Unique Concerns of the Woman Cyclist

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KEYWORDS

• Bike fit • Cycling biomechanics • Female cyclists • Cycling posture • Bicycle saddle • Pelvic pain • Overuse injury • Traumatic cycling injury

KEY POINTS

- Anatomic differences between female and male individuals in several cycling injury areas (head, breast, hip/knee, upper extremity, and perineal area) may change the incidence, presentation, and treatment of cycling-related injuries.
- Female cyclists with concussion or traumatic brain injury endorse different symptoms than male cyclists, both at baseline and postinjury
- Bicycle design specific for women is controversial; optimizing the bike fit to the rider is of greater value for injury reduction, comfort, and safety.
- Saddle design and choice can influence the overall health of the cyclist.
- Pelvic pain in female cyclists can have many different presentations.

INTRODUCTION

From the origins of cycling in 1817, when women were forbidden from riding,[1] the population of women cyclists has grown to 42.7% of riders in America.[2] In the late nineteenth century, physicians began to recommend cycling as a means for health promotion, but women were discouraged from riding because of concerns about decreased reproductive capacity, uterine displacement, injuries, and notably "Bicycle Face," a condition thought to impact thyroid function.[1,3] Another concern raised by physicians at that time was the impact that cycling would have on sexual health, or more specifically, "sexual purity," and that riding astride on a bicycle saddle was

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not considered feminine and might encourage masturbation.[4] Others were concerned that participating in cycling would cause physiologic sex reversal in women.[1] In spite of the absurdity and sexism of these assertions, it is the earliest recognition of the potential impact of cycling on women's health.[4]

Others in the medical community recognized the potential health benefits that helped grow bicycle adoption among women throughout the century.[1] At the time, progressive physicians claimed that an hour of cycling per day would help with conditions such as insomnia, anemia, and nervousness.[1] More recent research on cycling has provided evidence as a way to promote public health,[5] including benefits such as reduction in the risk of cardiovascular disease, type 2 diabetes, cancer, and obesity mortality.[5] And although women's participation in cycling is no longer considered controversial, cycling remains a male-dominated activity.[6] Data from competitive cycling federations show a significant gender disparity, with more men involved in the sport than women; in the United Kingdom, United States, and Australia, only 15% to 17.5% of athletes competing were registered within the women's cycling fields.[7] The commercial cycling industry is also male dominated, with 89% of all bike shops owned by men.[8]

Cycling-related injuries can range from high-velocity traumatic injuries to nontraumatic injuries that may evolve over an extended period. Overuse injuries predominate but traumatic tend to be more severe.[9,10] The purpose of this article was to provide a broad overview of the current literature on the clinical relevance of gender differences in cycling-related injuries. With respect to gender differences, it is important to note that clinical and research language remains binary, and the words woman/women/female may not encompass all non-cisgender male gender identities. A study on women's and gender-diverse participation in cycling conducted an open-ended demographic questionnaire to accurately define the population of cyclists who do not identify as cisgender male. Although most respondents identified as women, cisgender ("cis") women, or female, 12 additional gender identities were reported.[7] Hormonal changes related to gender transition and hormone replacement have not been thoroughly studied in cycling and are not discussed here. With respect to the cycling-related research that is discussed in this article, please refer to the individual articles cited for details of the study population.

HEAD INJURY

Cycling is a high-speed sport with potential for traumatic injury, particularly to the head. It is the most common sports-related cause of traumatic brain injury (TBI) in female individuals, and second only to football in male individuals.[11] Prior studies have shown an increased risk of head injury/concussion in female compared with male individuals in comparable sports,[12–14] although research on this topic has been historically problematic, as female individuals typically endorse more concussion symptoms at baseline and postconcussion (Kotler DH, Rice S, Iaccarino MA, unpublished data, 2019).[15] As sports-related head injuries are also frequently underreported,[16,17] the question of whether the sex differences in head injury are due to true difference or underreporting is not entirely answered.

Recent research on the expanding set of TBI and concussion surveillance efforts in sport has demonstrated sex differences in performance on both baseline and sideline outcome measures such as the ImPACT and SCAT5. One study showed that female National Collegiate Athletic Association Division 1 athletes demonstrated improved performance on verbal memory, visual motor speed, and reaction time domains of the ImPACT at baseline relative to their male counterparts,[18]

whereas others showed that female collegiate athletes endorse more symptoms of sadness, nervousness, and feeling more emotional at baseline than male subjects.[19] These differences may be significant when considering postconcussive symptoms and timing for return to sport.

Helmet use is generally accepted to help prevent TBI and concussion injuries in cycling.[20] Anthropomorphic data on female versus male skull dimensions and cortical bone thickness show that female individuals have straighter foreheads, less pronounced glabellae, and less pronounced orbital rims compared with male individuals.[21] In addition, female individuals undergo more cortical bone resorption during the adult years,[22] and thinner cortical bone offers less protection from skull fracture injuries.[23] There is a lack of sex-specific epidemiologic data, but these factors together suggest that female cyclists may gain substantial protective benefit against TBI by using a well-fitting cycling helmet.

