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MANAGEMENT OF LUMBAR SPONDYLOLYSIS IN THE ADOLESCENT ATHLETE USING A DYNAMIC NEUROMUSCULAR STABILIZATION PARADIGM: A CASE REPORT

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ABSTRACT

Objective: To describe a novel approach in treating a teenage athlete with spondylolysis of the L5 vertebrae using Dynamic Neuromuscular Stabilization principles.

Clinical Features: A 15-year-old female softball pitcher presented with progressive low back pain following a tournament. MRI revealed acute bilateral pars interarticularis fractures at L5 with bone marrow edema pattern, without anterolisthesis.

Intervention and Outcome: She was treated with therapeutic exercises, spinal manipulation, and soft tissue therapy over 8 weeks. Therapeutic exercises were organized according to Dynamic Neuromuscular Stabilization principles, focusing on optimizing core stabilization during functional movements. She experienced significant improvements in pain (reduction from 7/10 to 1/10 on the Visual Analog Scale), increased pain-free range of motion, and safely returned to her sport.

Conclusion: This case suggests that interventions combining manual manipulation, soft-tissue therapy, and therapeutic exercise based on Dynamic Neuromuscular Stabilization principles may be beneficial in conservatively managing pars interarticularis injuries in adolescent athletes.
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INTRODUCTION

Spondylolisthesis is a spinal condition characterized by the anterior displacement of one vertebra over the one beneath it, most commonly occurring in the lumbar spine. Clinical presentation varies depending on the severity and type of slippage, ranging from asymptomatic cases to significant symptoms like lower back pain, leg pain (due to nerve compression), muscle tightness, and reduced mobility. In severe cases, individuals may experience neurological deficits, such as numbness or weakness. The prevalence of spondylolisthesis increases with age, affecting approximately 6-9% of the general population, with higher rates observed in older adults, athletes, and individuals with congenital or degenerative predispositions. (1,2)

Dynamic Neuromuscular Stabilization (DNS) is a rehabilitative approach developed at the Prague School of Rehabilitation, which is based on developmental kinesiology; the rehabilitation process focuses on facilitating control of core stability through exercises in developmental positions. DNS aims to help restore dynamic load-sharing capacity throughout the injured region by training core stability across a range of functional movements. (3)

This report discusses the case of a teenage athlete who had a gradual onset of low back pain following a softball tournament. History and physical exam suggested injury to the pars interarticularis in the lower lumbar spine. MRI confirmed the diagnosis of an acute, bilateral spondylolysis at L5 without spondylolisthesis. She was treated with a combination of manual therapy and therapeutic exercise using techniques and principles derived from Dynamic Neuromuscular Stabilization (DNS) over 8 weeks.

CASE REPORT

Patient History

The patient was a 15-year-old female competitive softball pitcher. She had a gradual onset of increasing low back pain over 1 week following a softball tournament in which she pitched on back-to-back days. At the time of the exam, she reported her pain was midline in the lumbosacral spine and exacerbated with extension and rotation of the lower back. She reported 7/10 (Visual Analog Scale of Pain: VAS) midline pain in the lumbosacral spine. She felt the pain level as being relatively constant since the initial onset. She noted that her pain was relieved with rest and exacerbated with activity, especially movements involving lumbar extension and rotation. She reported no previous neuromusculoskeletal injuries and no significant medical history contributing to her presenting complaint.

Physical Exam

She had an accentuated thoracic kyphosis and lumbar lordosis. Static palpation confirmed midline tenderness in and around the lumbosacral spine (T12 through S1), which was exacerbated with end-range lumbar extension and rotation. The thoracic and lumbar paraspinal muscles were hypertonic and tender to palpation. The hamstring complexes and hip flexors were also hypertonic bilaterally but not tender to palpation. Motion palpation examination revealed multi-segmental extension restrictions at the cervicothoracic (C7-T4), midthoracic (T5-T8), and lumbosacral (L5-S1) junctions. A palpable step-off deformity in the lower lumbar spine was also noted with dynamic palpation.

