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A 14-year-old competitive, high-level athlete with unilateral low back pain: case report

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Objective: *To detail the presentation of a male adolescent competitive high-level soccer player with left sided low back pain that occurred while playing soccer. This case will outline the importance of early detection, risk of progression and management of active spondylolysis in adolescent athletes.*

Clinical Features: *The patient initially presented to a chiropractic sport specialist with left sided low back pain (9/10 on numeric pain scale rating) while kicking soccer balls with his left leg of one month duration. He was initially diagnosed with mechanical low back pain and successfully treated for acute pain management including removal from sport specific training and competition, soft tissue therapy and advice to rest. The chief complaint returned however, when the athlete resumed training and competition. A plain film imaging report suggested only postural alterations in an otherwise normal study of the lumbar spine. Computed tomography images taken three months later revealed a fracture at the left L5 pars interarticularis.*

Summary: *The early detection of spondylolysis combined with an effective plan of management*

Objectif : *Exposer en détail la lombalgie du côté gauche survenue chez un joueur de soccer adolescent compétitif de haut niveau alors qu'il jouait au soccer. Le présent cas souligne l'importance du dépistage précoce, le risque de progression ainsi que le traitement de la spondylolyse active chez les athlètes adolescents.*

Caractéristiques cliniques : *Le patient s'est présenté à l'origine chez un spécialiste de la chiropractie sportive avec une lombalgie du côté gauche (cotée 9/10 sur l'échelle numérique de la douleur) survenue, il y avait un mois, alors qu'il bottait des ballons de soccer de la jambe gauche. Le diagnostic établi à l'origine était celui de lombalgie mécanique et le patient a été traité avec succès au moyen d'un traitement de la douleur aiguë, qui comprenait un arrêt des activités liées à l'entraînement et à la compétition au soccer, une thérapie des tissus mous, et une mise au repos. L'objet de la plainte principale est cependant revenu lorsque l'athlète a repris son entraînement et la compétition. Le rapport de la radiographie sans préparation suggérait uniquement des ajustements posturaux à un examen par ailleurs normal de la colonne lombaire. Des images obtenues à une tomographie par ordinateur trois mois plus tard ont révélé une fracture à l'isthme interarticulaire gauche de la vertèbre L5.*

Résumé : *Une détection précoce de la spondylolyse, conjuguée à un plan de traitement efficace comportant du repos et une thérapie conservatrice avec un retour*

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including rest and conservative therapy with a progressive return to play may allow competitive athletes to resume participation at an elite level.
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KEY WORDS: back pain, soccer, adolescent, spondyloslysis

progressif à l'activité, peut permettre aux athlètes compétitifs de reprendre la participation à un niveau élite.
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MOTS CLÉS : douleur dorsale, soccer, adolescent, spondylolyse

Introduction:

The prevalence of low back pain in adolescents lasting at least one day in the past month has recently been reported as high as 39.8%.[1] More specifically, low back pain associated with spondylolysis in adolescents, although similar to prevalence in the general population[2], is significantly higher in adolescent athletes competing in certain types of sports.[3,4]

Sports that require repetitive lumbar hyperextension and rotation, such as soccer, are the most common to report data on spondylolysis in adolescent athletes.[5,6] It remains difficult, however, to fully understand the epidemiology, pathomechanics and clinical picture of this topic due to the lack of long term sequelae, and suspected underreporting of this condition.

As spondylolysis is not a symptomatic condition in all cases, experts have had difficulty concluding that it is a specific pain generator of the low back.[7] This has lead authors to coin the term "active" (an ongoing metabolic process within the bone), compared to "inactive" (a non-progressive condition).[7] It is also important to note that reports within the literature suggest that the repetitive loads causing an acute unilateral spondylolysis may also cause progression to bilateral pars interarticularis fracture leading to vertebral body endplate fracture and early degenerative changes.[8,9]

The purpose of this case report is to detail the presentation of a male adolescent competitive high-level soccer player with left sided low back pain that occurred while playing soccer. This case will outline the importance of early detection, risk of progression and management of active spondylolysis in adolescent athletes.

