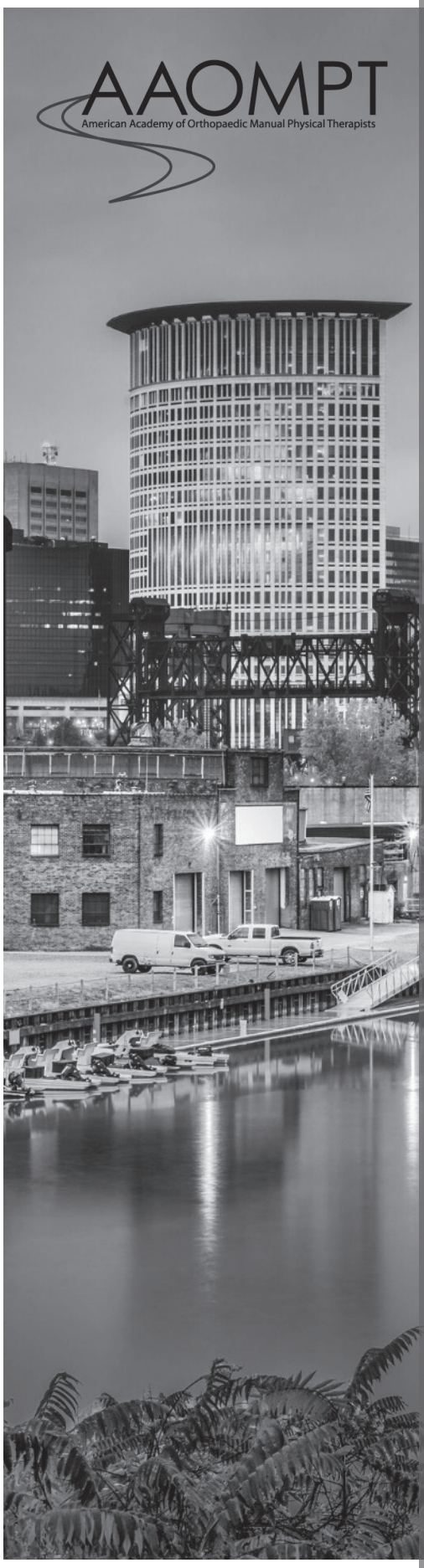
2021 / volume 33 / number 2

ORTHOPAEDIC PHYSICAL THERAPY PRACTICE

The publication of the Academy of Orthopaedic Physical Therapy, APTA

FEATURE:
Retrospective View of Patellofemoral Pain Classification Subcategories in a Marathon Runner: A Case Report

APTA American Physical Therapy Association



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The publication of the Academy of Orthopaedic Physical Therapy, APTA

In this issue

Regular features

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Editor's Note

In the year of our centennial, I hope to highlight some of our history to show how far we have come and the vision to keep going!

The APTA started as the American Women's Physical Therapeutic Association and changed its name to the American Physiotherapy Association in 1922.[1,2] In 1921, there were 274 members from 32 states across the United States. The first annual conference was held in Boston on September 13-16, 1922, with an attendance of 63 reconstruction aides.[1] The association's journal debuted in 1921 and was called the *P.T. Review*, a free publication.[3] The salary of assigned Physical Therapy Aides, as they were called in 1942 was $1,800 per year, less deductions for subsistence and quarters, when furnished.[1,3]

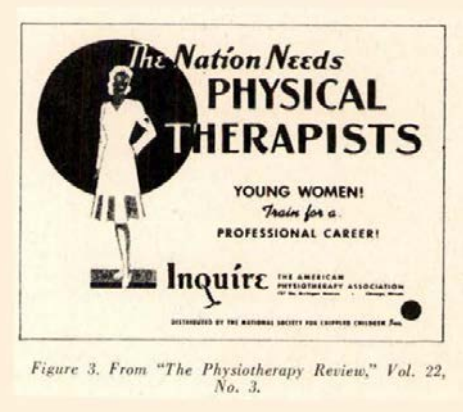

Figure 3. From "The Physiotherapy Review," Vol. 22, No. 3.

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"There is a great need for more physical therapy technicians to serve with the armed forces, and we realize also that many technicians are necessary for civilian care. In order to meet this demand more students must be enrolled and trained. Our schools are 'geared up' to do the job and we must keep the enrollment at its maximum.

Help our profession by encouraging and urging graduates from schools of physical education and students with two years of college, including twenty-six hours of science (courses in chemistry, physics and biology), to enroll in physical therapy courses.... Make it your individual responsibility to procure one or more new students, and we cannot fail to provide our armed forces with the necessary technicians of physical therapy who are needed as a vital part of the rehabilitation of our wounded. We must all do our part."

Mildred Elson
Editor-in-Chief
The Physiotherapy Review 1942;22(2):100

Figure 6. Ankle exerciser. From "The Physiotherapy Review," Vol. 25, No. 6.

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In order to consider where we are going, we have to consider where we came from. We need to have strategic foresight to consider our path to the future. Before the pandemic, the AOPT set forth to do just that by creating bold Vision and Mission statements. VISION: The Academy of Orthopaedic Physical Therapy will be a World leader in providing services to optimize movement and musculoskeletal health. MISSION: The Academy of Orthopaedic Physical Therapy empowers members to excel in orthopaedic physical therapy.

Look at the picture above again. How far have we come? What can each of us do to move forward towards our vision and mission?

Respectfully submitted,
John Heick, PT, PhD, DPT
Board certified in Orthopaedics, Sports, and Neurology

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2020 AOPT Historian Report

Tyler Shultz, PT, DPT, OCS

Driven by the global COVID-19 Pandemic, there is no doubt that 2020 was a year full of challenges and change for individuals, organizations, and society. Unfortunately, many individuals faced isolation, financial hardship, and the stress of dealing with personal effects of the pandemic. At the same time, many professional organizations struggled with the ability to provide members with resources needed to continue to provide patient care in this new health care landscape. Despite numerous challenges, the Academy continued to provide its members with leadership and resources. Additionally, the Academy continued to experience healthy membership levels, clear leadership, and continued to make contributions to the profession in the terms of education, research, and advancing orthopaedic physical therapy practice.

MEMBERSHIP

The current strategic position of the Academy was set by the current and past leadership and staff, and supported by the hard work from many volunteers. 2020 marks the end of the previous strategic plan, and the new Strategic Framework will be implemented in January 2021.

Total Academy membership at the close of 2020 was 18,049 members, a decrease of 7% from 2019. The AOPT membership decrease of 7% was marginally higher than the 5% decrease experienced by the APTA as a whole. A 4-year, year-over-year membership comparison to APTA change is seen in **Figure 1**. AOPT membership numbers were stable over the previous 3 years; however, the decline in membership in 2020 is likely due to financial constraints due to the Covid-19 pandemic. Total membership in the Academy (PT, PTA, SPT, SPTA members) represents 18.2% of overall APTA membership, despite decreased membership overall, this has stayed constant. The Academy continues to be the largest in the APTA by a wide margin. The next largest is the Academy of Sports Physical Therapy with 7,228 members.

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STANDARDS OF PRACTICE

The Academy has continued to make significant progress towards its vision of providing resources to optimize movement and musculoskeletal health. Part of the Academy's strategic framework is to promote the development and implementation of evidence to best practice. One initiative to achieve this is the publication of Clinical Practice Guidelines (CPGs) and continuing to develop advanced methods for providing educational content through the Independent Study Course (ISC) program. The Academy continued to make significant progress towards both initiatives in 2020. Additionally, the Academy provided resources to the membership to address the challenges of treating patients during the Covid-19 pandemic.

Figure 1. Year-over-year Membership Comparison to APTA

	AOPT Members	AOPT YoY # Change	AOPT YoY % Change	APTA YoY % Change
2020	18,049	- 1,363	- 7.02%	- 4.82%
2019	19,412	+ 39	+ 0.2%	- 0.13%
2018	19,373	- 340	- 1.72%	+ 2.51%
2017	19,713	+ 173	+ 0.88%	+ 6.07%

Currently, there are 15 CPG topics covered with 6 being on their second update since initial publication for a total of 21 publications. At the close of 2020, there are 6 CPGs in the revision stage and 9 are in the development stages. The following CPGs were added in 2020, and published in the *Journal of Orthopaedic and Sports Physical Therapy (JOSPT)*:

- *Physical Therapy Evaluation and Treatment after Concussion/Mild Traumatic Brain Injury*; Quatman-Yates et al. In collaboration with the Neurology Section and Sports Section.

There were no guideline topics with published revisions in 2020.

The Independent Study Courses (ISCs) offered by the Academy have been transitioned to an online/online plus print system, available at orthopt.org. Additionally, the ISCs continue to be an important contributor to the non-dues revenue of the Academy. The high-quality repository of topics continues to be developed and made available to both members and non-members of the Academy.

The AOPT worked individually and in collaboration with other Academies and with the APTA to respond to the Covid-19 pandemic. The Academy provided a resource list, which included information in the form of webinars, resource documents, and discussion forums. These resources provided membership with information regarding patient care, residency and fellowship education, and regulations.

EDUCATION AND PROFESSIONAL DEVELOPMENT

The Academy has continued to make progress toward education and professional development on several fronts. The Academy has continued to advance participation at CSM, increased growth of Orthopaedic Residency and Fellowship education, and continued to develop the Mentorship Program.

The 2020 Combined Sections Meeting was held February 12-15 in Denver, CO. The Academy accepted and presented 27 educational sessions and sponsored 1 preconference course. 2021 CSM is virtual and the Academy looks forward to providing continued course sponsorship in the new virtual format.

Orthopaedic residency and fellowship education has continued to increase in 2020. The American Board of Physical Therapy Residency and Fellowship Education (ABPTRFE) recognized 117 accredited Orthopaedic Residency programs at the end 2020. Additionally, there are 22 candidate programs and 13 developing programs. The ABPTRFE recognizes 43 accredited Orthopaedic Manual Physical Therapy Fellowships, with 3 candidate programs. There are 3 accredited and 2 candidate Spine Fellowship programs at the close of 2020.

The Membership Committee continued to sponsor the Mentorship Program in 2020 that matched 15 students. Areas of mentoring include research, academics/teaching, manual therapy, leadership, and private practice. The program is led by Megan Poll, PT, DPT, OCS, Membership Chair.

RESEARCH

In 2020 the Small Grant Program sponsored by the Academy awarded over $63,000 to researchers to further orthopaedic physical therapy research.

SUMMARY

Despite the lingering effects of a global pandemic, the Academy continued to make progress consistent with past year-to-year performance and should expect continued positive trajectory. Although membership numbers were down slightly, it should be noted that last quarter numbers suggest a quick recovery back to pre-Covid membership numbers, despite overall APTA membership being the lowest in November 2020. In 2021, the Academy looks forward to celebrating the APTA's 100-year Anniversary.

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Richard W. Bowling - Richard E. Erhard Orthopaedic Clinical Practice	*Not awarded in 2020*
Paris Distinguished Service	Joseph Godges, DPT University of Southern California

Retrospective View of Patellofemoral Pain Classification Subcategories in a Marathon Runner: A Case Report

Angela Huber, PT, DPT, OCS

Physical Therapist, PT Services Rehabilitation, Ottawa, OH & Assistant Professor of Physical Therapy, University of Findlay Doctor of Physical Therapy Traditional and Weekend Programs, Findlay, OH

ABSTRACT

Background and Purpose: Long-distance running can create an overload on the knee, predisposing runners to patellofemoral pain syndrome (PFPS). The PFPS Clinical Practice Guidelines proposed 4 impairment/function-based classification subcategories to guide intervention, but not specifically for distance runners. The purpose of this case report was to apply clinical reasoning retrospectively in review of multimodal interventions in a marathon runner with PFPS. **Methods:** The patient was a 33-year-old male distance runner with PFPS. Multimodal intervention addressed the subcategories along with immediate patient-specific training education and gait retraining. **Findings:** The patient ran without pain after 4 visits. He completed 8 visits total and subsequently 6 months later completed a marathon without pain. **Clinical Relevance/Conclusion:** The findings of this case highlight immediate, patient-specific inclusion of training education and gait retraining supports early pain relief. Multimodal intervention from all 4 subcategories resulted in long-term pain relief and prevention of reinjury during a progressive increase in running mileage.

Key Words: gait, knee, running, training

BACKGROUND AND PURPOSE

Running-related injuries in distance runners range from 19.4% to 79.3%, with an incidence of knee injury ranging between 7.2% and 50%.[1] One author noted that during training in the year prior to a marathon, 54.8% of male runners suffered an injury with 79.6% of these injuries occurring during training sessions. In these training sessions, the knee is the most common injury site.[2] Runners have an increased risk of new injury after their initial injury, and marathon runners are at greater risk for running-related injuries due to high weekly mileage and high running frequency,[1,3] complicating prognosis for running participation.

Runners with patellofemoral pain (PFPS) have altered biomechanics[4-6] and may have multiple training factors associated with injury.[1,3] This complexity of evaluating a patient and considering multiple factors that influence PFPS is difficult and involves more than just evaluating mobility and measuring performance. In an attempt to resolve some of the complexity in treating a patient with PFPS, Willy et al published a Clinical Practice Guideline (CPG) for patellofemoral pain. Willy et al proposed 4 PFPS Impairment/Function-Based Classification Subcategories linked to the International Classification of Functioning, Disability, and Health Model. These subcategories include Overuse/Overload, Muscle Performance Deficits, Movement Coordination Deficits, and Mobility Impairments.[7]

Multimodal intervention is recommended in the treatment of PFPS, although, the best combination of interventions is yet to be determined.[7] Education regarding training should be an integral part of interventions[8] to match load expectations with soft tissue stress tolerance. Gait retraining reduces pain and improves biomechanics in injured runners with PFPS, but the best type and schedule of feedback, retraining dosage, and gait correction techniques of greatest priority are not well defined in the literature.[9] Video analysis using two-dimensional (2-D) video can elucidate group differences in kinematic variables during running,[10] and intra-rater reliability (k_w>.80) improves with clinician experience.[11] While video applications for devices are being used in the clinic, published clinical cases using 2-D video analysis are lacking.

Exercise prescription is an intervention priority for patients with PFPS. Combined proximal hip and knee targeted exercise have been shown to optimize pain and function in patients with PFPS.[12] Treating soft tissue structures that lack mobility in patients with PFPS is common in clinical practice. Authors have noted that specifically the hamstring, gastrocnemius, soleus, quadriceps, and iliotibial band lack flexibility in patients with PFPS.[13] However, the time commitment to achieve high mileage necessary to run a marathon provides a unique challenge to the implementation of exercise programs in the running athlete.

