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Urogynecological and Neurological Consequences of Cycling in Women and Training Performance: From Compression to Biomechanical Protection: A Narrative Review

Authors

Maja Kowalczyk
Karol Marcinkowski University Hospital in Zielona Góra, Zyty 26 65-046 Zielona Góra, Poland
https://orcid.org/0009-0000-0074-1405, maja.u.kowalczyk@gmail.com

Paula Woźniakowska-Gondek
Clinical Department of Obstetrics and Gynecology
Karol Marcinkowski University Hospital in Zielona Góra, Zyty 26 65-046 Zielona Góra, Poland
https://orcid.org/0000-0002-4696-2956, paula.wozniakowska@gmail.com

Kalina Kreft
Karol Marcinkowski University Hospital in Zielona Góra, Zyty 26, 65-046 Zielona Góra, Poland
https://orcid.org/0009-0001-9584-7305, kreft.kalina@gmail.com

Lena Głuszkiewicz
University Clinical Center in Gdańsk, Dębinki 7, 80-952 Gdańsk, Poland
https://orcid.org/0009-0009-3627-0364, lgluszkiewicz@uck.gda.pl

Magdalena Wolff
Karol Marcinkowski University Hospital in Zielona Góra, Zyty 26, 65-046 Zielona Góra, Poland
https://orcid.org/0009-0003-8972-0273, magda.wolff@o2.pl

Agata Sobczak
University Clinical Center in Gdańsk, Dębinki 7, 80-952 Gdańsk, Poland
https://orcid.org/0009-0009-0396-3578, asobczak@uck.gda.pl

Anna Waldman
Poznań University of Medical Sciences, Aleksandra Fredry 10, 61-701 Poznań, Poland
https://orcid.org/0009-0001-2332-1814, anna.waldman29@gmail.com

Corresponding Author Maja Kowalczyk, maja.u.kowalczyk@gmail.com

Abstract

Introduction: Clinical consequences of perineal compression in female cyclists, such as neuropathy and edema, are described in the literature, but their direct impact on training quality and performance is rarely analyzed in research. Equipment not adapted to the female pelvis leads to injuries and secondarily limits athletic potential.

Aim of the study: To synthesize evidence from urogynecology and biomechanics to demonstrate how compressive perineal injuries, mental fatigue, and pain reduce training effectiveness. Additionally, the paper defines the role of professional bike fitting in maintaining training continuity.

Materials and methods: Twenty-five English-language publications from PubMed and PMC were included in the synthesis, integrating data on female pelvic anatomy, kinematics, mental fatigue, and vulvar pathology.

Results: A wider ischial tuberosity in women causes standard saddles to generate pathological perineal pressure. This results in saddle sores, urinary tract infections (UTI), chronic vulvar edema, and pudendal nerve compression. Chronically, pain and genital numbness increase mental fatigue, raise the rate of perceived exertion (RPE), and reduce cadence. These injuries force postural modifications, increasing the risk of training interruptions and sexual dysfunctions (FSD).

Conclusions: Urogynecological compression injuries pose a significant biomechanical and psychological limitation, directly disrupting training quality and continuity. Chronic pain leads to mental fatigue, negatively affecting performance, cadence, and riding economy. Equipment personalization through professional bike fitting is key to protecting intimate health and maximizing athletic potential. This requires close cooperation between coaching teams and uro-physiotherapists.

Keywords: women's cycling, training continuity, urogynecology, sexual dysfunctions (FSD), pudendal nerve, bike fitting.

1. Introduction

1.1. The Biomechanical Paradox of Modern Women’s Cycling

Modern women’s cycling is characterized by dynamic growth in popularity and a progressive increase in training loads. However, this phenomenon is accompanied by a significant biomechanical paradox: although cycling confers multidimensional systemic benefits (de Hartog et al., 2010), locally - at the pelvic contact point with the saddle - constant perineal pressure poses a high urogynecological risk (Vicari et al., 2023). The pursuit of maximizing sports performance often comes at the expense of soft tissue integrity. Resulting micro-injuries and pain reduce satisfaction from riding and force training breaks, ultimately limiting the athletic development of female cyclists (Burnie et al., 2026).

1.2. Topographical Anatomy of the Perineal Area in the Cycling Position

The etiology of urogynecological injuries stems directly from sexual dimorphism of the pelvis. The female pelvis features a wider ischial tuberosity width, a pubic symphysis shifted by 14.0–18.4 mm, and a pubic arch angle above 90° (Lin et al., 2023).

In the aerodynamic cycling position, pelvic anterior tilt in women is significantly greater than in men (on average 35° ± 7.7° versus 23° ± 6.7°). As a result of this rotation and the wider structure, standard narrow saddles do not provide the ischial tuberosities with stable support (Richter et al., 2023). The ischial tuberosities slip off the platform edge, transferring body weight directly onto the pubic arch and the soft tissues of the anterior perineum, which are not anatomically adapted to bear this load (Richter et al., 2023; Harrison & Edey, 2023).