Case Report:

A 14-year-old competitive, high-level soccer goalie presented to a chiropractic sport specialist for worsening left side low back pain. The complaint began approximately one month prior to presentation with a dull ache in his low back, worse on the left. His complaint peaked following a tournament involving three consecutive games over a weekend. The pain was sharp during soccer training particularly with left sided goal kicks where the athlete must make a considerable hyperextension wind up prior to kicking the ball from the ground to ensure the soccer ball reaches targets up to 50 meters away. He reported his pain with kicking had reached nine out of ten on the numeric pain scale rating. Additional activities such as bending forward and "twinges" of back pain while sitting were also affecting his activities of daily living. More recently he had been able to maintain a typical training regime with his provincial team, club team, and strength and conditioning despite his dull low back pain episode. Hamstring stretches had previously been relieving, however, had become aggravating since the exacerbation of his pain. Due to high level of pain he was experiencing, the patient had self-medicated with Robaxacet (200mg dosage of Methocarbamol combined with acetaminophen), an over-the-counter muscle relaxant for pain relief. He reported no previous occurrence of low back pain, radiation into his legs or pain with coughing or sneezing. His remaining health history and family history were unremarkable.

On physical examination, the patient displayed guarded and reduced lumbar range of motion. Flexion was reduced by approximately 30 degrees while extension was

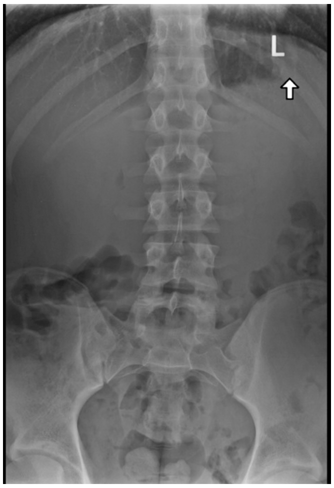

Figure 1A: *Radiographic imaging of the lumbar spine. AP view. No radiographic abnormalities noted.*

Figure 1B: *Radiographic imaging of the lumbar spine. Lateral view. No radiographic abnormalities noted.*

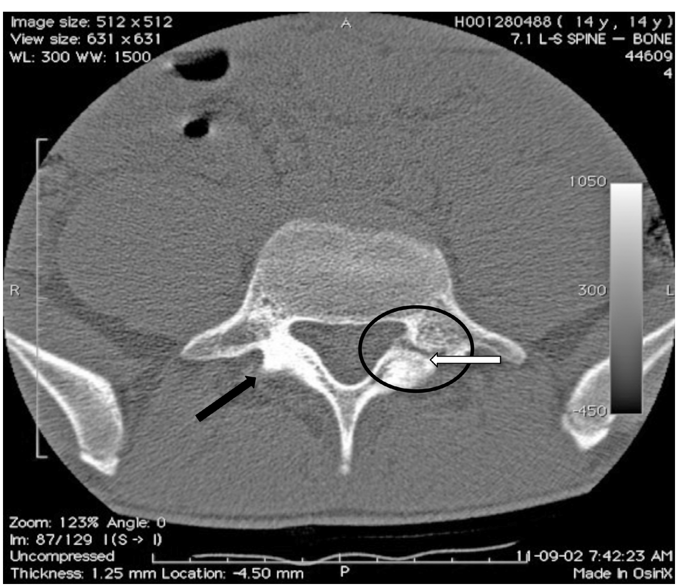

Figure 2: *Coaxial tomography imaging of the L5 lumbar spine taken three months after initial complaint. Bone window. Axial slice. Note the left pars interarticularis fracture with a "jagged edge" appearance and reported "fuzzy hair on-end" appearance (white arrow); suggesting an ongoing metabolic process (black circle) in addition to minimal compensatory sclerosis of the right pars (black arrow).*

