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Return to cycling protocol after chronic coccydynia: a case report

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Objective: *To outline a successful return to cycling protocol in a patient recovering from chronic coccydynia.*

Case Presentation: *A 34-year-old female recreational cyclist suffered chronic coccydynia for one year. She received a cortisone shot that provided relief until she had a hysterectomy, which then intensified the pain. She was referred to a pelvic floor physiotherapist where she was discharged after one visit due to no pelvic abnormalities. She then sought chiropractic care where she went through a return to cycling protocol based around coccydynia rehabilitation and pain management. The patient was able to return to cycling after 22 weeks of chiropractic care.*

Le retour au protocole de cyclisme après une coccydynie chronique: un rapport de cas

Objectifs: *Pour établir un protocole de retour au cyclisme réussi chez un patient en convalescence d'une coccydynie chronique.*

Présentation de cas: *Une cycliste récréative de 34 ans a souffert d'une coccydynie chronique pendant un an. Elle a reçu une injection de cortisone qui a apporté un soulagement jusqu'à ce qu'elle subisse une hystérectomie, ce qui a ensuite intensifié la douleur. Elle a été référée à une physiothérapeute du plancher pelvien où elle a été libérée après une visite en raison de l'absence d'anomalies pelviennes. Elle a ensuite eu des soins chiropratiques où elle a suivi un protocole de retour au cyclisme axé sur la réhabilitation de la coccydynie et la gestion de la douleur. La patiente a pu reprendre le cyclisme après 22 semaines de soins chiropratiques.*

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Summary: *Coccydynia is a painful condition that has no universally accepted treatment or guidelines for management. As such, there are no return-to-sport protocols for individuals who have developed coccydynia in sports. Here we present an evidence-based protocol that can assist practitioners in the management of chronic coccydynia.*

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KEY WORDS: chronic pain, coccydynia, cycling , rehabilitation, return to sport, chiropractic

Résumé: *La coccydynie est une condition douloureuse qui n'a pas de traitement ou de directives de gestion universellement acceptés. En tant que tel, il n'existe pas de protocoles de retour au sport pour les personnes ayant développé une coccygodynie dans le cadre du sport. Voici un protocole basé sur des donnée probantes qui peut aider les praticiens dans la gestion de la coccydynie chronique.*

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MOTS CLÉS : douleur chronique, coccydynie, cyclisme, réhabilitation, retour au sport, chiropratique

Introduction

The term coccydynia refers to pain located around the sacrococcygeal region.[1] The coccyx is located at the bottom of the spinal column, and it consists of three to five vertebrae located below the sacrum.[2,3] It is connected to the sacrum by a fibrocartilaginous joint called the sacrococcygeal joint.[2,3] This joint allows limited coccygeal movement, specifically with slight forward bending when in a seated position.[2,3] The anterior surface of the coccyx is the attachment site for pelvic floor muscles such as levator ani, iliococcygeus, coccygeus, and pubococcygeus.[2,3] Anatomical studies show that distally, the psoas fascia is continuous with the pelvic floor.[4] The posterior surface of the coccyx is the attachment site for the gluteus maximus.[2,3] The coccyx connects to the anterior and posterior sacrococcygeal ligaments, which continue between the anterior and posterior longitudinal ligaments.[2,3] The sacrotuberous and sacrospinous ligaments also connect to the coccyx on either side.[2,3] The coccyx also is connected to the anococcygeal raphe which is a structure that extends from the anus to the distal end of the coccyx.[2] It helps to stabilize the anus within the pelvic floor.[2] The coccyx is innervated by the coccygeal nerve, which is composed of the coccygeal plexus, and is responsible for receiving sensation from the coccyx region.[5] It is also innervated by the ganglion impar, located anterior to the coccyx, which represents the terminal end of the paravertebral chain of the sympathetic nervous system.[5] It is responsible for nociception and sympathetic innervation of the perineal region.[5] Of clinical relevance, nerve blocks in both these areas have been used to successfully treat coccydynia.[5]

The development of coccydynia is multifactorial and may include traumatic, idiopathic, infectious or tumor-related causes.[1] Coccydynia mainly affects females which has been attributed to the more posterior location of the sacrum and coccyx and the characteristics of the ischial tuberosities.[6-9] This anatomy leaves a female coccyx more exposed and susceptible to acute trauma such as childbirth or falls and repetitive microtrauma such as prolonged sitting or cycling.[10] Researchers have hypothesized that coccydynia is a dynamic condition rather than static.[11-13] Coccygeal translation or angular motion has been found in 69% of patients that present with coccydynia as seen in dynamic standing and seated radiographs.[14] Coccygeal mobility has been categorized into four types: 1) Luxation; posterior subluxation of the jutting out tip of the coccyx with sitting, 2) Hypermobility; direct seating axial pressure leading to coccygeal flexion over 25 degrees, 3) Immobile; less than 5 degrees of coccygeal flexion on sitting, and 4) normal; coccygeal mobility of 5-25 degrees on dynamic radiography.[14] Luxation-type coccydynia is thought to occur primarily in obese individuals due to restricted sagittal pelvic rotation leading to protrusion, retroversion, excessive pressure on the tip of the coccyx, and increased intra-pelvic pressure during sitting.[14,15] Whereas, the hypermobility type is thought to be more common in thin individuals.[14] Another potential cause of coccydynia is the intra-coccygeal articulations which are known to contain variants of intervertebral discs.[12] Degenerative changes in these discs have been implicated

as a cause of pain in 41% of idiopathic and 44% of traumatic coccydynia.[12] Mild cases of coccydynia can improve spontaneously, persistent cases have been shown to resolve with conservative care including NSAIDs, injections, lifestyle management, manual therapy, and rehabilitation exercises.[16] Those who fail conservative care may then resort to surgery.[16]

