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A COMBINED TREATMENT APPROACH EMPHASIZING IMPAIRMENT-BASED MANUAL THERAPY AND EXERCISE FOR HIP-RELATED COMPENSATORY INJURY IN ELITE ATHLETES A CASE SERIES.pdf

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CASE SERIES

A COMBINED TREATMENT APPROACH EMPHASIZING IMPAIRMENT-BASED MANUAL THERAPY AND EXERCISE FOR HIP-RELATED COMPENSATORY INJURY IN ELITE ATHLETES: A CASE SERIES

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ABSTRACT

Background/Purpose: Athletes experiencing hip, groin, and low back pain often exhibit similar clinical characteristics. Individuals with hip, groin and low back pain may have the presence of multiple concurrent pathoanatomical diagnoses. Regardless, similar regional characteristics and dysfunction may contribute to the patient's chief complaint, potentially creating a sub-group of individuals that may be defined by lumbopelvic and hip mobility limitations, motor control impairments, and other shared clinical findings. The purpose of this case series is to describe the conservative management of elite athletes, within the identified aforementioned sub-group, that emphasized regional manual therapy interventions, and therapeutic exercise designed to improve lumbopelvic and hip mobility, stability and motor control.

Case Descriptions: Five elite athletes were clinically diagnosed by a physical therapist with primary pathologies including adductor-related groin pain (ARGP), femoral acetabular impingement (FAI) with acetabular labral lesion and acute, mechanical low back pain (LBP). Similar subjective, objective findings and overall clinical profiles were identified among all subjects. Common findings aside from the chief complaint included, but were not limited to, decreased hip range of motion (ROM), impaired lumbopelvic motor control and strength, lumbar hypomobility in at least one segment, and a positive hip flexion-adduction-internal rotation (FADIR) special test. A three-phase impairment-based physical therapy program was implemented to resolve the primary complaints and return the subjects to their desired level of function. Acute phase rehabilitation consisted of manual therapy and fundamental motor control exercises. Progression to the sub-acute and terminal phases was based on improved subjective pain reports and progress with functional impairments. As the subjects progress through the rehabilitation phases, the delivery of physical therapy interventions were defined by decreased manual therapies and an increased emphasis and priority on graded exercise.

Outcomes: Significant reductions in reported pain (>2 points Numeric Pain Rating Scale), improved reported function via functional outcome measures (Hip and Groin Outcome Score), and continued participation in sport occurred in all five cases without the need for surgical intervention.

Discussion: The athletes described in this case series make up a common clinical sub-group defined by hip and lumbopelvic mobility restrictions, lumbopelvic and lower extremity motor control impairments and potentially other shared clinical findings. Despite differences in pathoanatomic findings, similar objective findings were identified and similar treatment plans were applied, potentially affecting the movement system as a whole. Subjects were conservatively managed allowing continued participation in sport within their competitive seasons.

Conclusion: Comprehensive conservative treatment of the athletes with shared impairments, as described in this case series, may be of clinical importance when managing athletes with hip, groin, and low back pain.

Level of Evidence: Therapy, Level 4, Case Series

Key Words: **Groin,** Hip, low back pain, movement system, return to aport

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INTRODUCTION

Athletes who participate in sports that require twisting and high-intensity change of direction forces, such as football, basketball, soccer, and hockey, often experience hip, groin, and low-back pain.[1,2,3,4] In athletes with groin and low back pain, accurate diagnosis and appropriate treatment can be challenging due to complex anatomy and similar clinical patient complaints,.[5,6,7] Musculoskeletal differential diagnosis within the lumbopelvic hip complex includes discernment regarding pathologies that may be intra-articular (i.e. acetabular labral tears, cartilaginous damage) or extra-articular (muscular in nature) to the hip. Dysfunction related to the core and adductor muscle complex and/or the pubic, inguinal, and lumbar regions must also be considered as a potential source of groin pain.[2,7]

Further complicating the presentation is the possibility of multiple coexisting diagnoses[3] and regional interdependence as a contributing factor to local pain and impairment,[8] as well as global movement system dysfunction. It has been found that up to 94.1% of athletes diagnosed with athletic pubalgia have radiographic evidence of femoral acetabular impingement (FAI)[9,10,11] while hip and groin pathology and low back pain have been proposed to be found concurrently in the same patient population.[12,13,14,15] Multiple diagnostic methods and modalities,[7,15,16,17] including a layered pathoanatomical approach,[1] have been proposed to help clarify the identification of specific diagnoses, guide treatment, and explain potential mechanisms of injury within the hip and lumbopelvic region.

Pathoanatomy of the hip has been proposed as a potential causative factor for injury.[1,2,3] FAI syndrome, which often includes a cam, pincer, or mixed cam/pincer morphology of the hip joint, has been proposed to contribute to athletic-related groin pain.[15,18] This anatomical presentation may result in abnormal hip ROM, which has been suggested as a risk factor for many of the previously noted injuries, such as intra-articular hip, core and adductor related injury, and LBP.[1,2,11,19] However, these bony and intra-articular features have also been identified in a large proportion of asymptomatic athletes and may not be solely responsible for pathology.[20] Athletes with asymptomatic hips have commonly been reported to present with cam (54.6%) and pincer (49.5%) morphology respectively, while 65.4% were found to have an acetabular labrum defect.[21] ROM limitations, regardless of bony architecture, have been associated with athletic groin injury.[22]