BREAST INJURY

Breast injury includes both traumatic and frictional injury. There is little research investigating breast injuries in sport, and even less regarding support and protection of the breasts. This may be in part because of a lack of reporting of breast injuries.[24] Breast trauma has been previously evaluated in the setting of a motor vehicle accident, but is certainly a risk in contact sports, as well as sports with potential for trauma, including cycling. Most hematomas are mild, with rupture of superficial capillaries secondary to blunt trauma. Fat necrosis can occur following the injury, with cyst formation, palpable nodules, and even calcification. These are not typically symptomatic, but may be evident on imaging and can even be mistaken for malignancy.[25] In the augmented breast, traumatic capsular hematoma can develop, and with more significant trauma, an implant may rupture.[26]

Mondor disease, a superficial thrombophlebitis of the anterior chest wall, may occur spontaneously or can be associated with direct trauma, which is often minimal and potentially not recalled by the athlete. A palpable tender cord may be seen in the location of the superficial vein.[27] This uncommon, benign condition is typically self-limiting but still should be evaluated by a breast specialist to rule out any association with breast carcinoma.

Management of breast trauma includes ice, analgesia, topical or oral anti-inflammatories, and firm support. Aspiration of hematoma may be necessary in some cases. With any abnormal findings on breast examination, mammographic examination should be considered to rule out an underlying malignancy, and abnormal imaging findings may be confirmed with biopsy if needed.

CYCLING AND BONE HEALTH

Cycling is considered nonimpact, which is a favorable quality with regard to wide participation across age groups and levels of fitness. Although cycling requires large muscular effort, there is minimal external loading and ground reaction forces, and as such, it does not promote an increase in bone density.[28] Most of bone mass is developed during adolescence and young adulthood, and is dependent on factors including genetics, weight-bearing/loading exercise, lean body mass, nutrition and energy availability, bone-building nutrients, and reproductive hormone levels.[29]

Prior research has found that decreased bone mineral density (BMD) is prevalent among cyclists, which is concerning for an activity in which there is also a risk of fractures related to crashing.[30–32] Much of the prior research, however, has been limited by a focus on a relatively homogeneous elite male cyclist population, which

is not representative of the general cycling population. Male cyclists have frequently demonstrated similar or lower BMD than sedentary controls, and significantly lower BMD than athletes participating in weight-bearing activity.[30] In one study, two-thirds of road cyclists categorized as elite and professional showed low BMD.[31] In a 7-year study of male masters cyclists compared with nonathletes, rates of osteopenia and osteoporosis were more common in the cyclists at baseline, with BMD showing a significantly greater decline in the cyclists throughout the course of the study. Those participating in weight training or impact exercise lost significantly less bone mass than those who did not.[32] Even within the sport of cycling, there are differences between disciplines with respect to bone density. In a comparison of radial bone size and strength between cyclists participating in road versus mountain biking, in which there is more external impact, the mountain bikers' radii showed increased size, density, and strength compared with those of the road cyclists and controls.[33]

Findings in competitive female road cyclists have shown similar decreases in BMD,[34] including when compared with runners. Comparison of the lumbar spine bone density between female cyclists, controls, and runners over 18 months of training showed decreases in the cyclists and controls but not runners, suggesting that the axial load of running may be protective to the lumbar spine bone density.[35] However, more recent research has examined a more diverse group of male and female bike racers to evaluate the contribution of factors including age, USA Cycling category, and racing type on body composition across a road racing season, using dual-energy x-ray absorptiometry and dietary recall. In this case, BMD values did not decrease over time, and in fact the female participants showed higher Z-Scores than male participants. In this study, nearly all female participants met daily calcium and vitamin D intake recommendations, reported calcium and vitamin D supplementation, whereas male participants did not, and female participants also reported weight-bearing physical activity in addition to cycling.[36]

Bone health in endurance sports, particularly cycling, is a challenging topic for research, as many confounding factors are prominent. Cyclists train long hours over many years and may spend little time doing weight-bearing or cross-training activity. In addition, cyclists of lean body type and low body mass index may self-select into their sport, as this phenotype provides an advantage, particularly over hilly terrain where power-to-weight ratio has a major impact on performance.[32] Relative energy deficiency in sport (RED-S) is a syndrome that describes consequences of the low energy availability state, including hormonal dysfunction in both men and women, and is a common issue in endurance athletes, with consequences in both health and performance. Although decreased energy availability is not necessarily a result of disordered eating, risk factors for disordered eating are prevalent in cycling, including the importance of power-to-weight ratio, body-contour-revealing clothing, and difficulty maintaining energy availability during training and competition.[29,37] The nature of cycling, requiring high workloads and caloric expenditure for long periods, poses a challenge for both maintenance of energy availability and calcium homeostasis during a long ride or race. Research has shown that exercise stimulates parathyroid hormone, a marker of bone turnover, including moderate-intensity, long-duration exercise, as seen in endurance cycling.[38] It has also been suggested that dermal calcium loss through sweat may lead to resorption of calcium from bone if not replaced through nutritional intake.[28] Multiple factors in addition to loading contribute to bone regulation, and the lack of a consistent negative correlation of any specific factor is a testament to this complexity.