reduced by approximately 12 degrees. Reproduction of his chief complaint occurred during both flexion and extension, actively and with passive overpressure. Straight leg raise (SLR) on the left reproduced his low back pain at 45 degrees, however was not provocative on the right. Valsalva maneuver was unremarkable. A bilateral lower limb neurological examination including motor, sensory and deep tendon reflex testing to L4, L5, and S1 nerve root distributions were within normal limits. Prone extension maneuvers including passive hip extension, Yeoman's maneuver and Ely's testing reproduced low back pain. Palpation of the lumbosacral junction was painful, the worst at L5-S1 on the left. Palpation of the lumbopelvic musculature revealed tenderness and hypertonicity throughout, and significant tenderness was present using nerve palpation techniques[10] at the sciatic notch, left mid-hamstring and left mid-gastrocnemius along the length of left sciatic and tibial nerves when compared to the right.

A working diagnosis of an acute left sided non-specific mechanical low back pain with associated neural mechanosensitivity in the sciatic nerve was provided. Relevant differential diagnoses considered included an acute spondylolysis and discopathy.

A conservative plan of management was started including immediate rest from sports and training, soft tissue therapy to the lumbopelvic musculature, spinal mobilizations, dural flossing progressing to stretches, and sciatic nerve flossing progressing to tensioning at a frequency of 2 times per week. Spinal manipulation therapy was not utilized on initial presentation due to the patient's intolerance of the position and the clinician's differential diagnosis of spondylolysis. A plain film imaging series of the lumbar spine was ordered and interpreted by a chiropractic radiologist. The imaging report stated only postural alterations exist in an otherwise normal study of the lumbar spine. (Figures 1A and 1B).

The patient showed signs of improvement with this plan of management. Within 1 month of this acute episode the patient had begun to resume training and playing soccer. At this time he reported feeling 100% improvement and his original positive examination findings were unremarkable.

The patient attended the clinic for 8 additional treatment sessions over the following 8 weeks due to an immediate recurrence of his pain consistent with resuming competition and training. Increased practice time involv-

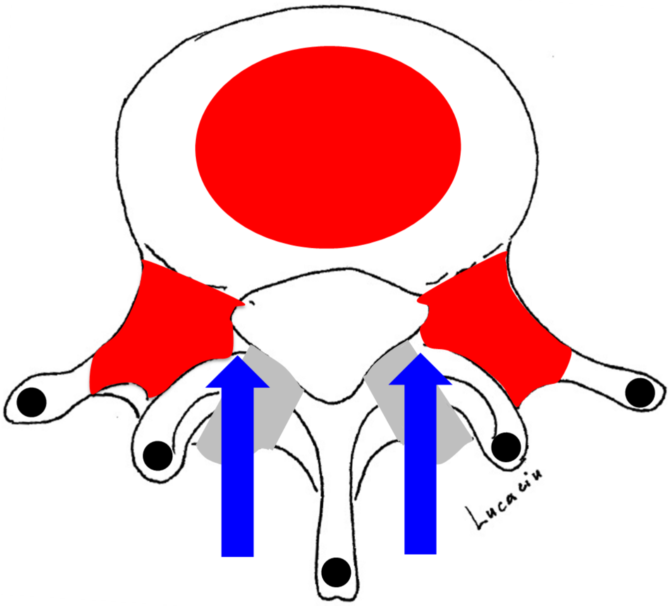

Figure 3: *Primary and secondary ossification centers of the lumbar vertebrae: Primary ossification centers (red), secondary ossification centers (black), and hyaline cartilage centers (light gray). Note the zone of transition between primary and hyaline cartilage at the pars interarticularis (blue arrow).*

ing goal kicks and increased strength training and conditioning sessions correlated with a recurrence of his original signs and symptoms. The recurrences prevented the patient from performing a regular training routine and resulted in missed practices and games. At this time an orthopedic referral was made to consider advanced imaging for better evaluation of the differentials diagnoses of spondylolysis or discopathy.