Cycling involves sustained pressure on the saddle which directly compresses the perineal region.[17] Discomfort with sitting on a bicycle saddle is one of the most common complaints among cyclists and it can be associated with numbness, nodules, chafing, sexual dysfunction, urethritis, and coccydynia.[10,17] Females may be at higher risk of developing pain in the saddle as researchers have shown that they experience less pressure reduction than males when switching from the top-hand position to the lower-hand position.[17] Females typically have a lower center-of-mass in the upper body, resulting in a reduced ability to offload weight onto the handlebars in the lower-hand position.[17] Bike saddle designs have evolved to improve comfort and reduce the likelihood of saddle-related pathologies; however, the prevalence of saddle-related issues remains high in female cyclists.[18] A 2023 study by Harrison and Edy reported that 37% of female cyclists suffer from saddle-related pain, 33% experience chafing, 27% have skin irritation, and 20% of recreational cyclists report infections linked to cycling.[18] The prevalence of coccydynia in female cyclists is currently unknown. Currently, knowledge about coccydynia in sports is sparse, and minimal research exists to help guide practitioners on managing this condition in athletes.[16] The basic protocols of rest, ice, coccyx cushions, and gentle exercises may be helpful for symptom relief in the general population, but they are not adequate for proper management and prevention of recurrence when coccydynia was developed in sports. Here we present a 34-year-old female cyclist who developed chronic coccydynia from repetitive and prolonged sitting on a bike saddle. The purpose of this case report is to outline a successful return to cycling protocol after experiencing chronic coccydynia. The return to cycling protocol was developed after evaluating anatomy, coccydynia pathology, and cycling biomechanics within the literature.

Case Presentation

The information from this case report is based on clinical documentation obtained during the patient's history and physical exam by a chiropractor and pelvic floor physiotherapist.

History

A 34-year-old female presented to our chiropractic office in September 2024 with chronic coccydynia, which she believed started from prolonged sitting on a bike seat, as this was when she first noticed symptoms in August 2023. She reported being a recreational athlete who participated in road cycling and taught indoor stationary cycling classes. She noted that she would spend five or more hours on a bike weekly, with each session averaging forty-five minutes to two hours. With both road cycling and indoor stationary cycling she would clip into the bike. Her road bike was a Cannondale Synapse 3 endurance road bike; her indoor cycling bike brand was not noted. She reported that she had a bike fitting done when she bought her bike. She reported that she would wear normal workout shorts during her indoor cycling sessions, and when she would use her road bike, she would use 3D padded cycling shorts.

The patient also thought that her pain might be linked to her most recent pregnancy in October 2021. She reported having three pregnancies, all of which were vaginal births without complications. She experienced second-degree tearing with her firstborn, but no tearing with her second or third births. Her third pregnancy was described as a difficult pregnancy. She reported experiencing symptoms consistent with gestational diabetes, but her doctors did not diagnose her. She was carrying excess amniotic fluid, and the baby was larger than her previous children, weighing nine pounds at birth. At the time of her assessment, she did not report any other pelvic floor complaints such as urinary or fecal incontinence, pain with sexual intercourse or regular pain with bowel movements.

She reported her pain increased in intensity and frequency around January of 2024 which she attributed to having an increase in teaching hours at the spin studio alongside her own training. She described the pain as a constant sharp pain with direct pressure on the area with sitting. The pain would subside a few minutes after standing but would be the worst during the transition from sitting to standing. Her pain would be at its worst in the evening after repetitive sitting to standing throughout the day, and laying down in bed on her back to sleep

would cause sharp pains. She reported no associated pain in the low back, hip or groin and no radiation or referral pains. The severity and frequency of the pain prompted her to seek medical attention. Her family physician sent her for X-rays that returned unremarkable (Figure 1). The X-rays showed that she had type 2 curvature of the coccyx by the classification first proposed by Postacchini and Massobrio and since modified by Nathan which classifies into six types.[19, 20] Seated X-rays were not taken. She was then referred to a rheumatologist, which took three to four months to have that appointment. Her family doctor prescribed naproxen, an anti-inflammatory medication, to manage the pain while waiting for the appointment. She reported that the pain medication helped, but the pain would always return after the medication wore off. She saw two rheumatologists in total. The first rheumatologist thought that she had a cyst that needed to be drained, which was proven to be incorrect. She was then sent to a different rheumatologist for a second option. The second rheumatologist explained that her coccyx was inflamed and recommended a cortisone shot. The doctor injected the area with a cortisone shot in May 2024 which provided temporary relief until shortly after her surgery in June 2024.