OVERUSE INJURY AND BIKE FIT

Overuse injury typically results from a combination of muscular imbalances, degenerative change, and suboptimal biomechanics. In a study of Division I college athletes across multiple sports, overuse injury rate was higher among female athletes, although the difference was less between comparable sports.[39] Previously seen alterations in the biomechanics of female individuals include increased knee abduction (valgus), and quadriceps to hamstring ratio during landing in female individuals, which have been associated with anterior cruciate ligament injuries.[40] This has been examined both in a drop and vertical jump, as well as in a single-leg squat, in which women were found to demonstrate increased pelvic rotation, hip internal rotation, hip adduction and rotation range, and knee mediolateral motion compared with men.[41] This lack of pelvic stability appears to also cause downstream effects on the knee, such as patellofemoral pain syndrome, particularly in female individuals.[42] In the cyclist, management of these injuries involves understanding the anatomic and biomechanical factors of the cyclist, the positioning of the rider on the bicycle, and the demands of the discipline of cycling.[10] In considering the fit needs of women cyclists, anatomic differences must be considered, including a wider inter-ischial distance, greater genu and/or coxa valgum, shorter legs, narrower shoulder width, and smaller hands.[43]

A frequent complaint of cyclists is anterior knee pain. Patellofemoral pain syndrome (PFPS) refers to pain in the patella or surrounding soft tissues, and is more common in female individuals.[44,45] Dynamic valgus during functional activity has been associated with PFPS and has been more frequently observed in female athletes compared with male athletes. In cycling, overuse-related knee pain is typically associated with medial deviation of the knee in pedaling and altered activation of the vastus medialis and vastus lateralis muscles.[46] The role of Q-angle in patellofemoral pain syndrome has been debated and is not thoroughly understood.[47] One factor that can contribute to patellofemoral pain is the crank length of the bicycle drive-train. If these are too long for their inherent hip range of motion, cyclists' knees may deviate laterally with some external rotation at the knee joint at the top of the pedal stroke. The larger the Q angle, the greater the deviation between the top and bottom of the pedal stroke. This can result in significant medial-lateral patellar movements that can result in PFPS. Biomechanical imbalances may also contribute to overuse injuries, such as lateral hip pain.[48,49]

Using a shorter crank arm helps to reduce shear force across the knee joint and maximum knee and hip flexion at the top of the pedal stroke, which may be especially beneficial for female riders with shorter legs and increased Q angle.[50] Some biomechanical faults may also be addressed through improved foot support in the shoe, and allowing for slight medial and lateral rotation of the foot, known as pedal float (**Fig. 1**). Saddle position is adjustable, both up and down, as well as fore and aft. Riders with a wider pelvis may require adjustment of stance width (width of the feet) (**Fig. 2**), which can be done through the adjustment of cleat position, the addition of washers to space the pedals, or use of pedal spindle extenders. On the front end of the bike, smaller hands may require repositioning of the shifters and brake levers or use of shims to allow for easier reach (**Fig. 3**). This can be a critical safety issue, as female cyclists' smaller hands may not otherwise easily be able to reach the bicycle brakes from the drop portion of the handlebar. Short-reach or compact geometry handlebars may also improve comfort for some riders.

Upper extremity peripheral nerve injuries, including cervical radiculopathies and ulnar and median entrapment neuropathies, are common in cyclists.[51] The posture of a cyclist on the bike is generally characterized by a forward head, extended neck, and

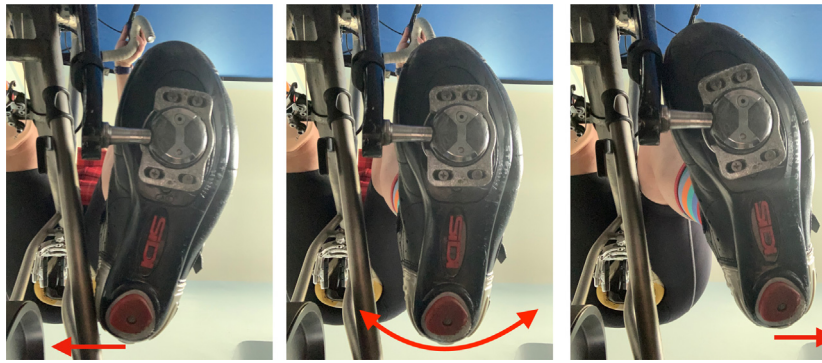

Fig. 1. Having a pedal float allows the foot to rotate while being clipped into the pedal.

significant pressure on the elbows and extended wrists, which can cause entrapment or pressure neuropathies at multiple sites.[52] There are important epidemiologic differences between men and women who experience these injuries. One study showed that women have a twofold lower incidence of ulnar nerve entrapment at the elbow.[53] In contrast, women have twofold to threefold increased incidence of median nerve entrapment at the wrist.[54] For both male and female cyclists, entrapment injuries of the deep branch of the ulnar nerve at the wrist can evade early detection, as lesions of the deep palmar motor branch may present without sensory deficits.[55] A recent study demonstrated that EMG-diagnosed median nerve injuries at the wrist in the absence of ulnar nerve injury may present with pain or reported paresthesias in an apparently ulnar nerve distribution.[56] Together, these lines of evidence support a comprehensive neurologic and electrodiagnostic workup for a female cyclist who is suspected to have the classic "cyclist's palsy" or another upper extremity nerve injury.