Under such conditions of critical compression and friction, the vulva, local blood and lymphatic vessels, and structures of the pudendal canal (Alcock's canal) sustain damage. The pudendal nerve is particularly vulnerable, subjected to simultaneous compression and stretching during pedaling (Partin et al., 2014). Prolonged pressure initiates local hypoxia, a measurable decrease in genital sensation (confirmed by biothesiometry at 8 perineal points), and may lead to nerve entrapment (Guess et al., 2011; Partin et al., 2014). These phenomena constitute the mechanical starting point for a cascade of structural changes, such as chronic labial edema (bicyclist's vulva) or perineal nodules (cyclist's nodule). The chronic discomfort generated in this way creates a health barrier that, in turn, limits the continuity of training for female athletes (Partin et al., 2014).

1.3. The Interdisciplinary Care Model and Training Continuity: Health and Education as Determinants of Sports Adaptation

Training continuity is a key condition for exercise adaptation. In addition to classic musculoskeletal injuries, this process in female cyclists is often disrupted by specific urogynecological pathologies. Chronic pressure and friction predispose athletes to lower urinary tract dysfunction (LUTS) (Saulicz et al., 2024), skin damage (saddle sores) (Burnie et al., 2026), and intimate infections, which force up to 43.5% of those surveyed to limit activity (Harrison & Edey, 2023).

Perineal pain forces microabsences and shortens training sessions, leading to a loss of adaptive potential. Moreover, the constant need to cope with pain constitutes a cognitive burden that promotes the development of mental fatigue. This fatigue increases the subjective rate of perceived exertion (RPE), disrupts pacing strategies, and may involuntarily reduce cadence

(Habay et al., 2026). The problem is further complicated by a sociological taboo present in sport - female athletes tend to hide symptoms from male coaching staff, which delays intervention and facilitates the progression of acute to chronic conditions (Harrison & Edey, 2023; Burnie et al., 2026).

1.4. Aim of the Review

Given the interdisciplinary nature of the problem, the main aim of this narrative review is a synthetic analysis of cause-and-effect relationships related to pelvic-saddle contact in female cyclists. The paper aims to provide a detailed classification of the pathophysiological cascade - from primary mechanical microtraumas to established compressive neuropathies and structural tissue changes. The focus is also on assessing the impact of intimate discomfort on biomechanical parameters, exercise capacity, and overall training continuity of female athletes. The final applied goal, developed based on literature from 2010–2026, is to create an integrated prevention and management scheme. This algorithm is intended as an evidence-based tool for athletes, bike-fitting specialists, uro-physiotherapists, and coaching staff.

2. Literature Search Methodology

The PubMed, Scopus, Web of Science, and Google Scholar databases were searched (publications from 2010–2026) using the following combination of keywords: ("female cyclists" OR "women cycling") AND ("saddle pressure" OR "pelvic biomechanics") AND ("pudendal neuropathy" OR "genital numbness" OR "saddle sores" OR "LUTS") AND ("training continuity" OR "mental fatigue" OR "RPE").

A total of 25 full-text, English-language articles were included in the final synthesis. Inclusion criteria encompassed studies analyzing: the biomechanics of the female pelvis (Lin et al., 2023; Richter et al., 2023), pathomechanisms of compression, neuropathy, and urogynecological disorders (Guess et al., 2011; Partin et al., 2014; Harrison & Edey, 2023; Saulicz et al., 2024), as well as their impact on exercise parameters and training continuity in female athletes (Burnie et al., 2026; Habay et al., 2026). Preventive guidelines were based on systematic reviews and EBM algorithms (Chiaramonte et al., 2021; Napier & Heron, 2022; Torosis et al., 2024). Journalistic publications and studies concerning only men (except for analyses of sexual dimorphism) were excluded.

3. Pathophysiological Cascade: From Mechanical Compression to the Decline in Training Quality and Continuity

3.1. Ischemic Mechanism

Because the soft tissues of the vulva are not anatomically adapted to bearing support loads (Harrison & Edey, 2023), the pathophysiological cascade in female cyclists begins with mechanical perineal compression. Prolonged saddle pressure, intensified by the aerodynamic torso position, closes the lumen of capillaries and dorsal and cavernous arteries. This leads to significant restriction of genital perfusion and direct compression of structures within the pudendal (Alcock's) canal (Chiaramonte et al., 2021; Vicari et al., 2023).

Although a measurable drop in oxygen pressure and tissue hypoxia develops within the first five minutes of riding, this dynamic has been objectively documented mainly in men (Chiaramonte et al., 2021). The lack of direct measurements of vulvar oxygenation in female cyclists is a key research gap (the so-called gender data gap), forcing scientists to extrapolate male ischemic mechanisms to female anatomy (Guess et al., 2011; Zhukava et al., 2026).

The absence of regular perineal relief (e.g., by periodically riding out of the saddle) significantly prolongs the duration of ischemia (Chiaramonte et al., 2021; Vicari et al., 2023). Repeated cycles of hypoxia initiate the development of microneuropathy, lymphatic stasis, and passive congestion, which, through a vicious circle mechanism, increase the susceptibility of perineal tissues to further mechanical injury (Partin et al., 2014; Vicari et al., 2023).

3.2. Mechanical Compression of the Pudendal Nerve: From Transient Paresthesia to Persistent Neuropathy

In parallel with vascular compression, persistent saddle pressure leads to direct injury of the pudendal nerve trunk and the dorsal nerve of the clitoris. As these structures pass through the pudendal canal (Alcock's canal), they are subjected to twofold damage mechanisms: direct compression between the saddle profile and pelvic bones, and repetitive stretching during pedaling (Partin et al., 2014; Chiaramonte et al., 2021).