Athletic movement requires appropriate hip mobility. When limited, altered motor control[23] may lead to compensatory redistributions of force across the pelvis in order to perform the desired sport-specific movement.[24] For example, hip ROM limitations associated with cam morphology has been linked to increased motion and stress at the pubic symphysis[25,26] Aside from morphology, regional contributions may also affect hip mobility, as the posture of the pelvis can further reduce the ROM available at the hip[27] while those with FAI syndrome demonstrate a decreased ability to functionally rotate the pelvis posteriorly.[28] It has been suggested that the relationship of FAI and the lumbopelvic region play a role in LBP.[2,12,14] The mobility of soft tissue structures surrounding the hip joint can also contribute to functional losses in ROM.[13,18, 29,30]

In addition to limited hip ROM, other risk factors include impaired regional strength and motor control. Inadequate strength profiles of the hip musculature have been identified in those who have sustained groin and lower extremity injury,[31,32,33,34] while individuals with groin pain and LBP have been found to demonstrate motor control deficits of the lumbopelvic region and lower quarter.[14,23,24,35] Those with FAI have been reported to demonstrate altered lower body kinetics and force attenuation, potentially resulting in excessive impulse to the joint.[36] Motor control deficits have been linked to reports of impaired sport performance and pain.[35,37]

Uneven distribution of forces across the pelvis, in part due to limited regional mobility[22] and impaired strength[31,32,33] and neuromuscular control[15,35] may result in mechanical overload and subsequent acute or chronic injury,[1,4] ultimately impacting the movement system. These previously noted findings about the hip and lumbopelvis have been proposed to be related irrespective of any individual pathoanatomical diagnosis.[1,8] Recently, authors have recommended assessment and intervention focusing less on painful structures and more on the resolution of

comprehensive movement impairments and injury risk reduction strategies.[24,37] The purpose of this case series is to describe the conservative management of elite athletes, within the identified aforementioned sub-group, that emphasized regional manual therapy interventions, and therapeutic exercise designed to improve lumbopelvic and hip mobility, stability and motor control.

CASE DESCRIPTIONS

Five male athletes, aged 19 to 27, were included in this case series. The subjects were all evaluated and treated by one of two physical therapists, and referred for diagnostic imaging and evaluation by their respective team orthopedic physician as necessary. Outcomes were assessed by utilizing the Numeric Pain Rating Scale (NPRS),[38] outcome measures specific to the chief complaint (i.e Hip and Groin Outcome Score for groin pain cases)[39] and return to sport participation. Long-term follow up was performed at one year following the initial course of treatment.

Subject Presentations

Subject 1

Subject 1 was a 22 year-old professional basketball player who reported chronic, (> 3 months) progressive, left-sided groin pain of insidious onset. Pain was produced with sprinting and cutting maneuvers and was occasionally experienced bilaterally when the presentation was most severe and irritable. The subject described at least two instances of 'sharp pain' and 'tearing' sensations in the adductor musculature during linear sprinting and cutting in the weeks prior to the initial evaluation. Plain radiographs revealed bilateral cam morphology while MRI revealed a mild anterosuperior labral lesion of the left hip.

Subject 2

Subject 2 was a 19-year-old professional basketball player reported with chronic (>6 months) right-sided groin pain. Magnetic resonance imaging (MRI) revealed osteitis pubis, grade I avulsion of the right adductor longus, grade I avulsion of the rectus abdominis, and bilateral cam morphology. The subject also noted a history of LBP.

Subject 3

Subject 3 was a 20-year-old collegiate hockey player who reported tripping on the front blade of his skate during competition, moving his left hip into excessive extension and external rotation, resulting in acute hip and groin pain. MRI revealed a moderate anterosuperior labral tear unilaterally and mixed cam and pincer hip morphology bilaterally. His team physician provided him the option of surgical or conservative care.

Subject 4

Subject 4 was a 20-year-old professional basketball player who presented with acute LBP. The athlete experienced intense LBP when he attempted to pivot left (abduct and externally rotate about the right hip) and change direction while playing defense. MRI of the lumbar spine was unremarkable. Plain radiography revealed cam morphology of the right hip. Follow-up MRI identified bilateral cam morphology and anterosuperior labral lesions.

Subject 5

Subject 5 was a 27 year-old male professional basketball player who presented with acute low back pain and episodic bilateral groin pain. The chief complaint was pain across the inferior lumbar spine. Also reported was inconsistent 'sharp' pain through the proximal 1/3 of each medial hip/thigh with running and multiplanar sport tasks. MRI of his lumbar spine revealed a chronic, grade 1 L5-S1 spondylolisthesis. Plain radiographs demonstrated cam morphology of bilateral hips.

Clinical Examination

A detailed subjective history, systems review, and objective examination was performed on each subject. Clinically relevant subjective information included, but were not limited to, pain reported in the groin, popping, clicking, or locking of the hip, chronic groin tightness, local pain when bearing down, and "C" sign.[3,7,18] Physical examination consisted of regional palpation,[7,17] active and passive lumbar and hip range of motion, strength assessment via manual muscle testing, passive joint motion, neurodynamic testing,[40] and appropriate special testing determined from the information gathered during assessment.[18] In particular, the hip FADIR and FABER (flexion-abduction-external rotation) test,[16] the adductor

squeeze test,[41] and abdominal curl-up test[18] were identified as clinically valuable due to their ability assist in ruling in and out during differential diagnosis. Sacroilliac dysfunction was assessed via provocation testing.[42] Movement testing (i.e overhead squat, lunge, single leg squat, Y-Balance Test)[18, 35] was also utilized to identify aberrant or painful movement and compared to prior assessment when possible. Clinical findings that were similar across subjects were abnormal hip (decreased and/or asymmetrical, specifically in internal and external rotation, abduction, and flexion) ROM, impaired lumbopelvic strength and motor control defined by aberrant motion and/or functional movement assessment, at least one segment of the lumbar spine that was painful and/or hypomobile, and a painful, but not necessarily concordant, FADIR test. Respective patient clinical findings are found in Table 1.