She had no neurological signs or symptoms. A neurological exam of the lower body was performed and deemed to be normal, including reflex, muscle strength, and sensory testing of the L4-S1 levels. The single-leg hyperextension maneuver ("Stork Test") reproduced her reported pain when performed with either leg. Kemp's test also reproduced her lower back pain with extension and rotation in either direction. She could not perform prone lumbar extensions without midline lumbosacral pain, but her pain was temporarily relieved with sustained lumbar flexion in the supine position, with her knees brought to her chest for approximately 1 minute. She scored a 6/10 on a hypermobility exam using Beighton criteria (the thumbs, elbows, and knees were hypermobile, bilaterally).

History and exam findings were consistent with a lumbar pars interarticularis injury. Due to the lack of neurological findings and upon discussion with the patient and her family, a 2-week trial of conservative care with activity restriction was begun. During these 2 weeks, she was instructed to refrain from sports participation and to avoid activities that increase pain, particularly those involving extension and rotation of the spine. It was mutually decided that if her symptoms were persistent after 2 weeks, imaging would be warranted to investigate the extent of the injury, further clarify her prognosis, and guide return-to-activity decision.

Imaging

After 2 weeks of conservative care with activity restriction, there was minimal improvement in her symptoms. Per the mutually agreed upon decision with the patient and her family, further investigation with diagnostic imaging was warranted. MRI was chosen because of its lack of radiation exposure and utility in identifying chronicity/severity of bone stress injuries through visualization of bone marrow edema commonly seen in early stress fractures of the pars interarticularis (4). Multiplanar and multisequence 1.5 Tesla MR imaging of the lumbar spine was performed without intravenous contrast. The MRI revealed acute bilateral pars interarticularis fractures at L5 with bone marrow edema pattern, without anterolisthesis.

Interventions and Outcomes

Interventions

The treatment plan consisted of patient education, manual therapy, and therapeutic exercise. The treatment plan was 8 weeks long, consisting of 2 30-minute visits per week, for a total of 16 visits. The patient and her family were educated on the nature and prognosis of her injury. They were informed about the importance of initial rest and activity restriction to allow for healing, with explicit instruction on limiting physical activity and athletic participation. The risks of continued activity and sports participation were explained, along with instructions to avoid movements that exacerbate pain, particularly those involving lumbar extension and rotation. She was instructed to gradually reintroduce activities as treatment progressed. We emphasized the importance of maintaining fitness through low-impact alternatives during recovery. Emphasis was placed on the role of therapeutic exercise in her recovery process. The complementary roles of in-office treatments and home exercises were explained, stressing the importance of consistency with the home exercise program. Education also covered the long-term management of her condition and a phased return to sports participation with a discussion of criteria that would be used to make a mutual return to sports decision. Table 1 provides a comprehensive overview of the treatment plan, detailing the progression of manual therapy techniques and therapeutic exercises and their corresponding goals across each rehabilitation phase.