A key factor predisposing to these injuries is pelvic sexual dimorphism. The wider distance between the ischial tuberosities in women (average 13.5 cm versus 12.0 cm in men; Chen & Yang, 2016) causes the pelvis to slide forward on standard saddles. This generates non-physiological pressure directly on soft tissues and the nerve trunks running through them (Chen & Yang, 2016; Lin et al., 2023).

The early manifestation of developing compressive neuropathy - caused by transient fiber ischemia and conduction blockade - includes episodic paresthesia and numbness of the genital organs, reported by 34–58% of active female cyclists (Lui et al., 2021). While initially the symptoms subside within a few hours after training, chronic exposure to compression promotes the formation of a demyelination block and the development of persistent pudendal neuropathy (Chiaramonte et al., 2021).

Recurring pudendal nerve dysfunction significantly reduces athletes' quality of life. It results in chronic neuropathic pain (pudendal neuralgia) and secondary sexual dysfunctions (female sexual dysfunction, FSD), including anorgasmia, dyspareunia, and disorders of arousal and lubrication (Greenberg et al., 2019; Lui et al., 2021). This indicates that pudendal nerve micro-injuries are a serious clinical issue with far-reaching psychosexual consequences.

3.3. Epithelial Barrier Disruption and Skin Micro-Injuries

Superficial dermatological pathologies in female cyclists are induced by repetitive friction and shearing forces between the pelvis and the saddle (Bury et al., 2021; Napier & Heron, 2022). The occlusive environment of the chamois - characterized by high temperature and sweat accumulation - exacerbates epidermal maceration and facilitates the penetration of physiological microflora into the hair follicles (Burnie et al., 2026; Napier & Heron, 2022).

This process initiates acute inflammatory conditions such as painful abrasions, folliculitis, and boils, collectively referred to as saddle sores (Bury et al., 2021; Burnie et al., 2026). Untreated micro-injuries and persistent inflammation over time lead to damage of lymphatic vessels and the formation of organized connective tissue infiltrates. Ultimately, this manifests as persistent labial edema (bicyclist's vulva) (Aljuhani et al., 2024). Due to the discomfort they cause, these ailments disrupt training continuity, often forcing athletes to miss sessions (Burnie et al., 2026; Napier & Heron, 2022).

3.4. Chronic Tissue Response to Repetitive Injury

Years of perineal exposure to pressure and micro-injuries lead to permanent, macroscopic structural remodeling of tissues. A characteristic pathology is chronic, often asymmetric, growth of the vulva (bicyclist's vulva). Compression of lymphatic vessels by the saddle profile obstructs lymph drainage, and prolonged lymph retention, combined with inflammation, stimulates pathological connective tissue proliferation and sclerosis of the labia.

Another form of structural change is the perineal nodule (cyclist's nodule), usually located in the deep subcutaneous tissue over the ischial tuberosities. This benign fibrous pseudotumor arises from focal fat necrosis and fibroblast proliferation, induced by repetitive shearing forces and vibrations. The resulting sclerosis, sometimes containing cystic spaces (pseudocysts), is highly resistant to conservative treatment and in advanced stages justifies surgical excision.

3.5. Secondary Decline in Training Quality and Biomechanical Disturbances: Pain Compensation, Mental Fatigue, and Training Continuity

The development of persistent structural changes and chronic perineal pain goes beyond dermatological discomfort, directly limiting the quality and continuity of the training process. Pain and unilateral edema (e.g., bicyclist's vulva) force subconscious pedaling asymmetry and non-physiological pelvic positioning on the saddle. Such compensation disturbs the force vectors transmitted to the pedals, reduces mechanical cycling efficiency, and, secondarily, increases the risk of lower-limb joint overload (Marcolin et al., 2015; Burnie et al., 2026).

Another common compensatory strategy is frequent "hovering" (standing out of the saddle). Assuming a standing position temporarily decompresses the perineal structures but simultaneously forces the cyclist out of the optimal aerodynamic posture. Increased frontal resistance means that maintaining race speed requires generating more power, which significantly reduces energy efficiency (Gaither et al., 2018; Burnie et al., 2026).

The constant need to cope with pain is also a significant cognitive burden for the nervous system, leading to increasing mental fatigue. This burden raises the subjective perception of exertion (RPE), disrupts pacing strategies during races, and induces an involuntary, compensatory decrease in cadence (Habay et al., 2026).

The ultimate effect of this cascade is the loss of training continuity. Pain, inflammation, and mental fatigue lead to shortened training sessions, microabsences, or complete withdrawal from target competitions (Bury et al., 2021; Harrison & Edey, 2023; Burnie et al., 2026). This clearly indicates that vulvar micro-injuries are not merely a superficial medical problem but constitute a critical barrier limiting adaptation and the realization of the athletic potential of female cyclists.

4. Clinical and Functional Spectrum of Urogynecological Complaints

Chronic perineal pressure on the saddle predisposes female cyclists to specific urological and sexual complaints. Although epidemiological analyses indicate that the incidence of these dysfunctions is not higher in this population compared to other active sportswomen (Gaither et al., 2018), and their severity rarely constitutes a serious clinical problem (Saulicz et al., 2024), they generate chronic discomfort, which consequently reduces the quality of life and training potential of female cyclists.