The purpose of this case report was to provide a physical therapy evaluation and multimodal intervention framework using shared decision-making[14] in an injured male distance runner training for his first marathon. The patient in this case presented with a new onset of PFPS before the publication of the Patellofemoral Pain Clinical Practice Guideline. Retrospective subcategorization following Impairment/Function-Based Classification of Patellofemoral Pain Syndrome is presented to provide a clinical reasoning framework for prioritization of evaluation and interventions. A patient-specific multimodal intervention approach was used to address multiple lower extremity pain locations and the patient-specific goal of running his first marathon was weighted into the plan of care decisions.

CASE DESCRIPTION

Patient History

The patient was a 33-year-old male runner with a chief complaint of left peripatellar knee pain, preceded by left anterior ankle pain, which was described as sharp during a half marathon 6 weeks before the initial evaluation. The patient ceased running for 2 weeks after his initial injury and then attempted to return to running over 4 weeks, but was limited by continuous sharp anterior and peripatellar left knee pain upon footstrike rated at 6/10 on the Numeric Pain Rating Scale (NPRS). The primary functional outcome measure used was the Patient-Specific Functional Scale (PSFS), which measures activity difficulty on an 11-point scale from 0 (unable to perform) to 10 (able to perform at the same level before injury).[15] The patient rated running at 1/10, jumping 7/10, and squatting 6/10. He also reported left knee stiffness after 4 hours of sitting during work. Since the injury, the patient continued with unmodified cross-fit classes 3 to 4 days a week. His past medical history consisted of infrequent migraines and low back pain with left radiculopathy. A lumbar magnetic resonance imaging confirmed central and left

paracentral disc herniation/protrusion at the L5-S1 vertebral level with severe left lateral canal stenosis 2 years prior. At that time, the patient received 2 left L5-S1 transforaminal epidurals (Dexamethasone and Lidocaine) and one caudal epidural (Bupivacaine and Lidocaine). The patient, although unconcerned with the lumbar history, reported his left lower extremity numbness worsened after prolonged running. Care of this patient met the Health Insurance, Portability, and Accountability Act (HIPAA) requirements for the protection of health information.

Clinical impression #1

The initial clinical impression was a likely diagnosis of left PFPS due to overload with differential diagnosis of iliotibial band syndrome, patellar tendinitis, or meniscal tear. Anterior talocrural joint impingement was also suspected. International Classification of Function Activity Limitations included squatting, jumping, and running. Participation restrictions included an inability to participate in running in preparation for marathon completion and prolonged sitting discomfort brought on by work requirements. Personal factors that had the potential to negatively influence function included habitual training and high motivation to finish the marathon on a timeline set before injury. A positive personal factor included an established habit of regular physical activity.

Examination

A general clinic medical intake form along with the subjective interview confirmed no night pain, unexplained weight loss, or bowel and bladder changes. The past medical history revealed no current or past diagnosis related to the renal, immune, hepatic, cardiopulmonary, and endocrine systems. No integumentary impairments were noted by observation. The chronic numbness and tingling along with the history of disc herniation/protrusion indicated further lumbar screening was necessary. The primary system with impairment was the musculoskeletal system leading to detailed tests and measures. The patient ambulated with no antalgic or gait disturbance. Observation revealed no effusion or edema, although the patient reported mild left anterior knee swelling at the initial onset of symptoms. The patient exhibited bilateral pes planus, bilateral patella baja, normal left lower extremity Q angle of 7°, and neutral spinal posture in standing. Lumbar active range of motion was normal and repeated motion testing did not reproduce symptoms. Radicular symptoms, when present, followed a fifth vertebral dermatomal pattern but there was no sensory loss to light touch. The patient exhibited 5/5 bilateral knee manual muscle testing, but weakness at the lower abdominals, trunk extension, bilateral hip extension, and left greater than right hip abduction. Myotomes were 5/5 except at L3 and L4 as noted by bilateral hip extension and left greater than right hip abduction weakness. The patient's left knee lacked 2° of knee extension active range of motion and had a deficit of 5° of flexion active range of motion compared to the uninvolved knee. The left patellofemoral joint was hypomobile in the inferior and superior directions and the left talocrural joint was hypomobile in the posterior direction. The rectus femoris, iliopsoas, gastrocnemius, and hamstring flexibility were limited bilaterally. The straight leg raise test was negative bilaterally. No concordant pain was created with palpation of the left knee joint line, left iliotibial band, lumbar vertebrae, sacroiliac joint, or left knee and ankle ligamentous structures. The patient was mildly tender at the left patellar tendon. **Table 1** provides a detailed description of the test and measures results.

The initial clinical impression of PFPS indicated a need for thorough special testing and diagnostic criteria assessment to rule out other conditions. Meniscal Pathology Composite Score[16] revealed 4/5 negative findings; no history of catching or locking, a negative McMurray, negative joint line tenderness, and negative pain with forced hyperextension. Iliotibial band syndrome was no longer suspected due to the pain location and lack of tenderness at the iliotibial band. Due to left knee joint active range of motion limitations and edema within 12 hours of the onset of pain, a knee ligamentous screening was carried out. Knee valgus stress and Lachman tests for the medial collateral and anterior cruciate ligaments respectively, were negative for pain and laxity. No giving way or feeling of "pop" at injury onset was reported indicating a low likelihood for ligament damage.[17] Patellar tendinopathy was a possible diagnosis based on localized tenderness at the patellar tendon and aggravation with jumping activity during cross fit.[7] This patient was below the age of 40 and had isolated anterior knee pain, indicating a high likelihood of having PFPS (SP .93, +LR 8.70).[18] The patient's activity limitations mimicked the majority of patients with PFPS; difficulty with squatting (93.7%), running (90.8%), and prolonged sitting (54.4%).[19]

Movement coordination impairments were assessed to further gather information on functional movement quality, pain provocation, and for intervention planning. Left single leg squat revealed excessive hip internal rotation, hip adduction, and quadriceps dominance. See **Table 1** for details. Running gait analysis was performed using 2-D video analysis on a smartphone with freeware. Athletic tape was placed at the patient's fifth metatarsal head, lateral knee joint line, superior and inferior portions of the heel shoe counter, posterior superior iliac spine, and seventh cervical spinous process. Souza et al recommend further placement at the greater trochanter, anterior superior iliac spine, lateral malleoli, and midpoint of the calf.[20] However, that was not performed in this case due to time constraints. A warm-up consisting of a 5-minute treadmill run at a light self-selected speed was completed, and then speed was increased to a self-selected moderate intensity, and video was taken at a right angle laterally and posteriorly. The freeware was used to visualize angles looking for symmetry and abnormalities. Kinematic variables evaluated from a posterior view included base of support, heel eversion magnitude, foot progression angle, knee window, pelvic drop, and trunk side bending. From a lateral view, foot strike pattern, vertical displacement of the center of mass (vertical excursion), the tibial angle at loading response, foot inclination angle, a distance of heel to the center of mass, knee flexion at initial contact, hip extension during late stance, and trunk flexion was evaluated.[20] Cadence was determined by counting each right foot contact in 60 seconds at 2 separate time intervals and averaged. **Table 2** provides details on the related kinematic variables. Running gait analysis revealed a slow running cadence (162 steps per minute), asymmetrical forefoot strike pattern (left with greater dorsiflexion at initial contact), floating emphasized by excessive vertical excursion with a lack of hip extension, and asymmetrical pelvic drop (left greater than right). Informed consent was obtained for publication of photographs.

Clinical impression #2

Based on the initial evaluation findings, the health condition was determined to be PFPS due to overload/overuse. Patellar tendinopathy could not be ruled out as a secondary condition. Patellofemoral pain was supported by the patient's younger age, peripatellar pain location, concordant pain with squats, running, and prolonged sitting, and exclusion of other knee-related diagnoses. Retrospective reflection revealed the patient had characteristics of all Impair-

Table 1. Retrospective PFP Impairment/Function-Based Classification Subcategorization With the Patient's Initial Evaluation Findings and Interventions to Address the Subcategory

PFP Impairment/Function-Based Classification Subcategories	Initial Evaluation Findings			Interventions
Overuse/overload without other impairment	Onset of symptoms: increase loading magnitude at patellofemoral joint during half marathon competition			- Frequency: reduce lower extremity strength and plyometrics to 1-2 days a week, 1 rest day in between running sessions - Intensity: pain-free running only, running between 60-70% estimated max HR zones - Duration: flexible 10-20% weekly and longest run distance increase after achieving a 3 mile run without pain - Type: begin with walk/run combination, home exercise program initiated and progressed as intervention advanced
Muscle performance deficits		**Left**	**Right**	- Spinal stabilization: small muscle neuromuscular recruitment progressed to global trunk strengthening - Hip abduction, extension, and external rotation and knee resistance training open and close chained
	Knee extension	5/5 crepitus	5/5	
	Knee flexion	5/5	5/5	
	Hip abduction	4/5	4+/5	
	Hip extension	3+/5	3+/5	
	Ankle all directions	5/5	5/5	
	Trunk extension	4/5		
	Lower abdominals	2-/5		
Movement coordination deficits	**Single leg squat**	**Running gait analysis with 2-D video**		- Gait training with phased feedback visits 1-3: Step cadence increase 10%, symmetrical strike, reduce vertical center of mass excursion - Independently practice 1 minute every 10 minutes of running - Squat and jump technique visit 3: Hip hinge, dynamic eccentric control with a reduction in hip internal rotation, adduction, and knee abduction
	Excessive hip internal rotation	Slow cadence – 162 steps		
	Excessive hip adduction	Asymmetrical forefoot strike		
	Excessive knee abduction	Lack of hip extension		
	Quad dominance	Left > right pelvic drop		
Mobility impairments	**Right**	**Left**		- Low-load long-duration static stretches daily and after aerobics with total end range time 60 seconds: hamstring, quadriceps, iliopsoas, gastrocnemius, and piriformis - Quad sets until full knee extension active ROM - Maitland Grade III-IV posterior talocrural joint mobilizations
	Lack 35 hamstring 90/90	Lack 25 hamstring 90/90		
	+ Thomas	+ Thomas		
	Knee active ROM lack 2-133° capsular end feel	Knee active ROM hyperextends 2-138°		
	+ Ely	+ Ely		
	Left patellar gliding – superior and inferior hypomobility			

Abbreviations: PFP, patellofemoral pain; ROM, range of motion

ment/Function-Based Classification Subcategories: Overuse/Overload (not in isolation), Movement Coordination Deficits, Mobility Impairments, and Muscle Performance Deficits.[7] Anterior ankle impingement was suspected based on the location of the pain at the anterior talocrural region provoked by maximum dorsiflexion movement, which likely resulted in joint stiffness, limited dorsiflexion, and edema from an impingement of either soft tissue or bony structures.[21]

Intervention

A multimodal intervention approach initially targeted interventions that could be subcategorized into Overuse/Overload, lower extremity Movement Coordination Impairments, and Mobility Deficits. Training modifications included an initial walk and run interval progression until 3 miles of continuous pain-free running was achieved, followed by a weekly mileage increase of 10% to 20% as tolerated. The patient was advised to reduce cross-fit lower extremity strengthening and plyometrics to 1-2 days a week. Final training education emphasized running between 60% and 70% of estimated heart rate maximum to manage intensity while mileage increased. Focus shifted to exercise that could be subcategorized as interventions addressing Muscle Performance Deficits as the pain subsided, and as the patient demonstrated increased independence with movement coordination retraining and educational training load concepts 2 weeks into treatment. Intervention details can be found retrospectively organized according to PFPS Classification Subcategories in **Table 1**. The patient preferred to focus intervention on his recent knee and ankle injuries due to his desire to return to marathon training. However, neurologic symptoms were monitored for change while progressing into higher running loads, lower extremity neurodynamic glides were initiated, and asymmetrical lower

Table 2. Two-Dimensional Video Analysis of Running Kinematic Variables for the Patient in This Case Report

Video analysis view	Gait cycle	Kinematic variable	Initial evaluation results	Results at 8-week follow-up
Posterior	Mid stance	Base of support Normal or scissoring	Normal	Normal
Posterior	Mid stance	Heel eversion magnitude Normal, excessive, limited	*Excessive	**Normal
Posterior	Mid stance	Foot progression angle Normal, excessive out toe, in toe	*Excessive toe out right Normal left	***Excessive toe out right Normal left
Posterior	Mid stance	Knee window Closed window, open window	Open Window	Open Window
Posterior	Mid stance	Pelvic drop Normal, excessive	*Left excessive Right normal	***Left excessive Right normal
Lateral view	Initial contact	Strike pattern Forefoot, midfoot, or rearfoot	*Forefoot bilateral (left more than right)	** Symmetrical midfoot strike
Lateral view	Initial contact	Foot inclination angle	N/A	
Lateral view	Distance of heel at initial contact to the center of mass	Vertical to anterior superior iliac spine, anterior to anterior superior iliac spine	Vertical to anterior superior iliac spine	Vertical to anterior to superior iliac spine
Lateral view	Loading response	Tibial angle Extended, vertical, flexed	Vertical	Vertical
Lateral view	Mid stance	Knee flexion ➢ or = 40, < 40	➢ 40°	➢ 40°
Lateral view	Mid stance	Trunk lean Normal, Reduced flexion, Excessively Flexed	Normal	Normal
Lateral View	Late Stance	Hip Extension Normal, Limited, Compensatory lumbar lordosis	*Limited	**Normal
Lateral View	Floating	Vertical Excursion Excessive, Normal	*Excessive	**Normal
Step Cadence			*162 steps per minute	**176 steps per minute

*Abnormal findings
**Findings that changed after intervention
***Findings that did not change with intervention

extremity and trunk muscle length and weakness deficits were addressed with exercise intervention.

The patient was seen for 6 visits during the first 4 weeks of the 8-week plan of care. The visit frequency was reduced as the patient's symptoms resolved, compliance was maintained, and self-directed training increased. The 2 final visits were completed during the last 4 weeks.