Table 1. Overview of Treatment Plan

Phase	Manual Therapy Techniques	Therapeutic Exercises	Goals & Progression
Weeks 1-2	- Spinal manipulation at cervicothoracic (C7-T4), midthoracic (T5-T8), and thoracolumbar (T10-L2) regions. - Myofascial release and pin-and-stretch targeting thoracic/lumbar paraspinal muscles, hamstrings, and hip flexors.	- Focus on proper diaphragmatic breathing and intra-abdominal pressure (IAP) regulation. - Static core exercises in developmental positions (e.g., DNS 3-month supine/"dead bug"). (3,5,6)	- Address joint and soft-tissue mobility restrictions. - Educate patient on core stabilization and breathing. - Improve ability to perform basic exercises. - Challenge core activation patterns and improve core engagement.
Weeks 3-5	- Continued use of manual therapy, as needed, to address joint mobility and soft tissue restrictions.	- Progression to dynamic core exercises (e.g., DNS side bridge). (3,6) - Introduction of functional movement patterns (hip hinge, squat, etc.) with gradual load progression.	- Focus on maintaining proper form and IAP regulation during more complex exercises. - Begin training functional movements to build strength and stability in preparation for sport-specific activities.
Weeks 6-7	- Manual therapy used as needed to support increased functional demands of exercise program.	- Integration of core stabilization into sport-specific exercises (e.g., using a cable resistance machine to train softball-specific rotational movements).	- Advance exercises to mimic sport-specific demands. - Prepare her for return to sport with complex movement patterns integrated with previously learned stabilization techniques.
Week 8	- Manual therapy continued as needed to address any residual soft tissue or joint mobility restrictions.	- Final exercises focused on simulating full demands of softball participation while maintaining core stabilization and proper movement patterns.	- Ensure she is prepared for safe return to sport. - Reinforce proper stabilization and movement patterns in sport-specific scenarios. - Provide clearance for return to full athletic participation if ready.
Throughout	- Clinician reassesses the effectiveness of manual techniques and adjusts accordingly. - Soft-tissue and spinal manipulation are modified based on patient needs.	- Home exercise program: DNS side bridge, DNS 3-month supine ("dead bug"), bird dog (6,7) progressed from static holds to dynamic movements. - Home exercises prescribed 2-3 times daily, 10-second holds with rest periods, until 80% RPE is reached.	- Home exercise program reinforces in-clinic work and promotes consistent progress. - Exercises continually modified based on patient's progress, ensuring adequate challenge and maintaining proper form and IAP control.

Outcomes

Following the 8-week treatment period, she demonstrated significant improvements in both objective and subjective measures. The primary outcome was a marked reduction in pain, with her reporting a decrease from the initial 7/10 on the Visual Analog Scale (VAS) to 1/10 after treatment. This reduction in pain allowed for improved function and participation in daily activities. Objectively, she exhibited increased spinal mobility, with improved, pain-free spinal range of motion in flexion, extension, and rotation. The single leg hyperextension maneuver ("Stork Test") and Kemp's test, which initially reproduced her reported pain, were negative at the end of treatment. She could perform prone lumbar extensions without midline lumbosacral pain, suggesting reduced irritability of the pars interarticularis. Her core stabilization strategy improved, as evidenced by her ability to maintain proper IAP during functional movements and sport-specific activities. This was assessed using the Core360 belt (Back in Balance Physical Therapy, Los Angeles, CA, USA) with the OhmTrak sensor (Ohm Belt, Nilus Medical LLC, 2019 © OHMBELT, Redwood City, CA, USA), which demonstrated her capacity to regulate IAP effectively during progressively challenging tasks.

She successfully demonstrated the ability to perform full softball hitting and pitching motions with proper control without an increase in pain, suggesting improved load-sharing capacity throughout the injured region. Return-to-sport clearance was granted based on her ability to meet predetermined functional criteria, including pain-free spinal range of motion, successful completion of sport-specific activities, and maintenance of proper IAP through functional movement patterns. At the conclusion of the treatment period, the patient, her parents, and the treating clinician agreed that she was ready to return to full activity and athletic participation. A phased return-to-play protocol was implemented to ensure a safe transition to competitive softball. The protocol began with lower-impact activities such as jogging, light throwing, and hitting balls off a tee during practice. Activities were then progressed to higher impact sport-specific movements at 50% effort, incorporating pitching practice, live batting practice, and fielding drills. These were initially performed on alternate days to monitor symptom response. As the athlete remained asymptomatic, the intensity was gradually increased to 75% effort. The final phase included full participation in team practice with progression to 100% effort and game intensity. The athlete successfully completed all phases without pain recurrence and returned to competitive gameplay by the end of week 4. At a 1-month follow-up, she remained pain-free and fully participated in her sport, returning to pre-injury performance levels.

DISCUSSION

This case report highlights the potential effectiveness of a conservative treatment approach incorporating Dynamic Neuromuscular Stabilization (DNS) principles in managing recent lumbar spondylolysis in an adolescent athlete. The treatment led to significant pain reduction, improved functional movement, and a successful return to sport, suggesting that this approach could be beneficial in similar cases.