4.1. Urological and Lower Urinary Tract Dysfunctions (LUTS)

The pathomechanism of lower urinary tract symptoms (LUTS) in female cyclists is based on chronic compression of the urethra and pudendal nerve, as well as increased intra-abdominal pressure in the flexed trunk position. The severity of these symptoms increases in proportion to athletes' training experience and weekly training volume (Saulicz et al., 2024). The main manifestations include daytime urinary frequency (resulting from irritation of pelvic floor structures), bladder pain, as well as stress and urge urinary incontinence. These result from overload of the musculo-ligamentous apparatus and secondary compressive neuropathy of the sphincters (Saulicz et al., 2024). Importantly, the severity of urinary incontinence in female cyclists strongly correlates with a history of vaginal childbirth, which clearly indicates the need to introduce specialized pelvic floor training in athletes returning to sport after pregnancy (Saulicz et al., 2024).

Prolonged exposure to saddle pressure also increases the risk of urinary tract infections (UTIs), showing a dose-effect correlation with the total distance covered during one's career (Gaither et al., 2018). The anatomically short female urethra facilitates the ascending migration of pathogens, which is further exacerbated by the microclimate of the cycling chamois. The accumulation of moisture, high temperature, and poor ventilation in the occlusive perineal area create optimal conditions for bacterial growth (Gaither et al., 2018; Saulicz et al., 2024). The resulting acute pain symptoms are a direct barrier, forcing undesired interruptions in the training process.

4.2. Sexual Dysfunctions and Perineal Compression Neuropathy

The complex spectrum of urogynecological complaints is complemented by secondary sexual dysfunctions (female sexual dysfunction, FSD), affecting up to 52–54% of active female cyclists (Greenberg et al., 2019; Lui et al., 2021). The primary cause is chronic compression of the pudendal nerve trunk and the dorsal nerve of the clitoris, which significantly impairs peripheral sexual response.

Importantly, objective training parameters - such as weekly distance, speed, or cycling experience - do not correlate with FSD. This clearly indicates that the triggering factor is not the exercise volume itself, but rather compressive injury resulting from improper cycling biomechanics (Greenberg et al., 2019; Lui et al., 2021).

The strongest prognostic factors for disorders are the frequency, location, and duration of compression. The risk of developing FSD increases six-fold when perineal numbness persists for more than half the training time, and nearly thirteen-fold when pain appears within the first hour of riding. The probability of dysfunction is also increased by numbness lasting up to 24 hours after exercise. From a topographical perspective, the most dangerous for psychosexual health is direct compression of the clitoris and deep perineal structures (Greenberg et al., 2019; Lui et al., 2021).

Studies using the Female Sexual Function Index (FSFI) questionnaire confirm that sustained mechanical pressure destabilizes local vascularization and disrupts afferent conduction to the spinal cord. This results in a clinically significant decrease in sexual satisfaction, reduced arousal and lubrication scores, and a significantly impaired ability to achieve orgasm (Greenberg et al., 2019; Lui et al., 2021).

5. Feedback Loop: Urogynecological Pain, Biomechanics, and Training Quality

Pain in the pelvic contact area with the saddle creates a pathological feedback loop. The subconscious attempt to reduce discomfort alters cycling biomechanics and imposes a significant cognitive burden, directly reducing the effectiveness of the training process.

5.1. Kinematic Compensations Induced by Pain

A protective reaction to perineal injuries (saddle sores, reported by 39–89% of female cyclists; Burnie et al., 2026) often involves subconsciously offloading the compressed structures. In the aerodynamic sport position, female cyclists initially assume a greater anterior pelvic tilt (on average 35° versus about 23° in men; Richter et al., 2023), which concentrates pressure on the front part of the saddle and the vulvar soft tissues (Partin et al., 2014). Increasing pain forces a change in the support point, leading to asymmetric pelvic rotation and uneven loading of the ischial tuberosities (Lin et al., 2023). Such asymmetry is not only a result of pain but also a compensatory mechanism that, in turn, disrupts the stability of the entire biokinematic chain.

Although studies on the effects of fatigue on 3D kinematics have been conducted mainly in men, they demonstrate consistent biomechanical principles. Under conditions of extreme load (85–100% of maximal aerobic power), the musculoskeletal system responds by limiting the range of hip flexion/extension and knee adduction/abduction (Pouliquen et al., 2021). Considering that women naturally display greater transverse rotation and lateral pelvic tilt while riding (Partin et al., 2014; Burnie et al., 2026), overlaying pain-induced seat asymmetry disrupts movement patterns. Compensatory pelvic displacement reduces the efficiency of force transfer. It promotes non-physiological knee joint movements outside the sagittal plane, which is a primary mechanism of cycling overuse injuries in the lower limbs (Pouliquen et al., 2021).

5.2 The Effect of Discomfort on Biomechanical Indices and Power Loss

Effective force transmission from the main driving muscles (gluteus maximus, rectus femoris) requires stable pelvic positioning (Pouliquen et al., 2021). However, increasing perineal pain or unilateral vulvar edema triggers subconscious compensatory mechanisms - prompting the athlete to offload tissues through lateral body tilt or frequent, reflexive standing out of the saddle (Burnie et al., 2026).