Due to a large benign tumor (polyp) causing cramping, excessive bleeding, and heavy bleeding, she had a full hysterectomy in June 2024 entailing the removal of her uterus and cervix, while leaving her ovaries. She reported surgery was laparoscopic and vaginally assisted, with only three small incisions made. Recovery from the surgery was about six weeks long and she reported that the pain started to return around three weeks post-surgery. She reported that the coccydynia pain was significantly worse post-surgery, her pain was more constant and felt higher in intensity. She reported that post-surgery, when she would transition from sitting to standing the pain would linger for up to thirty minutes. She would be in pain while walking around, compared to prior to surgery the pain would dissipate immediately upon standing. She reported that after the surgery, she had some constipation issues. She started to put a large focus on diet to ensure regular bowel movements because if she was constipated, she noticed the tailbone pain with walking and standing as well as sitting. Whereas, with regular bowel movements,

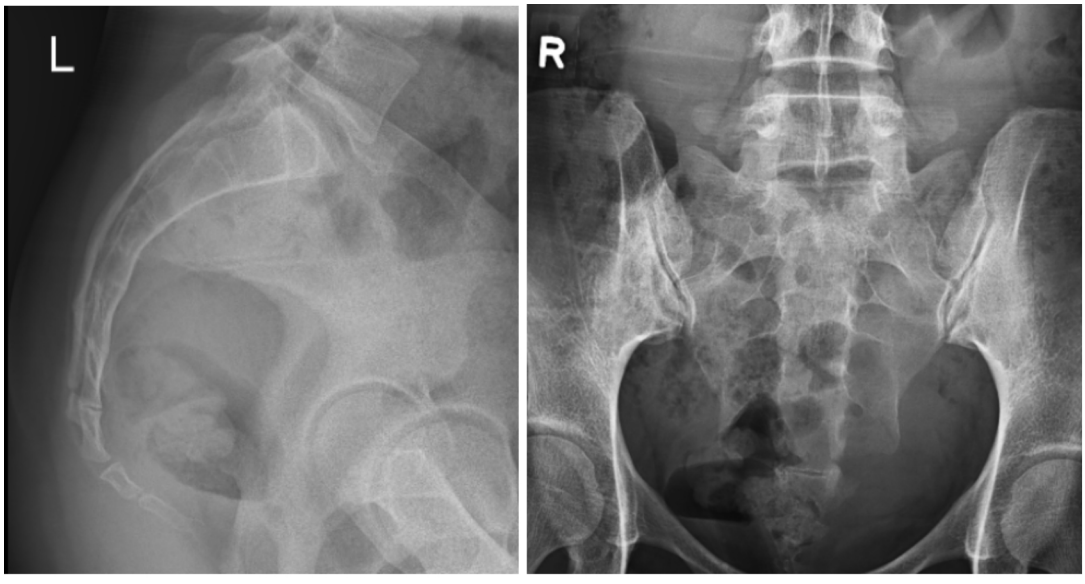

Figure 1.
On the left is a lateral view of the coccyx. On the right is an anterior-posterior view of the coccyx. All X-rays were read as normal. The patient was deemed to have a type 2 curvature by the classification first proposed by Postacchini and Massobrio and since modified by Nathan which classifies into six types.[19]

the pain was only experienced with sitting, however, it was still the worst it had ever been. She also noticed that she would get more pain with repetitive hip flexion. At this point, she decided to pursue conservative care for management.

Upon initial chiropractic assessment, she rated her pain on a numeric rating scale (NRS) to be between 4-8/10. Her Oswestry score was 34% indicating moderate disability. She rated on a visual analog scale (VAS) that the problem bothers her extremely, 10/10. She rated on a VAS that she is extremely motivated to correct the problem, 10/10. She reported feelings of frustration and fear that she will have to continue to take medications and have repetitive injections or have surgery. She also reported being fearful that she would not be able to return to cycling. Her main goals were to be able to sit through her son's hockey game without pain and to return to cycling.

She reported that leading up to the onset of her symptoms, and during the past year while living with the pain, she maintained a healthy lifestyle. She reported working out about five or six days a week with a mixture of cardio and strength training while maintaining a well-balanced diet with no dietary restrictions. She reported that after the onset of symptoms she avoided any movements that required pressure on her coccyx, including sit ups and minimal lower body strengthening. She reported that she is a non-smoker and would have an average of three or four drinks per month. She did not report any underlying health conditions or regularly take medications besides the anti-inflammatories prescribed for her coccydynia. Stress levels were reported to be medium due to having three children while working a full-time job, however, she reported that she has a supportive partner and family help. She reported that her sleep could be better but is now improving as her youngest is now sleeping through the night most of the time. Family history revealed that her father suffered from prostate cancer. The only previous injury reported was entrapment of the lateral cutaneous nerve of the thigh in her left hip two years ago that she received chiropractic treatment that focused on soft tissue release of the left iliopsoas muscle, with no recurrence of symptoms since. Menstrual cycle history revealed the age of menarche as twelve years old, and she reported that her cycle was regular, however, she could not recall the length of her cycle. She reported that she was on birth control for two years but discontinued in 2013. She went on birth control because of pregnancy prevention and acne control. She reported that she suffered from severe cramping and bleeding during her menstrual cycle, which she attributed to the tumor growing, which was the reason for her hysterectomy.