The rehabilitation process centered on facilitating spinal stabilization across various functional movement patterns. Spinal stabilization is the product of passive, active, and neural systems. (8) The vertebral bodies, intervertebral discs, zygapophyseal joints, zygapophyseal joint capsules, and spinal ligaments form the passive system. The active system comprises all the spinal musculature, and the neural system is the effective modulator between the two systems. As abnormal transmission of forces in the spine is the primary cause of pain in spinal osteoarthritis, and abnormal patterns of stress distribution correlate with discogenic pain (9), paradigms emphasizing proper control of abdominal musculature during movement could reduce stress on an injured pars interarticularis.

The pathophysiology of spondylolysis is particularly relevant to the DNS approach used in this case. Spondylolysis typically develops due to repetitive microtrauma to the pars interarticularis, especially during movements involving lumbar extension and rotation—common in sports like softball pitching. (10) The pars interarticularis is particularly vulnerable to shear forces, especially during rapid, repetitive loading in athletic activities. (11)

Dynamic Neuromuscular Stabilization focuses on restoring optimal neuromuscular control of the spine through developmental positions. As described by Frank et al. (3), this approach emphasizes the regulation of intra-abdominal pressure (IAP) through coordinated activity of the diaphragm, abdominal wall, and pelvic floor muscles to create a stable foundation for movement. This stabilization is crucial in spondylolysis as it can help distribute forces more evenly throughout the spine, potentially reducing stress on the injured pars interarticularis.

The treatment plan systematically targeted this stabilization mechanism. Beginning with basic diaphragmatic breathing and IAP regulation, exercises progressed to more dynamic movements while maintaining proper core stabilization. This progression allowed for improved motor control patterns that could be applied to sport-specific movements, potentially reducing the repetitive stress that led to the initial injury.

In this case, manual therapy techniques, including spinal manipulation and soft tissue therapy, complemented the exercise program. These interventions addressed joint mobility and soft tissue restrictions, aiming to enhance the athlete's ability to perform the prescribed exercises. Similarly, the gradual progression of exercises, from static core stability in developmental positions to dynamic, sport-specific movements, aimed to establish a safe, sequential return to function without fear of additional overloading or injury.

Patient education was likely a key component in this case's successful outcome. She was thoroughly educated on the injury mechanism, the avoidance of provocative movements, and the importance of proper core stabilization during therapeutic exercises in the office and at home. As reflected in her testimonial, she demonstrated understanding and compliance with the principles and exercises taught, reporting that she incorporates them into her daily routine for ongoing injury prevention. This suggests that comprehensive education can enhance treatment compliance, improve outcomes, and provide tools for long-term self-management.

The athlete's successful return to play was achieved in an 8-week timeframe. Overley et al. (12) reviewed return-to-play rates in adolescent athletes suffering from spondylolysis and found an average time-of-return in non-operative cases of 5.9 months. This represents an almost 3-fold length of time increase over this individual case. It is important to note that average times are not directly relatable to individual cases; however, it suggests there could be merit in further examination of the exercises and principles utilized in this report.

While this case report is a promising description of care, several limitations must be acknowledged. As a single case, these results cannot be generalized to all adolescent athletes with lumbar spondylolysis. Similarly, the natural course of healing may have contributed to the observed improvements, making it difficult to determine the exact impact of the treatment approach. Additionally, while the short-term outcome was positive, long-term follow-up is necessary to assess the durability of the results and the potential for injury recurrence. It is also unclear from this case if the order of delivery and singular or combined therapeutic interventions may have interacted with this patient's recovery. Further targeted work is needed to parse these influences into specific effects.

CONCLUSION

This case underscores the potential value of incorporating DNS principles into the management of lumbar spondylolysis in adolescent athletes. This approach, combined with manual therapy, patient education, and a progressive return to sport-specific activities, may facilitate recovery and return to play. However, further research is needed to more definitively establish the effectiveness of this approach compared to other conservative management strategies. Future studies could explore the specific components of this treatment approach (DNS exercises, manual therapy, education, progression of activities) to determine their relative contributions to the outcome. Additionally, investigating the long-term effects of this approach on recurrence rates and spinal health in young athletes would be valuable.

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