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Physical Therapy Management of an Adolescent Dancer Diagnosed with an L5 Spondylolysis: A Case Report

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Abstract

Background: Spondylolysis is a stress fracture occurring in the pars interarticularis of the vertebral arch. Due to the nature of their activities and immature skeletal system, adolescent athletes are highly susceptible. Nearly 50% of those experiencing low back pain in this cohort can be attributed to spondylolysis. Currently there is a large knowledge gap in the literature in effective physical therapy management of young athletes with a spondylolysis. **Case Description:** The patient was a 16-year-old female dancer diagnosed with an L5 spondylolysis**. Interventions:** Treatment of the patient consisted of a 3-phase progression. Phase 1 consisted of soft tissue mobilization and non-weightbearing core and hip extensor/abductor strengthening. Phase 2 added weight-bearing and plyometric activities. Phase 3 was a maintenance period while the patient returned to her sport. **Outcome Measures**: The 3 primary outcome measures assessed were: Modified Oswestry Low Back Pain survey, manual muscle testing, and percent of return to sport. Following 8 weeks of physical therapy, the patient demonstrated a 20% improvement in her Oswestry score, full strength and endurance of musculature tested, and returned to 100% of sport specific activities **Discussion**: The patient had made a complete return to dancing following 8 weeks of immobilization and 6 weeks of physical therapy, with an additional 2 weeks of continued physical therapy. This aligns with the time frame of return to sport average established in the literature of 3.7 months. This case demonstrated the safe use of a progressive, phased rehabilitation approach to return the patient back to dancing activities.

Key words: Spondylolysis, physical therapy, return to sport.

Introduction:

Low back pain (LBP) is one of the most predominant conditions that plagues the health of Americans. More than 80% of individuals will experience low back pain during their lifetime and this debilitating dysfunction has imposed great costs to our healthcare system. Extensive research has been performed on causes of pain and dysfunction and efficacy of treatment on adults with LBP, but what about the pediatric cohort? Over the past few decades, LBP in adolescents has been an increasing interest to the field of research[1]. It has been reported in the literature that 18-51% of adolescent children experience low back pain[2].Much like in the adult population, LBP in adolescents has a variety of etiological causes, with as many as 50% of adolescent athletes experiencing LBP due to spondylolysis[3].

A spondylolysis is a defect or stress fracture occurring in the pars interarticularis of the vertebral arch. The pars interarticularis is a region of the lamina and found between the superior and inferior articular processes. This anatomical structure functions to add stability to its vertebral segment and impedes the segment from either sliding forward or backward within the spinal column[4]. As there are two pars interarticularis per vertebral segment, fracture of one segment is deemed a unilateral spondylolysis. When both are fractured, it is called a bilateral spondylolysis. Unilateral defects constitute 20% of cases, while bilateral are more predominant and account for 80% of pars fractures[5]. Bilateral fractures are more common since unilateral defects typically inflict increased stress to the contralateral pedicle leading to a bilateral condition[6].

Typically, a fracture of this area is due to repetitive mechanical stress imposed on this structure, occurring most commonly with trunk hyperextension or rotation based movements. Participating in athletic activities that involve recurring extension, rotation, or impact increases a person’s chances of generating this skeletal defect. To highlight this, the probability of a pars defect is 2 to 5 times higher in adolescent athletes compared to nonathletes[7].Pars interarticularis fractures begin as stress reactions to repetitive mechanical loading. When the loading continues and imposes increased stress, they can progress to acute fractures and finally chronic fractures[8]. When the defect becomes a complete fracture, especially when it occurs bilaterally, it can lead to either anterolisthesis or retrolisthesis, in which the effected vertebrae will move anterior or posterior in relation to the vertebrae directly inferior[9].

