, Cleats with a lot of flotation, Reach too long.
Lower Back (Lumbar)	Pain	Excessive lumbar flexion, Long reach, Low handlebar (drop), Saddle with the nose tilted upwards, High saddle, Saddle shaped to block pelvic rotation, Sitting behind ischial tuberosities.
Hip-Buttock-Perineum Injuries	Buttock-perineum skin pain	Friction and sweat, Saddle with insufficient padding, Narrow saddle (in relation to the distance between sit bones), High or low saddle, Saddle too inclined up or down, Too much reach or drop.
	Neuropathy/vasculopathy of the Perineum, medial nerve impingement Of the gluteus, ischial bursitis, Proximal hamstring tendonitis	Narrow saddle, Saddle with insufficient padding, Saddle that slopes too far up or down, High saddle, Saddle type, Handlebars higher than the saddle or too low handlebars, Forward handlebars.
	Endofibrosis and iliac artery kink	Very aggressive aerodynamic position, Low handlebar, Rear saddle.
	Trochanteric tendinitis/bursitis, Iliopsoas tendonitis and gluteal tendinopathy	High or low saddle, Excessive hip adduction, Excessively rotated cleats (toes pointing inwards), Cranks too long, Very aggressive aerodynamic position.
	Pain and vascular problems in the hip	Excessively rotated cleats (toes pointing inwards), Cleats with non-existent floatation, Forward cleats, Too long cranks, Too long mated (on aero bars, TT couplings), Low saddle, Rear saddle.
Lower Leg and Foot	Achilles tendinopathy	High or low saddle, Backward saddle, Forward cleats, Over-rotated cleats (toes pointing inwards), Very soft shoe sole.
	Plantar pain (Plantar neuropathy and Morton's neuroma, plantar fasciitis, plantar metatarsalgia.)	Low saddle (plantar fasciitis), Narrow shoes, Very stiff shoe sole, Large or small shoe size, Forward cleats, Cleats with non-existent floatation.
Neck & Shoulders	Pain	Hyperextension of the cervical spine, Long reach, A lot of drop, Very aggressive aerodynamic position (grip from below, or in couplings), Narrow handlebars in relation to the shoulders.
Hand and Arm Injuries	Ulnar-medial neuropathy, carpal Tunnel syndrome and hand-forearm Pain	Low and/or forward handlebars (a lot of drop and reach), Insufficient padding, Downwardleaning saddle, Low saddle, Forward-leaning levers, Wrist hyperextension.
	Pain in the arms	Prolonged use of couplings, A lot of reach and drop, Downward inclined saddle, Narrow handlebar.

6 Optimal Bicycle Fit (Guideline)

Below is a guideline for adjusting the bicycle to prevent the injuries mentioned above. The information presented here is derived from the book by Guanziroli et al. (2020) and has not been extensively verified, as the literature review does not specifically address this topic. However, for pedagogical and guidance purposes, it is considered appropriate to include this section in the review.

Another consideration for safe practice is proper bicycle fitting to prevent overuse injuries and injuries caused by overload and compression:

- Frame: When standing over the bicycle, the distance between the frame and the crotch should be 1–2 inches (2.54–5.08 cm) for road bikes and 4–6 inches (10.16–15.24 cm) for mountain bikes.
- Saddle Height: Saddle height affects joint angles and ranges of motion. Two measurements can be taken: using the cyclist's inseam length (109% of the length) or measuring the distance from the greater trochanter to the ground. For leg length, the numerical value is used as the distance from the pedal at the bottom dead center position to the top of the saddle, measured diagonally along the seat tube. On the bicycle, with the pedal at the bottom dead center position, the knee should be at 25– 30° of flexion in the extended leg (or 150° if measured from the rear, as is common in Europe, as shown in the image below).