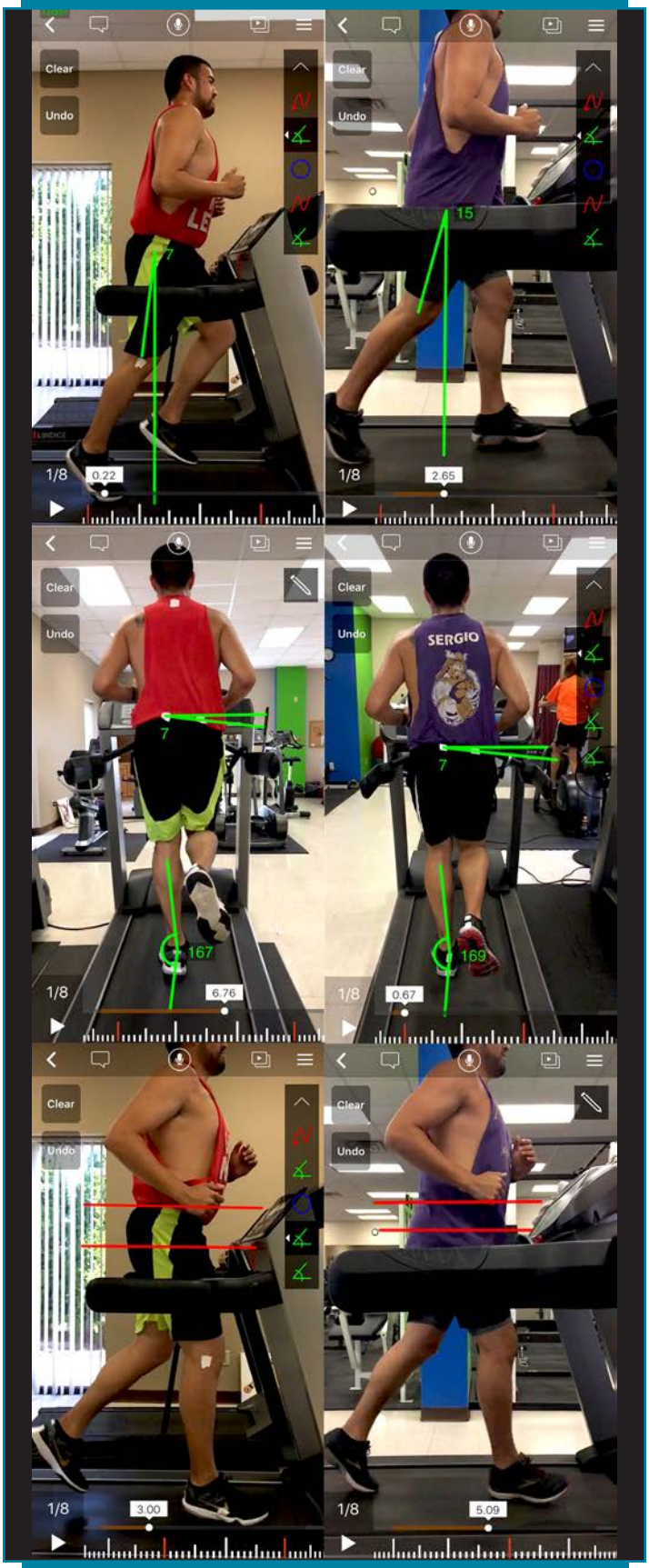
Outcome

The patient was able to achieve his primary goal of returning to running without knee pain after 4 treatment sessions. At discharge and a 6-month phone follow-up, the patient improved beyond the minimal detectable change of 2.5 points[15] on the PSFS for all activities. He scored a 10 on the PSFS for running (initially 1), jumping (initially 7), and squatting (initially 6). The PSFS has high test-retest reliability (r=0.84.).[15] The patient no longer complained of pain with prolonged sitting, and scored beyond the minimally clinically important difference of 1 point or 15% on the NPRS[22] at the knee and ankle, rating all activity a 0/10 at discharge and 6-month follow-up (6/10 initially).

Two-dimensional video analysis at discharge revealed an increase in hip extension at late stance, 176 steps per minute cadence, symmetrical midfoot strike, and reduced vertical excursion. The posterior view revealed no changes in asymmetrical pelvic drop. See **Table 2** for details of all kinematic variables. See **Figure 1** for video analysis images.

Education on training modification resulted in the patient's ability to create a long-term marathon training program with minor suggestions for alterations. However, he did experience hamstring tendon discomfort when initially progressing to a longer running distance. The patient finished his first marathon pain-free and was training for his second with no reoccurrence of injury at a 6-month follow-up. The hamstring soreness resolved with a reduction in stretching intensity. The patient felt what helped him most was changing his running form and performing a consistent low load duration stretching program included in the initial home exercise program. He believed the strengthening exercises helped him maintain his new running form and improved his running performance. The patient remained engaged with his home exercise program 4 days a week.

Figure 1. Two-Dimensional Video Analysis



Images at evaluation on the left in descending order (hip extension, pelvic drop, vertical excursion). Images at discharge on the right in descending order (hip extension, pelvic drop, vertical excursion).

DISCUSSION

This case report provides an example of a comprehensive evaluation using shared decision-making and multimodal interventions in a male with PFPS training for his first marathon. This patient case was complicated by a personal goal that included high loading athletic activity, secondary diagnosis of anterior talocrural joint impingement, and medical history of chronic lumbar radiculopathy provoked by prolonged running. However, despite these complicating factors and the PFPS provoked by overuse/overload this patient rehabilitated while progressing the cumulative load expected during marathon training. Perhaps, more importantly, the patient in this case retained intervention benefits despite continued long-distance training and competition.

Retrospective clinical reasoning presented in this case suggests that a PFPS Classification System may help clinicians prioritize impairments into subcategories: Overload/Overuse, Muscle Performance, Mobility Deficits, and Motor Coordination including gait retraining. Based on the results of this case and past studies, combining interventions is optimal. What specific combination of interventions is best for patients with PFPS is yet unknown.[7] Subcategorization may provide a means to guide intervention decisions in a patient-specific multimodal manner to enhance outcomes. Due to the retrospective nature of this clinical reasoning report, classification of subcategories was dependent on tests and measures commonly used in the clinic, but not necessarily supported by evidence. The dynamic valgus Lateral Step-Down Test and frontal plane valgus during single-leg stance is recommended to identify coordination deficit.[7] In this case, the quality of functional movement was assessed by the clinician without an objective measure. Measuring for a 10° change in frontal plane valgus during the single-leg squat would have added validity to the identification of the Movement Coordination Deficit Subcategory. Manual muscle testing was used in this case to Subcategorize Muscle Performance Impairments, but isokinetic dynamometry is recommended to identify weakness.[7,23] The Hip Stability Isometric Test identifies posterolateral hip weakness and is a reliable and valid test.[24] Using the Foot Posture Index provides a composite score observing 3 body planes,[25] giving clinicians greater confidence in making decisions regarding intervention strategies related to Mobility Deficits, such as an orthotic prescription that was not considered in this case. Future research is needed to prospectively subcategorize patients using recommended tests and measures described in the PFPS Clinical Practice Guidelines.

What is lacking from this case is the successful management of lumbar radiculopathy while running loads continued. This plan of care followed patient preferences by maintaining a primary focus on eliminating knee and ankle pain with prolonged running but may have missed important lumbar findings and lumbar outcome measures to identify change. The patient did report a reduction in radiculopathy intensity with the inclusion of neurodynamic gliding procedures recommended for chronic low back pain with radiating symptoms,[26] but this incomplete improvement is consistent with a lack of research directing the management of chronic low back pain with radiating symptoms in runners. A randomized controlled trial by Cai et al[27] noted that lower limb, lumbar extensor exercise, and lumbar stabilization exercise all improved pain levels in recreational runners, with lower limb exercise having the largest effect. Recreational runners in this study did not have radiating systems, rather localized back pain, unlike this case study patient. Asking the patient to discontinue running was not advised secondary to the literature supporting that running does not degrade disc pathology. Mitchell et al found middle-aged endurance runners that had the greatest weekly mileage had a less

age-related decline in lumbar intervertebral discs.[28] Due to minimal change with intervention, a referral was indicated.

This case describes a patient with PFPS with a mechanism of injury being Overload/Overuse, thus providing training modification is consistent with the literature.[8] However, recommending a loose 10% to 20% increase based on fitness and symptoms challenged the common practice recommendation of increased duration/distance of 10% at most. Buist et al found implementing a 10% graded training program did not correlate with injury prevention, although this study was completed on novice runners.[29] A systematic review by Damsted et al reported increased injury risk if running mileage progressed more than 30% or if one or more of the following was changed: velocity, and/or distance, and/or frequency.[30] Ramskey et al reported types of injury are not associated with specific progressions of either intensity or training volume.[31] Clinical reasoning led the physical therapist to quantify intensity with heart rate monitoring while the mileage was being increased, to prevent training-related injury in this patient case due to paralleled volume and intensity continuously ramping up to marathon distance. Cross-fit lower extremity strengthening and plyometrics frequency was reduced in this case to prevent detrimental kinematic changes that result from muscle fatigue while this patient-focused on increasing mileage for marathon training.[32]

Video analysis was easily incorporated into the evaluation and plan of care for this patient. Kinematic variables were rated as normal versus abnormal as described by Souzza et al[20] due to a lack of consensus on ideal kinematic joint angles with running. Due to a lack of consensus on feedback protocols and frequency of gait retraining,[9,33] the video feedback sessions were limited by schedule matching with the physical therapist. Two sessions using 2-D video and verbal feedback were completed and then phased to one verbal feedback session less than 20 minutes duration within the first 2 weeks of treatment. A final video assessment and feedback session was completed on the last visit to reemphasize positive gains in running form. The remaining visits were delivered by a physical therapy assistant under the plan of care direction and intraprofessional communication. This case provides an example of how neuromuscular reeducation using 2-D video feedback could be considered in the multimodal plan of care.

Patient-specific gait retraining was targeted on reducing the vertical center of mass displacement (vertical excursion) and equalizing bilateral dorsiflexion range of motion upon forefoot strike by equalizing landing sound which was not part of the PFPS Clinical Practice Guideline recommendations, although, increasing step cadence was.[7] Wille et al recognized vertical excursion as a kinematic variable component of subsets estimating peak vertical ground reaction force, peak knee extensor moment, and braking impulse.[34] Therefore, vertical excursion is a reasonable kinematic variable to modify during gait retraining. However, increasing step rate reduces vertical excursion[35] so focusing cues on reducing floating characterized by excessive vertical excursion may not have been necessary for this patient. Increasing step cadence has the potential to change strike patterns in heel strike runners to either midfoot or forefoot strike.[36] This patient was unique because he had a forefoot strike that adapted to a midfoot strike with an increase in cadence. A study by Kasmer et al[37] found that of 1991 marathon runners, 93.67% were heel strikers, 5.07% were midfoot strikers, 0.71% split strikers, and only 0.55% were forefoot strikers. It is possible runners change strike pattern as training distance increases such as was seen with this case. Further investigations are warranted to determine if runners with a natural forefoot or midfoot strike adapt to heel strike with a change in running distance, such as seen in marathon training. It is unclear if the outcomes in this case, specifically new midfoot strike pattern, increase in hip extension, and decreased vertical excursion was a direct result of one or a combination of patient-specific gait retraining cues.

Hip abduction and extension weakness were identified in patients with PFPS.[6,7] Combined hip and knee resistance exercises in open and closed chain positions[12,27] are recommended in the literature and were used to address hip abduction and extension weakness in this case (see **Table 1** for manual muscle testing results). Despite the hip resistance exercises, the patient's pelvic drop in the frontal plane that was noted on 2-D video gait analysis did not improve as suggested in the literature.[38] Perhaps the lack of neuro reeducation focusing on the timing of muscle recruitment and functional movement during the specific activity of running limited improvements in gait quality. The intensity of the resistance program was not prescribed as a percentage of a 1 repetition maximum, therefore, may not have maximized muscle performance. The workload demand placed on an individual's hip during running cannot be quantified clinically, therefore, the ideal training workload is also difficult to quantify. Typical hip abduction resistance exercises do not mimic the function of running, therefore, do not follow the concept of specificity of training. Future studies investigating optimal dosing parameters, optimal exercises mimicking the demands on the hip during running, and neuro reeducation may be warranted to optimize exercise prescription in distance runners with PFPS.

CLINICAL APPLICATIONS

Evaluating and treating lower extremity injuries in the running population is a challenge for clinicians due to multiple impairments of body function and structure and high risk of reinjury. Patient-specific multimodal interventions are a vital part of managing the care of the running population who are prone to multiple site injuries, and long-term outcomes of combined intervention are needed to guide management. Viewed retrospectively, PFPS Classification Subcategories have the potential to provide a framework for clinical reasoning to guide evaluation and intervention priorities in distance runners with PFPS. Gait retraining using 2-D video analysis has the potential to enhance outcomes in runners training at marathon distances where joint loading and soft tissue stress is central to participation.

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Neuromuscular Adaptations to Plyometric Training in the Triceps Surae Muscle-Tendon Unit and Implications to Tendon Loading: A Literature Review

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ABSTRACT

Background and Purpose: The current evidence-based rehabilitation approach for Achilles tendinopathy is heavy slow resistance loading. However, this approach at times fails to reduce symptoms and improve function for a significant number of patients. The purpose of this study was to review the literature related to the neuromuscular adaptations that occur at the triceps surae muscle tendon unit with plyometric loading and the implications these changes have in performance and tendon loading. Additional investigation was to determine whether further research on plyometric loading is warranted within injured populations. **Methods:** A literature search was performed for articles in the English language using the following MeSH terms, "plyometric", "gastrocnemius", "stretch shortening cycle", "muscle-tendon unit", "Achilles tendinopathy", which were entered into the following databases, Google Scholar, PubMed, ScienceDirect, SAGE journals. Databases were searched in order to identify articles that examined the effects of plyometric-based training on the behavior of the triceps surae muscle tendon unit in healthy adults using EMG and/or dynamic ultrasound during plyometric exercise. **Results:** Plyometric training increased EMG activity and decreased fascicle muscle length during the braking phase of a plyometric activity. **Clinical Relevance:** Increased EMG activity during the braking phase allows for greater use of elastic energy stored within the tendon and helps to improve the function and performance of plyometric activities. Conclusion: Plyometric training creates neuromuscular adaptations that enhances elastic use of the Achilles tendon that may have implications for prevention and treatment of patients with Achilles tendinopathy. As this literature review did not include those with Achilles tendinopathy, the authors cannot generalize to patients with Achilles tendinopathy. The authors of the current study suggest more evidence needs to be gathered before this can be answered.