Computed tomography images taken three months later revealed a pars interarticularis lucency with a jagged fuzzy hair on end appearance noted within the lucency at the left L5 region with minimal compensatory sclerosis of the right L5 pars interarticularis suggesting that ongoing healing process was occurring (See Figure 2).

Following the diagnosis of active left L5 spondylolysis, the patient was informed of the available conservative interventions using an evidence-based approach. Specifically, a three-month cessation of competitive sport and training based on typical healing rates of long bone fractures was recommended. Over the initial 4-week course of passive weekly treatments (similar to initial plan of management), the soccer player followed the advice and gradually experienced pain relief while positive exam findings such as lumbar spine extension, palpation and straight leg raise returned to normal. At this point the attending chiropractor and patient agreed on an active but cautious approach to care involving an 8-week progression of pain-free exercises. The active care began with core stabilization techniques. The progression involved the athlete successfully completing the 'Bunkie' test protocol[11] method (see Figures 4-8) that employs static isometric contraction for periods of 25 seconds before returning to sport-specific drills. During the initial four weeks of the active care the patient's signs and symptoms remained stable. The final four weeks of care involved sport specific training. The patient began to perform soccer specific drills and was informed to avoid goal kicks. In addition, sport specific training was not performed on consecutive days in order to ensure adequate recovery for the patient. The patient made a full return to competitive play and training regime following his three months of relative rest and progressive training.

Discussion:

The prevalence of spondylolysis in adolescent athletes has previously been reported as high as 27% in unilateral motion type sport events, while the overall prevalence of spondylolysis in sports remains as low 8%.[4] The incidence of spondylolysis in the adolescent athlete with reported LBP has been reported as high as 47%.[12] While the reported incidence is high in adolescent athletes, occurrence in adulthood is not supported within the literature. Since spondylolysis does not appear to occur in adulthood, and is not frequently reported as a pain generator in adults, an increased awareness and understanding towards the skeletally immature population is necessary. Given that spondylolysis is common in adolescent athletes with LBP, it is important to understand the relevant anatomy and associated pathomechanics in order to make an early diagnosis, modify the risk of progression and outline a plan of management that will allow an effective and pain-free return to sport.

Anatomy

According to Moore and Dalley, there are three primary

Figure 4: *'Bunkie test' Posterior power line.*

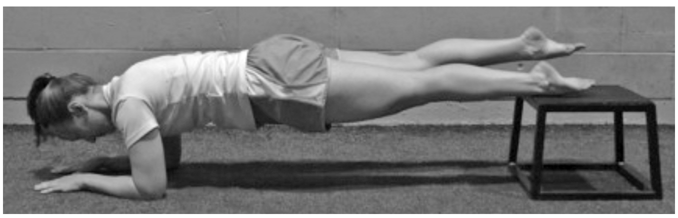

Figure 5: *'Bunkie test' Anterior power line.*

Figure 6: *'Bunkie test' Posterior stabilizing line.*

Figure 7: *'Bunkie test'. Lateral stabilizing line.*

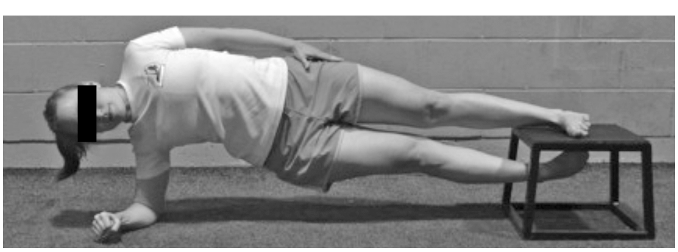

Figure 8: *'Bunkie test' Medial stabilizing line.*

and ossification centers within the spine.[13] One of these ossification centres forms the vertebral body as the centrum, and two are part of the neural arch. It is worthy to note that the primary ossification of the neural arches meets hyaline cartilage at the site of the pars interarticularis, and this region is therefore a zone of transition.[14] This region can also be considered a zone of transition due to the trabeculation patterns observed here. Debnath et al. report an area of dense trabecular bone in the pars interarticularis and inferior articulating facet that transitions to less dense trabecular bone in the pedicle.[15] Given the trabeculation patterns reported, it may be speculated that unilateral repetitive loading such as kicking a ball may lead to stress fractures in areas that are considered a zone of transition, however, it is also prudent to explore the pathomechanics before any conclusions can be determined.