  The primary adaptations to increasing saddle height occur in the knee and ankle plantar flexion, so adjusting saddle height is one of the most effective ways to alleviate or prevent knee pain.
- Saddle fore-aft position: When pedaling at the 3 o'clock position, the kneecap should be directly above the front of the crank arm.
- Saddle tilt angle: The front of the saddle should be slightly elevated or parallel to the ground, with a slight downward tilt for time trial cyclists.
- Handlebar Height: Defined by the stem height, the top of the handlebar should be at least 1–3 inches (2.54–7.62 cm) below the top of the saddle. The upper body should flex at 45° with hands on the brake hoods and approximately 60° with hands on the drops.
- Handlebar Reach: Defined by the stem length. With the elbow placed at the tip of the saddle, the extended fingers should reach the handlebar's crossbar. The distance between the elbows, flexed at 60–70° in the drops, and the knees at their maximum height should be up to 2 inches (5.08 cm).
- Handlebar Width: Should match shoulder width.
- Pedals: The optimal foot position on the pedal is the forefoot position. This helps reduce tension on the knee ligaments and provides a mechanical advantage to the gastrocnemius and soleus muscles for turning the crank. The use of cleats or clipless pedals can also influence the efficiency of different pedal positions. The foot should be in a neutral position, with the head of the first metatarsal placed directly over the pedal axle."

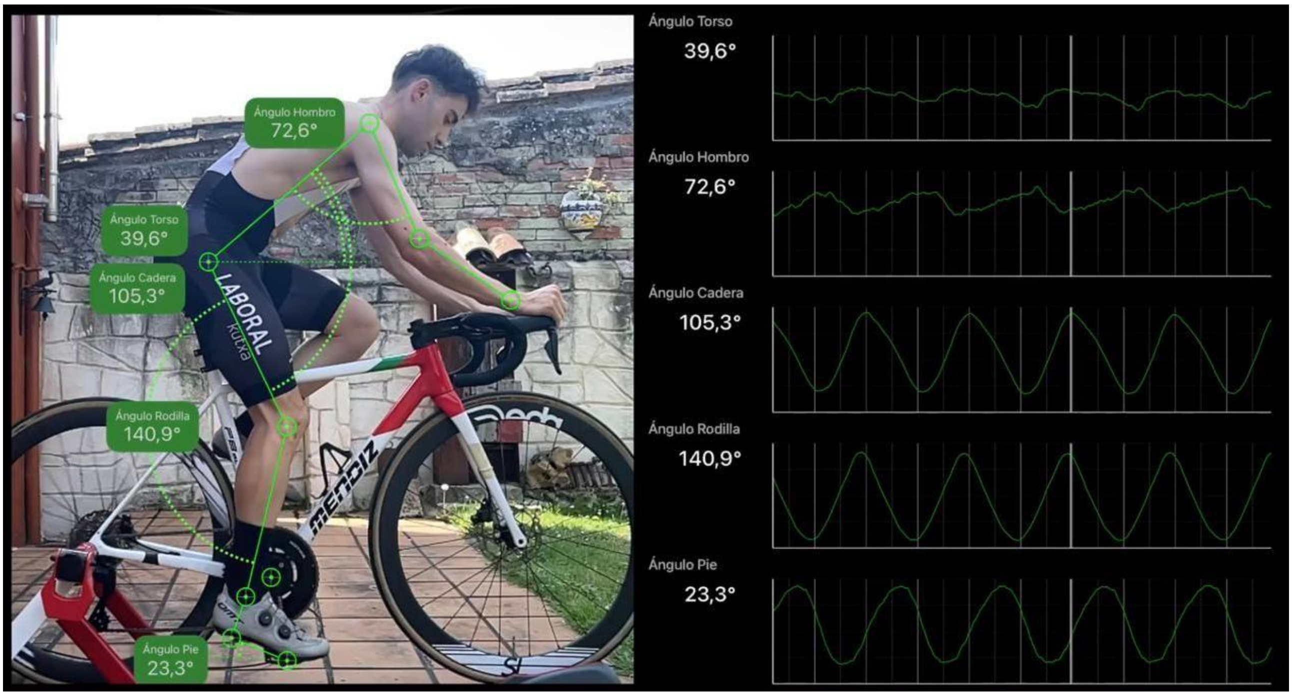

Figure 1. The angles referred to when adjusting a bicycle can be observed, as well as the anatomical points used as biomarkers to determine these angles. It is important to reiterate that these measures are merely guidelines, and there is significant debate regarding several of them. Therefore, it is recommended to consult recent scientific sources that specifically address the topic of optimal bicycle fitting.