INTERVENTION

Three phases of rehabilitation were implemented: Acute, Sub-Acute, and Participation. Transition between phases was dependent on clinical presentation, NPRS, pain reduction in identified sport-specific impairments (i.e. sprinting, defensive shuffling, pivoting, angular jumping, skating push-off) and performance on objective measures. Programs were individualized to treat identified impairments.[16,43] All athletes were impacted during the competitive season (including pre-season) and required individualized activity modification, particularly in the acute phase. At a minimum, practice time was lost or decreased due to injury, while games lost due to injury was based on severity of presentation.

Acute

Following examination, the first phase of rehabilitation consisted of pain modulation and modification of activities. Treatment was provided five to seven days per week for the duration of individual presentation. Athletes were prescribed non-steroidal anti-inflammatory drugs by their treating physician, and common variations of cryotherapy and compression modalities were utilized for their potential pain and inflammatory mediating mechanisms. Manual Therapy (MT) was provided three to five times a week for the associated comprehensive mechanical,[44] neurophysiological,[45] and regional benefits.[8] (Table 2)

Table 1.

	Clinical Exam				
Patient	Tender to Palpation	Painful LROM	Clinical Hip ROM Impression	Hip Internal Rotation ROM	Hip External Rotation ROM
1	B Adductor Longus;Pubis	None	LTD ABD, ROT; Asymetrical	L=20 R=26	L=21 R=27
2	R Adductor Longus;Pubis	R Quadrant + Overpressure	LTD ABD, ROT; Asymetrical	L=29 R = 32	L=30 R = 39
3	L Iliopsoas; L Adductor Longus	Extension	LTD ABD, FADIR;Symetrical	L=48 R = 44	L=36 R = 40
4	None	FLX; EXT; L Rotation	LTD ABD, ROT; Asymetrical	L = 22 R = 27 (painful)	L = 32 R = 36
5	L5 Spinous Process, B Adductor Longus	EXT	LTD IR and ER Bilaterally	L = 16 R=14 (painful)	L= 22 R= 25
	Total Hip Rotation ROM	Hip Abduction Strength	Hip Adduction Strength	Lumbar Passive Joint Assessment	
1	L=41 R=53	4/5	3+/5	2/6 Hypomobile at T12/L1	
2	L = 59 R = 61	4-/5	3/5	2/6 Hypomobile at T12/L1	
3	L=84 R = 84	4/5	3+/5	2/6 Hypomobile T12/L1, L4/L5;Refered Groin Pain	
4	L = 54 R = 63	4-/5	4-/5	2/6 Hypomobile at T12/L1, L4/L5;Refered Groin Pain	
5	L = 38 R = 39	4-/5	4-/5	2/6 Hypomobile at L3/L4, L4/L5	
Patient	FADIR	FABER	Squeeze Test	Curl Up	Valsalva
1	+ Painful not concordant	-	+ and Weak	+	+
2	+ Painful not concordant	-	+ and Weak	+	+
3	+ Concordant Pain	+	+ and Weak	-	-
4	+ Painful, refered posterior	+	- and Weak	-	-
5	+Painful, concordant hip pain	-	- and Weak	-	-
Patient	Pop/Click/Locking of Hip	Aberrant Motion with LROM	NPRS	Functional Movement Impairment	
1	+	+		7 Pain with single leg squat; Y-Balance Posterolateral Asymmetry = 12	
2	-	+		6 Pain with single leg squat; Y-Balance Posterolateral Asymmetry =5 cm	
3	+	+		7 Pain with overhead squat, lunge, and all Y-Balance	
4	-	+		8 Pain with pivot (Standing hip external rotation) Y-Balance Posteromedial Symmetry =8	
5	-	+		7 Pain with single leg squat, pain with single leg pivot (hip IR/ER)	

** Taken During Participation Phase
*** Only 10 month follow-up available

Abbreviations

ABD=Abduction	ADD=Adduction	FADIR=Flexion-Adduction-Internal Rotation	FABER=Flexion-Abduction-External Rotation		LROM=Lumbar Range of Motion
B=Bilateral	L=Left	R=Right	FLX=Flexion	EXT=Extension	LTD=Limited	ROM=Range of Motion

*Hip Rotation Tested in Prone

Table 2.