Upwards of 85-95% of the recorded cases are found at the L5 vertebrae and 5-15% at the L4 vertebrae[10]. The predominance of fractures occurring at the lumbosacral junction can be attributed to high amounts of inherent shear stress imposed at L5-S1 and subsequent mechanical load placed on the pars interarticularis[11]. A cadaveric study completed by Cyron and Hutton performed cyclic flexion-extension loading to the inferior articular processes of the lumbar spine[12]. Their results demonstrated pars fractures in 55 of the 74 vertebrae studied, which exhibited the susceptibility of the pars in this region to chronic loading[12].

As this injury typically occurs due to progressive and repetitive spinal extension and rotation, adolescent athletes who partake in activities that require theses motions are more susceptible to acquiring a spondylolysis. Skeletally immature adolescent’s bones are still in growth stages and subsequently have weaker osteochondral junctions and thinner cortices[13]. When coupling this boney susceptibility with sport activities that require hyperextension, rotation, and repetitive loading, such as dancing, gymnastics, football, etc., they may generate this defect. Not only do these athletes partake in activities that impose axial and rotational stresses to this imperative anatomical structure, the extent of their activity levels does not allow adequate rest and healing.

A patient presenting with this skeletal deficiency will often present with focal and dull LBP, either unilaterally or bilaterally. Their pain will worsen with activities, especially those that require lumbar extension and rotation. Radicular symptoms or urinary disturbances are rare, unless it has progressed to a spondylolthesis that has impeded on neural tissue. If the patient presents with neurologic symptoms upon clinical examination, the patient will most likely have an observed hyperlodotic posture and tight hamstrings, iliopsoas, and thoracic/lumbar paraspinals[14].

Currently there is limited research to identify optimal treatments for those experiencing a spondylolysis. If sufficient instability is present, surgical fixation may be necessary. In the dancing population, surgical interventions should be used in those who cannot obtain pain-free activity following 6-12 months of conservative management, if extent of displacement is increasing, or neurologic symptoms are occurring[10]. If the patient is not an adequate surgical candidate or has not trialed conservative care, treatments consisting of rest, bracing, and physical therapy should be implemented. There is limited research focused on physical therapy interventions and guidelines regarding treatment post spondylolysis diagnosis. Thus, to bridge the gap within the literature, the aim of this case study is to outline the conservative rehabilitation of an adolescent female diagnosed with a L5 spondylosis, with full return to activity.

Case Description:

A 16-year-old female had been experiencing low back pain for 6 months prior to diagnosis, prompting her to seek physical therapy (PT) intervention. Despite PT efforts, she continued to experience worsening symptoms with dance practice and competitions, thus was referred to an orthopedic specialist. Imaging was performed, which confirmed diagnosis of L5 spondylolysis. Following diagnosis, she was placed in a semi-rigid TLSO corset brace for the first 4 weeks and then was placed in an elastic corset brace for the following 4 weeks. At initial visit, she had been discharged from the elastic brace with recommendations to participate in physical therapy for lumbo-pelvic stabilization and to progress her return to dance.

She was complaining of 2/10 dull, achy low back pain and denied any radicular symptoms. She attributed her low pain rating to lack of movement as she was currently restricted from participating in any dynamic activities. Her pain was most notable when sitting unsupported and while lying in bed. Her functional disability was rated at 20% utilizing the Oswestry Low Back Pain survey. Her primary goal to reach through physical therapy was to have a full return to dancing competitively without pain or physical limitations. Following subjective information gathering, a complete examination was completed.

Examination:

To assess the patient's current status, a combination of palpation, sensory testing, deep tendon reflexes, manual muscle testing, flexibility special testing, and active and passive range of motion were all completed. A detailed outline of results for palpation, sensory, and reflex testing can be found in Table 1. The patient did not have any sensory deficits and deep tendon reflexes were all scored as a 2+, which indicated normal responses. These results, combined with her denial of radicular symptoms, indicated that it was unlikely she had neural involvement. Palpation indicated mild hypertonicity throughout bilateral thoracic paraspinal, gluteals, short hip rotators, and iliopsoas. She also denied tenderness to palpation throughout all musculature and soft tissue assessed. Manual muscle testing (MMT) results can be found in Table 2. Finally, active range of motion, passive range of motion, and flexibility special testing can be found in Table 3.