7 Limitations

This review has certain limitations. The first and most significant limitation is the quantity and quality of studies on specific injuries, as there is limited updated scientific research on some injuries, while others have been more extensively studied. Additionally, current biomechanics is a relatively modern science, heavily based on experience and empiricism. This results in a lack of high-quality scientific articles on certain injuries, and some potentially harmful biomechanical parameters may not have been included in this review due to the absence of research on them. Finally, the scarcity of prospective studies on this topic is also a limiting factor. Therefore, the conclusions of this systematic review are associated with the limitations of the available evidence.

8 Conclusions

In conclusion, this study compiles an evidenced record of all common biomechanically related injuries in cycling. All injuries have been analyzed and categorized by the body region where they occur, and the biomechanical causes (bicycle fit and its components) have been identified. Most studies, reviews, and books agree on the factors contributing to various injuries. It is true that some articles on specific injuries mention certain causes that are not addressed by other studies; however, no study contradicts the others. Instead, they focus on the biomechanical maladjustments they consider relevant or have studied, without refuting the rest. This could be due to individual differences in how people respond to the same stimuli, highlighting the need for individualized approaches. Certain bicycle maladjustments may be harmful for some individuals but not for others. A table has been created to present these injuries and their causes in an organized and visual manner, as existing tables were not as comprehensive as the one presented here. It is hoped that this table will be highly useful for those involved in cycling biomechanics.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

Akuthota, V., Plastaras, C., Lindberg, K., et al. (2005). The effect of long-distance bicycling on ulnar and median nerves: An electrophysiologic evaluation of cyclist palsy. *American Journal of Sports Medicine*, 33(7), 1224–1230. doi: 10.1177/0363546505275131

Asplund, C., & St. Pierre, P. (2004). Knee pain and bicycling: Fitting concepts for clinicians. *The Physician and Sportsmedicine*, 32(4), 23–30. doi: 10.3810/psm.2004.04.201

Bailey, M., Maillardet, F., & Messenger, N. (2003). Kinematics of cycling in relation to anterior knee pain and patellar tendinitis. *Journal of Sports Sciences*, 21(8), 649–657. doi: 10.1080/0264041031000101943

Bini, R. R., & Di Alencar, T. A. (2014). Non-traumatic injuries in cycling. In R. Bini & F. Carpés (Eds.), Biomechanics of cycling (pp. 85–100). *Springer*. doi: 10.1007/978-3-319-05539-8_6

Bini, R. R., Flores Bini, A. (2018). Potential factors associated with knee pain in cyclists: A systematic review. *Open Access Journal of Sports Medicine*, 9, 99–106. doi: 10.2147/OAJSM.S136653

Bini, R. R., & Hunter, J. R. (2023). Pain and body position on the bicycle in competitive and recreational road cyclists: A retrospective study. *Sports Biomechanics*, 22(4), 522–535. doi: 10.1080/14763141.2021.1948556

Bini, R. R., Hume, P. A., & Croft, J. L. (2011). Effects of bicycle saddle height on knee injury risk and cycling performance. *Sports Medicine*, 41(6), 463–476. doi: 10.2165/11588740-000000000-00000

Bini, R. R., Hume, P. A., Lanferdini, F. J., & Vaz, M. A. (2013). Effects of moving forward or backward on the saddle on knee joint forces during cycling. *Physical Therapy in Sport*, 14(1), 23–27. doi: 10.1016/j.ptsp.2012.02.003

Burnett, A. F., Cornelius, M. W., Dankaerts, W., & O'Sullivan, P. B. (2004). Spinal kinematics and trunk muscle activity in cyclists: A comparison between healthy controls and non-specific chronic low back pain subjects—A pilot investigation. *Manual Therapy*, 9(4), 211–219. doi: 10.1016/j.math.2004.06.002

Burt, P. (2014). Bike Fit: Optimise Your Bike Position for High Performance and Injury Avoidance. *Bloomsbury Publishing*.