Acute Phase Exercise Intervention (Day 1-5)	Sets/Repetitions	Frequency	Intensity	Approximate %1RM
Supine Pelvic Tilt & Abdominal Draw-In	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<3	<60%
Double and Single Leg Glute Bridinging	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<3	<60%
Sub-Maximal Adductor Squeeze in Hooklying	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<2	<60%
Sidelying Hip Abduction	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<3	<60%
Quadruped Hip Extension/Birdog	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<3	<60%
Side Plank	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<3	<60%
Side Plank with Clamshell	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<3	<60%
Prone Hip Internal and External Rotation	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<3	<60%
Prone Abdominal Draw-In with Hip Rotation Manual Perturbations	3x>15 and/or Fatigue	Daily	RPE=4-7 Pain<3	<60%
Conditioning				
Unloaded Long, Slow Aerobic Activity (Arm Ergometer, Stationary Cycle)	1x20-60minutes	3-5x Weekly	60-70% HRMax	Pain Free
Sub-Acute Phase Exercise Intervention (Day 6-19)	**Sets/Repetitions**	**Frequency**	**Intensity**	**Approximate %1RM**
Continue Acute Phase Core Program with Progressions*	2-3x8-12	5xWeekly	RPE=5-8 Pain<2	
Core-X Multi-Movement Circuit with Abdominal Hollowing*	2-3x8-12	5xWeekly	RPE=5-8 Pain<2	
Front Plank*	2-3x45 seconds	3xWeekly	RPE=5-8 Pain<2	
Sub-Maximal Adductor Squeeze at 0/0 with Abdominal Draw-In*	2-3x8-13	3xWeekly	RPE=5-8 Pain<2	
Lateral Step-Ups	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Single Leg Step-Down Variations	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Single Leg Deadleft Regression and Progressions	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Goblet Squat	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Rearfoot Elevated Split Squat	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Hip Thrust	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Lateral Band Walking Abductor Resistance*	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Lateral Band Walking Adductor Resistance*	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Eccentric Hamstring Slides	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Reverse Slide Lunge	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Lateral Adductor Slide Non-Lunge Leg	3x8-12	3xWeekly	RPE=5-8 Pain<3	60-80%
Half-Kneeling Anti-Rotation Cable Press (Horizontal & Overhead)*	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Half-Kneeling Cable Chops*	3x8-12	3xWeekly	RPE=5-8 Pain<2	60-80%
Upper Extremity Resistance Training	3x8-12	2xWeekly	RPE=5-8 Pain=0	70-85%
Conditioning				
Long, Slow Aerobic (Elliptical,Staitonary Cycle, Alter-G, Pool)	30-45 Minutes	2xWeekly	60-70% HRMax	Pain Free
Graded Aerobic/Anaerobic Tempo & Interval Activity (Elliptical, Alter-G, Pool)	20-30 Minutes	1xWeekly	80-90% HRMax	Pain Free
Controlled Plyometric and Agility Drills				
Supervised Sport Skill Drills	20-30 Minutes	1-3xWeekly	60-80% HRMax	Pain Free
*Included in Core Program				
Participation Phase Exercise Intervention (Day 20-Beyond)	**Sets/Repetitions**	**Frequency**	**Intensity**	**Approximate %1RM**
Continue Core Program with Additions from Previous Phase	2-3x6-10	4xWeekly	RPE-6-9	
Front Plank Perturbation and Rollout Variations*	2-3x6-15	3-4xWeekly	RPE-6-9 Pain=0	80-95%
Copenhagen Adduction Isometric Hold*	2-3x15-30 seconds	2xWeekly	RPE-6-9 Pain≤1	80-95%
Lateral & Crossover Step-Ups	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Forward Step-Up with Overhead Kettlebell Press	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Single Leg Step-Down Variations	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Single Leg Deadlift	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Goblet Squat	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Rearfoot Elevated Split Squat	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Eccentric Hamstring Slides	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Reverse Slide Lunge	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Lateral Adductor Slide Non-Lunge Leg	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Lateral Adductor Slide Lunge Leg	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Deadlift Variations (Hexbar and/or Inverted Dumbbell)	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Medicine Ball Slam	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Medicine Ball Overhead Toss	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Half-Kneeling Medicine Ball Lateral Toss	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Kettlebell Swings	2-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Upper Extremity Resistance Training	3-5x4-8	2xWeekly	RPE-6-9 Pain=0	80-95%
Conditioning				
Graded Aerobic/Anaerobic Intervals (Elliptical, Alter-G, Small Sided Games)	20-30 Minutes	1xWeekly	80-90% HRMax	Pain Free
Supervised Sport Skill Participation	45-60 Minutes	4-6xWeekly	60-80% HRMax	Pain Free

Ongoing assessment of the aforementioned impairments was conducted daily with note of the identification of, or changes in any comparable signs.[6,47] MT techniques included, but were not limited to soft tissue mobilization, joint mobilization and manipulation, and dry needling. Intervention was targeted towards the adductor longus & brevis, pectineus, rectus femoris, tensor fascia lata, gluteal musculature, lumbar paraspinals, the thoracic and lumbar spine, the hip joint, and their associated soft tissue structures. (**Figures 1-8**)

Non-aggravating activities initiated in this phase included low-level lumbopelvic exercises recommended in surgical and non-surgical progressions described in previous literature.[43, 44,48,49] The goal of was to promote pain-free motor recruitment of the lumbopelvic musculature and appropriate motor control of the trunk and lower extremity. Of note, isometric exercise was integrated, specifically to the adductor musculature, in part due to its potential pain-modulating effects.[33,41,50] (**Figure 9**)

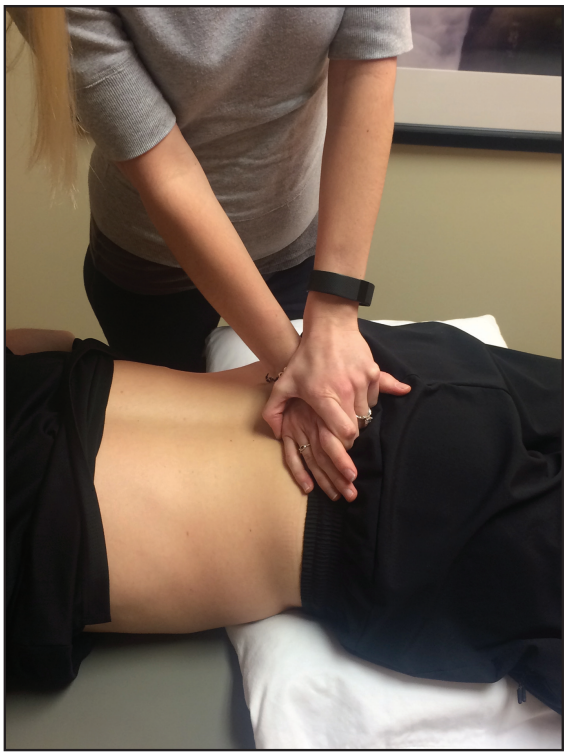

Figure 1. *Lumbar Posterior to Anterior Central and Unilateral Graded Mobilization.*