To evaluate pertinent musculature extensibility, the Thomas Test and 90/90 hamstring flexibility test were completed. The Thomas Test is a measure utilized to examine flexibility of the iliopsoas, rectus femoris, and Tensor Fascia Latae (TFL). Results of this test indicated decreased flexibility of bilateral iliopsoas, rectus femoris, and TFL. The 90/90 hamstring flexibility test was recorded as negative, indicating normal hamstring flexibility. Lumbar active range of motion (AROM), specifically forward bending, left rotation, and right rotation was then completed. AROM testing indicated mobility dysfunctions in forward bending and rotation, with left rotation being more limited than right. With forward bending she was able to reach to bilateral ankles, but due to the mobility necessary for her sport, it was deemed dysfunctional. Bilateral hip passive range of motion (PROM) was then assessed and recorded as within functional limits.

Hip manual muscle testing indicated 4/5 strength with bilateral hip extension and abduction. Lumbar protective mechanism testing is utilized to assess a patient's ability to maintain postural stability when resistance is applied. Testing revealed good activation and strength of anterior and posterior diagonals but poor endurance. Endurance was noted to be an important factor for this patient, as her sport requires upwards of 20 hours per week of practice and repetitive movements.

Table 1. Sensation, Reflex Testing and Palpation Assessment

Sensation:	Light touch within normal limits in bilateral lower extremities
Reflex testing:	-Patellar Tendon (L3-4): 2+, symmetric -Tibialis Posterior (L4-5): 2+, symmetric -Medial Hamstring (L5-S1): 2+, symmetric -Achilles Tendon (S1-2): 2+, symmetric
Palpation:	-Patient was only tender to palpation of bilateral iliopsoas. -Tone: hypertonicity palpable in bilateral thoracic paraspinal, gluteals, short hip rotators and iliopsoas

Table 2. Muscle Strength Assessment

Muscle group tested:	Grade on Evaluation	Grade on 10th visit
Hip Flexion	5/5 Bilaterally	5/5 Bilaterally
Knee Extension	5/5 Bilaterally	5/5 Bilaterally
Dorsiflexion	5/5 Bilaterally	5/5 Bilaterally
Great Toe Extension	5/5 Bilaterally	5/5 Bilaterally
Hip abduction	4/5 Bilaterally	5/5 Bilaterally
Hip Extension	4/5 Bilaterally	5/5 Bilaterally
Lumbar Protective Mechanism-Anterior and Posterior diagonals	Good activation, good strength, poor endurance	Good activation, good strength, good endurance

Table 3. Active/Passive Range of Motion and Flexibility Assessment

Assessment:	Findings:	
Multisegmental Flexion	To bilateral ankles, no lateral deviation	
Multisegmental Right Rotation	75%	
Multisegmental Left Rotation	50%	
Hip Flexion PROM	Left: 110 degrees	Right: 105 degrees
Hip Extension PROM	Left: 15 degrees	Right 15 degrees
Hip Internal Rotation PROM	Left: 40 degrees	Right: 45 degrees
Hip External PROM	Left: 85 degrees	Right: 85 degrees
Thomas Test	Left: Positive for TFL, RF, and Iliopsoas	Right: Positive for TFL, RF, and Iliopsoas
90/90 Hamstring Flexibility	Lacking 0 degrees	Lacking 0 degrees

Interventions:

Currently there is no gold standard established for conservative physical therapy management for athletic populations diagnosed with a lumbar spondylolysis. Thus, we utilized critical reasoning and the limited research available to produce an efficient plan of care to return the patient to her sport. The patient was seen for a total of 10 visits and her episode of care can be broken down into 3 distinct phases. The patient was deemed appropriate to advance to the subsequent phases when she was able to consistently complete exercises with adequate form and was pain free during the movements.