Callaghan, M. J. (2005). Lower body problems and injury in cycling. *Journal of Bodywork and Movement Therapies*, 9(3), 226–236. doi: 10.1016/j.jbmt.2005.01.007

Clarsen, B., Krosshaug, T., & Bahr, R. (2010). Overuse injuries in professional road cyclists. *American Journal of Sports Medicine*, 38(12), 2494–2501. doi: 10.1177/0363546510376816

Davis, A., Pemberton, T., Ghosh, S., Maffulli, N., & Padhiar, N. (2011). Plantar pressure of clipless and toe-clipped pedals in cyclists—A pilot study. *Muscles, Ligaments and Tendons Journal*, 1(1), 20–24. doi: 10.11138/mltj/2011.1.1.020

De Bernardo, N., Barrios, C., Vera, P., et al. (2012). Incidence and risk for traumatic and overuse injuries in top-level road cyclists. *Journal of Sports Sciences*, 30(10), 1047–1053. doi: 10.1080/02640414.2012.687112

Dettori, N. J., & Norvell, D. C. (2006). Non-traumatic bicycle injuries: A review of the literature. *Sports Medicine*, 36(1), 7–18. doi: 10.2165/00007256200636010-00002

Farrell, K. C., Reisinger, K. D., & Tillman, M. D. (2003). Force and repetition in cycling: Possible implications for iliotibial band friction syndrome. *The Knee*, 10(1), 103–109. doi: 10.1016/S0968-0160(02)00089-8

Fletcher, J. R., Asmussen, M. J., Nigg, S. R., MacIntosh, B. R., & Nigg, B. M. (2019). The effect of torsional shoe sole stiffness on knee moment and gross efficiency in cycling. *Journal of Sports Sciences*, 37(13), 1457–1463. doi: 10.1080/02640414.2019.1565650

Gregersen, C. S., Hull, M. L., & Hakansson, N. A. (2006). How changing the inversion/eversion foot angle affects the nondriving intersegmental knee moments and the relative activation of the vastii muscles in cycling. *Journal of Biomechanical Engineering*, 128(3), 391–398. doi: 10.1115/1.2193543

Greenberg, D. R., Khandwala, Y. S., Breyer, B. N., Minkow, R., & Eisenberg, M. L. (2019). Genital pain and numbness and female sexual dysfunction in adult bicyclists. *The Journal of Sexual Medicine*, 16(9), 1381–1388. doi: 10.1016/j.jsxm.2019.06.017

Guanziroli, N., Billières, J., & Menetrey, J. (2020). Cycling injuries. In W. Krutsch, H. O. Mayr, V. Musahl, F. Della Villa, P. M. Tscholl, & H. Jones (Eds.), Injury and health risk management in sports (pp. 605–614). *Springer*. doi: 10.1007/978-3-662-60752-7_92

Kotler, D. H., Babu, A. N., & Robidoux, G. (2016). Prevention, evaluation, and rehabilitation of cycling-related injury. *Current Sports Medicine Reports*, 15(3), 199–206. doi: 10.1249/JSR.0000000000000261

Leibovitch, I., & Mor, Y. (2005). The vicious cycling: Bicycling related urogenital disorders. *European Urology*, 47(3), 277–286. doi: 10.1016/j.eururo.2004.10.024

Marsden, M. (2010). Lower back pain in cyclists: A review of epidemiology, pathomechanics and risk factors. *International SportMed Journal*, 11(1), 216–225.