Figure 2. *Supine Lumbopelvic Manipulation.*

Figure 3. *Supine Thoracolumbar Extension Manipulation.*

Sub-Acute

Progression to this phase was dependent upon a clinically significant (minimal clinically important difference) reduction in pain , pain-free ROM and improved strength.[18,33] MT utilization was reduced

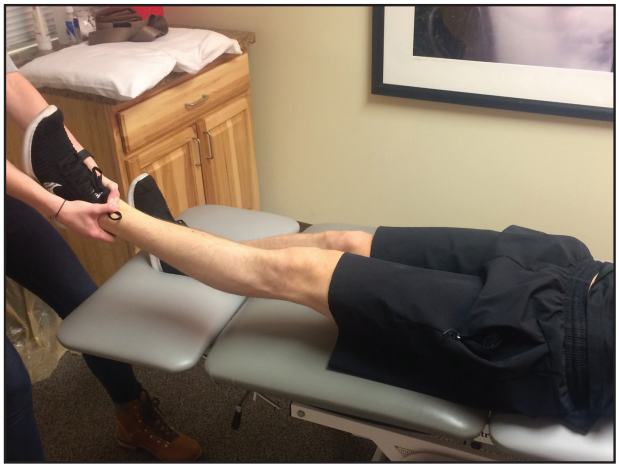

Figure 4. *Long Axis Traction Hip Manipulation.*

Figure 5. *Inferior and Lateral Glide Hip Mobilization.*

Figure 6. *Posterior Glide Hip Mobilization.*

Figure 7. *Prone FABER Hip Mobilization.*

Figure 8. *Soft Tissue Mobilization of the Adductor Musculature and Related Soft Tissues.*

Figure 9. *Adduction Squeeze at 45 degrees.*

Figure 10. *Self Hip Mobilization -Posterior Glide-Hip Extension.*

Figure 11. *Self Hip Mobilization - Hip Flexion - Inferior Glide.*

to approximately two to three times per week, with techniques continued from the first phase of treatment. Foam rolling of the lumbopelvic and lower extremity soft-tissues and pain-free self-mobility exercise, such as band assisted mobilization with movement of the hip[29,30] was implemented to continue to improve regional mobility as appropriate while promoting self-efficacy and avoid reliance on manual therapy. (**Figures 10-13**)

Figure 12. *Self Hip Mobilization - Squat Mobilization with Movement.*

Figure 13. *Self Hip Mobilization - Posterior Glide - External Rotation - Posterior Glide.*

Treatment was progressed to include increased closed chain and single leg exercises, due to their motor recruitment abilities, regional interplay and specificity to sport.[18,24,51] (Table 3) A focus on eccentric-based exercise was implemented based on findings supporting its impact on mobility, strength, and injury risk.[52,53,54] Core exercise was progression from specific stabilization[55] techniques to more general stabilization and strengthening exercises that focus on global recruitment and muscle synergies. Tasks such and jogging, shuffling, jumping and skill development were implemented along

Table 3.

Acute Phase (Day 1-5)		
Manual Therapy Intervention Technique	**Sets/Repetitions**	**Frequency**
Hip Long Axis Distraction Mobilization & Manipulation	3x30 and/or Change in Asterisk Sign	3-5x weekly
Anterior to Posterior Hip Mobilization	3x30 and/or Change in Asterisk Sign	3-5x weekly
Inferior Hip Mobilization	3x30 and/or Change in Asterisk Sign	3-5x weekly
Lumbopelvic Manipulation	1x1-2 and/or Change in Asterisk Sign	3-5x weekly
Thoracic and Thoracolumbar Manipulation	1x1-2 and/or Change in Asterisk Sign	3-5x weekly
Lumbar Central and Unilateral Posterior to Anterior Mobilization	3x30 and/or Change in Asterisk Sign	3-5x weekly
Lumbopelvic Soft Tissue Mobilization	Until Change in Reported Pain or ROM Asterisk Sign	3-5x weekly
Dry Needling (i.e Adductor Longus, Tensor Fasciae Latae)	1-6 Twitch Responses	PRN
Sub-Acute Phase (Day 6-19)		
Manual Therapy Intervention Technique	**Sets/Repetitions**	**Frequency**
Hip Long Axis Distraction Mobilization & Manipulation	3x30 and/or Change in Asterisk Sign	1-3x weekly
Anterior to Posterior Hip Mobilization	3x30 and/or Change in Asterisk Sign	1-3x weekly
Inferior Hip Mobilization	3x30 and/or Change in Asterisk Sign	1-3x weekly
Lumbopelvic Manipulation	1x1-2 and/or Change in Asterisk Sign	1-3x weekly
Thoracic and Thoracolumbar Manipulation	1x1-2 and/or Change in Asterisk Sign	1-3x weekly
Lumbar Central and Unilateral Posterior to Anterior Mobilization	3x30 and/or Change in Asterisk Sign	1-3x weekly
Lumbopelvic Soft Tissue Mobilization	Until Change in Reported Pain or ROM Asterisk Sign	2-3x weekly
Dry Needling (i.e Adductor Longus, Tensor Fasciae Latae)	1-6 Twitch Responses	PRN
Hip Mobilization With Movement Variations	3x15	2-3x weekly
Self-Soft Tissue Mobilization (Foam Rolling)	Each Lower Extremity Muscle Group to Change in Pain and/or ROM	1-3x weekly
Participation Phase (Day 20-Beyond)		
Manual Therapy Intervention Technique	**Sets/Repetitions**	**Frequency**
Hip Long Axis Distraction Mobilization & Manipulation	3x30 and/or Change in Asterisk Sign	1-2x weekly
Anterior to Posterior Hip Mobilization	3x30 and/or Change in Asterisk Sign	1-3x weekly
Inferior Hip Mobilization	3x30 and/or Change in Asterisk Sign	1-3x weekly
Lumbopelvic Manipulation	1x1-2 and/or Change in Asterisk Sign	PRN
Thoracic and Thoracolumbar Manipulation	1x1-2 and/or Change in Asterisk Sign	PRN
Lumbar Central and Unilateral Posterior to Anterior Mobilization	3x30 and/or Change in Asterisk Sign	PRN
Lumbopelvic Soft Tissue Mobilization	Until Change in Reported Pain or ROM Asterisk Sign	1-2x weekly
Dry Needling (i.e Adductor Longus, Tensor Fasciae Latae)	1-6 Twitch Responses	PRN
Hip Mobilization With Movement Variations	3x15	2-3x weekly
Self-Soft Tissue Mobilization (Foam Rolling)	Each Lower Extremity Muscle Group to Change in Pain and/or ROM	1-3x weekly