Women's specific bicycle design has been the source of some controversy. In the past, the prevalent theme was "Shrink it and pink it," meaning to manufacture smaller sizes and make items that aesthetically appeal to women. This compromised functionality and often resulted in lower-quality equipment. Research and development went into improving bicycle fit for women, primarily based on the assumption that women are shorter and have proportionally shorter torsos than men.[57] However, newer data obtained while a cyclist is in the cycling position, rather than while standing, suggests that the sex differences in bike fit are not nearly as clear as previously thought, and the differences are not dissimilar to the heterogeneity within an all-female or all-male population.[57] A bicycle geometry must work with an individual's proportions, and women have a variety of body types and proportions, some of which may not require a women's-specific bicycle. In addition, variables such as experience level, flexibility, and preferred body position may be more relevant to bike selection than gender. As such, over the past few years, many bicycle manufacturers have reverted to a unisex platform for frame geometry, and now emphasize the importance of bike fitting for the individual rather than gender-specific design.[57,58]

In contrast to frame geometry, saddle design must be more nuanced to accommodate for anatomic differences between individuals. The bicycle saddle is 1 of 3 contact points of the rider with the bicycle and is essential for providing pelvic support to enable efficient pedaling and safe handling of the bicycle.[59] A proper position on the saddle typically involves the cyclist's weight being equally distributed over the ischial tuberosities and the inferior pubic rami, with proportionally less compression over the soft tissues and neurovascular structures.

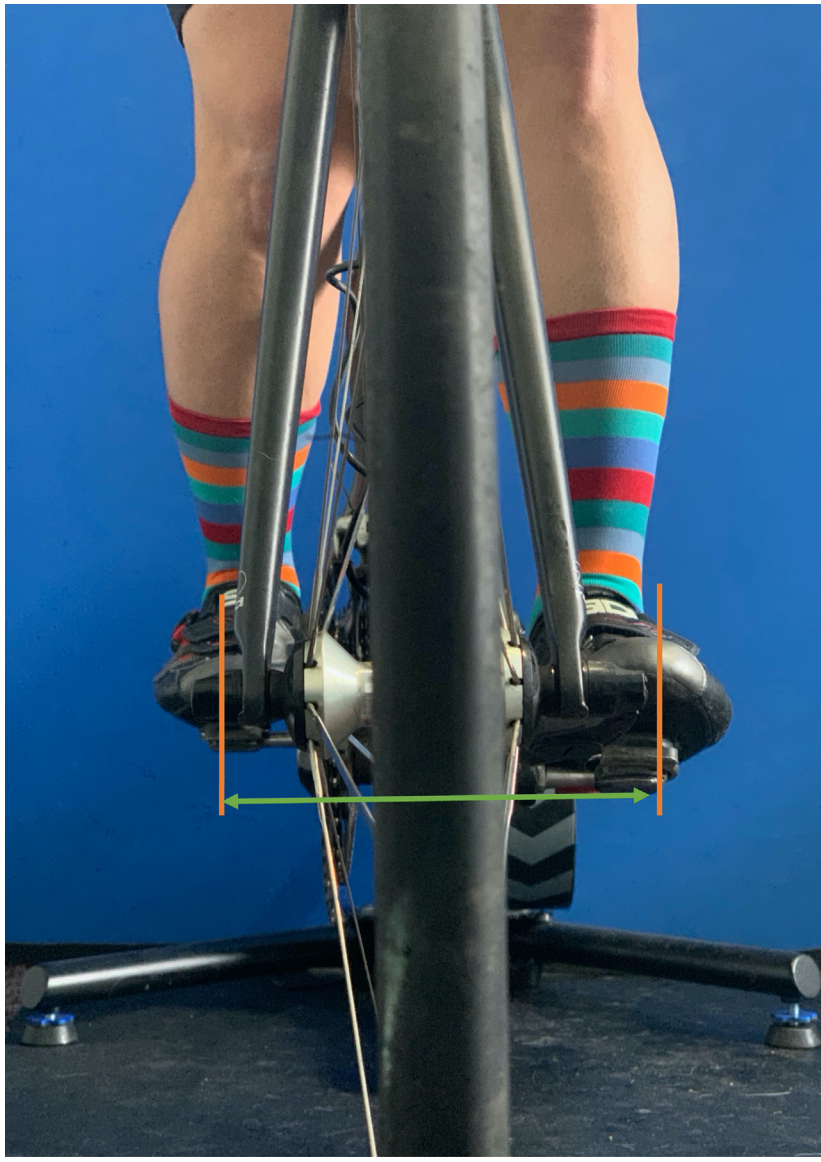

Fig. 2. Stance width.