Ménard, M., Domalain, M., Decatoire, A., & Lacouture, P. (2020). Influence of saddle setback on knee joint forces in cycling. *Sports Biomechanics*, 19(2), 245–257. doi: 10.1080/14763141.2018.1466906

Ménard, M., Lacouture, P., & Domalain, M. (2020). Iliotibial band syndrome in cycling: A combined experimental-simulation approach for assessing the effect of saddle setback. *International Journal of Sports Physical Therapy*, 15(6), 958–966. doi: 10.26603/ijspt20200958

Patterson, J. M. M., Jaggars, M. M., & Boyer, M. I. (2003). Ulnar and median nerve palsy in long-distance cyclists: A prospective study. *The American Journal of Sports Medicine*, 31(4), 585–589. doi: 10.1177/03635465030310041801

Peach, G., Schep, G., Palfreeman, R., Beard, J. D., Thompson, M. M., & Hinchliffe, R. J. (2012). Endofibrosis and kinking of the iliac arteries in athletes: A systematic review. *European Journal of Vascular and Endovascular Surgery*, 43(2), 208–217. doi: 10.1016/j.ejvs.2011.11.019

Piotrowska, S. E., Majchrzycki, M., Rogala, P., & Mazurek-Sitarz, M. (2017). Lower extremity and spine pain in cyclists. *Annals of Agricultural and Environmental Medicine*, 24(4), 651–656. doi: 10.26444/aaem/75616

Priego Quesada, J. I., Pérez-Soriano, P., Lucas-Cuevas, A. G., Salvador Palmer, R., & Cibrián Ortiz de Anda, R. M. (2017). Effect of bike-fit in the perception of comfort, fatigue and pain. *Journal of Sports Sciences*, 35(14), 1459–1465. doi: 10.1080/02640414.2016.1215496

Sanner, W. H., & O'Halloran, W. D. (2000). The biomechanics, etiology, and treatment of cycling injuries. *Journal of the American Podiatric Medical Association*, 90(7), 354–376. doi: 10.7547/87507315-90-7-354

Silberman, M. R. (2013). Bicycling injuries. *Current Sports Medicine Reports*, 12(5), 337–345. doi: 10.1249/JSR.0b013e3182a4bab7

Spears, I. R., Cummins, N. K., Brenchley, Z., Donohue, C., Turnbull, C., Burton, S., & Macho, G. A. (2003). The effect of saddle design on stresses in the perineum during cycling. *Medicine & Science in Sports & Exercise*, 35(9), 1620–1625. doi: 10.1249/01.MSS.0000084559.35162.73

Streisfeld, G. M., Bartoszek, C., Creran, E., Inge, B., McShane, M. D., & Johnston, T. (2017). Relationship between body positioning, muscle activity, and spinal kinematics in cyclists with and without low back pain: A systematic review. *Sports Health*, 9(1), 75–79. doi: 10.1177/1941738116676260

Srinivasan, J., & Balasubramanian, V. (2007). Low back pain and muscle fatigue due to road cycling—An sEMG study. *Journal of Bodywork and Movement Therapies*, 11(3), 260–266. doi: 10.1016/j.jbmt.2006.08.003

Tamborindeguy, A. C., & Bini, R. R. (2011). Does saddle height affect patellofemoral and tibiofemoral forces during bicycling for rehabilitation? *Journal of Bodywork and Movement Therapies*, 15(2), 186–191. doi: 10.1016/j.jbmt.2010.03.002

Van Hoof, W., Volkaerts, K., O'Sullivan, K., Verschueren, S., & Dankaerts, W. (2012). Comparing lower lumbar kinematics in cyclists with low back pain (flexion pattern) versus asymptomatic controls—Field study using a wireless posture monitoring system. *Manual Therapy*, 17(4), 312–317. doi: 10.1016/j.math.2012.02.012

Vicari, D. S. S., Patti, A., Giustino, V., Figlioli, F., Alamia, G., Palma, A., & Bianco, A. (2023). Saddle pressures factors in road and off-road cyclists of both genders: A narrative review. *Journal of Functional Morphology and Kinesiology*, 8(2), 71. doi: 10.3390/jfmk8020071

Visentini, P., & Clarsen, B. (2016). Overuse injuries in cycling: The wheel is turning towards evidence-based practice. *Aspetar Sports Medicine Journal*, 5, 486–492.