PRN=As Needed

*Target Regions for Self-Soft Tissue Mobilization**

Adductor Group

Tensor Fascia Latae/Lateral Quadriceps

Posterior Hip (Gluteal Group/Hip Rotators)

with continued sport-specific cardiovascular conditioning.[56] In this phase, four out of five subjects returned to sport participation and/or competition. (**Figures 14-20**)

Participation

All subjects continued an individualized management program[37,43,57] in the participation phase of rehabilitation that continued to focus on regional mobility, stability, strength, and power deficits. The strength and conditioning staffs primarily implemented exercise programs during this phase while the team medical staff continually monitored the athletes' status. Each player's plan of care consisted of booster sessions[57] of MT that was reinforced through exercise in their respective strength and conditioning programs. Continued assessment using objective measures such as the HAGOS, Y-Balance Test, Adductor Squeeze Testing, and additional movement assessment throughout the athlete's course of care assisted in clinical decision making, providing the clinicians with valuable information regarding severity and irritability of symptoms, response to manual interventions, progress of rehabilitation,

Figure 14. *Eccentric Adduction Walks.*

Figure 16. *Rearfoot Elevated Split Squat.*

Figure 15. *Single Leg Deadlift.*

Figure 17. *Eccentric Based SL Squat Variation.*

Figure 18. *Core-X Pivot Squat.*

Figure 19. *Lateral Slide Lunge.*

readiness for participation, and level of function while participating in sport.

Subject Specific Intervention Strategies

Due to common regional impairments and the capabilities of a balanced strength and conditioning program, the exercise interventions were very similar across all subjects and are described in Table 3. The identification of a movement based comparable sign, or asterisk sign, was the baseline daily measure for the need for manual therapy. Although all subjects received each of the described interventions, the pragmatic application of interventions resulted in slight differences for each subject. Individual management plans were based off of intervention responses within the acute and sub-acute phases and continued throughout the participation phase.

Figure 20. *Hip Adduction Plank.*

Subject 1

In the acute phase, the application of soft tissue mobilization and dry needling to the adductor musculature resulted in reports of decreased groin 'tightness' and overall pain reductions on the NPRS. Graded hip mobilization was prioritized in the sub-acute phase, resulting in decreased pain with single leg squatting. Pain-free adductor squeeze exercises, adductor plank isometrics, and eccentric lunge variations in the participation phase coincided with improved performance on the HAGOS Sport. (**Figure 21**)

Subject 2

The subject showed a positive response to soft tissue mobilization of the adductor longus and pectineus in the acute phase. Graded joint mobilization of the lumbar spine resulted in improved capability of abdominal drawing-in exercises, which decreased reported pain in the groin, the pubic symphysis and

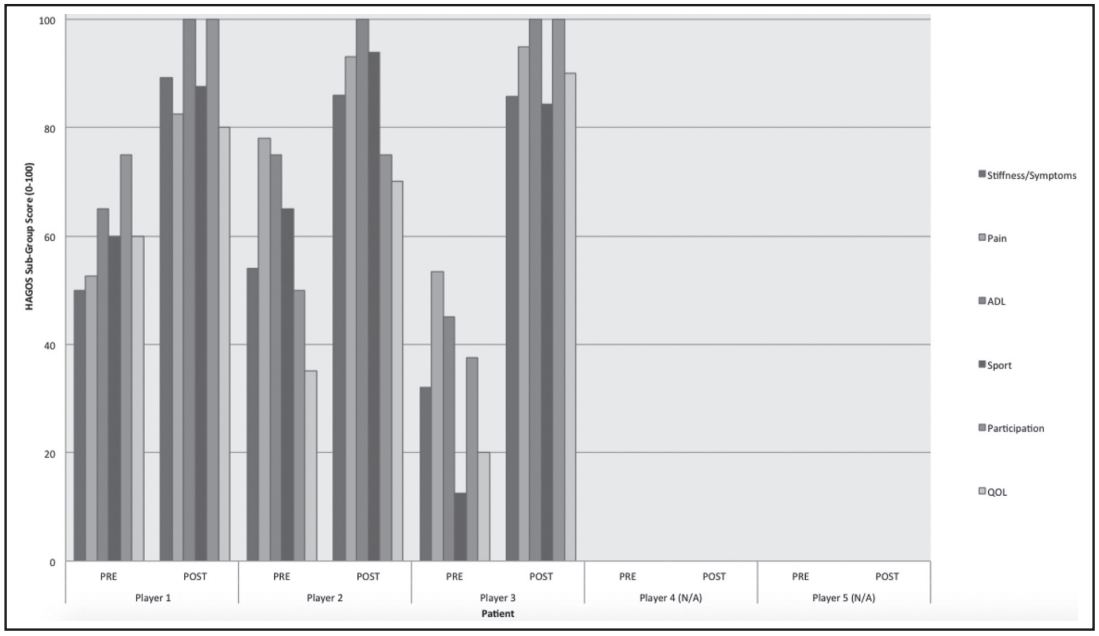

Figure 21. *HAGOS Outcomes.*

proximal adductor longus attachment . Joint-based mobilization techniques were continued into the sub-acute phase, as they were preferred over manipulation by the subject. Adductor squeeze assessment[33] corresponded with the severity of functional complaints during subject management in the participation phase. This was utilized to grade the intensity of core exercise, with isometrics taking priority when symptom presentation was severe. (Figure 9)