A documented tendency in women to asymmetrically load the ischial tuberosities in response to discomfort reduces pedaling efficiency and induces unilateral overloads (Lin et al., 2023). Furthermore, the loss of stable support modifies muscular electrical activity (EMG) and promotes non-physiological joint movements. The neuromuscular system is forced into extra stabilization work, increasing energy cost, accelerating local fatigue, and reducing the ability to generate maximal aerobic power (Pouliquen et al., 2021).

In practice, these ailments prevent the precise execution of training load plans. Forced reductions in intensity or shortening of ride time directly impact the quality of the training process, inhibiting key exercise adaptations in female cyclists (Burnie et al., 2026).

5.3. Psychophysical Cost and Cognitive Load: Chronic Pain as a Distraction During High-Intensity Training

Chronic perineal pain serves as a strong stressor, which during intense training forces the athlete to engage considerable cognitive resources in ignoring nociception. This ongoing cognitive load directly contributes to mental fatigue.

Mental fatigue does not alter peripheral physiological parameters (such as heart rate, lactate, or glucose levels), but instead impacts psychomotor performance (Habay et al., 2026). Athletes under cognitive strain can maintain the required power output, but this comes at the cost of a much higher rate of perceived exertion (RPE). As a result, a cyclist may perceive the effort as maximal long before exhausting her peripheral metabolic reserves (Habay et al., 2026).

Moreover, mental fatigue induces a statistically significant decrease in pedaling cadence, a tendency toward worse distance outcomes, and a prolonged motor reaction time, all of which directly reduce safety when riding in a peloton (Habay et al., 2026). In practice, a premature spike in RPE, caused by pain, forces the shortening or interruption of intervals. This generates a high cognitive cost, depletes attentional resources, lowers exercise tolerance, and ultimately disrupts the continuity of the training process, preventing the achievement of planned adaptations (Burnie et al., 2026).

6. Multilevel Management and Preventive Actions

Effective prevention of urogynecological pathologies and protection of training quality require a structured procedure. Due to the interdisciplinary nature of perineal injuries, prevention and treatment are based on four complementary pillars that tightly integrate bicycle biomechanical engineering with advanced medical and physiotherapeutic care.

6.1.1. Pillar I: Biomechanical Adjustment of the Bicycle (Bike Fitting)

The primary goal of optimizing the spatial relationship between the bicycle and the athlete is to relieve the anterior soft tissues of the perineum in favor of the bony structures of the pelvis. The key modifications in the bike-fitting process concern three parameters: handlebar height, saddle height, and saddle tilt. Lowering the handlebars has been shown to force deep anterior pelvic tilt, increasing pathological pressure on the vulva and resulting in decreased genital sensation (Partin et al., 2014). Aligning the handlebars with the saddle or raising them, on the other hand, reduces the risk of numbness and skin injuries (Gaither et al., 2018). However, this setup always requires a strict compromise between urogynecological protection and optimal aerodynamics.

Another crucial element is saddle height. Setting the saddle at the level of the greater trochanter of the femur (greater trochanter height, GTH) minimizes excessive activation of the rectus femoris (RF), which increases exercise economy and delays fatigue (Bing et al., 2024). Any deviations from this norm are highly disadvantageous: a saddle set too low reduces the activity of the medial gastrocnemius (MG), worsening ankle joint stability and power transfer, whereas a saddle set too high overloads this muscle, accelerating local exhaustion (Bing et al., 2024).

The third important factor is the tilt angle of the saddle platform. Raising the front (nose) of the saddle increases discomfort and the instability of the body's center of pressure (CoP) (Vicari et al., 2023). Keeping the saddle level or applying a slight downward tilt (about 2 degrees) effectively relieves pressure on the anterior perineal area, significantly increasing the time one can ride without pain (Vicari et al., 2023; Burnie et al., 2026).

6.1.2. Pillar II: Material Construction of Equipment and Clothing

Selecting equipment to prevent urogynecological injuries must closely account for the different pelvic structure in women. The construction of the saddle, including the cut-out, plays a key role. Although intuitively this seems beneficial, studies indicate that in healthy athletes, such a cut-out paradoxically increases the average pressure on perineal tissues by about 4 kPa, and the peak pressure by as much as 11 kPa compared to solid saddles. This results from the pathological accumulation of forces at the edges of the cut-out, which intensifies pressure on local vessels and nerves (Guess et al., 2011).

However, this situation is completely reversed in specific clinical cases. For women with chronic vulvar dermatological conditions (e.g., lichen sclerosus, lichen planus, post-oncological treatment), personalized saddles with a central cut-out are a key off-loading solution that effectively reduces pain and skin fissures, enabling continued cycling (Van de Berg et al., 2026).

Another critical saddle parameter is its width. The wider distance between the ischial tuberosities in women necessitates a wider support platform. Selecting a saddle that is 1 cm wider than the athlete's ischial tuberosity span significantly reduces perineal pressure, decreases uneven loading, and improves pedaling symmetry (Lin et al., 2023).