Key Words: Achilles tendon, jumping, stretch shortening cycle, tendinopathy

INTRODUCTION

Tendinopathy is characterized by Cook and Purdam as an overuse injury that can occur in both the upper and lower extremities that results in pain, decreased tolerance to exercise, and a decrease in function.[1] Overuse injuries, including tendinopathies, represent approximately 7% of all primary care physician visits in the United States.[2] Tendon injuries make up anywhere between 30% and 50% of all sports injuries and account for 50% of all injuries to elite endurance runners.[3–5] Given its injury prevalence in elite endurance runners, the Achilles tendon has been an area of focus in research to understand the influences and disruptions to this tendon.[6–16] The prevalence of Achilles tendinopathy in runners has been cited as anywhere between 11% and 30% depending on the number of miles run.[5,17] Although tendinopathy is common in sports, 1 out of 3 patients with Achilles tendinopathy are not active in sport.[17] Some epidemiological studies show that up to 6% of the sedentary population will suffer from tendinopathy.[3]

For the past several decades, a major component of the rehabilitation of Achilles tendinopathy has focused on tendon loading exercises. In 1998, Alfredson published a study that supported the idea that heavy-load slow eccentric training was effective in the treatment of mid-substance Achilles tendinosis.[18] This study laid the groundwork for subsequent research that examined the effect of eccentric exercises on the treatment of tendinopathy, particularly of the Achilles tendon.[8–12,15] The APTA's 2010 and 2018 Clinical Practice Guidelines based on strong evidence, recommended eccentric loading and heavy slow resistance to decrease pain and increase function in patients with mid-substance Achilles tendinopathy.[6,7] Authors conducting mechanistic studies around the benefits of eccentric exercise have focused primarily on the structural changes that occur within the tendon such as matrix quality, collagen orientation, tendon thickness and tendon stiffness.[8,14,15]

Various authors suggest that structural degeneration does not always correlate proportionally with the clinical symptoms of tendinopathy.[1,19,20] Fredberg and Bolvig[21] revealed that 29% of Danish soccer players displayed abnormal ultrasonographic findings of the Achilles tendon during preseason testing despite the lack of symptoms. Further, post-season testing revealed that of the original 29% with abnormal ultrasonography findings, 36% were still asymptomatic and the tendons had normalized while another 18% remained asymptomatic with abnormal tendon structure following rehabilitation and participation in their sport, by the end of the season. Some authors have found that there is a subset of patients that either do not respond well to standard physical therapy interventions or those whose symptoms recur after discharge. One literature review cited that "several clinical studies investigating Achilles and patellar tendinopathy have verified a 40% to 60% good outcome after a home-based, twice daily, 12-week regime of mainly eccentric training."[17] Authors have demonstrated that individuals with Achilles tendinopathy show a diminished ability to load the Achilles tendon elastically during the eccentric or braking phase of athletic movement.[22–24] Authors have also shown that there are neuromuscular deficiencies within the triceps surae muscle tendon unit in individuals with mid-substance Achilles tendinopathy.[22–24] One study by Baur et al[24] compared the EMG activity of the gastrocnemius in runners with Achilles tendinopathy and in controls during running. This study showed that runners with tendinopathy showed decreased muscle activity during the weight acceptance phase of running.[24] These authors also showed that the EMG activity on the asymptomatic side in runners with Achilles tendinopathy demonstrated a similar decrease in muscle activity, suggesting that this movement strategy may have been present prior to the onset of symptoms. This suggests that other factors in addition to tendon

structure may impact the risk of and recovery from tendinopathy.

Stanish et al[25] were one of the early pioneers in research regarding tendinopathy rehabilitation and highlighted the importance of not only eccentric strengthening, but also sport specificity and increasing the velocity of loading. Despite this, current recommendations for exercise in the treatment of tendinopathy focus on heavy, slow resistance (HSR) exercise, and in particular eccentric dominant loading.[6] The support for eccentric exercise was founded on the premise that individuals with Achilles tendinopathy displayed diminished eccentric strength and that maximal loading of the tendon occurred during the eccentric portion of an athletic movement.[18,25] The assumption of these loading programs is that the muscle-tendon unit (MTU) mechanics are similar during slow and fast eccentric activities. However, an emerging body of literature regarding MTU activity points toward a different phenomenon occurring during stretch shortening cycle (SSC) activities.[26–36]

Most of the research investigating the effect of loading on tendinopathy has neglected to consider that the muscle and tendon can lengthen in different amounts and different rates from one another. Recent studies that explore the activity of the individual muscle and tendon components in the MTU when the velocity of loading is increased may help to guide researchers in designing more effective loading programs, as well as the role that loading velocity plays in the rehabilitation of tendinopathy. The SSC is classically thought of as a quick eccentric contraction, followed by an isometric, and then a concentric contraction. During the eccentric phase of an SSC movement, the muscle is isometrically or even concentrically contracting and this allows for the tendon to lengthen and store elastic energy, so that it may be used as a propulsive force in the latter half of a movement.

Unfortunately, the majority of the research in this area has been done on healthy athletes using sports performance metrics as the primary outcome variable.[28–36] Within this article, any activity that elicits the SSC response of an MTU will be referred to as plyometric loading.

The main parameter that elicits a change in the way an MTU functions is movement velocity.[32] At increased velocities, the MTU functions as described above, with greater amounts of muscle shortening concurrent with greater amounts of tendon lengthening.[32] Additionally, the tendon also experiences greater amounts of tensile loading compared to lower velocity modes of loading, ie, eccentrics or HSR training.[32] Increasing the speed of loading would be more applicable to sport specific movements, and potentially more appropriate to apply to sporting populations who are at an increased risk for suffering from tendinopathy and require SSC loads as part of their activity, including runners and field and court athletes that rely heavily on the SSC during participation in their sport.

The purpose of this study was to review the literature related to the neuromuscular adaptations that occur at the triceps surae muscle tendon unit with plyometric loading and the implications these changes have in performance and tendon loading. Additional investigation was to determine whether further research on plyometric loading is warranted within injured populations.

METHODS

Search Methodology

Relevant articles were obtained by using different combinations of the following search terms and Boolean operators: OR/plyometric, stretch shortening, stretch shortening cycle, SSC; OR/loading, training, program, rehabilitation; OR/Achilles, tendon, Achilles tendon, triceps surae, tendo-achilles, gastroc-soleus; OR/ tendinopathy, tendinitis, tendinosis; OR/EMG, electromyography; OR/dynamic ultrasound, dynamic US, ultrasound, US. The search was performed across the Medline, CINAHL, PubMed, PEDro, and Cochrane Review databases. A hand search of references within articles returned by this search strategy and of the APTA's 2010 and 2018 Clinical Practice Guidelines for Achilles Tendinopathy was also performed for relevant literature which fit the inclusion/exclusion criteria as detailed in **Figure 1**.

Inclusion and Exclusion Criteria

Articles that were to be included in this review must have had the following criteria: the study observed the triceps surae, the study needed pre-test, intervention, and post-test components, the intervention needed to include plyometric loading, the data needed to be recorded during the plyometric activity, the measurements needed to be made using EMG and/or dynamic ultrasound (**Table 1**). Articles excluded from this review had the following criteria: The study did not observe the triceps surae, the study was missing either a pre-test, intervention, or post-test component, the intervention did not include plyometric loading, the only recorded data was during non-plyometric activities, the measurements were not made using dynamic ultrasound or EMG.

Quality Assessment

The PEDro scale was used as a measure of quality for each article. The score of each article is depicted in **Table 2**. Two of the authors performed quality assessments of each of the selected articles, a third author then reviewed each of the two assessments in order to resolve any discrepancies between the two assessments. Limitations of the quality of the articles are discussed further in the discussion section.

RESULTS

See results in **Table 3**.

DISCUSSION

It is well documented in the literature that the storage of elastic energy that occurs in tendons during the SSC has direct implications to performance.[35–40] During plyometric exercise, the MTU is lengthened and then quickly shortened to produce force. It stands to reason that if MTU lengthening

Figure 1. This Figure Depicts the Process of Article Selection for This Review

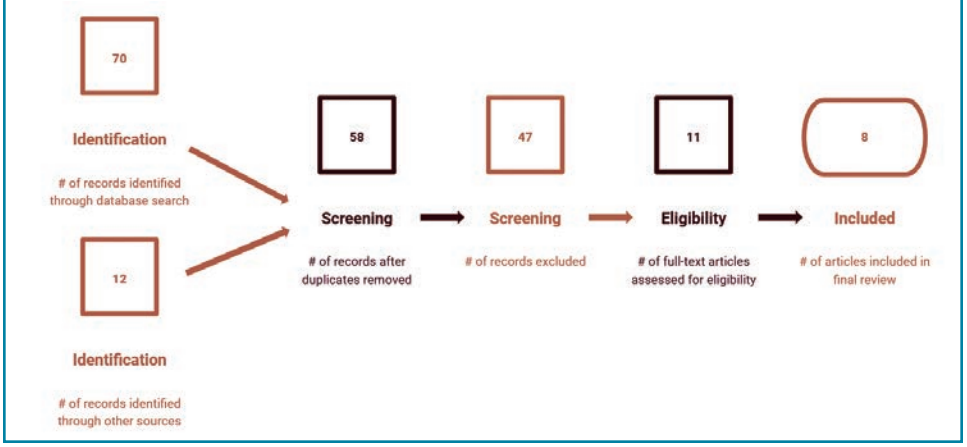

Table 1. Inclusion and Exclusion Criteria for Selecting the Articles Within This Review

Inclusion Criteria	Exclusion Criteria
- Looks at triceps surae - Has pre-test, intervention and post-test components - Used plyometric loading intervention - Data recorded during plyometric activity (in-task) - Measurement made using either EMG or dynamic ultrasound	- Does not look at triceps surae - Missing a pre-test, intervention, post-test or any combination of those components - Does not use plyometric loading intervention - Data only recorded during non-plyometric activity (out-of-task) - Measurement not made using either EMG nor dynamic ultrasound

*Viitasalo et al[43] did not perform an intervention but the athletic background of the experimental group was accepted as a sufficient independent variable

Table 2. Quality Assessment Scores of Each

Description
Eligibility criteria were specified
Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)
Allocation was concealed
The groups were similar at baseline regarding the most important prognostic indicators
There was blinding of all subjects
There was blinding of all therapists who administered the therapy
There was blinding of all assessors who measured at least one key outcome
Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups
All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"
The results of between-group statistical comparisons are reported for at least one key outcome
The study provides both point measures and measures of variability for at least one key outcome
Total **0-3 "poor", 4-5 "fair", 6-8 "good", 9-10 "excellent"**

occurs without a change in length from the muscle component, the increase in length of the overall MTU is primarily achieved by the tendon. This review supports the idea that neural adaptations to plyometric exercises optimize this elastic behavior of the MTU. For clarity in this discussion, the phases of a plyometric movement will be described in binary terms, using the terms braking and propelling to distinguish between the lowering and rising phases of a jump.

EMG Changes

One of the primary adaptations that was observed by this review was a shift in EMG activity towards the braking phase of a plyometric movement. If the primary neural adaptation to plyometric training is centered around taking advantage of the elastic nature of the muscle tendon unit, then timing is critical. Internally generated forces need to be sufficient enough to resist external forces. In order to suit this need, it appears that the nervous system pre-tenses the musculature before initial contact during a predictable plyometric task.[40–42] Increases in EMG activity of the triceps surae were also seen during the braking phase of plyometric activities.[36,40–44] Often times, the results of the selected studies demonstrated that the overall amount of EMG would remain unchanged following plyometric exercise intervention, but the timing of peak contraction would occur sooner.[36,40,41]

There are other variables that can be changed during the training process in order to alter the timing of the contraction. For example, the height of the box, which would dictate the force of the impact, as well as the type of training prior to testing or the dosage of training prior to testing. It was shown that increasing the height of the box moves the peak of the EMG activity to occur later on during a plyometric task, meaning that there is increased time to complete the braking phase of the plyometric.[40,43,44] While performing plyometric activities from lower heights, enables better usage of MTU elasticity.[44] Clinically, if one of the goals of rehabilitation is to improve the use of tendon elasticity, which would demonstrate improved recovery of the tendon and improve performance in jumping activities leading to greater readiness to return to athletic activities, then increasing the height of a box could serve as a potential exercise progression as long as the patient demonstrates peak muscle activity sooner in the braking phase. As shown by Viitasalo et al,[43] without any pre-test training outside of their respective sport elite level triple jumpers were able to increase the amount of pre-activation and early braking phase muscle activity as they progressed from a 40 cm drop jump to an 80 cm drop jump. Whereas, the control group demonstrated significantly decreased amounts of pre-activation and breaking phase activity, and increased their amount of latter phase propulsion activity as the height of the box increased. Thus, delaying the timing of peak muscular contraction and limiting the amount of elastic utilization. It is worth noting that that the jumper's potential natural proclivity for this strategy should be considered, but their extensive training history should not be disregarded. Taube et al[44] also demonstrated that training at lower heights of 30 cm drop jumps shifted peak EMG to occur sooner, thus having a shorter braking phase, even when tested at higher heights of 50 cm drop jump. Whereas individuals who trained at much higher box heights of 50 cm to 75 cm demonstrated a peak EMG that occurred much later and thus the braking phase took longer to complete. These results suggest that plyometric training done with a box at lower heights will enable peak EMG to occur sooner, and that this has the potential to transfer to plyometric activities done with higher box heights and thus greater external forces. However, if initial training is done with a box height that forces the peak EMG to occur later and prolong the braking phase then use of tendon elasticity will not be optimized.

The specific methods of training were also shown to be relevant to the timing of muscular contraction. Arabatzi et al[42] demonstrated that 8 weeks of Olympic weight lifting increased the EMG activity of the triceps surae during the propulsion phase of a vertical jump, but decreased its braking activity, whereas 8 weeks of plyometric training shifted peak EMG to occur sooner during the braking phase. Interestingly, the group that combined weight training and plyo-

Article via the PEDro Scale

	Kryölänen et al[46]	Kannas et al[40]	Arabatzi et al[42]	Viitasalo et al[43]	Taube et al[44]	Hirayama et al[35]	Kubo et al[31]	Kryölänen et al[41]
	N	N	Y	Y	Y	Y	Y	N
	N	Y	Y	N	Y	N	Y	N
	N	N	N	N	N	N	N	N
	Y	Y	Y	N	Y	Y	Y	Y
	N	N	N	N	N	N	N	N
	N	N	N	N	N	N	N	N
	N	N	N	N	N	N	N	N
	Y	Y	Y	Y	Y	Y	Y	Y
	Y	Y	Y	Y	Y	Y	Y	Y
	Y	Y	Y	Y	Y	Y	Y	Y
	Y	Y	Y	Y	Y	Y	Y	Y
	5	**6**	**7**	**5**	**7**	**6**	**7**	**5**

metric training still showed a more eccentric dominant strategy in testing, however, this was shown in quadricep musculature as opposed to the gastroc/soleus. This can be attributed to the practice of more hip and knee dominant strategies in Olympic and resistance training with compound movements, but also the practice of using elastic energy during plyometric training.