Chiropractic examination

Chiropractic examination was completed six days before the pelvic floor physiotherapy examination. Range of motion testing for the lumbar spine was within normal physiological limits. Hip range of motion testing revealed active left hip extension was limited by approximately 50% with no pain, passive left hip extension was pain free and within normal physiological limits with a spring like end feel. All other ranges were within normal physiological limits. Left hip extension strength was graded 4/5 and right was 5/5. Orthopedic testing for the lumbar spine showed a positive lumbar Kemps test on the right for discomfort in the low back but did not reproduce the chief complaint. Neural tension testing for sciatic, femoral and obturator nerves were unremarkable. Sacro-iliac joint provocative testing was unremarkable. Thomas test showed elevation of the thigh on the left, indicating shortening of the iliopsoas. Palpation revealed tenderness with pressure on the external surface of the coccyx, more so on the left side, that recreated the chief complaint. Muscle palpation revealed mild tenderness at the left gluteus maximus attachment on the sacrum and coccyx, but this did not fully recreate the chief complaint. There was also moderate tenderness with palpation of the iliopsoas on the left hip, but this did not recreate the chief complaint. The pain was recreated by doing a sit-up action from lying supine to sitting upright, as well as sitting. She has some mild pain recreated with rolling over and going from side-lying to sitting upright. All other orthopedic testing, including palpation of the hamstrings, adductors, and other hip flexors, was unremarkable. At the time of assessment, the patient was not evaluated in the cycling position or while seated on the saddle. Based on the functional findings, we may expect to see a posterior pelvic shift in attempt to offload the perineal region leading to excessive lumbar flexion and pelvic rocking due to muscular imbalances in the hip flexors and extensors.[21, 22] The diagnosis was chronic hypermobility of the coccyx that is aggravated by coccygeal flexion. Differential diagnoses included pelvic floor muscle spasm, luxation of the coccyx, discogenic

pain from the lumbar spine or intra-coccygeal articulations, and chronic pain syndrome. A referral was made to the pelvic floor physiotherapist to rule out pelvic floor contributions.

Pelvic floor physiotherapy examination

Observation revealed mild descent of the perineum with no visible prolapse. Visible contraction showed a strong contraction and ability to lift the perineum. External palpation revealed mild tenderness over both the left and right abdominal scars and tenderness over the coccyx, more on the left side, with a posterior to anterior pressure applied. More adhesion was noted around the umbilical scar but presented with less tenderness. Internal palpation revealed mild tenderness at the left iliococcygeus muscle with no reproduction of coccyx pain with any palpation of pelvic floor musculature. There was no pain with vaginal coccyx palpation when an anterior to posterior pressure was applied. Pelvic floor muscle strength with contract-relax testing was graded 4/5 with no pain. Connection to diaphragmatic breathing was unremarkable.

Pelvic floor physiotherapy treatment plan

The treatment plan was to refer for chiropractic treatment as it was deemed there was no pelvic floor involvement. A home exercise program was given to complete silicone cupping around abdominal scars, ice the tailbone as needed, and roll the gluteus maximus with a lacrosse ball, and a discussion of pelvic floor strengthening progression was given. No further pelvic floor physiotherapy appointments were made.

Chiropractic treatment plan

The full treatment plan can be found in Table 1. The chiropractor refrained from taking another set of X-rays to include seated X-rays as they felt it was unethical to expose the patient to more radiation. Considering rehabilitation programs should mainly be driven off clinical findings, and not imaging findings, the chiropractor designed a rehabilitation program based off clinical findings that matched cycling compensation patterns found in the literature.[21-37] The main clinical findings to determine diagnosis were: 1) reproduction of the chief complaint with posterior-to-anterior pressure on the coccyx, but not with anterior-to-posterior pressure; 2) reproduction of the chief complaint during a sit-to-stand motion; and 3) X-ray evidence of a type 2 coccyx, which is the most susceptible to hypermobility.[19,20] The diagnosis was chronic hypermobility of the coccyx that is aggravated by coccygeal flexion. The patient had been dealing with coccydynia for a year, and she failed conservative treatments that would normally have coccydynia resolved in four to 12 weeks.[38] Therefore, the treatment plan was expected to be almost double the amount of time. It was designed with progressive overload techniques and was split into five different phases, each phased was expected to last anywhere from four to six weeks using a linear periodization model.[39,40] The goal of the program was to progressively load the coccyx over time to decrease pain, increase stability and ultimately have the patient return to cycling.

The first phase was the "early rehab phase" which was planned to be three to four weeks long. The main goal of this phase was to decrease pain, build tolerance to sitting on soft surfaces, and to start activating the pelvic floor, core, and gluteus maximus as separate entities. Treatment included low-level laser therapy (LLLT) over the sacrum and coccyx, spinal mobilization to the lumbar and sacroiliac regions, and soft tissue to the gluteus maximus and psoas muscles on the left. The treatment frequency was once per week. Rehabilitation exercises included pelvic tilts, quadruped bodyweight single-leg hip extension, abdominal breathing, and bracing alongside pelvic floor relaxation and contraction. Sitting progressions included using the coccyx cushion to sit on all surfaces for the first week. Each week the patient was advised to try and sit for three to five minutes without the cushion on soft surfaces only and to try and increase this time each week. Milestones for progression were no pain with sitting on a soft surface for 15 minutes and no pain with rolling over, sidelying to sitting up. The patient was able to progress after four weeks.