An important aspect of prevention is the chamois pad in cycling shorts, which absorbs shocks and disperses pressure. Biomechanical studies demonstrate that low-density foams (60 kg/m^3) lose their cushioning properties after just 20 minutes of riding, increasing peak pressure. For long rides, materials with higher density (e.g., 120 kg/m^3) are recommended (Marcolin et al., 2015). It should be emphasized, however, that pad wear dynamics have been studied mainly in male groups to date. Due to the different anatomy of the female pelvis (which modifies pressure zones), the optimal thickness and density parameters for women's pads remain unknown. This represents a significant research gap requiring urgent scientific verification.

6.1.3. Pillar III: Dermatological and Hygiene Management

Skin injuries and hair follicle infections are a direct result of shearing forces and the occlusive, moist microclimate in the saddle area. Effective prevention is based on rigorous hygiene, modification of hair care, and individualized use of protective preparations.

Regarding pubic hair, complete removal (shaving, depilation) increases the risk of micro-injuries to the epidermis, ingrown hairs, and folliculitis, which can lead to painful ulcers. Instead, sports practice recommends only trimming - retained hair forms a natural barrier against friction and significantly reduces inflammation (Bury et al., 2021; Harrison & Edey, 2023; Burnie et al., 2026).

Commonly used protective creams (chamois creams) are intended to reduce friction, but in some athletes they may block pores, facilitating bacterial growth and inflammation (Burnie et al., 2026). They require strict, individualized selection and should never replace optimal biomechanical bike fitting. There is a critical research gap in this area - a lack of prospective, randomized clinical trials evaluating the effectiveness of the ingredients in these creams prevents the formulation of evidence-based guidelines (Bury et al., 2021; Napier & Heron, 2022; Burnie et al., 2026).

The accumulation of moisture, sweat, and heat inside cycling shorts creates an ideal environment for pathogens, increasing the risk of intimate infections (yeast infections, bacterial vaginosis) and urinary tract infections (Harrison & Edey, 2023). The key principle of prevention is to avoid prolonged wearing of sweaty clothing (e.g., during recovery breaks and stops) and to immediately wash the perineum and change shorts after riding (Bury et al., 2021; Burnie et al., 2026).

Female cyclists who are peri- and postmenopausal also require particular support. Physiological estrogen deficiency and secondary atrophic changes make the thinner, less elastic vulvar epithelium much more susceptible to abrasions. Topical estrogen therapy can effectively improve tissue nutrition, protect against micro-injuries, and alleviate urological symptoms. However, as current knowledge is based mainly on surveys (which carry a risk of systematic error), further prospective studies are needed to verify these treatment schemes (Harrison & Edey, 2023).

6.1.4. Pillar IV: Urogynecological Physiotherapy and Medical Care

If symptoms exceed tissue adaptation thresholds and manifest as increased pelvic floor tension, lower urinary tract symptoms (LUTS), or established neuropathy, equipment modifications must be supplemented with targeted medical management. According to the structured treatment algorithm for high-tone pelvic floor dysfunction (HTPFD), management is stepwise (Torosis et al., 2024).

The first-line intervention is always pelvic floor physical therapy (PFPT). Its role in HTPFD patients is fundamentally different from the standard approach (e.g., for stress urinary incontinence)—isolated strengthening exercises are strictly avoided, as they can secondarily exacerbate defensive urinary frequency and pain. Therapy, planned for 8 to 12 weeks, is based on myofascial relaxation, internal and external manual therapy, mechanical decompression of the pudendal nerve, and biofeedback techniques to restore physiological resting tone (Torosis et al., 2024).

If there is no lasting improvement after PFPT, second-line treatment includes local anesthetic injections into tender points (TPI) using bupivacaine without steroids, as well as intravaginal muscle relaxants (e.g., diazepam). These interventions should be supported by cognitive-behavioral therapy (CBT). Third-line therapy, reserved for refractory cases, consists of botulinum toxin A (BTXA) injections to break chronic muscle spasm. The fourth line—for patients with concomitant urge symptoms - is sacral neuromodulation (SNM) (Torosis et al., 2024).

In extremely advanced pathological states (e.g., infected, deep ulcers or persistent nodular changes), gynecological or surgical intervention is necessary, including targeted antibiotic therapy and drainage of purulent lesions (Burnie et al., 2026). For surgical excision of chronic, resistant perineal nodules, modern techniques such as intraoperative indocyanine green (ICG) monitoring to precisely obliterate damaged lymphatic vessels, combined with postoperative negative pressure wound therapy (NPWT), are successfully used to minimize the risk of recurrence (Mayer et al., 2024).

6.2. Practical Summary: A Guide for Coaching Staff

To facilitate early threat identification and implementation of immediate corrective actions, key behavioral and physiological markers are summarized in Table 1.

Table 1. Guide for coaching staff: early behavioral and physiological markers (Red flags).