As for dosage of plyometric training, Hirayama et al[35] demonstrated that peak EMG would occur sooner, muscle fascicles would increase the amount of shortening, and tendon would increase the amount of lengthening during the braking phase of a plyometric activity within a single practice session. Subjects performed 2 intervals of 3 sets of 3 counter movement jumps on a sledge apparatus with 3 minutes of rest between each set. It is unclear how long this change in performance would be retained over longer periods of time. All other studies reviewed performed their interventions over a time period of 4 weeks,[40,44] 8 weeks,[42] 12 weeks,[31,41] and 15 weeks[46] with a frequency of activity between 2 and 4 times per week. Dosage of sets and repetitions as well as types of plyometric activities varied between studies, however most of the studies reviewed demonstrated similar results in changes in timing of triceps surae EMG despite wide variations in exercise prescription.[35,40–44,46]

Joint Kinematics

There were notable differences in the timing of peak dorsiflexion and knee flexion after plyometric training. Kyrolainen et al[41] observed that although the angular velocities did not change, the timing of knee and ankle flexion occurs sooner in response to plyometric training. This suggests that the experimental group made neuromuscular adaptations to plyometric training that enabled the peak EMG and braking phase to occur sooner thus causing the peak knee and ankle flexion to occur sooner, supporting the idea that one of the primary adaptations to plyometric training is an increase use of elastic energy of the MTU.

Viitasalo et al[43] observed the hip, knee, and ankle kinematics at different stages within the drop jump and found significantly different kinematics between athletes and non-athletes. The athletes demonstrated significantly less angular displacement at the hip, knee, and ankle than the non-athletic control group during the braking phase and during the propulsive phase. Greater angular velocities were observed at the ankle in the athletic group during the braking phase. The athletic group was able to increase their jump height by moving through a smaller range of motion faster than the non-athletic group. This difference is likely due to improved neuromuscular coordination and utilization of the MTU.

Table 3. This Table Presents the Structure of Each Study as well as the Pertinent Results

Authors	Participants	Test Battery & Intervention Duration	Dynamic Ultrasound	EMG	Joint Kinematics	Jump Performance
Kryölänen et al[46]	N=23 (23 males) Mean Age=24 Control group=10 Experimental group =10	Countermovement jump on sledge apparatus 2x/wk for 15 wks	N/A	Control group: no change Experimental group: no change	N/A	Control Group: no change Experimental Group: increased take off velocity
Kannas et al[40]	N=20 (20 males) Mean Age=21.3 Incline plyometric group=10 Plane plyometric group=10	Countermovement jump Drop jump 20 cm Fast drop jump 20 cm Drop jump 40 cm Fast drop jump 40 cm 4x/wk for 4wks	Fascicle length of medial gastrocnemius: Decreased during initial jump phases in majority of testing trials for both groups	Gastrocnemius EMG: increased significantly more during the initial phases of jumping in majority of testing trials for both groups	N/A	Jump height: increased in the majority of trials for both groups
Arabatzi et al[42]	N=36 (36 males) Mean Age=20.3 Plyometric group=9 Olympic weight lifting group=9 Weights and plyometrics group=10 Control group=8	Countermovement jump Plyometric group trained with only plyometric exercises Olympic weight lifting group only trained with Olympic weightlifting Weights and plyometrics group trained with a combination of weight training and plyometrics. 3x/wk for 8 wks	N/A	EMG of gastrocnemius: - Plyometric group: increased in eccentric phase, decreased in concentric phase - Olympic weight lifting group: increased in concentric phase - Weights and plyometrics group: decreased in eccentric and concentric phases EMG of Rectus Femoris: - Plyometric group: decreased in eccentric phase - Olympic lifting group: increased in concentric phase - Weights and plyometrics group: increased in eccentric phase	Plyometric group: decreased max knee angle Olympic weight lifting group: increased max hip and knee angle Weights and plyometric group: decrease in max hip angle	Plyometric group: increased jump height by 14.6% and eccentric power by 78% Olympic weight lifting group: increased jump height by 14.4% and eccentric power by 57% Weights and plyometric group: improved jump height by 15.1% and eccentric power by 41%
Viitasalo et al[43]	N=18 (18 males) Elite Jumpers=7 (mean age=27.6) Control=11 (mean age=20.6)	Drop jump 40 cm Drop jump 80 cm Prior sporting participation	N/A	EMG of gastrocnemius: -Jumpers showed greater amounts of activity during braking phases of 40 cm and 80 cm drop jumps	Drop jump 40 cm: Jumpers and controls displayed similar knee and ankle kinematics Drop jump 80 cm: Jumpers displayed smaller ankle kinematics and similar knee kinematics	Jumpers: significantly shorter contact times than controls in both drop jump 40 cm and drop jump 80 cm

Table 3. *(Continued from page 82)*

Authors	Participants	Test Battery & Intervention Duration	Dynamic Ultrasound	EMG	Joint Kinematics	Jump Performance
Taube et al[44]	N=33 (19 males, 14 females) Mean Age=24 stretch-shortening cycle group 1=11 stretch-shortening cycle group 2=11 Control=11	Drop jump low height (30 cm) Drop jump moderate height (50 cm) Drop jump high height (75 cm) Stretch-shortening cycle group 1 trained with DJs from the varying heights Stretch-shortening cycle group 2 trained with drop jumps from only from low height Both groups trained 3x/wk for 4 wks	N/A	EMG of soleus: -Stretch-shortening cycle group 1: displayed greater EMG during the latter phases of drop jump height -Stretch-shortening cycle group 2: displayed greater amounts of EMG activity during the early phases of drop jumps	Stretch-shortening cycle group 1: displayed greater amounts of flexion during braking phase of all drop jumps Stretch-shortening cycle group 2: not measured due to device malfunction	Stretch-shortening cycle group 1: significantly increased jump height in all 3 jumps Stretch-shortening cycle group 2: upward trend of jump height in all drop jumps Stretch-shortening cycle group 1: increased their ground contact time for all 3 drop jumps, stretch-shortening cycle group 2 decreased their ground contact time for all 3 phases
Hirayama et al[35]	N=8 (8 Males) Mean Age=22	Countermovement jumps on a sledge apparatus situated to 30° Each subject performed 2 initial test trials, then 3x3 of practice Countermovement jumps, then 2 final test trials	-In the first trial, subjects displayed both fascicle and tendon lengthening during braking, and then rapid tendon shortening during propulsion -In the fourth trial, subjects displayed slight fascicle lengthening and then isometric and slight fascicle shortening with greater amounts of tendon lengthening in braking, and even more rapid tendon shortening during propulsion	EMG of gastrocnemius heads and soleus: -Amount of EMG activation did not change between trials -Fourth trial had a faster onset of EMG activity when compared to the first trial	-There was no difference in the amount of dorsiflexion between the first and fourth trial	-There was a significant increase in the maximal ground reaction force during trial 4 compared to trial one
Kubo et al[31]	N=10 (10 Males) Mean Age=22 Plyometric training on one leg Weight training on the other leg	Countermovement jump - Squat jump -Drop jump Plyometric training included hopping	N/A (used during isometric testing) N/A	EMG of gastrocnemius: No significant difference between weight training group and plyometric training group	-There were no differences in ankle kinematics pre- and post-testing or in between groups	Plyometric training leg showed significantly greater ability to perform countermovement jump and drop jump when compared to weight training leg

(Continued onpage 84)

Table 3. *(Continued from page 83)*

Authors	Participants	Test Battery & Intervention Duration	Dynamic Ultrasound	EMG	Joint Kinematics	Jump Performance
Kubo et al[31] *(Continued from page 83)*		and drop jumping at 40% 1 RM Weight training included resistance exercises at 80% 1 RM 4x/wk for 12 wks				Both legs showed improvements in squat jump, plyometric training leg showed greater improvements Plyometric training leg showed greater pre-stretch augmentation in both counter-movement jump and Drop jump, and a significantly greater relative pre-stretch augmentation when compared to weight training. The weight training leg showed a decrease in pre-stretch augmentation Squat jump: significant ↑ vs control countermovement jump: significant ↑ vs control Drop jump: significant ↑ vs control
Kryölänen et al[41]	N=17 (17 females) Mean Age=25.5 Experimental=10 Control=7	-Two different Drop jumps, one from a height of 20 cm jumping to 90% max height, one from 80 cm jumping to 60% max height Training included sledge jumps, Drop jumps, hurdle jumps, countermovement jumps, and standing 5 jump (5 reps per set) 3x/wk for 12 wks	N/A	EMG of gastrocnemius & soleus: -Peak EMG did not change from before and after, but did occur sooner after training. The concentric EMG also occurred later on post training	-Amount of knee and ankle flexion did not change post training -Participants displayed peak knee and ankle flexion sooner post training	Training group showed an increase in mechanical efficiency during high elastic loading trials. This is due to an increase in eccentric work over a small amount of time and an overall decrease in concentric work

Taube et al[44] had different findings as the experimental group significantly increased maximal ankle joint dorsiflexion during the braking phase of the drop jump. The reason for this increase is likely due to the SSC1 group in which this change was observed had performed drop jump training from 30 cm, 50 cm, and 75 cm over a period of 4 weeks. As discussed in the previous section, it is likely that increasing the height of the drop jump favors a more concentric dominant strategy to create force in response to the cue of "rebound as fast and as high as possible." It is unfortunate that the kinematic data from the SSC2 group, who performed drop jump training from only 30 cm, was not obtained due to a malfunction in the measurement device caused by a "loose contact within the cable connecting the goniometer."[44] It would have been interesting to observe the differences in the kinematics between the SSC2 and SSC1 groups to see if the results from the SSC2 group did suggest a more eccentric dominant strategy.

Arabatzi et al[42] observed a correlation between increased hip and knee joint kinematics and jump height in the group that performed Olympic lifting. One of the reasons for this correlation could be a change in jump strategy as an adaptation to the hip and knee dominant patterns inherent in Olympic lifts. Not only were there no significant increases in hip and knee kinematics in the plyometric training group, there was actually a significant decrease in knee flexion angle. This can likely be attributed to the more ankle and knee dominant patterns inherent in the plyometric training performed in this study, as evidence by the greater amount of knee and ankle movement. It would not be as likely for plyometric training to significantly affect hip flexion angle for this reason.[42] Notably, the insignificant decrease in hip flexion angle and the significant decrease in knee flexion angle in the plyometric training group was accompanied by an increase in max jump height compared to the Olympic lifting group. This suggests that the improvements in counter movement jump height in the plyometric training group were likely a result of better use of elastic energy rather than concentric power obtained by moving quickly through a larger joint range of motion.

This finding is consistent with the work of Viitasalo et al[43] in that the non-athletic control group used larger angular displacements to decelerate their body particularly when the height of the drop jump was increased. The athletic experimental group was able to jump higher than the control group with less angular displacement indicating that the neuromuscular system was better equipped to respond to the high tensile load placed on it during the drop jump.

Jump Performance

In a majority of cases the primary variable required for return to sport following Achilles tendinopathy is the resolution of symptoms. Authors have shown that full symptom resolution does not ensure full recovery of muscle-tendon function. Silbernagel et al[45] revealed that only 25% of patients who had full symptomatic recovery had fully recovered muscle-tendon function following Achilles tendinopathy when measured against a battery of jump performance tests. This suggests that the critical neural adaptations required for proper muscle-tendon function are not being met by current rehabilitation protocols.

This review revealed positive impacts on jump performance following plyometric training despite using several different measurement metrics. Jump height was improved in both training groups observed in Kannas et al.[40] While the improvement was determined to be insignificant between groups, this can be attributed to both groups being exposed to plyometric training for 4 weeks.[40] If the two plyometric training groups had been compared to a control group rather than to one another, it is likely that a more significant improvement in jump height would have been observed. Improved jump height was also observed in Arabatzi et al,[42] Kubo et al,[31] and Kryölänen et al.[41] Each study exposed their subjects to training 3 times a week for 8 weeks, 4 times per week for 12 weeks, and 2 times per week for 15 weeks, respectively. The improved jump height in these studies was attributed to an improved pre-stretch augmentation.[31,41,42] An improved ability to rapidly decelerate and absorb the impact forces before efficiently transitioning into the concentric phase demonstrates increased neural drive and an improved ability to use elastic energy via the stretch shortening cycle.

Kyrölänen et al[46] reported improved take off velocities following plyometric training. The improved take off velocity was attributed to an increase in mechanical efficiency, ie, decreased energy expenditure through improved use of elastic energy. This change in MTU behavior was also exhibited in Hirayama et al.[35] However, in this study the change in MTU behavior resulting in improved ground reaction force production was attributed to neural modulation. What must also be taken into consideration is that this intervention lasted one day, which exhibits the speed at which the neuromuscular adaptations to plyometric training can occur.[35]

Limitations

Of the 8 studies under review, 2 of them observed no differences in neuromuscular adaptations between groups. However, these studies still demonstrated differences in jump performance. There are a few potential reasons that jump performance improved without any significant change in EMG signal.

The first article under review by Kyrölänen et al[46] showed that there was an increase in take-off velocity and an improvement in mechanical efficiency after 15 weeks of SSC style power training, but also showed no differences in muscular recruitment strategy as well as ground contact time. In their conclusion, the researchers explained that these improvements were a result of improved joint control and an increase in the rate of force development of the knee extensors. A limitation this group noted was the difference in the parameters for testing when compared to their training style. Athletes trained with a sledge apparatus and additionally performed different quick hopping and jumping activities independent of the sledge. However, when tested on the sledge apparatus, the athletes were to assume a knee flexion angle of ~90°. This type of jump strategy is presumably much different from those used in training. Beginning a jump from 90° of knee flexion would likely bias a hip and knee dominant strategy as evident in previous studies reviewed.[42,44] A hip or knee dominant jump strategy favors concentric rather than eccentric power generation and would likely limit the amount of MTU elasticity usage at the triceps surae/Achilles tendon complex. This could explain why no differences were seen pre- and post-training in this particular study.

Kubo et al[31] also obtained EMG activity data that is somewhat inconsistent with the majority of the other studies reviewed. This study observed better jump performance as measured by jump height and pre-stretch augmentation when comparing an SSC trained leg with a resistance trained leg of the same subject. In their conclusion, the main variable that they deem responsible for this difference is joint stiffness. They define joint stiffness as the joint's resistance to angle change during the eccentric portion of the jump. This change in joint stiffness cannot be explained from the results that they reported. Resistance training showed greater relative structural changes, including muscle volume

and tendon stiffness, however, this group demonstrated lower stiffness than the SSC group during the jump testing. Kubo et al[31] also showed no significant difference between a resistance trained group and an SSC trained group in regards to the overall amount of EMG activity during the different phases of the jump testing for the plyometric group.