Phase 1 composed of visits 1-3 in which soft tissue limitations were addressed and low-level, non-weightbearing core and hip extensor strengthening was performed. She was seen only 1 time per week, due to conflicts in scheduling. Increased frequency may have been more desirable during this time and may have led to faster advancement through the first phase. The primary purpose of this phase was to reduce soft tissue restrictions that can lead to dysfunctional movement patterns and to initiate lumbo-pelvic stabilization exercises. Specific soft tissues addressed were the patient's bilateral lumbar paraspinals, iliopsoas, rectus femoris, vastus lateralis, and TFL. These muscles, specifically iliopsoas, rectus femoris, and lumbar paraspinals, were addressed as decreased muscle length or increased tone can facilitate hyperlordosis of the lumbar spine and subsequent stress on the patient's healing tissues. Low-level core and hip extensor strengthening included supine abdominal exercises, double and single leg bridges, and quadruped exercises.

Figure 1: Demonstrating an example of the 90/90 overhead reach.

All core exercises were built on a foundation of properly bracing abdominal musculature in a neutral spine position. This was completed in the hooklying position where the patient was given verbal and tactile cues to properly engage the transverse abdominis (TA). Once she was able to properly engage TA, she was educated on diaphragmatic breathing and various extremity movements while maintaining activation of TA. This ability to properly breathe via her diaphragm while maintaining TA activation was important as the patient participates in a dynamic and cardiopulmonary intensive sport. During long and tiresome practices, the ability to increase intra-abdominal pressure with an increased respiratory rate would be imperative to facilitate spinal stability. Another cornerstone supine abdominal exercise was the 90/90 overhead reach. An example of this exercise can be seen in Figure 1. This exercise challenges the patient to maintain tension in abdominal musculature while reaching overhead with bilateral upper extremities to resist increasing lumbar lordosis. Retraining the patient's motor plan to oppose this excessive lordosis was a key focus of Phase 1 as it would provide her stability when evolving her treatments to dynamic and load bearing exercises in the subsequent phases.

Phase 2 consisted of treatment sessions 4-8. She was seen for 1-2 visits per week throughout this phase, based on the availability in her schedule. Exercises were progressed to load bearing, strengthening, stabilization, and plyometric activities. Soft tissue mobilizations provided in Phase 1 were utilized throughout Phase 2 as well. A key component to the stabilization portion of this phase was implementation of the hip hinge pattern. This movement pattern involves flexion/extension originating at the hips and maintaining a neutral spine position. The hip hinge pattern is the fundamental movement for exercises such as deadlifts and Romanian deadlifts. The clinical reasoning behind this progression of exercise was to retrain the patient's motor plan to initiate flexion and extension movements at the hip, rather than via spinal movement. The patient held a hockey stick on her back and was instructed to maintain contact in 3 areas: base of her occiput, middle thoracic spine, and sacrum. The purpose of this placement was to provide the patient with tactile cues to maintain a neutral spine. This also allowed us to easily notice if the patient was increasing her lumbar lordosis, which signified dysfunctional movement patterns and inadequate spinal stabilization. Resistance bands were applied after the patient was able to demonstrate quality form. She was cued to drive into the band and activate her gluteals to reach full hip extension. The final stage was a Romanian deadlift. This single limb exercise not only emphasizes the hip hinge concept but can also enhance rotational stability when holding a weight in the ipsilateral hand.

Half-kneeling hip thrusts with an unweighted or weighted overhead reach was another key treatment intervention. In this movement sequence, the patient began in a half-kneeling position, sitting back toward her heels. The patient then extends hips with a thrust movement, while reaching arms overhead. The purpose of this pattern was to ensure that the patient is creating this large amplitude extension movement via hip extension and thoracic extension, rather than hyperlordosis of her lumbar spine. To maintain lumbar stability, she was also verbally cued to posterior pelvic tilt and maintain tension in her abdominals. Weighted overhead reach was introduced once the patient demonstrated competency and consistency with the movement unweighted to add difficulty. This exercise was typically completed at the end of the session to engrain the motor plan even when she is fatigued as her dance practices are 2-3 hours long.