The second phase was the "mid-rehab phase" which was planned to be four to six weeks in length. The goals of this phase were to decrease pain, start to build strength of the pelvic floor, core, and gluteus maximus as separate entities, and to build tolerance to sitting on soft surfaces for longer periods of time. Treatment was the same as the "early rehab phase" and the frequency started at once per week for two weeks, then went to once every two weeks. Rehabilitation exercises included pelvic tilt progressions with pelvic floor and gluteus maximus activation, resisted quadruped bodyweight single-leg hip extension, and dead

bugs with isometric hip flexion. Cycling was avoided until the patient was able to better tolerate sitting. Sitting progressions included using a coccyx cushion for sitting on soft surfaces after at least 15 minutes and trying to increase time without by three to five minutes each week. Milestones for progression were no pain with sitting on a soft surface for 30 minutes and no sharp pain or increase in pain with going from sitting to standing or from supine to sitting up. The patient was able to progress after four weeks.

The third phase was the "late rehab phase" which was planned to be four to eight weeks in length. The goals of this phase were to decrease pain, strengthen the pelvic floor, core, and gluteus maximus in double-leg functional movements, and build tolerance to sitting on hard surfaces. Treatment was the same as the previous two phases, but the frequency was once every two weeks. Rehabilitation exercises included weighted pelvic tilt bridges, Romanian deadlifts, goblet squats, and planks. Cycling was introduced in this phase using a recumbent bike, short sessions to start that were gradually progressed in length and bike resistance. Sitting progressions included using the coccyx cushion on hard surfaces once symptoms began, with trying to increase by three to five minutes each week. Milestones to progress included no pain with sitting on soft surfaces for more than an hour and no pain with sitting on hard surfaces for 15 minutes. The patient was able to progress after 4 weeks.

The fourth phase was "physical preparation for return to sport" and this phase was expected to last four to eight weeks. The goals of this phase were to continue to decrease pain, strengthen the pelvic floor, core, and gluteus maximus in single-leg functional movements, and to build tolerance to sitting on harder surfaces. Treatment was the same as the previous phases and frequency was once every two to three weeks. Rehabilitation exercises included single-leg bridges, single-leg deadlifts, gluteal dominant high step-ups, plank with resisted single-leg hip flexion, and side planks with hip abduction and adduction variations. Cycling was continued in this phase with the introduction of a regular bike seat on an indoor stationary bike. The patient was advised to start to build a tolerance to sitting on a stationary bike seat with very light resistance on the pedal stroke. Once they felt the onset of discomfort, they were advised to add a gel cushion and continue. Once the discomfort started again, they switched to the recumbent bike. Overall time spent total on the different bike surfaces, and total resistance on the bike both started low and gradually increased each week. Sitting progressions included using the coccyx cushion for sitting on hard surfaces after 15 minutes when the onset of symptoms started. Each week they were advised to try and go another three to five minutes longer without the cushion. Milestones to progress included no pain with sitting on a hard surface for 30 minutes and no pain with sitting on a bike seat for a total of 15 minutes. The patient was able to progress after four weeks. At this point, they were able to sit on hard surfaces with no issues and they were able to sit on a bike seat for a total of 15 minutes, with only getting pain with going in and out of the saddle on the bike seat.

The final phase was the "return to sport transition" which was expected to last six to eight weeks. The goals of this phase were to continue to decrease pain, to work on power and endurance of single-leg functional movements while still engaging pelvic floor, core, and gluteus maximus, and to build a tolerance to sitting on a bike seat. Treatment remained the same and the frequency lowered to once every three to four weeks. Rehabilitation exercises included elevated shoulders and feet single leg bridges, walking swing lunges, weighted gluteal dominant high step-ups, and mountain climbers. The tempo in this phase was changed to add more of an explosive emphasis during the concentric phase to mimic a powerful bike pedal stroke. Sitting progressions included only using the coccyx cushion when sitting on hard surfaces, if necessary, using a gel cushion or 4D padded bike shorts as needed, and slowly progressing to no longer needing the cushion on the bike seat and using 3D padded shorts. Cycling progressed to stationary bike only, slowly increasing time spent on the bike and resistance added each week. Once 60 minutes on the stationary bike was tolerated, the patient was advised that they could return to cycling on a road bike. They were advised to get their bike properly fitted and have the specialists help find the appropriate bike seat. The patient did not report what new type of bike seat was chosen but did report that they had purchased a new one. Milestones to be cleared for back to sport were no pain with sitting on a hard surface for an hour or more, no pain with sitting on a bike seat for 30 minutes or more total with no added cushion, and no pain from going to a sit to stand on the bike seat. These milestones were to be

hit using 3D padded bike shorts. The patient was able to return to sport after six weeks. Her Oswestry score was 2% indicating very minimal disability. She continues to be able to participate in sport with minimal issues, she will receive chiropractic treatment as needed when she feels some discomfort in the area. This will tend to happen intermittently after longer rides, which happens once every six to eight weeks on average, however her pain levels have not returned to a level that interferes with her sport or activities of daily living.