General limitations were identified throughout the reviewed articles. One of which was the ambiguity and variability in the definition of jump performance. In the articles reviewed, there were many aspects of jumping that could be included in the appraisal of jump performance, making it difficult to interpret due to a heterogenous data set. However, because the timing of the eccentric portion of the jump is relevant to the use of an MTU, the variables that would be related to this were taken into consideration.

The participants and the sample sizes within these articles also limits the generalizability of the results. The sample sizes ranged from 8 to 36 subjects, but the experimental group was never more than 11. Only 2 studies had a total sample size of >20 participants. Articles reviewed did test either male or female, but the number of female participants were limited. Only one study tested both males and females. Lastly, the mean age of the participants tested never surpassed 25.5 years and was never less than 20. Future studies should seek to acquire larger sample sizes as well as more diverse age and sex populations.

The authors of this review are interested in the implications of plyometric training for a population of patients with Achilles tendinopathy; however, all of the subjects in this review were healthy. Information on neuromuscular ability to access MTU elasticity, as well as the ability to respond to plyometric training is limited in the injured population. Some studies have demonstrated a decrease in jump performance in patients with Achilles tendinopathy,[3,45,47,48] as well as efficacy for using plyometric loading with tendinopathy patients.[3,25,48] However, the exact neuromuscular strategies exhibited by an unhealthy population and the subsequent adaptations from training are not yet known.

Suggestions for future research

Suggestions for further research should include studies looking at MTU use in a population of patients with Achilles tendinopathy. It would be useful for subsequent research to look at the effect of a more structured training protocol than was described in the majority of the studies in this review. Periodization, progression and specificity are well documented strength and conditioning principles and would likely have an effect on the outcome of any graded plyometric loading program.[49] The plyometric loading protocols that were presented in the studies reviewed were wide ranging, both in their exercise selection as well as dosage. Though the majority of them showed an increase in the ability to use elasticity of an MTU, guidance as far as selecting the best exercise and dosage for patients with Achilles tendinopathy is limited. In the future, studies demonstrating a more principled way of exercise selection and construction of periodization may be helpful in order to decrease the heterogeneity in exercise program design.

Although all the studies in this review used EMG as a measurement tool, few of them segmented their data to look at timing of EMG, as it appears the timing of muscle activation is the primary adaptation to plyometric training. It is recommended that future research investigates the timing of the EMG signal and applies dynamic ultrasound to better quantify the tendon versus fascicle length change during plyometric activities.

Finally, a limitation of the research in this area is the quality of the evidence as there are a lack of randomized controlled trials investigating this population.

CONCLUSION

Previous research has shown an inconsistent correlation between tendon structural changes, pain, and rehabilitation outcomes.[20,45,50] Studies have also demonstrated that individuals with Achilles tendinopathy have a reduced ability to harness elastic energy from the MTU.[3,45,47,48] Additionally, recent literature supports the idea that protocols of heavy slow resistance or eccentric overload training will improve the perceived pain of tendinopathy, but may not be effective in returning individuals with Achilles tendinopathy to prior levels of function.[20,45] Evidence shows that the MTU in healthy subjects functions via contraction of the muscle and elongation of the tendon during loading situations with greater velocities.[26–28,32,36,37,40,51] This review suggests that the neuromuscular adaptations to plyometric loading increased the speed and timing of the muscular contraction of the triceps surae thereby improving the ability to load the Achilles tendon and use stored elastic energy. Based on these findings, the authors of this review suggest that progressive, plyometric based loading may be an integral component in rehabilitation. More research needs to be done to investigate using plyometric based loading in patients with Achilles tendinopathy.

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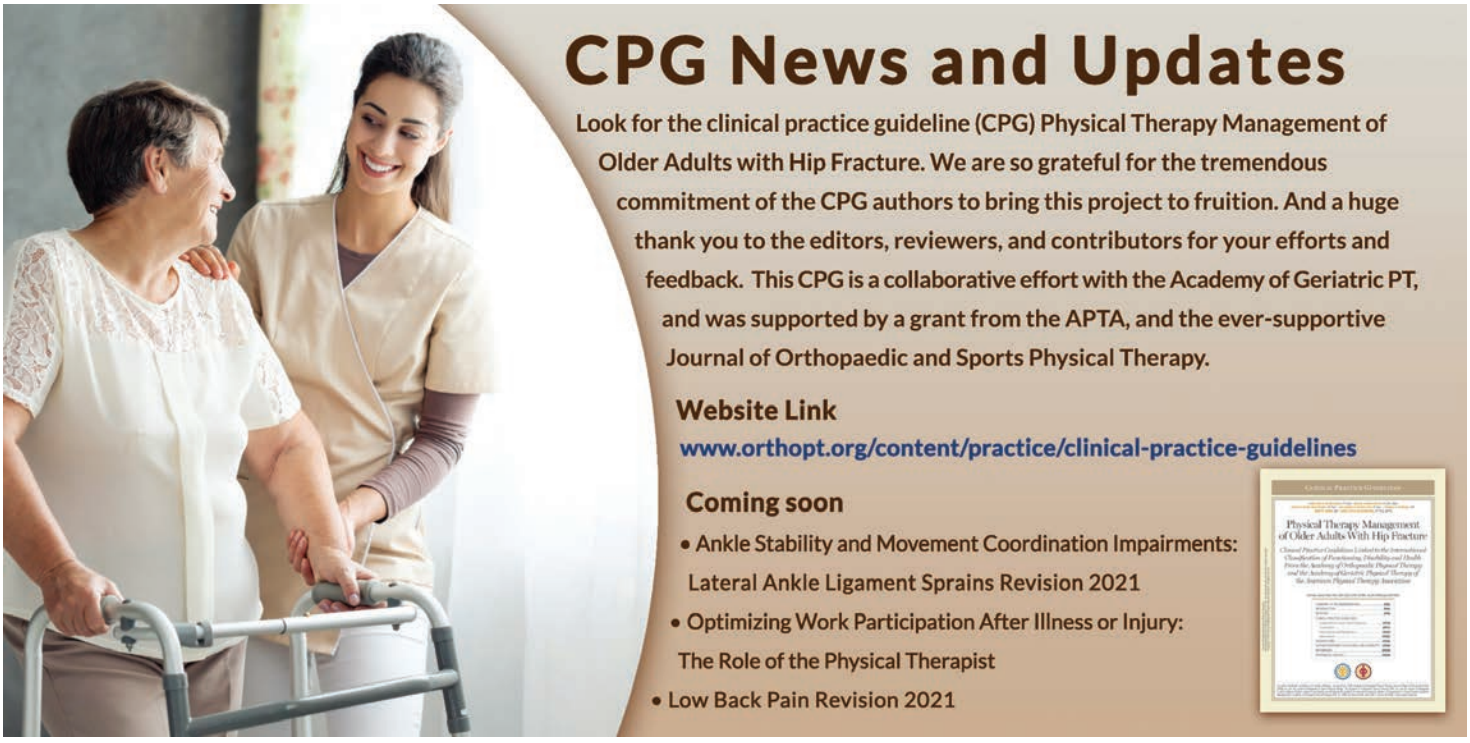

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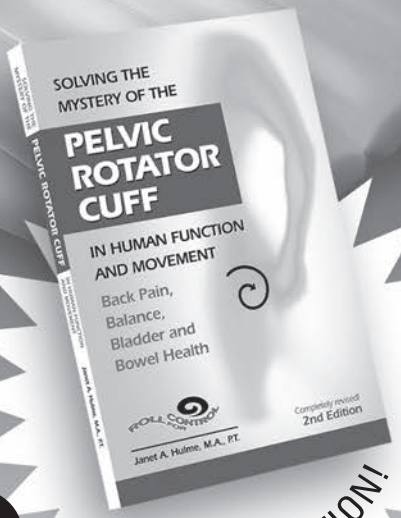

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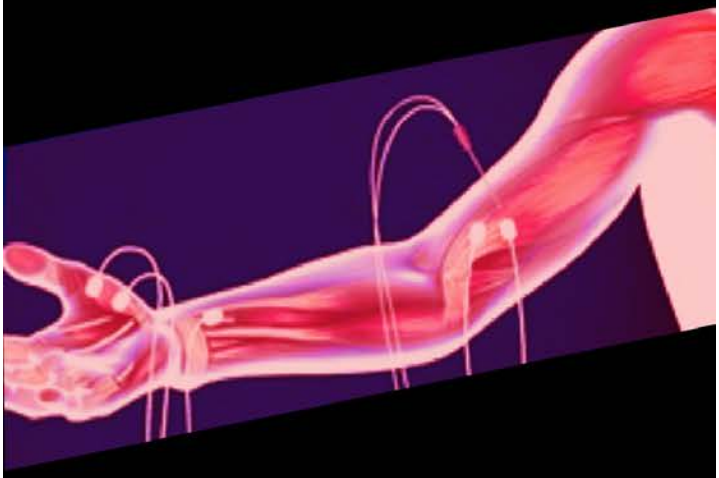

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Physical Therapy for a Patient with Complex Regional Pain Syndrome and History of Morton's Neuroma: A Case Report

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ABSTRACT

Background: Injury to nervous tissue is the leading cause of Complex Regional Pain Syndrome (CRPS), which is a multifaceted condition affecting both the peripheral and central nervous systems. The purpose of this case report is to present a physical therapy program that helped reduce the impact of CRPS on a patient's body impairment, activity, and participation. **Description:** A 61-year-old female presented with a chief complaint of right foot pain and abnormal gait secondary to CRPS. Three months prior the patient underwent surgery for the excision of a Morton's Neuroma. Using clinical practice guidelines for orthopaedic conditions and chronic pain intervention strategies, physical therapy management was applied. **Outcomes:** After 8 weeks, significant improvements were observed in pain level and return to function. **Conclusion:** A multimodal evidence-based approach was successful in the management of a patient diagnosed with CRPS.

Key Words: allodynia, foot pain, hyperalgesia, manual therapy

BACKGROUND

Complex regional pain syndrome (CRPS) is a condition that affects both the central and peripheral nervous systems with pain being the most prominent characteristic.[1,2] It often occurs after surgery, minor trauma, periods of immobilization, or cerebrovascular accidents.[1-4] Clinical features of CRPS include allodynia (pain from a non-noxious stimulus), motor disturbances, hyperalgesia (heightened sensitivity to pain), vasoconstriction, vasodilation, edema, changes in skin temperature and color, trophic changes to the skin, hair, and nails, and body perception disturbances.[1-4] It typically affects one area of the body with a glove or stocking distribution being the most common presentation.[1,3,4] The incidence of CRPS ranges 1-2 per 100,000 annually and is 3 to 4 times more likely to affect women than men.[1,2] The pathophysiology of CRPS is quite complex with disturbances and changes in the sympathetic, somatosensory, and motor nervous system.[1] Initially, the sympathetic reflexes are affected leading to increased susceptibility of hormones and neurotransmitters into blood vessels making nociceptive receptors hypersensitive.[1,4] This is thought to cause alterations in the Ph levels of tissues causing a reduction in oxygen.[1] Complex regional pain syndrome is also associated with an increase in pro-inflammatory proteins that may have a significant role in the development and maintenance in CRPS by ultimately sensitizing nerve endings.[1] The central nervous system is affected by the activation of glia cells on the spinal cord that may contribute to increased pain transmission.[1,2] Constant activity of the primary nociceptive neurons eventually may lead to reorganization of the somatosensory cortex in the brain that alters the motor cortex.[1,3] Neoplastic changes in the brain can cause difficulty performing tactile discrimination, body perception disturbances, and referred sensations.[1,3] The degree of cortical plasticity is reported to be directly related to the pain intensity of CRPS.[3]

Physical therapy has been shown to be effective in the management of CRPS to treat the impaired movement patterns, fear-avoidance behaviors, and peripheral manifestations associated with this disorder.[1,3] Recently, evidence suggests in addition to targeting the peripheral symptoms, treatments should also address the central process of CRPS through strategies such as tactile discrimination, exposure therapy, desensitization, and mirror therapy.[1,3]

A common cause of CRPS is insult to nervous tissue. The most common neuroma in the foot is an intermetatarsal neuroma, known as a Morton's neuroma. A Morton's neuroma is defined as inflammation and/or damage to the digital nerves and is typically located between the third and fourth metatarsals. This type of nerve insult can cause debilitating pain, which may require surgery to excise the neuroma. A possible complication of surgery to remove a Morton's neuroma is development of CRPS post-operatively.

Complex regional pain syndrome can affect many aspects of a person's life including their body structure and function, activity, and participation. The purpose of this case report is to present a physical therapy program that helped reduce the impact of CRPS on a patient's body impairment, activity, and participation.

CASE DESCRIPTION

The patient was a 61-year-old female who presented to physical therapy with right foot pain. She underwent surgery for Morton's neuroma 3 months prior. Following the procedure, the patient reported her pain continued to gradually increase prompting her to return to her physician. She was diagnosed with CRPS by her medical doctor and was referred to physical therapy. She presented to the clinic wearing a soft walking boot on her right lower extremity and antalgic gait pattern; decreased stance time on the right limb due to pain. The patient was also unable to tolerate wearing socks, driving, and weight bearing for longer than 15 minutes due to pain. Other significant past medical history was a sympathetic lumbar nerve block that the patient had received one month ago for the management of CRPS without any symptom relief. The patient reported she had experienced an adverse reaction to the nerve block including feeling malaise, flushing of the facial skin, with no decrease in her pain. The patient was asked to rate her pain using the numeric pain rating scale (NPRS). The NPRS is an 11-point scale with reported validity of r = 0.87 and moderate reliability (ICC = 0.67; 0.27 to 0.84).[6] The patient rates pain on a 0-10 scale, with 0 being no pain at all and 10 being the most intense pain imaginable.[6] The patient rated her worst pain a 10/10 during any weight-bearing activities and a 7/10 at best when her foot was at rest without any tactile stimulation. At the time

of the initial evaluation, the patient reported she was experiencing a 7/10 pain.