Pathomechanics

Understanding the pathomechanics of this injury will help to elucidate why the correct diagnosis is often difficult and delayed. Wiltse et al. initially reported that repetitive stress is associated with the development of spondylolysis.[16] Current literature suggests that spondylolysis develops over time and has focused on a repetitive stress model.[15] Since there are no prospective in vitro methodologies available, research often has relied on modelling to understand strains from repetitive stresses. Chosa et al. designed a 3 dimensional finite element (FE) model to study the effects of repetitive strain on the pars interarticularis.[17] The study suggests the distribution of stress in the posterior elements of the lumbar spine, specifically the pars interarticularis is highest during compression with extension and compression with rotation.[17] With respect to this case, the Chosa et al. findings support the hypothesis that repetitive unilateral kicking motions may be associated with the development of spondylosis. In addition, it is important to understand that injury may exist at subclinical levels until adequate repetitive loading causing cumulative microtrauma leads to the eventual fracture.

Although spondylosis is rarely associated with long-term sequelae in skeletal mature adults, the risk of progression, pain and future outcomes must be addressed when managing an adolescent with spondylosis.[7] A case series found that 53.8% of subjects developed a contralateral pars interarticularis fracture, and the subsequent FE model supported the hypothesis that unilateral spondylolysis has the risk of progressing to bilateral.[8] The authors also suggest that the increased loading caused by spondylolysis has the potential to lead to endplate fractures of the vertebral bodies in adolescents.[8]

The risk of progressive functional limitations and degenerative changes has also previously been reported in unilateral spondylolysis adolescents. In a long-term follow-up study, Miller et al. demonstrated that when healed, a unilateral spondylolysis resulted in improved functional outcomes when compared to bilateral spondylolysis that underwent further degeneration and possible spondylolisthesis.[5] In the short-term, pain is the most limiting factor for these patients.[8] To examine a potential cause of pain in the acute phase, Sairyo et al. recently published a case series involving radicular symptoms associated with acute spondylolysis.[18] Extraosseous swelling causing nerve root tension was associated with acute spondylolysis.[18] Neural mechanosensitivity following a sciatic and tibial nerve distribution was identified in these patients, and inflammation at the nerve root was due to extraosseous edema.[18] In the current case report, the patient reported neural tension type symptoms in the left sciatic and tibial nerve distributions when performing an SLR suggesting that nerve trunks may have become tethered to their surroundings due to inflammation at the root.[10,19]

It is important to understand that neural mechanosensitivity caused by trauma and eventual tethering of nerve trunks may be relieved with proper management. Clinicians must encourage athletes to allow the fracture to heal and therefore reduce the osseous edema and subsequent nerve trunk tension and mechanosensitivity.[10,18,19]

Detailed knowledge of the relevant anatomy and pathomechanics of this injury is key to early detection and reduction of pain provocation. The diagnosis and management however remains difficult as most cases within the literature are reported on small retrospective series or involve complex modelling that may limit the ability for the clinician to draw conclusions in unique clinical presentations. The current case exemplifies the difficulty with diagnosis as the patient appeared to have mechanical low back pain and continued to play competitive soccer while undergoing assessment and treatment before a confirmatory diagnosis could be made.