In visits 6-8 of Phase 2, plyometric activities were introduced to assess her readiness to return to dance practices. Initially, double leg plyometrics in the frontal and sagittal planes were utilized. These exercises included: double leg hops, box jumps, step down jumps, and lateral hops. Once the patient was able to complete these movements pain free and with quality mechanics and load acceptance, exercises were progressed to single limb. Rotational movements in the transverse plane were also introduced to simulate the increasingly dynamic movements she would be performing in dance practices and competitions. Throughout her plyometric progression, her form and ability to maintain lumbar stability was assessed. As she demonstrated proper mechanics and load acceptance, she was instructed to return to 25% of practices prior to the 7th visit and 50% prior to the 8th visit.

After 8 weeks of bracing, followed by an additional 6 weeks of physical therapy, the patient finally returned to participating in 100% of practices following the 8th visit. Her full return began Phase 3 which consisted of treatment sessions 9 and 10. She was seen once per week to reassess her response to return to dancing. At this time in her episode of care, treatment was centered around maintaining soft tissue/joint mobility and reinforcement of key motor plans from the previous phases. The rationale behind this approach was to ensure that the patient was not restricted via soft tissue or joint mobility and to ensure that she was performing movements that would impose the least stress possible on her lumbar spine. Primary soft tissues addressed were bilateral iliopsoas, rectus femoris, and lumbar paraspinals. These were focused on as tightness in these muscles would induce anterior pelvic tilt and lumbar lordosis. Lumbopelvic stabilization exercises utilized at this phase included, but were not limited to: plank variations, deadlifts, Romanian deadlifts, weighted anti-rotation press, and half kneeling hip thrust with overhead reach. Difficulty of stabilization exercises and exertion during treatment sessions were decreased during this phase as the patient presented to the author with increased muscular soreness and fatigue as she was back to 100% of practices. At the completion of Phase 3, she did not report of any pain or difficulty performing during practices, indicating a safe and effective return to sport. She continued to participate in physical therapy following the departure of the author.

Outcomes:

To assess the patient's progress through conservative management, the Modified Oswestry Low Back Pain survey, manual muscle testing, and percent of return to sport were utilized. The Modified Oswesty Low Back Pain survey is a clinical tool utilized to gauge the patient's self-reported measure of disability due to low back pain. The survey takes approximately 5 minutes to complete and 1 minute to score, thus making it a time efficient option to assess the patient's perceived disability both prior to and following their episode of care[15]. The resulting score can be used to calculate a disability index. Prior to beginning physical therapy, the patient rated herself at 20% disability via the Oswestry. On the 10th visit, the patient demonstrated improvement to 0% disability. Copay et al 2008 illustrated that the minimally clinically important difference between pre-intervention and post-intervention scores is 12.8%[16]. This statistic signifies that the 20% improvement in the patient's function was a meaningful improvement through physical therapy.

Manual muscle testing on the 10th visit is illustrated in Table 2. It is demonstrated in this figure that the patient had received 5/5 grades for all muscle groups tested. This is an improvement from the initial visit, which indicated decreased strength in bilateral hip abductors and extensors. Prior to treatment, the patient also exhibited reduced endurance with both posterior and anterior diagonals when utilizing the lumbar protective mechanism test. Following treatment, this endurance rating improved to "good". These strength and endurance gains in all muscle groups are imperative as abdominals, paraspinals, and gluteals create anterior and posterior spinal stability. It should be noted that although the patient may have the necessary strength to provide stability, the clinician should continually observe for undesirable motor plans. When coupling the improved strength and motor sequencing practiced during sessions, the patient demonstrated a sufficient and resilient neuromuscular system ready to return to dancing.