Upon examination, her foot appeared red, shiny, and swollen (**Figure 1**). The patient reported that her foot often turned purple, white, or blanched and was unpredictable to the color change. A surgical scar was noted over the dorsal aspect of her right foot between the third and fourth metatarsals and appeared to be healing well. The active range of motion (ROM) for all the joints of the lower extremity was assessed using goniometric measurements. All joint active ROM measurements for the lower extremities were within normal limits as defined by the American Academy of Orthopedic Surgeons, except the right ankle, which lacked 10° of dorsiflexion.[7] The goniometer is reported to have good to excellent reliability in measuring ankle-foot ROM (ICC=0.58-0.97); with >0.75 interpreted as being excellent, 0.40-0.75 as fair to good, and, 0.40 as poor.[9] Passive ROM including accessory joint mobility of the right third and fourth metatarsophalangeal joints was inconclusive at the time of the evaluation due to pain and high tissue reactivity. Strength assessment of the lower extremity was performed using manual muscle testing (MMT) protocol as cited by Kendall,[11] In a systematic review on the reliability of manual muscle testing by Bohannon et al,[12] MMT reliability was stated as pairwise agreement (Kw), and ranged from 0.04 to 1.00; with 30.7% between 0.61 and 0.80 (substantial) and 41.3% between 0.81 and 1.00 (almost perfect).[12] The patient's hip and knee strength tested strong and equal bilaterally. Assessment of right ankle strength, however, was inconclusive due to increased pain with attempts to apply manual resistance to her foot.[11]

Light touch sensation testing was performed using the Ten Test for Sensation. This sensory test evaluates the patient's perception of gentle tactile stimulation of the skin area being tested, and compares it to the referenced normal area.[13] The Ten Test for Sensation has been found to have excellent inter-observer reliability with a kappa value of 1.0 ($p<0.003$) – a kappa score of 1.0 indicates perfect reliability, a score of zero indicates no reliability, and a kappa score of 0.61-0.81 indicates substantial inter-observer reliability.[14] Decreased sensation was found over the surgical incision area between the right third and fourth phalanges possibly due superficial sensory nerve damage during surgery. All other areas of the right foot demonstrated hyperalgesia/allodynia with decreased tolerance to light touch.

Figure 1. Initial Observation of the Involved Lower Extremity

The Lower Extremity Functional Scale (LEFS) was the patient-reported outcome measure used to objectively document the level of impairment and functional ability of the patient at initial evaluation to compare to after intervention. The LEFS is a 20-item measure where the patient is asked to rate 20 activities from 0-4 in difficulty with 0 being extreme difficulty/unable to do, and 4 being no difficulty.[15] The final score is obtained by taking the sum of all 20 items scored, with a score of 0 as the minimal possible score indicating extreme limitations, and 80 as the maximal achievable score signifying no functional limitations.[15] The LEFS has been shown to demonstrate excellent reliability (ICC=0.89-0.99) and validity showing high correlation with self-reported measures such as the WOMAC, the Knee Injury and Osteoarthritis Outcome Score function subscale, and the SF-36 physical functioning subscale ($r < 07$).[15] The patient scored a 10/80 on the LEFS at initial evaluation that signified the patient was functioning at 12.5% of maximal functioning.[15]

EVALUATION

The American Physical Therapy Association recommends physical therapists use the International Classification of Functioning, Disability and Health (ICF) model to organize aspects of a patient's health condition to aid in decision-making, research, and policy.[16] The ICF model integrates both enablement and disablement perspectives.[16] The patient's primary impairments that were identified included right foot pain, hyperesthesia of the distal aspect of her right lower extremity, and edema of the right forefoot. Her secondary impairments consisted of decreased active ROM and weight-bearing tolerance of her right lower extremity. The primary and secondary impairments contributed to the patient's activity limitations of difficulty standing, walking, driving, and showering. Participation restrictions included an inability to participate in family outings in the community, grocery shop, or attend her weekly Pilates class. According to the Guide to Physical Therapist Practice, the patient was given a physical therapy diagnosis of right foot pain and abnormal gait secondary to her medical diagnosis of CRPS.[5]

INTERVENTIONS

To address the identified body impairments, functional limitations, and activity limitations, the patient was seen twice a week for 8 weeks and was also given a home exercise program (HEP).[1-3] The interventions progressed from very light gentle exercises and manual techniques to more aggressive and functional interventions based on the patient's tolerance. Therapeutic exercise, gait training, joint mobilizations, desensitization, minimization of body perception disturbances, taping, massage, and patient education were implemented throughout the course of treatment. The following patient and physical therapy goals were set for 8 weeks: the patient will be able to ambulate 500 ft on uneven surfaces with a pain rating of 3/10 or less in order to travel abroad on her scheduled family vacation. The patient's prognosis was good because she was young, healthy, and motivated with no comorbidities.

Implementation of Intervention

Each of the identified impairments was addressed with an evidence-based intervention (see **Table 1** for summary of interventions). During the first 2 weeks of physical therapy, the primary focus was on desensitization of the right lower extremity. Desensitization interventions commenced by exposing the extremity to the texture of a tissue.[3,17] The tissue was gently brushed against all surfaces of the right lower extremity in strokes starting from the most distal aspect of the phalanges proximally to the mid-tibia area. Once the texture of the tissue was easily tolerated, a new texture exposure of a soft washcloth was implemented into the plan of care.[3,17] Gradually increasing sensory stimulus has been proposed to desensitize the hypersensitive tissue by altering the central processing of the nervous system.[17] Effleurage massage was also performed to the right lower extremity at the start of the treatment sessions with

Table 1. Intervention Progression Summary for the Patient in this Case Report

Interventions	Weeks 1-2	Weeks 3-6	Weeks 7-8
Desensitization	Tissue >> washcloth	Crumbled paper	Mirror therapy
Effleurage massage	Light pressure 20 min	Moderate pressure crossing midline 20 min	Moderate pressure manual mirroring 20 min
Range of motion	Dorsiflexion/plantar flexion 3 x 15 reps	Dorsiflexion/plantar flexion 3 x 15 reps	Plantar flexion in standing Dorsiflexion/plantar flexion 3x15 reps
Graded exposure therapy	Weight-shift seated Anterior-posterior, lateral 5 reps each	Weight-shift standing Anterior-posterior >> modified tandem 1 x 10 reps each	Weighted plantar flexion
Minimization of body impairments	Refer to affected limb as "right foot" Positive encouragement	Positive encouragement	Positive encouragement
Joint mobilization		Plantar and dorsal glides of MTPS; Grades II-IV 1 x 5 reps, 5 sec hold	Plantar and dorsal glides of MTPS; Grade IV Separation stretch to 3rd and 4th mets holding for 3-5 min
Gait training	Boot	25 ft flat surfaces without boot	>25 ft flat surfaces without boot
Stretching		Hamstrings, quadriceps, gastrocnemius 1 x 30 sec hold	Hamstrings, quadriceps, gastrocnemius 1 x 30 sec hold
Tape for edema		Distal leg and dorsal foot	Distal leg and dorsal foot
Neural mobilization	Nerve glides 1 x 10 reps	Nerve glides 1 x 10 reps	Nerve glides 1 x 10 reps
Right left discrimination			Identify right and left shoe on-line activity
Home exercise program (performed daily)	Desensitization ROM Neural mobilization	Desensitization ROM Neural mobilization Standing weight-shifts	Desensitization Neural mobilization Gait training Right/left discrimination

Abbreviations: reps, repetitions; ft, feet; sec, seconds; min, minutes; METs, metatarsals; ROM, range of motion

very light pressure to decrease edema and augment desensitization.[17,18] To improve ROM and decrease edema, the patient was instructed in active ROM exercises including supine ankle dorsiflexion and plantar flexion.[17,19] Additionally, gentle passive ROM of the right great toe was implemented to maintain mobility.

Graded exposure therapy has been shown to improve function, decrease fear-avoidance behaviors, and decrease pain-related fear in patients with CRPS.[1-3] Therefore, graded exposure therapy including weight-bearing therapeutic exercises such as seated weight shifts with feet in full contact with the ground, and slow and controlled seated right ankle plantar flexion were implemented into the treatment program.[2,3,17] The patient continued to use a soft boot during ambulation to increase weight-bearing tolerance.

Neural mobilizations were also performed as they have been shown to improve intraneural fluid dispersion, reduce intraneural edema, reverse increased immune responses, and decrease hyperalgesia following a nerve injury.[21] To perform the neural mobilizations, the patient stood with upper extremity support and her right foot placed on a platform to decrease weight bearing.[20,21] The patient was instructed to flex her right knee, hip, and spine, and then glide the nerve by moving into right dorsiflexion, knee extension, hip extension, and finally extension of the spine. The foot position was altered during the mobilization from a neutral position, into internal rotation, and then into external rotation to target the nerve glide to different lower extremity nerves.[21]

Body perception disturbances, another characteristic common to CPRS, can present in various ways including neglect of the effected limb.[3] Minimization of body perception disturbances was integrated into the plan of care by the physical therapist continuously emphasizing the labeling of the affected extremity as the "right lower extremity" and "right foot", as the patient tended to refer to her foot as "it."[3] Neglect of the involved side can be an acquired attribute of patients with CRPS. Encouraging interaction and acknowledgement of the affected body part promotes

normalization of sensory and motor responses of the affected limb as well as influences cortical mapping.[3] Pain science research involving right/left discrimination tasks has also been shown to be an effective intervention strategy in addressing body perception disturbance in chronic pain patients.[3]

In addition to the interventions provided, the patient was also given a HEP and instructed to complete daily: texture exposure using a tissue, progressing to a washcloth as tolerated, neural mobilizations, and active right ankle plantar flexion and dorsiflexion.[3,17,21] Videos demonstrating and explaining the home exercises were provided to the patient as videos have been shown to have a positive effect on the compliance of HEPs.[22]

As the patient progressed during weeks 3-6, effleurage massage continued progressing to increased manual pressure to moderate.[17,18] Minimization of body perception techniques were also introduced at this time and involved placing the patient's affected limb across midline during effleurage massage.[3,17] Patients with CRPS often demonstrate a shift in the subjective body midline. Placing the affected limb across the center of the body has been shown to positively influence the skin temperature and tactile discrimination.[17] Effleurage massage across midline was performed every treatment session during weeks 3-6.

At week 4, the patient was able to tolerate joint accessory mobility testing, which revealed hypomobility of the third and fourth metatarsophalangeal joints.[23,24] Accessory motion testing reliability of the ankle-foot has shown to vary greatly (ICC -0.67 to 0.84), with greater consistency found with more experienced clinicians.[9] Joint mobilizations of the third and fourth metatarsophalangeal joints were therefore performed into plantar and dorsal directions.[25,26] Posterior glides to the right talus was specifically incorporated to improve ankle dorsiflexion, followed by active and passive talocrual ROM.[17,19,26] Mobilization with movement has been reported to be an effective intervention to restore ROM.[27] To perform this technique, the patient stood with her right foot on a platform. She then lunged forward to provide a passive dorsiflexion stretch while the therapist simultaneously applied a posterior glide to the talus. The patient also continued to perform neural mobilizations with upper extremity support and use of a platform. Appearance of the limb was notably improved and objectified through photographs at week 4 (**Figure 2**).

Figure 2. Observation of the Lower Extremity After 4 weeks of Physical Therapy

During weeks 3-6 the patient also progressed to standing gait training activities with use of bilateral upper extremity support.[3,17] She slowly weight shifted in all directions and was later progressed to more challenging weight shifts in a modified tandem stance with decreased upper extremity support.[3,17]

The patient was introduced to right/left discrimination activities. Determining right from left has been shown to enhance neuroplasticity and cortical remapping that is often altered in patients with CRPS.[17] The patient enjoyed shopping online so was instructed to practice right and left discrimination when shoe shopping by identifying if the shoe that was displayed on the screen was a right or left shoe.[17] Improvements in right/left discrimination have been shown to decrease symptoms of the effected extremity.[17]

At week 6, the patient was able to walk short distances within the facility without the use of her soft boot. Taping (kinesiotape) was also added at this time to address the chronic edema using two 6-inch pieces of tape cut with 1-inch bases and 6 small strips.[28] The bases of the tape were placed on the distal aspect of the tibia with the strips making a criss-cross pattern over the dorsal aspect of the right foot. Taping has been shown to restore lymphatic circulation and reduce edema by increasing the space between the skin and the fascia, which then leads to decreased nociceptor compression and improved circulation.[28]

Stretching of the hamstrings, quadriceps, and gastrocnemius muscles was also continued to maintain tissue mobility.[29] While stretching the gastrocnemius, upper extremity support was used to adjust weight bearing through the right extremity. The patient was instructed to continue her HEP (**Table 1**), and progress her tactile exposure to crumpled tissue paper, and add weight shifts as tolerated.[3,17] Videos of the weight shifts were provided as reference on proper HEP techniques to be completed once a day. Weight shifts and stretching were also encouraged to be performed in a swimming pool to take advantage of the hydrostatic pressure and reduced weight-bearing benefits of the water.[1-3] When immersed in water, hydrostatic pressure can assist in decreasing swelling, and buoyancy may assist with reduced load on joints.[30]

Abnormal or absent sensory feedback of an extremity as displayed in CRPS may lead to cortical reorganization of the primary somatosensory and motor cortex that amplifies the pain and symptoms of the affected limb.[31] During the final 2 weeks of therapy, mirror therapy was therefore implemented to desensitize the right foot.[3] Mirror therapy is a component of the graded motor imagery approach to treating patients with chronic pain, and is considered a progression from right/left discrimination tasks. It is thought to facilitate desensitization and normalization of cortical organization, and therefore was integrated into the plan of care.[17,31] Mirroring was implemented during effleurage massage of the affected limb with the addition of a second physical therapist, who simultaneously provided moderate pressure effleurage to the unaffected limb.[17,18]

Minimization of body impairments was integrated throughout physical therapy by providing positive encouragement regarding outcomes.[3,17] Many psychological aspects associated with chronic pain influence the prognosis of CRPS. Education and positive encouragement have been reported to be crucial in the management of CRPS to decrease the perception of pain.[17]

A summary of the interventions and progressions are provided in **Table 1**.

OUTCOMES

After 8 weeks of physical therapy, the LEFS outcome measure improved from 10/80 to 38/80. The minimal detectable change (MDC) for the LEFS is 9 points indicating the patient's level of function had significantly improved.[15] Pain levels also significantly decreased from 7-10/10 to 3-5/10 exceeding the MDC of a 2 point change.[6] Joint mobility of the metatarsophalangeal joint increased from hypomobile to normal mobility.[24] The end-feel of the joint motion was no longer limited by pain but improved to a normal capsular end-feel.[23] Right ankle dorsiflexion increased 5° allowing for an

improved gait pattern. The appearance of her foot improved as well with normal coloring, texture, and decreased edema (**Figure 3**). The patient met her activity participation goals of ambulating 300 ft on even surfaces with minimal pain and without the use of a boot, and driving for 15 minutes with no pain. The patient was also able to participate in grocery shopping and attend her vacation abroad.