Subject 3

The subject initially presented with an inability to perform a posterior pelvic tilt. Anterior hip pain was reproduced with posterior to anterior spinal mobility assessment (T12/L1, L4/L5). Spinal manipulation and graded lumbar mobilization resulted in visual and palpable improvement in motor control during a posterior pelvic tilt while decreasing the report of 'pinching' in his groin with a double leg squat and forward lunge. Hip joint mobilization and iliopsoas and adductor complex soft tissue mobilization in the sub-acute phase resulted in pain-free performance of the double leg squat. Hip mobilization using mobilization with movement techniques decreased symptoms in the forward lunge and single leg squat. Upon the resolution of pain, posterior pelvic tilt and 'neutral' spine motor control drills were reinforced into similar movement patterns.

Subject 4

Due to the acute onset of LBP, spinal manipulation was favored in the acute phase. Hip internal rotation assessed in supine (90 degrees of hip flexion) and prone (0 degrees of hip flexion) also produced the concordant pain. Graded lumbar mobilization was utilized, as mobility assessment (T12/L1, L4/L5) reproduced lumbar and groin symptoms. Graded hip mobilization was prioritized moving into the sub-acute and participation phases. This was supplemented with gluteal group dominant motor control exercises, with the intention of dynamically stabilizing aberrant lumbopelvic motion and rotary hip motions.

Subject 5

Within the acute phase, the subject demonstrated good intra-session improvements with soft tissue mobilization to the iliopsoas, adductor longus, and myotendinous region of the pectineus and it's tenoperiosteal junctions. Hip mobilization with movement for internal and external rotation was performed with a belt, followed by a long axis hip thrust manipulation. Lastly, the subject was provided a supine lumbopelvic manipulation technique by the

treating physical therapist.[8,46] These interventions immediately increasingly reduced both his inferior lumbar and medial hip symptoms. After several sessions, the treatment focused shifted trunk stability exercises in supine, then quadruped, and finally in weight bearing that emphasized a stable trunk during concurrent extremity movement. When the ability to demonstrate a dynamically stable pelvis coinciding with a significant decrease in pain was achieved, exercise was progressed to more global, movement-based exercise patterns in the sub-acute and participation phases.

OUTCOMES

All subjects were managed conservatively within their competitive seasons and training cycles. Players were able to maintain sport performance at or above their prior levels of function with significant reductions in reported pain upon returning to participation and competition. (Table 4)

Subject 1

Initially, the athlete was withheld from two practices. Due to scheduling, one week of active rest occurred two weeks after the initial examination, in which non-aggravating cardiovascular activity and basic lumbopelvic exercise[48,56] were performed. No competitive games were missed. The subject's NPRS and HAGOS (Figure 1**)** both improved by the minimal clinically important difference by the participation phase. The athlete re-aggravated his injury two weeks following the completion of the initial bout of rehabilitation, increasing his NPRS to a 6/10. The rehabilitation protocol resumed, continuing through the end of the season, with pain decreasing to a weekly average of 2/10 and resulting in only two additional missed practices. At one-year follow-up, the athlete reported no groin pain (0/10) or groin tightness. The athlete sustained a grade three right adductor longus strain the following competitive season.

Subject 2

No significant changes were made for four weeks following the initial diagnosis and treatment. A scheduled break in competition allowed for the acute phase of rehabilitation to then appropriately take place with no games to be missed. Practice

Table 4.

	Outcomes				
Patient	NPRS**	HAGOS Sport**	Hip ROM Impression**	Hip Strength Impression**	Special Testing
1	0	87.5	Painfree, Symetrical	WFL	All (-), FADIR Uncomfortable
2	1	94	Painfree, Asymetrical	WFL	All (-), FADIR Uncomfortable
3	1	84.4	Painfree, Symetrical	WFL	All (-), FADIR Uncomfortable
4	0	N/A	Painfree, Asymetrical	WFL	All (-), FADIR/FADER Uncomfortable
5	0	N/A	Painfree, Asymetrical	WFL	All (-), FADIR Uncomfortable
Patient	Games Missed	Functional Impairment	1 Year NPRS at Worst	1 Year Follow-Up Subjective Complaints	
1		0 Pain-free FMS/Y-Balance/Single leg squat		0 Occasional stiffness/tightness	
2***		0 Pain-free FMS/Y-Balance/Single leg squat		Relief lasting for 6 months with gradual return of symptoms.	
				Completed competitive season & referred for surgical consultation	
3		2 Pain-free FMS/Y-Balance/Single leg squat		1 Rare soreness	
4		1 Pain-free FMS/Y-Balance/Single leg squat		0 No complaints	
5		5 Painfree FMS/Y-Balance/Force Plate Jumping		7 One episode of low back pain resulting in 5 missed games	

** Taken During Participation Phase
*** Only 10 month follow-up available

Abbreviations
ABD=Abduction ADD=Adduction FADIR=Flexion-Adduction-Internal Rotation FABER=Flexion-Abduction-External Rotation LROM=Lumbar Range of Motion
B=Bilateral L=Left R=Right FLX=Flexion EXT=Extension LTD=Limited ROM=Range of Motion
*Hip Rotation Tested in Prone

was missed for two weeks before graded reconditioning[56] and sporting skill drills were allowed. The subject returned to full participation six weeks following initial evaluation. Significant improvement was noted on outcome measures along with full participation of the following season. After six months of relief, signs and symptoms gradually returned. The individual was referred for surgical consultation, underwent surgical repair, and returned to participation in 8 weeks. It was hypothesized that the chronic nature of his condition (>six months prior to initial evaluation) contributed to the response to conservative care.