Following diagnosis, the patient was placed in 2 different spinal orthoses for 8 weeks and then completed an additional 6 weeks of physical therapy prior to reintroduction to her sport. In a review of the current literature, Panteliadis et al 2016 found that the weighted mean of full return to sport in patients treated conservatively with bracing and/or physical therapy was 3.7 months[17]. The case study presented reinforces this timeframe as the patient had returned to dancing at approximately 3.5 months post conservative interventions. When clinically determining a patient's readiness for return to sport the clinician should ensure that the patient demonstrates adequate strength and mobility and completes necessary activities pain free. At the 8th week of physical therapy, assessments of the patient's Oswestry score, muscle strength, motor control, and pain levels exhibited the patient's improvement through conservative management.

Discussion:

Spondylolysis is a surprisingly common condition in adolescent athletes and leads to pain and lack of participation in their sport. The research has shown that 18-51% of adolescent athletes experience low back pain. Of the cohort experiencing low back pain, upwards of 50% experience low back pain due to spondylolysis[2]. Although there is a high incidence of this diagnosis, the conservative care via physical therapy is poorly researched and understood. Thus, the purpose of this case study of a 16 year-old female diagnosed with an L5 spondylolysis is to outline effective and efficient treatments to facilitate the athlete's full return to dancing.

LBP posts a significant threat to disturbing adolescents' quality of life and participation in sports. The importance of correctly treating adolescents with all forms of LBP cannot be emphasized enough. Harreby et al 1996 reported that 90% of children with LBP suffered LBP 25 years later as an adult[18]. This information highlights the significant role clinicians can play to reducing lifetime disability. Specifically, in the dancing population, percentage of performers who experience some form of LBP is significantly higher. One study examined the prevalence rates of LBP in 128 dancers and found that 70% of the cohort had experienced LBP in the recent 12 months[19]. Although there is no current gold standard of treatment for those who have a acquired a spondylolysis, clinicians can effectively treat these patients by addressing mobility and movement dysfunctions related to their condition.

Rest and activity restriction should be initiated immediately following diagnosis. This period of rest and restriction from sport may last up to 6 months, depending on the severity of the fracture[20]. Immobilization should also be utilized to minimize the amount of range of motion the patient can go through to reduce stress on the healing fracture site. The duration of bracing can vary based on the severity of the patient's fracture and their goals.

Physical therapy management should also be utilized to return the patient to his/her desired sport. Treatment should involve reducing soft tissue limitations that influence spinal stability and motor training to reduce dysfunctional movement patterns. Roussel et al 2013 observed the relationship between lumbopelvic motor control and LBP in 41 dancers. They found that dancers with LBP demonstrated altered motor control when compared to dancers without pain. They also stated that previous history of low back pain and joint hypermobility were both unable to predict future low back injuries, but dysfunctional lumbo-pelvic stability did[21]. For example, the Arabesque position, a common dancing movement, requires 90 degrees of hip extension/external rotation with an extended leg during stance. It is known that dancers who lack necessary external rotation compensate by hyperextending their lumbar spine to obtain Arabesque position[21]. Thus, these types of compensations can lead to injuries such as lumbar spondylolysis.

Providing neuromuscular reeducation to elicit more desired movements should be a key focus of physical therapy management. In this case study, the patient tended to hyperextend at her lumbar spine during extension movements and was exacerbated when her arms would go overhead. Exercises such as the 90/90 overhead reach seen in Figure 1 helped to retrain her motor control to effectively stabilize her lumbar spine during these movements. Once she was able to complete all exercises with consistent and correct form in a pain free manner, she was deemed ready to return to her sport. Upon returning to dance, she continued physical therapy management. Sakai et al 2017 found a 26.1% recurrence rate of stress reactions in pediatric patients with healed lumbar spondylolysis[22]. Due to the high prevalence of reinjury, she continued physical therapy throughout her initial return to ensure a successful and complete return to sport.

In conclusion, this case study provides a detailed example of the management of an adolescent female dancer diagnosed with a spondylolysis and a desire to return to her sport. The 3 phase treatment philosophy outlined was successful at aiding the patient to a full and safe return to sport utilizing a plan of conservative treatment. Although this treatment progression was successful, further research is needed to ensure that clinicians are providing the most optimum level of care.

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