Saddles can vary widely in shape, width, and other more granular features. Saddle design has evolved to improve comfort, as various ailments can arise from sitting improperly on a saddle, particularly for long durations.[60] Saddle design may include a dome-shaped, flat, or sloping surface, fabricated with different types of material and padding, all of which impact the amount of pelvic movement that occurs while riding and can contribute to adequate support. Some saddles are designed with cut-out centers or channels intended to decompress the neurovascular structures.[61] Modifications to saddle design have included full removal of the nose of the saddle,

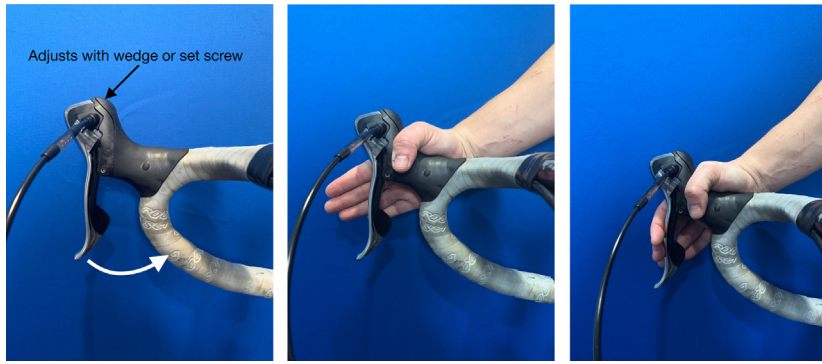

Fig. 3. Smaller hands may require repositioning of the shifters and brake levers or use of shims to allow for easier reach.

intended to reduce compression of the perineal area.[61,62] The nose of the saddle itself has been tested at varying widths to assess the impact on pressure distribution and perceived discomfort.[61] Saddle pressure distribution will shift depending on the posture of a rider.[63] A person riding with a fairly upright posture will have their weight distributed differently from a cyclist riding in an aerodynamic posture. Saddles are designed to support the specific weight distribution of the riding discipline. For example, if a rider is going to participate in time-trialing, which requires an aerodynamic position, and will also commute by bike, they will likely benefit from 2 different saddles to support the different postures for each type of riding.

An improper saddle selection or position may contribute to overuse issues elsewhere, such as in the spine, hip, or even the upper extremities.[59] If a saddle is not positioned in a way that optimally supports the rider, excess or imbalanced pelvic motion can occur, and this can translate into dysfunction axially or peripherally.[64] Sauer and colleagues[43] noted sex differences in pelvic motion in seated cycling. Although inherent differences in pelvic anatomy will influence position on the saddle, it was noted that when changing hand positions, female individuals exhibited increased anterior pelvic tilt in the drops position compared with male individuals that was not correlated with lumbar flexibility, but rather the anatomic differences.[43] This highlights the importance of inquiring not only how frequently one rides, but also what type of cycling they participate in, and which positions they prefer.

Although it is important to have a well-positioned saddle that matches the pelvic shape and riding discipline, it is equally important for female cyclists to wear well-fitting bicycle shorts with a chamois (pronounced sham-ee) appropriate for the type of riding. The location of the chamois padding will differ based on the riding discipline and where the pressures are distributed. An overall thicker chamois may increase perineal pressure and is not always recommended.[65] A poorly fitted chamois or one that is too thick can cause pain, even in the presence of an appropriate saddle in the proper position.

It is important to note that there are no data on the effects of the bicycle saddle on transgender women who have undergone gender re-affirming surgery. More research is needed to understand this impact. Many of the studies have been conducted on a binary population, but with the increased acknowledgment of nonbinary populations, future research needs to include these populations in their analyses.

PELVIC PAIN

Causes of pelvic pain specific to cycling can be somatic or neuropathic (Table 1),[66–68] and just as an inappropriate saddle can cause dysfunction in other areas of the body, pain, injury, or dysfunction elsewhere in the body can translate into an inability to sit properly on the saddle resulting in pain and dysfunction. Causes of pelvic pain may be related to musculoskeletal pelvic etiologies (eg, postpartum changes in the pelvic floor muscles and joints), cyclist posture/positioning (eg, repetitive muscle or nerve irritation, injury, or compression), or muscle imbalances and overuse/underuse injuries.

Discomfort localized to the saddle region may be attributed to pressure, friction, tissue traction, and shear, sometimes contributing to skin breakdown, and other times causing focal pressure or pain over bony structures, soft tissues, urethra, or neurovascular structures. A basic understanding of the muscles, nerves, skeletal anatomy, and referral patterns can provide clues to the possible causes of pelvic pain in cyclists. Although pelvic pain can be a result of noncycling causes, such as endometriosis or bladder hyperactivity/interstitial cystitis, a thorough pain assessment can provide clues to the cause of pain. For instance, pain in the perineum or genitalia may be a sign of peripheral nerve compression (eg, pudendal nerve entrapment) from an improper bicycle fit, or due to lumbar or hip joint pathology referring to the perineum.