Discussion

Cycling involves a complex interplay of muscle recruitment patterns and joint mechanics, particularly in the lower body. The cycling motion can be divided into three phases: the propulsive or power phase (downstroke), the pulling or recovery phase (upstroke), and the pushing phase, where the foot is pushed forward at the top dead center of the pedal stroke.[25] The coactivation of agonist and antagonist muscles, such as the psoas major (PM) and gluteus maximus (GM), is key in optimizing power transfer while protecting major joints from injury.[25] Interestingly, greater muscle-specific hypertrophy of PM compared to rectus femoris or sartorius has been demonstrated in competitive cyclists compared to untrained men.[26,27] Although PM has been well established as a hip flexor in the literature, it also has other roles such as a flexor of the lumbar spine on the pelvis[28], a lateral flexor of the lumbar spine[29], a stabilizer of the lumbar spine[30-33], and a stabilizer of the hip[34-37]. All of the proposed actions of PM are of consideration during the motion of cycling.[26-28, 34-37] The PM is the only muscle that connects the lumbar spine to the lower limbs and is an important contributor to both trunk, pelvis and lower limb biomechanics.[26,27]

The GM also plays a crucial role in force generation, pelvic stabilization, and efficient power transfer during cycling.[21,25] The GM is most active during the pushing phase of the pedal revolution, with its range of action occurring between 340° and 130° of the cycle.[21,25] During this phase, the GM generates net hip extension torque, delivering energy to the entire limb, then subsequently transferred to the crank via net ankle torque, facilitating the propulsion of the bike.[21,25] At higher cycling intensities, the GM demonstrates the greatest increase in activation compared to other lower limb muscles, highlighting its role as the primary initiator of force.[21,25] With higher intensity, the body adopts a more forward-leaning position to generate maximal power output.[21] This forward position involves greater lumbar and elbow flexion, and significant changes in thoracic lean angle, however the hip joint angle remains the same.[21] The increased forward lean lengthens the GM, enabling it to produce greater force.[21] Increased GM activity may also aid in stabilizing the pelvis, ensuring efficient force transfer across the hip joint and reducing strain on surrounding structures.[21]

Increased lumbar flexion posture is not only adopted at higher intensities but also as a compensatory mechanism in the presence of muscular imbalances and limited hip range of motion (ROM).[21] Common compensations observed with restricted hip ROM include pelvic rocking, excessive lumbar flexion, and lateral knee deviation, all of which can disrupt proper biomechanics and contribute to discomfort or injury.[22] These same compensatory patterns could be attributed to the PM, given the actions of PM on the trunk and lower limb.[28-37] Additionally, in the case of saddle discomfort, riders will shift their weight posteriorly onto the ischial tuberosities to reduce pressure on the perineum, leading to increased lumbopelvic flexion.[22] This posture, along with pelvic rocking, may result in greater pressure on the coccyx.[22] The female sex is at higher risk to pelvic-related pain secondary to these compensation patterns due to the posterior location of the sacrum and coccyx and the characteristics of the ischial tuberosities.[6-9] Depending on the coccyx orientation, these compensations may put the coccyx at higher risk of luxation, hypermobility or damage to the intra-coccygeal articulations and discs, with the type two coccyx orientation being the most susceptible.[14,15,19,20]

Currently, rehabilitation protocols for chronic coccydynia are sparse within the literature. This may be due to most cases of coccydynia resolving within weeks to months with or without conservative treatment, but for some patients, the pain can become chronic and debilitating.[16] The documented conservative treatments are relatively simple and they are sufficient in most cases.[16] These include coccygeal or donut cushions for sitting, modifying sitting postures, heat or cold therapy, and nonsteroidal anti-inflammatory drugs (NSAIDs).[16] The only physiotherapy exercise that has been reported to show benefit is pelvic floor physiotherapy focusing on the relaxation of the pelvic floor when pelvic floor muscle spasms have been identified as a contributing factor.[16] For chronic coccy-

dynia, injections of local anesthetic with steroids around the coccyx are used for both diagnostic and therapeutic purposes.[16] These injections are often used to help identify patients who might benefit from a coccygectomy.[16]

This case outlines a rehabilitation protocol for chronic coccydynia that aims to increase the stabilization of the coccyx through exercise. Based on the anatomy of the coccyx and the patient's presentation upon physical exam, it was hypothesized that the patient's lack of hip extension on her left side and the observed shortening of the PM on her left side may be a sign of weakness and compensation of the muscles stabilizing the pelvic region. Considering her pelvic floor examination was unremarkable, it was again hypothesized based on anatomical review that weakness in the left GM may be a driving factor. Considering the contributions of the PM to the biomechanics of cycling[26,27] and the fascial connections to the pelvic floor[4], it was again hypothesized that the PM and the GM may synergistically work together to help stabilize the coccyx during cycling and other methods of physical activity. Based on the information above, if there was weakness in the left GM, a compensatory pattern would be to increase lumbar flexion and pelvic rocking.[21,22] Lumbar flexion is an action of PM and pelvic rocking could be in part to increased lateral flexion through contraction of the ipsilateral PM.[28,29] Hypothetically, this compensatory pattern and the increase in force production of the PM can pull up on the pelvic floor at the same time as the seat presses on the coccyx without the GM being able to adequately work as an antagonist to this action. These biomechanical compensations may increase mechanical stress on the coccyx and contribute to symptom provocation during cycling. The rehabilitation exercises were prescribed to retrain the movement patterns on the hip. The main goal was to increase the strength of the hip extensors, particularly the GM, while synergistically activating the pelvic floor and PM. The resistance, repetitions and tempo were progressed to work on power and endurance, similar to the demands of the sport of cycling.[25] The design of the protocol was similar to other rehabilitation protocols which aim to increase the dynamic stability of the lumbar spine[41], cervical spine[42], shoulder[43], and more.