Symptom (Red Flag)	Potential Mechanical/ Physiological Source	Impact on Exercise Parameters (RPE, cadence, power)	Corrective Action
Numbness, tingling, loss of sensation (pudendal neuropathy)	Direct compression of the pudendal nerve; excessively low handlebar position forcing extreme anterior pelvic tilt (Partin et al., 2014).	Limits ability to ride, forces non-physiological changes in saddle position; long-term risk of developing sexual dysfunctions (FSD) (Greenberg et al., 2019).	Raise handlebar height relative to the saddle. Regularly stand on pedals to restore perfusion.
Bladder pain, frequent urination, episodic incontinence (LUTS / HTPFD)	Increased pelvic floor tension (HTPFD) caused by ongoing defensive contraction and increased intra-abdominal pressure with a flexed trunk (Torosis et al., 2024; Saulicz et al., 2024).	Discomfort in the lower abdomen significantly hinders long training sessions.	Implement targeted urogynecological physiotherapy (PFPT) with a focus on myofascial relaxation. Strictly avoid isolated pelvic floor strengthening exercises (Torosis et al., 2024).
Abrasions, folliculitis, infections (UTI)	Friction, high humidity and temperature in the contact zone; short female urethra.	Acute pain significantly limits tolerated time in the saddle, threatening breaks in competition (Burnie et al., 2026).	Trimming pubic hair instead of shaving. Apply barrier creams (chamois cream) and immediately change out of wet clothing (Harrison & Edey, 2023).
Unilateral vulvar swelling / perineal nodules	Mechanical blockage of venous and lymphatic drainage (bicyclist's vulva); chronic microtrauma leading to fibroelastic changes (PNI) (Mayer et al., 2024).	Critical pain and permanent structural changes preventing riding and requiring long breaks from training.	Urgent modification of pressure distribution on the saddle. Rest, limb elevation, and cold compresses during acute phase. For persistent changes (PNI), surgical intervention is necessary (Mayer et al., 2024).

Asymmetric pedaling and increased center of pressure (CoP) path	Saddle too narrow to provide stable support for ischial tuberosities (Lin et al., 2023). Loss of shock absorption in low-density pads (e.g., 60 kg/m³) (Marcolin et al., 2015).	Reduced economy and mechanical efficiency due to asymmetry. Increased peak pressure on one ischial tuberosity.	Choose a saddle approximately 1 cm wider than the athlete's ischial tuberosity width (Lin et al., 2023). Use shorts with a high-density pad (endurance, 80–120 kg/m³) (Marcolin et al., 2015).
Kinematic changes outside the sagittal plane (e.g., knee abduction)	Increasing peripheral fatigue at loads of 85–100% of maximal aerobic power (MAP) (Pouliquen et al., 2021).	Increased risk of overuse injuries to the musculoskeletal system (knee, hip joints) and decreased efficiency of power transfer to the pedals.	Monitor riding technique under increasing fatigue.
Unexplained drop in cadence and sense of exhaustion	Prolonged cognitive and psychophysical load (mental fatigue) (Habay et al., 2026).	Distinct, involuntary decrease in pedaling cadence and spike in RPE with no changes in heart rate or lactate (Habay et al., 2026).	Monitor RPE as a fatigue marker independent of heart rate; evaluate workload and pacing strategies.

7. Discussion and Directions for Future Research

Cycling brings documented population-level health benefits that, for the most part, outweigh the overall risks associated with this activity (de Hartog et al., 2010). However, in women, intensive participation in this sport is associated with specific risk factors for the urogynecological system and skin, predisposing, among others, to the development of sexual dysfunctions (FSD), pudendal nerve neuropathy, and chronic nodular changes of the perineum. Despite growing awareness of this problem, a critical analysis of the literature reveals deep methodological deficits that significantly hinder the development of preventive and therapeutic guidelines grounded in solid scientific evidence (Evidence-Based Medicine, EBM).

7.1. Sociological Barrier in Coaching Staff

A significant obstacle to reliably assessing the scale of the problem and implementing preventive measures is the sociological barrier. The historical dominance of men in cycling, as well as the predominance of male staff among coaches and bike-fitting specialists, create a communication barrier. This prompts female athletes to hide their complaints and treat urogynecological discomfort as an unavoidable cost of practicing the sport (Burnie et al., 2026). This specific environmental taboo directly delays diagnosis and facilitates the persistence of pathological changes (Zhukava et al., 2026).

7.2. Methodological Limitations and Research Gaps

The conclusions of previous analyses are often at risk of systematic error. The dominance of retrospective surveys poses a risk of recall bias (Greenberg et al., 2019; Burnie et al., 2026) and introduces survivorship bias. Female athletes suffering from the most severe pain often quit cycling, and therefore do not participate in studies, which underestimates the true scale of the problem in the literature (Gaither et al., 2018; Greenberg et al., 2019; Lui et al., 2021). Furthermore, diagnoses have rarely been verified using objective clinical tools, such as cultures, blood flow measurements, or urinary incontinence tests (Gaither et al., 2018; Saulicz et al., 2024).

Another critical problem is the marginalization of female anatomy - cycling equipment was often designed by simply scaling down male models in proportion (Lin et al., 2023). Biomechanical studies have often been conducted within unnaturally short time windows that do not capture the full impact of terrain vibrations and hours of fatigue (Guess et al., 2011; Marcolin et al., 2015). Reliable meta-analyses are also hindered by the lack of standardized nomenclature in describing perineal injuries (Napier & Heron, 2022; Mayer et al., 2024), and the exact pathomechanism of progression from early subclinical symptoms to established tissue dysfunction still requires ultimate clarification (Greenberg et al., 2019; Lui et al., 2021).