Table 1
Example of somatic versus neuropathic causes of pelvic pain in the cyclist

Somatic	Neuropathic
Hip-related referred pain in the absence of trauma	Pudendal neuralgia • numbness or pain in the rectum, perineum, vagina/penis/scrotum (see *Nantes Criteria*, Labat 2008[102]) • ± sexual dysfunction
Pelvic floor muscle inflammation/ tightness (eg, pelvic floor muscle dysfunction leading to dyspareunia, vaginismus, or anorectal pain)	Anterior abdominal cutaneous nerve entrapment syndrome (ACNES) (Scheltinga 2018[101]) • pin-point, localized pain in the abdominal wall • positive Carnet sign • typically relieved by local anesthetic nerve block/trigger point injection in the area of pain
Pubic symphysis instability/inflammation (osteitis pubis)	Ilioinguinal neuralgia (eg, secondary to inguinal hernia or anatomic nerve compression)
Abdominal wall/myofascial inflammation or dysfunction (eg, lumbopelvic pain)	Genitofemoral neuralgia (may lead to clitoral or upper vaginal pain)
Anterior iliopsoas muscle dysfunction	
Labial hypertrophy	
Coccygodynia/coccyx pain	

(*Data from* - Scheltinga M, Roumen R. Anterior cutaneous nerve entrapment syndrome (ACNES). *Hernia.* 2018;22(3):507 to 516; - Labat JJ, Riant T, Robert R, Amarenco G, Lefaucheur JP, Rigaud J. Diagnostic criteria for pudendal neuralgia by pudendal nerve entrapment (Nantes criteria). *Neurourology and Urodynamics: Official Journal of the International Continence Society.* 2008;27(4):306 to 310.)

There are several nerves that innervate the perineum but the pudendal nerve primarily supplies the "undercarriage," including the perineum and genitalia. The pudendal nerve stems from the sacral plexus (S2-3-4) and passes under the sacrospinous ligament through the Alcock canal to innervate the genitalia. In addition, the internal pudendal artery and veins pass through the same canal, which then branches into the various arteries of the genitalia.[69] When seated on a bicycle saddle, there is consistent pressure in the region of these structures, which can lead to dysfunction. Over time, compression can result in chronic fibrotic changes that can reduce blood flow.[69] And although it may be intuitive to use a cut-out saddle to relieve the pressure of these central vessels, one study showed that cut-out saddles have a negative effect on weight distribution, and can increase the pressure on the perineum.[70,71]

PELVIC PAIN ASSESSMENT IN THE CYCLIST

Pain assessment should always begin with the personal pain narrative. This is an opportunity for the cyclist to describe physical symptoms along with the palliating and provocative factors while the provider pays close attention to the important emotional details. This permits the provider to respond empathically to the personal pain narrative.[72] When evaluating a female cyclist, questions should include the volume and type of riding they do, and how aggressive their riding position is. A saddle position that offers a significant drop in height from saddle to handlebars can put increased pressure on the ischiopubic rami, which can lead to painful saddle pathologies and decreased genital sensation.[43,73–75]

Pain assessment also should include an evaluation of functional status, as well as a full medical, sexual, psychosocial, and substance use history. In addition to the impact pelvic pain can have on cycling, acute or chronic pelvic pain can negatively impact day-to-day function and sexual function, as well as overall emotional well-being.

Pain diagrams can aid the physical examination in localizing the pain generators, as the term "pelvic pain" is quite nonspecific. The physical examination should focus on inspection, palpation, hip range of motion or pain, patient guidance to the pain location, and both an external and internal vaginal examination and possibly a rectal examination if indicated based on the patient's symptoms. Often, the pain narrative and diagram can provide the necessary clues to the diagnosis, and an internal examination may not be needed by the general practitioner.

SADDLE SORES

"Saddle sore" is a generic and colloquial term that describes painful skin injuries that occur on the buttocks, perineum, and upper inner thigh.[76] Generally, these occur from saddle pressure and chafing and can lead to ulcerations, folliculitis, nodules, and cysts that interfere with the ability to sit on the saddle.[76–78] Very little empirical evidence exists that describes the prevalence of saddle sores in women cyclists, although anecdotal reports suggest that it is a common occurrence in this population.[76] When these sores are in the form of an abscess, they can be treated conservatively, but if large enough to warrant intervention, they can be treated with incision and drainage, oral antibiotics, and time off the bike for recovery and healing.[79] An unpublished survey of 18 professional female cyclists in the United Kingdom found that all respondents have had painful saddle problems that have interfered with training and competition[80]; however, the specifics of these saddle concerns were not well defined. As a result of this survey, a team of experts was convened to try to address the problem. The team implemented a number of interventions, including antimicrobial wash, paraffin-based moisturizer, and a moratorium on shaving pubic hair.[80] This, combined with subtle

adjustments to saddle fit and chamois choice, resulted in an elimination of saddle concerns 6 months postintervention.[80]

More well defined in the literature is the term "cyclist's nodules." These are an underdiagnosed condition of the perineum and have been classified in multiple case studies as perineal nodular induration (PNI).[81–83] These are more extensively reported in male than in female cyclists, which has led these nodules to sometimes be referred to as a "cyclist's third testicle."[81,83–86] Described in case reports as a solid nodule, a painful mass, and a focal area of tenderness with a nodular indurated area in the perineum, PNIs are a type of saddle sore.[81,83,84,87] A histologic analysis reported on vulvar nodules identified in 4 female cyclists with PNI noted that all lesions shared features of ischemic fasciitis, which is a non-neoplastic proliferation of atypical fibroblasts that is thought to result from prolonged pressure on soft tissues.[82]