Summary

Coccydynia is a condition that can significantly impact daily activities and athletic performance, yet it remains underexplored in the context of athletic populations, particularly female cyclists. Here, we presented the case of a 34-year-old female with chronic coccydynia, likely due to dynamic instability of the pelvis and coccyx, along with other contributing factors, such as previous pregnancies. In this patient, notable muscle imbalances were found between GM and PM with associated restricted hip extension. Her pain was attributed to cycling as the onset was first noted while sitting on a bike seat, it did not start near the date of her pregnancy deliveries, and her pelvic floor musculature was deemed unremarkable. Cycling requires precise biomechanics and coordinated muscle recruitment to optimize performance and minimize injury risk.[25-27] Key pelvic stabilizers, such as the GM and PM, play a critical role in transferring forces from the trunk to the lower limbs, propelling the bike forward effectively.[21,25-27] Compensatory cycling patterns can expose the perineal region to increased compressive forces which can lead to instability of the coccyx, especially in females, who are at higher risk for the development of coccydynia due to the wider ischial tuberosities and more posterior location of the sacrum and coccyx.[6-9,21,22] This case report outlines a successful rehabilitation protocol that aimed to increase the dynamic stability of the pelvis and coccyx using progressive overload techniques.

Limitations

The authors recognize that there are limitations to this case report such as poor interrater reliability and validity of certain assessment techniques used. A proper biomechanical evaluation by the patient cycling would have added to the strength of this case report and unfortunately was not conducted. The evaluation of cycling mechanics was solely completed through review of the literature, and it was hypothesized that the patient had compensatory patterns based off clinical findings off the bike. As with all case reports, there is an inherent limitation in that the findings cannot be broadly generalized. Rather, their purpose is to highlight observations and to encourage further research in the field, which is the intended aim of this report. Another limitation is the lack of a control group therefore it is difficult to conclude that the improvements seen were because of the rehabilitation program, or of natural history. Considering the length of time the patient had the coccydynia and the relief provided with steroid injections; the next medical step would have been

surgery. It was the patient's choice to refrain from surgery and seek a second opinion on how to manage the condition conservatively. There was also a lack of confirmation of a hypermobile coccyx through sit to stand radiographs, which would be considered the gold standard, although repeating radiographs to confirm this is not recommended due to unnecessary radiation exposure.

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Table 1.
Detailed outline of the return to cycling protocol after chronic coccydynia used over a total of 22 weeks.

	Early Rehab
Goals of phase	Desensitization of pain Start to work on activation of pelvic floor, core and gluteus maximus as separate entities Build tolerance to sitting on soft surfaces
Approximate timeline progression	3-4 weeks
Functional milestone progressions	No pain with sitting on soft surfaces for 15 minutes No pain with rolling over, side-laying to sitting up
Manual therapy and modalities Frequency of treatment	LLLT over Sacrum/coccyx Spinal mobilization and Manipulation – Lumbar and Sacroiliac regions Soft tissue therapy Left gluteus maximus and psoas 1x per week

	Early Rehab
Rehab exercises Frequency/reps/sets/rest	Pelvic tilts: working on pulling up with the pelvic floor and relaxing the gluteal muscles in the posterior tilt position Quadruped body weight single leg hip extension: working on gluteus maximus activation without lumbar extension Abdominal breathing and bracing with pelvic floor relaxation/contraction Sets: 2-3 to be done 1-2x per day Reps: 6-8 with Tempo: 3-1-3-1 Rest: 30-60 seconds
Sitting Progressions	To use a coccyx cushion for sitting to relieve pressure on the tailbone on all surfaces Each week, sit for 3-5 extra minutes on a soft surface without cushion (couch, chair)

	Mid Rehab
Goals of phase	Desensitization of pain Start to build muscles of pelvic floor, core and gluteus maximus as separate entities Build tolerance to siting on soft surfaces
Approximate timeline progression	4-6 weeks
Functional milestone progressions	No pain with sitting on soft surfaces for 30 minutes No sharp pains with going from sit to stand or from supine lying to sitting up
Manual therapy and modalities Frequency of treatment	LLLT over Sacrum/coccyx Spinal mobilization and Manipulation – Lumbar and Sacroiliac regions Soft tissue therapy Left gluteus maximus and psoas 1x per week for 2 weeks 1x every 2 weeks
Rehab exercises Frequency/reps/sets/rest	Pelvic tilts: working on pulling up with the pelvic floor and relaxing the gluteal muscles in the posterior tilt position Quadruped body weight single leg hip extension: working on gluteus maximus activation – add resistance each week Dead bug isometric holds (pushing hand into knee): increase strain on hip flexors with pelvic floor relaxation/contraction Sets: 3 one time every 2 days (1 day of rest) Reps: 10-15 with Tempo: 3-1-3-1 Rest: 60-90 Sec
Sitting Progressions	To use a coccyx cushion for sitting to relieve pressure on the tailbone on most surfaces – start to add it on soft surfaces after 15 minutes Each week, sit for 3-5 extra minutes on a soft surface without cushion (couch, chair)