7.3. Directions for Future Research

Efforts to raise the standards of care for female cyclists require that future research be directed toward several key areas. There is an urgent need to implement long-term prospective (cohort) studies. These will allow for precise determination of the causal sequence between equipment selection and training loads and the development of neuropathy, perineal injuries, and infections (Lui et al., 2021; Napier & Heron, 2022).

Another key postulate is the development of equipment engineering that accounts for sexual dimorphism. Conducting female-focused biomechanical analyses - including both pressure mapping and surface electromyography (sEMG) measurements - creates the opportunity to develop equipment standards appropriate to the anatomy of the female pelvis (Lin et al., 2023; Bing et al., 2024; Burnie et al., 2026).

Equally important is destigmatizing the problem and universal education. The development of dedicated training programs for coaches and bike-fitting specialists will help break down communication barriers and accelerate the early diagnosis of urogynecological conditions (Burnie et al., 2026).

The standardization of clinical management must complement these efforts. Creating evidence-based (EBM) unified guidelines for conservative and surgical treatment - closely integrating targeted pharmacotherapy and urogynecological physiotherapy - is an absolute foundation for improving the quality of medical care in this group of athletes (Napier & Heron, 2022; Torosis et al., 2024).

8. Conclusions

Based on a critical analysis and synthesis of the current literature in cycling medicine, biomechanics, and urogynecology, the following evidence-based conclusions were formulated:

- **Equipment mismatch:** A wider ischial tuberosity distance in women means that standard (narrow) saddles transfer weight to the perineal soft tissues, causing micro-injuries. The saddle should be about 1 cm wider than the rider's ischial tuberosity width, which improves pressure distribution.

- **Position and cut-out:** A low handlebar forces an anterior pelvic tilt, increasing pressure on the front of the pelvis. Saddles with a cutout in healthy female cyclists increase peak pressure at the edges of the opening but provide effective offloading for patients with vulvar dermatoses.

- **Dermatological and structural injuries:** Chronic pressure and moisture predispose to skin damage (e.g., saddle sores) and urinary tract infections (UTIs). Damage to lymphatic vessels leads to persistent vulvar edema (bicyclist's vulva) and the formation of fibrous nodules (cyclist's nodule).

- **Compressive neuropathy and sexual dysfunctions (FSD):** Pudendal nerve compression causes numbness and pain. Although cycling itself does not worsen sexual function, local urogynecological injuries are strongly correlated with an increased risk of secondary sexual dysfunctions (FSD), lowering arousal and sexual satisfaction.

- **Equipment optimization and hygiene:** It is key to use shorts with a high-density pad (80–120 kg/m³ endurance) and to set the saddle height to the greater trochanter (GTH) to minimize muscle overload. These actions must be supported by prophylaxis: trimming rather than removing pubic hair, immediately changing wet clothing, and regularly standing up on the pedals to restore normal perfusion.

- **Psychophysical costs:** Long-term intimate discomfort fosters mental fatigue. This leads to a spike in the rate of perceived exertion (RPE) and an involuntary decrease in cadence, which directly reduces training quality.

- **Specific syndromes (menopause and childbirth):** Atrophy in perimenopausal women increases susceptibility to abrasions (topical estrogen therapy is recommended). After vaginal deliveries, LUTS symptoms occur more frequently, which absolutely requires the implementation of pelvic floor muscle training.

- **Sociological barrier:** The historical dominance of men in coaching staff and among bike-fitting specialists hinders open communication. Female athletes often hide intimate complaints, mistakenly treating them as an unavoidable cost of the sport.

- **Treatment (HTPFD and PNI nodules):** In cases of increased pelvic floor tone (HTPFD), the basis is relaxing physiotherapy (PFPT), with strict exclusion of strengthening exercises. Resistant cases require pharmacotherapy (muscle relaxants, botox) or neuromodulation (SNM). Persistent perineal nodules (PNI) are treated surgically, with the high risk of recurrence in mind.

- **Aggravating factors:** Higher BMI directly increases the risk of genital numbness, and vibrations in off-road cycling intensify skin damage. Extreme fatigue forces non-physiological, non-sagittal movements, overloading the locomotor system.

- **Research gap (gender data gap):** The lack of equipment standards forces female cyclists to select saddles by trial and error. There is an urgent need for randomized controlled trials (RCTs) focused on female anatomy to eliminate systematic error from the literature and create guidelines compliant with the EBM standard.

Disclosure section: Authors' contributions:

Conceptualisation: Maja Kowalczyk, Paula Woźniakowska-Gondek, Kalina Kreft, Lena Głuszkiewicz

Methodology: Maja Kowalczyk, Paula Woźniakowska-Gondek, Kalina Kreft, Anna Waldman

Validation: Maja Kowalczyk, Paula Woźniakowska-Gondek,

Formal analysis: Maja Kowalczyk, Paula Woźniakowska-Gondek

Investigation: Agata Sobczak, Magdalena Wolff

Resources: Agata Sobczak, Magdalena Wolff

Data curation: Anna Waldman

Writing – original draft preparation: Maja Kowalczyk, Paula Woźniakowska-Gondek

Writing review and editing: Maja Kowalczyk, Lena Głuszkiewicz

Project administration: Maja Kowalczyk

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