Diagnosis

The diagnosis of active spondylolysis requires a thorough history, physical examination and necessary imaging based on an understanding of the mechanism as previously mentioned. As discussed, hyperextension and rotation involved in athletic movements combined with repetitive training may play a role in the development of acute spondylolysis.[2] Pain is reported on movement, and can be either acute or gradual onset.[2] While pain is the most critical part of the clinical picture, often the pain associated with acute spondylolysis may be misdiagnosed as growing pains.

In a retrospective study, Gregg et al. found that when compared to a single photon emission computed tomography (SPECT) bone scan, age and gender had a statistically significant association with spondylolysis while the single leg hyperextension test did not have a significant association.[20] The physical examination may reveal pain on palpation, a hyperlordotic posture, or rarely nerve root compression signs, while the use of the range of motion positions such as the single leg hyperextension test has limited clinical value.[2,20]

Given the vague and non-specific nature of the history and physical examination, lack of improvement with conservative care and recurrence of symptoms when returning to sport specific exercise should prompt clinicians to consider advanced imaging immediately in adolescents when suspecting an acute spondylolysis. Radiographic imaging is limited to the diagnosis of chronic cases, as it is unable to examine the metabolic process within the bone.[7] CT is effective at demonstrating an interruption or break in the pars interarticularis, however it is also limited to identifying chronic spondylolysis, due to the inability to detect metabolic activity.[7] SPECT has been previously shown to be effective in diagnosing an acute metabolic process, however, it is not able to determine the underlying cause or process.[21] In addition, CT and SPECT imaging involve a high dosage of radiation exposure for an injury primarily found in an adolescent population. For these reasons, magnetic resonance (MR) imaging is gaining popularity in the diagnosis of acute spondylolysis.[21]

Campbell et al. developed a modified grading system to effectively use MR as a first-line imaging modality for differentiating between active and non-active spondylolysis.[21] Grade I MR imaging suggests continuous marrow through the pars interarticularis with intact bone cortex. Grade II reveals sclerosis or low signal extending through the pars with the cortex remaining intact. Grade III is indeterminate between active or non-active. Grade IVa reveals discontinuity of the cortex on one side of the pars whereas grade IVb is complete discontinuity. Grade I and II therefore demonstrate an ongoing active metabolic process at the pars interarticularis whereas grade III and IVa/b show discontinuity in the cortex of the pars without osseous edema.[21] The authors recommend using MR as initial screen followed up with a localized CT image to confirm a spondylolysis.[21] The current case may have had a more definitive diagnosis using MR imaging and the Campbell et al. grading system during the initial presentation.[21] Identification of an acute spondylolysis with associated osseous edema using the grading system may have allowed for a more effective management and earlier detection without the exposure to radiation associated with CT imaging.

Management:

Management of the active spondylolysis has traditionally been divided into operative versus non-operative care. Operative management, according to Radcliff et al., is indicated when the likelihood of improvement after six months of non-operative treatment is sufficiently low and persistent pain and non-union remain at nine to 12 months.[22] In skeletally immature patients, surgical fixation is recommended after nine to 12 months if there is evidence of a spondylolisthesis of at least 50% and pain is ongoing. Additionally, persistent neurological deficit or radiculopathy are a relative indication for surgical fusion.[22] For those patients who are not surgical candidates, there are a number of non-operative interventions described in the literature. Iwamoto performed a narrative review on conservative versus surgical care of active spondylolysis.[6] The results of the review suggest that rest and anti-lordotic bracing are effective.[6] Furthermore, Debnath et al. report that conservative management can be broken down into four categories: reduction of activity levels that cause pain, stretching of the hamstrings and gluteus musculature, abdominal and back extensor strengthening, and a graded return to previously painful activities.[15]

Chiropractic care as part of non-operative management of spondylolysis has previously been reported in a case series.[23] This report suggests that spinal manipulation should be avoided in the active phase of spondylolysis, while the chronic inactive phase may be managed for pain relief with the use of manipulation[23]. The study reports the following recommendations for chiropractic management of the acute spondylolysis: no spinal manipulation, orthopedic referral for bracing, ensure healing of fracture through follow-up imaging, provide pain relief, and optimize function.[23]