Subject 3

The subject missed the final two games of the season following the injury. Initial physical therapy evaluation occurred into the off-season, approximately eight weeks following the end of the season, with no on-going sport participation. Upon beginning the sub-acute phase, rehabilitation was performed by his team athletic trainer. The subject returned to skating at 12 weeks post-injury and full participation at the beginning of the preseason. Surgical management of the condition was no longer indicated as the athlete decided to initially trial conservative care, and the subject was able to complete the following competitive season with an increase in playing time from the prior season.

Subject 4

The subject missed one practice and one game before returning to competition. It was hypothesized that the lack of regional mobility and segmental control created on uneven load through the region, creating non-specific LBP and referred groin pain.[2,12,13] The subject quickly progressed through the sub-acute phase, returning to competition and continuing a management plan in the participation phase with no return of symptoms that limited performance or participation.

Subject 5

The subject missed two weeks of preseason basketball training before resuming graded basketball and weight room activities. Given the chronic nature of his L5-S1 spondylolisthesis, the authors' believe his significant hip mobility impairments bilaterally, magnified during terminal stance phase (push-off) while running, contributed to increased stress to his inferior lumbar spine. The subject was able to play in a competitive game four weeks from his symptom onset.

DISCUSSION

This case series depicts the complex, yet similar clinical presentation and impairment-based management of five elite athletes. Common anatomical features such as posture and bony hip morphology may impact function[23,24,35,36] and potentially result in pathology. However, asymptomatic findings and concurrent pathoanatomical diagnoses make treating specific structures challenging. Clinical findings and identification of movement-based functional impairments guide treatment beyond a single structure.[4,5,18,23,24] Key clinical findings in this case series were consistent with risk factors for athletic hip, groin and low back pain previously identified in the literature.[1,6]

Initial treatment focused on pain reduction while promoting exercise that addressed identified functional impairments and risk factors, and is consistent with conservative management of similarly described cases. [4,5,48,49] While morphological presentation may restrict an individual to a predisposed and compensatory regional ROM, addressing these restrictions with manual therapy may illicit comprehensive neurophysiological[45]and mechanical[30,44] effects that facilitate the retraining of impaired movement patterns and sporting tasks.[58,59] The mechanical focus of MT at the hip was to improve the inferior and posterior glide of the hip while reducing the anterior stress on the joint.[44] MT directed at the spine was implemented to induce positive changes in pelvic posture by reducing anterior pelvic tilt, increasing local mobility, and facilitating motor control.[4,5,8] Neurophysiological effects may inhibit pain, reduce subjective reports of tightness, and enhance exercise interventions.[45,57,58] Reinforcing ROM improvements through exercise may lead to lasting ROM development.[29,30] It is hypothesized that improving ROM may alter movement patterns[24,37] and favorably modify the distribution of force about the pelvis, positively impacting dynamic movement.

However, increases in mobility may be transient and overall load tolerance is likely crucial to the

outcomes in these cases. The regional synergy required to athletically move about and stabilize the pelvis place an importance on addressing muscle imbalances,[18,31,32] motor control,[37] strength, power and work capacity abilities via an appropriately loaded training program[60] in order to allow the athlete to develop a resistance to risk factors while preparing for sport.[61]

The exercise programs that were prescribed in these cases potentially served to dynamically stabilize the lumbopelvic region and may have improved force distribution and load tolerance,[63] while unloading irritated structures and building a tolerance to repeated bouts of sporting activity. Additionally, a focus was placed on motor control of the lumbopelvic region and lower extremity during single leg movements.[35,36,44] The exercise progression described, particularly in the sub-acute phase, is thought to be clinically significant, as advancing a training stimulus targeting the kinetic chain[62] may have greater impact on the movement system as compared to structure specific exercise.[18]

In the presence of performance limiting pathology, training load should be monitored and adjusted accordingly to address risk factors while decreasing the stress on irritated structures. As described in the second subject, there is a high risk of re-injury risk following an initially successful bout of conservative care, thus, high priority was placed on graded sport reconditioning throughout rehabilitation, as it is important to avoid any drastic increases in training load (i.e appropriate acute:chronic workload ratio) in order to reduce the risk of re-injury while returning to prior levels of participation. Once symptoms are improved, continuing an individualized program may be beneficial in further reducing this risk.[23,24,43]

Additional treatment sessions including manual therapy and exercise, like those implemented in this case series, may be beneficial in the long-term management of athletes, as they continue to address any potential long-term impairments[14,22,32,36,63] and may improve outcomes.[57] For comparison, it is common practice for baseball pitchers to perform an individualized throwers program in the presence of sport-specific morphological adaptations. Further research may indicate if similar programs are beneficial for the treatment and risk reduction for the sub-group identified in this case series.

Differences in pathoanatomic profiles, limited research, individualized care, and subtle variations in outcome measure utilization are limitations of this case series. Such limitations exist in all case report and case series research. Reporting of sports performance measures would have been valuable in assessing return to sport outcomes in this case series and should be used in the future. There appears to be a need for clinical trials identifying related clinical impairments and the best course of intervention to address these limitations.

CONCLUSION

Physical rehabilitation plays a large role in the treatment of athletes who experience hip, groin, and low back pain despite the lack of standardized guidelines for the conservative treatment of these conditions. Comprehensive intervention and on-going management strategies focused on addressing shared regional impairments may be of benefit for a sub-group of individuals, potentially enabling athletes to safely continue participation in sport with minimal time competition time lost.

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