LABIAL/VULVAR HYPERTROPHY

The vulva is the name of the external female genitalia, and it includes, among other features, the labia majora, often described as the "outer lips" and the labia minora that are often described as the "inner lips." These vary in size and shape from person to person and are rarely symmetric. While cycling, the labia are compressed from the rider being in contact with the saddle and this can result in significant pressure. In addition, there can be repetitive friction and shearing forces from inherent pelvic motion. Over time, both the labia majora and minora can increase in size and interfere with an individual's everyday activities, causing physical and psychological symptoms. Although not common in the general population, a few case reports and observational studies have described female cyclists who have experienced labial hypertrophy.[88–90] A number of factors may contribute to this phenomenon. Chronic inflammation in the vulvoperineal area related to friction and compression of the inguinal lymphatic vessels may contribute to altered lymphatic circulation.[88] Modifying the saddle position to ensure that pressure is well distributed throughout may help mitigate this risk. Saddles with cut-out centers have been designed with the intention of alleviating soft tissue and neurovascular pressure; however, subsequent research on labial hypertrophy discovered that these saddles can worsen hypertrophy in some women because gravity can pull lymphatic fluid into the cut-out portion, and this can exacerbate the swelling.[91]

Hypertrophy can result in irritation, pain, chronic infection, or poor hygiene. Pain and irritation can interfere with daily activities beyond cycling, such as walking, sitting, wearing tightly fitted clothes, and sexual activity. Many patients describe swelling and pain in the labia following activities, which then resolves after the activity is concluded. To mitigate these symptoms, many patients "fold up" their labia or push them into their vagina to decrease their symptoms. There are, however, patients in whom these symptoms do not resolve and continue to progress over time leading them to seek medical consultation for treatment.

Labia majora hypertrophy is characterized by the enlargement of the labia majora, and labia minora hypertrophy is a clinical diagnosis generally described as protuberant labial tissue that projects beyond the labia majora.[92] It is diagnosed by physical examination and based on the presence of physical and/or psychological symptoms that interfere with daily activities. Although there are no standard diagnostic criteria, clinicians describe the labia minora by using labial width. If the labia minora can be stretched greater than 6 cm from the midline to the lateral free edge, they are generally considered hypertrophic. Initially, functional symptoms can be addressed using methods of vulvar care (**Table 2**), reduced time in the saddle, and avoidance of form-fitting clothes.

Table 2
General vulvar care

Do	Do Not
• In everyday situations, wear cotton underwear- or no underwear when possible. • Wash with lukewarm water. • Use Vaseline, olive oil or coconut oil on the vulvar skin daily to keep it hydrated. Use nonmedicated chamois creams during cycling activities. • Avoid scented laundry detergents or fabric softeners for clothes that touch the vulvar skin. • Apply ice or cool compress to soothe the area if irritated. • Sleep with gloves or socks on your hands if you scratch in your sleep. • Use tampons for menses if possible. Constant contact with a pad causes more irritation. • If you use pads, avoid pads with significant latex content (eg, Always brand). • Use lubricant to make intercourse more comfortable.	• Wear underwear underneath bike shorts. This will increase friction. • Wash the vulva. If you feel like the area needs to be washed, do not scrub. • Use feminine wipes, powders, creams, or other over-the-counter products. • Douche. • Use tea tree oil, witch hazel, Gold Bond powder, Epsom salts or other "cleansing" products, because they irritate the skin. • Use over-the-counter yeast treatments without talking to the provider because they can be irritating to the vulva and may not treat the underlying condition.

(*Data from* Mitchell, C MD and Pascal, A DNP General Vulvar Care. [1]Department of Obstetrics and Gynecology, Massachusetts General Hospital, Boston, MA [2]Harvard Medical School, Boston, MA. General Vulvar Care. 12/2015.)

In those with recurrent symptoms who do not respond to conservative care, surgical management can be considered. Labiaplasty describes the surgical procedure that is used to reduce the size or restore symmetry of the labia by resecting the hypertrophic tissue.[93,94] These procedures can be performed using local anesthesia, sedation, or general anesthesia.[95] Careful screening for body dysmorphic disorder should be part of the preoperative evaluation. Alteration of labia in minors that is not deemed medically necessary can be considered female genital mutilation under federal law in the United States,[96] and surgical management in patients younger than 18 should be thoughtfully undertaken. Although labiaplasty is a relatively simple surgical procedure, there are complications, such as infection, bleeding, wound breakdown, and persistent pain.[97] In general, however, most patients experience a high level of satisfaction, and improved self-esteem.[98] Because of the risk of postoperative complications, it is imperative that cyclists remain off the bike for 8 to 12 weeks.