Given that the current state of literature with respect to non-operative management is limited, clinical experience must also guide the clinician. An acute spondylolysis is similar to a long bone fracture, and should be treated as such. Currently, there is a lack of evidence reporting a healing timeline for active spondylolysis. This may be due to difficulties with initial diagnosis and the realities of ongoing repetitive training associated with elite level sport. When an acute spondylolysis is identified, it should be recognized as a fracture. Long bone fractures typically require six to eight weeks before completely healed and therefore rest and limited activity in the first few weeks of an acute spondylolysis are important. As noted in the current case, relative rest until the patient is pain-free is essential before progressing the athlete toward return to play.

Return to play:

Return to play criteria is variable within the current spondylolysis literature. Recently, Iwamoto et al. published a narrative review that looked at conservative care versus surgical care return to play outcomes, using the percentage of athletes to return to play and the time between start of their treatment and return to sports activity as the outcomes.[6] The authors report a lack of evidenced-based literature to guide the clinician following both surgical and non-surgical interventions of spondylolysis.[6] There was no statistical difference comparing surgical to conservative return to play. For surgically managed patients, the return to play timeline is approximately seven to 12 months while conservative management had a return to play timeline of 5.4-5.5 months.[6] The results of this review should be interpreted with caution as the study did not provide a grading system to determine the admissibility of the included cases. Further, the difficulty in comparing the clinical efficacy of interventions must be noted, as the severity of pain and dysfunction in the included cases was not reported.

Given the paucity of evidence in the current literature with respect to return to play criteria, clinicians should rely on an evidenced-informed approach that involves not only an understanding of spondylolysis but also the patient's needs and expectations. Spondylolysis will either eventually heal or progress to non-union[7], however the pain and functional disability associated with spondylolysis coupled with the variable risk of progression suggests it is imperative for the clinician to rely on an athlete to be pain-free and highly functional before returning to play. As described in the current case report, the patient was advised to limit activity and rest until he was pain-free.

In the current case, return to play criteria then followed a progression of pain-free functioning to core stabilization to soccer specific drills and finally a return to practice. Specifically, the patient in the current case performed 15 minutes of warm-up on the stationary bicycle followed by the 'Bunkie test'. The 'Bunkie test' was modified as a training tool for core stabilization.[11] Three sets held for 25 seconds on each repetition was performed for the posterior power line (Figure 4), anterior power line (Figure 5), posterior stabilizing line (Figure 6), lateral and medial stabilizing line (Figure 7 and 8). Once the subject could perform the exercises pain-free, a trial of sport-specific soccer activity was used prior to returning to practice environment. The patient was also instructed to avoid going above 80-90% self-reported intensity for all sports and/or kicking until three months after the initial rest period.

Summary:

Acute spondylolysis in adolescent athletes exists in sport that involves repetitive movement typically associated with extension and rotation type movements.[2] Extension and rotation create stress on the pars interarticularis which can be considered an anatomical weak point that predisposes it to stress-type fractures.[17] Once a stress fracture occurs within the pars interarticularis, progression to bilateral fracture, degeneration, radiculopathy and spondylolisthesis may occur.[5] Given that it occurs in adolescents, proper early diagnosis and management including rest and possible bracing techniques is key to improving healing and functional outcomes while diminishing pain. This case report highlights the importance of early detection, risk of progression and conservative plan of management that allowed for an adolescent male soccer player to return to high-level competition. Future research should investigate the timeline of healing with respect to unilateral spondylolysis with the intent of reducing the risk of progression. It is important to note that although the patient involved in this case did return to play at an elite level, there may be numerous other adolescent athletes who may be misdiagnosed and do not return to play in an effective manner. Finally, validation of specific protocols and return to play criteria such as those listed in the current case report are also required to help guide the clinician and athlete in making an evidenced-based decision.

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