	Late Rehab
Goals of phase	Desensitization of pain Start to strengthen pelvic floor, core and gluteus maximus in double leg functional movements Build tolerance to siting on harder surfaces
Approximate timeline progression	4-8 weeks
Functional milestone progressions	No pain with sitting on soft surfaces for 60+ minutes No pain with sitting on hard surface for 15 minutes
Manual therapy and modalities Frequency of treatment	LLLT over Sacrum/coccyx Spinal mobilization and Manipulation – Lumbar and Sacroiliac regions Soft tissue therapy Left gluteus maximus and psoas 1x every 2 weeks
Rehab exercises Frequency/reps/sets/rest	Pelvic tilt bridges: working on pulling up with the pelvic floor into a pelvic tilt, while relaxing the gluteal muscles, then contracting the gluteal muscles to rise into a bridge – add weight to hips each week for the first 3 weeks – then increase ROM by elevating shoulders and/or feet Romanian deadlifts: engage pelvic floor and core at top – hinge – relax pelvic floor and reengage at bottom – lift Goblet squats: engage pelvic floor and core at top – hinge – relax pelvic floor and reengage at bottom – lift Planks: Focus on maintaining core, pelvic floor and gluteal engagement through breath Sets: 4 sets every 2-3 days (1-2 days of rest) Reps: 10-15 for the first 4 weeks with a Tempo: 3-1-3-1 For planks start with 30 seconds – increase time each week 10-15 reps for the last few weeks with a Tempo: 3-1-1-1 temp (increase speed on concentric phase) Rest: 60-90sec Begin to use Recumbent bike: Begin with short sessions (10-15 minutes), low resistance, and a comfortable saddle (use a padded or wide saddle). Increase cycling time/resistance gradually (start with 20 minutes, then 30 minutes, and so on) as tolerated.
Sitting Progressions	To use a coccyx cushion for sitting to relieve pressure on the tailbone on hard surfaces – start to add it once symptoms begin Each week try and go another 3-5 minutes without it on hard surfaces

	Physical Preparation for return to sport
Goals of phase	Desensitization to pain Start to strengthen pelvic floor, core and gluteus maximus in single leg functional movements Build tolerance to siting on harder surfaces
Approximate timeline progression	4-8 weeks
Functional milestone progressions	No pain with sitting on hard surface for 30 minutes No pain with sitting on a bike seat for 15 minutes total
Manual therapy and modalities Frequency of treatment	LLLT over Sacrum/coccyx Spinal mobilization and Manipulation – Lumbar and Sacroiliac regions Soft tissue therapy Left gluteus maximus and psoas 1x every 2-3 weeks
Rehab exercises Frequency/reps/sets/rest	Single leg bridges: working on pulling up with the pelvic floor and maintaining pelvic contraction while in single leg bridge – each week add weight to hips Single leg deadlifts: engage pelvic floor and core throughout movement – avoid opening through hips Glute dominant High step ups: engage pelvic floor and core throughout movement – maintain vertical shin and focus on pushing through centre of foot (maintain tripod contact) Plank with resisted single leg hip flexion (hold at peak hip flexion) & Side planks with hip abduction/adduction: Focus on maintaining core/pelvic floor engagement as leg moves Sets: 3 sets every 2-3 days (1-2 days of rest) Reps: 10-15 for the first 4 weeks with a Tempo: 3-1-3-1 Rest: 60-90sec Start to build tolerance to sitting on stationary bike seat – very light resistance for a few minutes as tolerated then switch and continue to use Recumbent bike: Begin with short sessions (10-15 minutes), low resistance, Try and use no cushion on seat Increase cycling time/resistance gradually (start with 20 minutes, then 30 minutes, and so on) as tolerated. Gradually increase time spent on stationary bike seat
Sitting Progressions	To use a coccyx cushion for sitting to relieve pressure on the tailbone on hard surfaces – start to add if needed after 15 minutes Each week try and go another 3-5 minutes without it on hard surfaces To use a gel cushion on bike seat OR padded bike shorts as needed on stationary bike

	Return to sport transition
Goals of phase	Desensitization to pain Start to work on power and endurance of single leg functional movements Build tolerance to sitting on a bike seat
Approximate timeline progression	6-8 weeks
Functional milestone progressions	No pain with sitting on hard surface for 60+ minutes No pain with sitting on a bike seat for 30+ minutes total without cushion No pain with going from sit to stand on bike seat
Manual therapy and modalities Frequency of treatment	LLLT over Sacrum/coccyx Spinal mobilization and Manipulation – Lumbar and Sacroiliac regions Soft tissue therapy Left gluteus maximus and psoas 1x every 2-4 weeks
Rehab exercises Frequency/reps/sets/rest	Elevated Single leg bridge: elevate both shoulders and feet to maximum ROM Walking swing lunges: each week increase weight High step ups: increase weight each week Weighted glute dominant high step ups: engage pelvic floor and core throughout movement – maintain vertical shin focus on pushing through centre of foot (maintain tripod contact) Mountain climbers: Increase time each week (start with 30 second intervals) Sets: 3 sets every 2-3 days (1-2 days of rest) Reps: 10-15 for the first 4 weeks with a Tempo: 3-1-1-1 Rest: 60-120 sec To start on Stationary bike: Begin with short sessions (total of 10-15 minutes seated), low resistance and in and out of saddle as needed Increase cycling time/resistance gradually (start with 20 minutes, then 30 minutes, and so on) as tolerated. Once 60 minutes is tolerated on stationary bike can progress to outdoor cycling. Switching between seated and standing positions on bike as needed. Ensure proper fitting on bike – advised to speak to bike fitting specialists to adjust seat as needed
Sitting Progressions	Try and sit on hard surfaces without coccyx cushion – only use as needed To use a gel cushion on bike seat OR padded bike shorts Slowly progress to no longer needing cushion on bike seat with time