PRACTICAL APPROACHES TO PELVIC CONCERNS IN WOMEN CYCLISTS

Treatment of pelvic concerns is dependent on the most likely etiology, and is most effective using a multimodal and interdisciplinary approach (**Table 3**).There are considerations that should be discussed with the cyclist as part of a plan to promote pelvic health and prevent cycling-related pelvic injury. Bicycle shorts should always be in direct contact with the vulva; underwear should not be worn underneath bike shorts. Chamois creams are commonly used barrier creams that reduce the friction between the cyclists' skin and the chamois of the bicycle shorts to help reduce skin concerns. These should be used for every ride and placed either directly on the skin or directly on

Table 3
Multimodal strategies for the prevention and treatment of pelvic pain in the cyclist

Treatment Category	Example Treatment Strategies
Cycling optimization	• Appropriate saddle/bike fitting • Appropriate clothing, such as bike shorts with properly sized chamois in direct contact with skin • Chamois cream to reduce friction • Avoid pubic hair removal • Cycling pause
Pharmacotherapy	• Topical agents (eg, local anesthetics) • Neuropathic medications (eg, antiepileptics) • Suppositories (eg, muscle relaxants inserted in rectum or vagina)
Physical therapy/exercise	• Pelvic floor vs general musculoskeletal physical therapy • Alternative guided exercise programs, cross-training, and appropriate strengthening vs myofascial relaxation strategies
Interventions	• Injection therapies for diagnostic/therapeutic benefit (eg, nerve blocks, muscle trigger points, or joint injections) • Surgery when indicated (eg, labiaplasty, nerve decompression)
Behavioral strategies	• Mindfulness and cognitive behavioral strategies to promote pain coping techniques and muscle relaxation • Mental health support to address the potential impact chronic pain or inability to cycle can have on psychological well-being
Alternative therapies	• Chiropractic care • Anti-inflammatory dietary strategies • Acupuncture

the chamois. A placebo-controlled study compared 1% hydrocortisone to 10% trolamine salicylate cream to a nonmedicated cream,[99] and showed that the medicated creams were no more effective than nonmedicated creams in preventing skin breakdown. Nonmedicated creams should be thick and should not easily absorb into the skin. Pubic hair also has a protective role in cyclists' vulvar health and its removal is not recommended. An unpublished study found that female cyclists eliminated their saddle concerns by avoiding pubic hair removal in a 6-month time frame.[80] Freshly shaved skin can also be a risk factor for the development of saddle sores.[77] Ensuring good hygiene by choosing clean clothing and quickly removing this clothing at the end of a ride is another important preventive measure.

Commercially available pressure-sensing technologies exist to evaluate areas of excess pressure. In the absence of technology, examination of the saddle to evaluate for uneven wear may provide insight into the sitting position and resulting biomechanics. Although it may be impractical to evaluate the saddle fit of a cyclist in the office, a rudimentary method to obtain a measurement of the ischial tuberosity width is to have a patient sit onto floral foam blocks, let ball-bearings settle into the depressions left behind, and measure the width between the ball bearings.[43] Once this measurement is obtained, it can be compared with the saddle to assess for discrepancies. This assessment measure may help to further characterize the concern of the patient and provide possible solutions with regard to their saddle. If the width between the ischial tuberosities does not match the widest part of the saddle, it suggests that the cyclist is using a saddle that is not well-fitted to their body.

CLINICS CARE PEARLS

- When evaluating a cyclist, inquire about the volume of riding, type of bike they ride, and if multiple, the volume on each. Inquire about the position that they typically ride in and if they are on a road bike, if they switch hand positions, or are in the drops or the hoods more often.
- If a patient has reported that they have had a bike fit, inquire when it was last done. Many overuse injuries can be improved through physical therapy and bike fit modifications, and a repeat bike fit analysis may be indicated.
- When a patient presents with a traumatic breast injury, consider breast cancer in the differential.
- For patients seeking care for pelvic pain, labial hypertrophy, or pudendal neuralgia, inquire about the use of cut-out saddles and encourage patients to discontinue their use, as these can worsen these conditions.

SUMMARY

Although an office-based visit is not a substitute for a proper bike fit performed by a certified fitter, the treating practitioner will gain a greater understanding of the concern by understanding how the bicycle can affect the cyclist. Both traumatic and nontraumatic injuries can be impacted by a cyclist's gender, and it is important to understand how this variable influences a particular concern.

A survey of more than 3000 female cyclists is noted to be the largest study to date on this population.[100] However, it focused only on sexual and urinary dysfunction and did not address other conditions seen in female cyclists. To fully examine the impact that cycling has on female cyclists, and to strengthen the recommendations for prevention and treatment, large-scale studies that identify the magnitude of concerns in female cyclists should be undertaken. There is a lack of epidemiologic studies to identify the distribution of concerns among women cyclists, and this limits the ability to adequately strategize solutions within this population. The growth of women in cycling provides evidence that large-scale studies are possible and warranted. Cycling provides a wide array of health benefits, and the options for appropriate cycling equipment for many different body types continue to emerge. The continued pursuit of scientific inquiry will further the opportunity to hone equipment design for a wider breadth of options for all cyclists. Removing barriers to a physical activity that can be accessible to so many deserves the attention of the scientific community.

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