Figure 3. Observation of the Lower Extremity After 8 weeks of Physical Therapy

DISCUSSION

This case report supports the effectiveness of a physical therapy program in managing a patient with CRPS. The patient demonstrated progress evident by her decreased impairments, increased activity tolerance, and increased participation in activities. The LEFS was used to objectively assess the functional progress and effectiveness of the plan of care. After 8 weeks of physical therapy, the patient's LEFS score improved by 28 points indicating the level of impairment significantly decreased.[15] The patient improved from 12.5% to 35% maximal function.[15] Her primary and secondary impairments were addressed as evidenced by improved right ankle active dorsiflexion, decreased tactile sensitivity, decreased pain, improved joint mobility, and decreased edema. Her activity tolerance increased with improved ability to ambulate, drive, and shower. She was also able to participate in more community outings and embark on a family vacation. Although the outcomes are likely due to the physical therapy interventions and are supported by literature, alternative explanations for the results must be considered.[1-4] The patient had received a sympathetic lumbar nerve block 4 weeks prior to beginning therapy that may have also contributed to the patient's outcomes. However, due to the lack in symptom change post injection, this is not likely the reason for improvement.

Overall, the outcomes of this case report are consistent with previous research; CRPS may persist for long durations, but by addressing the peripheral manifestations and central impairments, physical therapy can be effective in treating this chronic pain patient population.[1]

Limitations of this case report include the lack of objective documentation of some measurements. Edema of the patient's forefoot was not measured using circumferential measurement or water displacement.[32] Water displacement and circumferential measurements are reported to have excellent reliability in measuring edema[32] (ICC=0.93-0.96). The periodic measurements of the patient's right lower extremity swelling would have validated the significance of the change in swelling over the course of treatment in addition to therapist observation. Two-point discrimination was not tested. Two-point discrimination is often impaired in patients with CRPS and sensory discrimination training has been shown to decrease pain.[3] The evaluation of two-point discrimination would have provided more objective information on the effectiveness of interventions.[3]

Finally, additional interventions such as virtual reality and prism glasses have been reported to be effective in managing CRPS but were not used throughout treatment due to lack of resources, however, may have been beneficial.[3] Virtual reality uses technology to display images of the affected extremity altering its appearance and state.[3] Virtual reality has been reported to reduce activity of the caudal anterior cingulate cortex, thalamus, insula, and the somatosensory areas of the brain that function to localize pain and register pain intensity.[3] Prism glasses invert the image of the extremities making it appear to the patient that the unaffected limb is now on the side of the affected limb.[3] This has been shown to promote neuroplasticity, decrease pain, and therefore could have augmented the patient's rehabilitation program.

CONCLUSION

Chronic pain is challenging to treat and additional research is needed to optimize patient outcomes. This case report provides an example of an evidence-based physical therapy program that was effective in decreasing the impact CRPS had on a patient's body structure, activity tolerance, and participation following surgery for Morton's neuroma.

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Dry Needling in Physical Therapy Practice: Adverse Events Part 2: Serious Adverse Events

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ABSTRACT

Dry needling (DN) is a modality that is increasingly being used by physical therapists in the treatment of pain and dysfunction related to the musculoskeletal system. Knowledge of the frequency and types of adverse events (AEs) associated with DN is essential in the risk management of physical therapy practice. **Part 1** of this clinical commentary reviewed the types and frequencies of mild AEs associated with DN treatments. **Part 2** will consider the more serious and severe AEs that may occur with DN. A discussion of the concerns of treating pregnant patients with this modality is also included.

Key Words: acupuncture, pneumothorax, trigger point

INTRODUCTION

Most tracking of adverse events (AEs) related to dry needling (DN) in physical therapy practice has shown that the modality, in the hands of trained competent practitioners, is very safe.[1,2] As outlined in **Part 1** of this clinical commentary, most AEs are mild and transient in nature. Although rare, significant, and serious AEs have been reported in the literature and include pneumothorax and hemothorax, infections, serious bleeding, cardiac tamponade, and nerve injuries. Special concerns related to possible needle breakage or forgotten needles and complications related to pregnancy must also be considered when choosing this modality. Serious AEs are commonly associated with practitioner negligence and poor adherence to practice standards.[3] A review of these various AEs and their prevention and management follows.

SERIOUS AND SEVERE ADVERSE EVENTS

Pneumothorax/Hemothorax

The AE that garners the most media attention is a pneumothorax or hemothorax. It is the most common serious complication of acupuncture or DN interventions and is of legitimate concern since needling around the rib cage and upper trapezius region is common. Most patients who sustain a pneumothorax will fully recover and mortality is rare but prevention of this AE is essential as it has the potential to be life threatening. Physical therapists must be conversant in the clinical presentation of a pneumothorax in order to help manage this condition.

A pneumothorax is the presence of air or gas (or blood in the case of a hemothorax) in the pleural cavity. Pneumothorax can be spontaneous or traumatic in nature. A spontaneous pneumothorax can be primary or secondary dependent on a concurrent pre-existing lung condition. Primary spontaneous pneumothorax is associated with smokers and is much more common in males (6:1 ratio). Other risk factors include a tall, slender body type, Marfan's syndrome, pregnancy, or a positive family history of spontaneous pneumothorax. Secondary spontaneous pneumothorax may be associated with chronic lung conditions like tuberculosis, chronic obstructive pulmonary disease, cystic fibrosis, and severe asthma. The incidence of spontaneous pneumothorax is between 7.4 and 18 cases per 100,000 in males and 1.2 and 6 cases per 100,000 in females.[4]

A traumatic pneumothorax can be classified as non-iatrogenic or iatrogenic. Examples of causes of non-iatrogenic traumatic pneumothorax include trauma (both penetrating and non-penetrating), rib fractures, and high-risk sports like SCUBA diving or flying (due to increased barometric stresses). A practitioner may induce an iatrogenic traumatic pneumothorax inadvertently when inserting a needle too far into the tissue and puncturing the pleura or lungs. The incidence of acupuncture-induced pneumothorax has been reported as less than 0.01/10,000 interventions.[5] This low estimate may not reflect the true frequency as many acupuncture interventions may not even include needling over the high-risk thoracic region. The signs and symptoms may develop after a treatment session and a practitioner may not even be aware of the development of a pneumothorax. A complication of an iatrogenic pneumothorax is the development of a tension pneumothorax when the pressure in the plural space is positive throughout the respiratory cycle. This can result in a decrease in venous return, hypoxia, and hypotension.

A pneumothorax or hemothorax can present with symptoms similar to musculoskeletal pain (pain in the chest that can radiate into the shoulder or back) and will affect ventilation and impair oxygenation. The clinical signs and symptoms are dependent on the degree of lung collapse and may include dyspnea, increased respiratory rate, dry cough, malaise, cyanosis, and diaphoresis. They may present with decreased breath sounds on auscultation and present with a mediastinal shift. It must be noted that an iatrogenic DN induced pneumothorax may take several hours to develop and may not be evident initially. The signs and symptoms can vary as a result of a person's overall health. If in poor health, a small pneumothorax can result in severe symptoms but in a healthy person, mild symptoms may prevent a patient from seeking immediate medical attention. The rate of intrapleural gas absorption in untreated lesions is 1.25% of the thoracic volume per day. A small pneumothorax may reabsorb spontaneously, which may result in under-diagnosing or underreporting of the AE.[6]

The treatment of a pneumothorax is dependent on the degree of lung collapse. According to the American College of Chest Physicians,[7] patients who are clinically stable and present with a spontaneous pneumothorax of less than 3 centimeters from apex to cupola are usually treated conservatively with observation. Larger pneumothorax may require needle aspiration or chest tube placement. Oxygen supplementation may be required if oxygen saturation levels are low.

Dry needling in the area of the upper trapezius, the thoracic erector spinae, and levator scapulae region have been associated with an increased risk of iatrogenic pneumothorax. The subclavicular and supraclavicular regions, the intercostal and interspinal spaces, and abnormal congenital foramen in the scapulae and sternum have also been linked to increased risk.[8] Practitioners needling these areas understand the relevant and vital anatomical structures in the area. Iatro-

genic pneumothorax mostly is unilateral but cases of bilateral iatrogenic pneumothorax have been described.[9,10]

Knowledge and practice in the correct needling direction and needle depth, and palpation of these areas are essential when being trained in DN techniques. Lack of training, practitioner negligence, and poor knowledge of surface and underlying anatomy can put a patient at risk of an AE. The safe needling depth over the lungs to avoid a pneumothorax can be as small as 10 to 20 mm.[11] Mitchell et al[12] using ultrasound imaging demonstrated that there are differences in the skin-to-lung tissue depth dependent on the patient's position on a treatment table. When a person is lying in a prone position and a bolster is placed under the shoulder to bring it into a more retracted position, there is an increase in the depth to the lung tissue. Body composition differences between males and females and the body mass index (BMI) can also affect the distance to the lung tissue when needling the thorax. Grusche et al[13] reported 3 cases of traumatic pneumothorax following acupuncture or DN interventions seen at an emergency room in Victoria, Australia. All involved young women with low BMI. Karavis et al[14] also presented a case study of an acupuncture-induced haemothorax involving a woman with a low BMI.

Infections

Infection rates with DN and acupuncture have decreased over the decades through improvements in educational standards and the use of single-use disposable needles. Since 1984, the Council of Colleges of Acupuncture and Oriental Medicine have developed and administered the *Clean Needle Technique* (CNT) course, which is mandatory training for acupuncture licensing in the United States. These guidelines were developed to reduce the risk of spreading infections and avoid other risks associated with acupuncture and ensure the safety of both patients and practitioners. The course material is regularly updated with information from the Centers for Disease Control and the Occupational Safety and Health Administration (OSHA) as best practices change and evolve. This course is only available at present for acupuncture students but the manual, currently in the 7th edition, is a good resource for practitioners performing needling interventions. All physical therapists in the United States study the Occupational Safety and Health Administration's blood-borne pathogen regulations (standards – 29 CRF) and this will not be discussed in great detail in this paper.

Infections are a concern when needling, as the skin normally acts as a barrier to infection. Infections can be either autogenous (caused by an infectious agent that the patient already carries) or a cross-infection where a pathogen is acquired from another person or the environment. A percutaneous infection at the needle entry site will show the classic signs and symptoms of redness, swelling, local heat, and pain. Severe infections can also be accompanied by fever. Most infections related to DN are associated with mycobacterium or methicillin-resistant *S. Aureus* (MRSA).

Xu et al[15] reviewed case reports published between 2000 and 2011 and found 239 cases of infection associated with acupuncture interventions. The vast majority of the cases occurred in Korea, and were related to non-sterile needles or inadequate disinfection of other equipment. The routes of infection and their frequency have changed over the years now that disposable needles are the current clinical norm, but the increased pervasiveness of MRSA and mycobacterium infections in health care settings further illustrate the continuing importance of hygiene in clinical environments. Dry needling and acupuncture can be complicated by autogenous infections caused by organisms on the patient's own skin flora. The most commonly used skin disinfectant used prior to needling is 60% to 70% isopropyl (or ethanol) alcohol yet some mycobacteria have been shown to be relatively resistant to it.[16] For patients with a compromised immune system, or poor hygiene, cleaning the skin with products containing 0.5% chlorhexidine or povidone iodine may be a better choice. Formal regulations regarding skin disinfection prior to needling must be followed in a practitioner's jurisdiction.[17]

Infections related to DN are rare. In fact, Hoffman reported that bacterial infections caused by deep needling are uncommon because the needle tip is too small to carry a sufficient amount of inoculum from the skin.[18] Recently, however, 3 case studies related to DN and infections have been published. Kim et al[19] described a case study of a 16-year-old boy who developed an abscess in the posterolateral distal aspect of the right thigh after undergoing DN intervention for iliotibial band syndrome. The infection resolved but required a hospitalization and the continuation of intravenous antibiotics for an additional 3 weeks after the hospital discharge. The CNT was documented by the treating physical therapist and it was uncertain if the abscess development was coincidental or a clinical error associated with improper CNT. Two other cases discussed the development of infections after DN with patients who had undergone previous surgical interventions. A 15-year-old who had had spinal arthrodesis for treatment of an idiopathic scoliosis 21 months prior, developed a deep spine infection after having DN in the medial periscapular region for chronic back and shoulder pain. The periscapular abscess necessitated an operative debridement and 2 months of antibiotic therapy. The authors concluded that the deep infection from DN might have contaminated existing spinal instrumentation.[20] A Dutch case study described a 57-year-old patient who underwent a total hip replacement and then developed a bacterial infection after DN interventions 7 months after the surgery. Antibiotic interventions were unsuccessful and debridement and irrigation of the area was required.[21] Although there was no strong evidence for a causal relationship between DN and these infections, caution should be used in patients with joint replacements or other hardware in the area of DN.

Cardiac Tamponade

Another serious, although rare, complication related to needling in the area of the sternum has been reported. The presence of a rare congenital abnormality called a sternal foramen occurs in 5% to 8% of the population as a result of an incomplete fusion of the sternal plates. The foramen is usually at the level of the 4th intercostal space but cannot be reliably palpated as tendon fibers, thin connective tissues, or bone lamella may conceal it. If a needle punctures this hole, a cardiac tamponade may occur. A compression of the heart may occur when blood or fluids build up around the pericardium, and can be fatal. The signs and symptoms of a cardiac tamponade may include chest pain, which may radiate into the neck, shoulder or abdomen, and worsens with deep breathing or coughing, anxiety, hypotension, difficulty breathing, palpitations, and fainting. Caution must be taken when needling the sternalis or pectoralis major muscle trigger points that overlie the sternum. (It is noted that the sternalis muscle is highly variable in its presence and laterality). Injury to the pericardium or heart can occur if needling deeper than 13 to 25 mm over the sternum occurs.[22] Needling in this area must be performed in an oblique cephalad direction.

Nerve damage (peripheral and central nervous system)

For over a century there have been pub-

lished reports of neurological damage that can occur as a result of intramuscular needling using hypodermic needles.[23-25] The resultant motor and sensory nerve damage can be catastrophic and only 28% have a favorable recovery.[26] The signs and symptoms associated with traumatic nerve damage depend on the severity of the nerve injury. The structural and functional changes can categorize the injury as a neuropraxia, axonotmesis, or neurotomesis.[27] Fortunately, the smaller gauge needles used with DN interventions make complications from nerve injury far less common and less serious than those encountered with hypodermic needles. The most common type of nerve injury related to DN or acupuncture is a neuropraxia resulting from a hematoma causing nerve pressure. Prognosis of neuropraxia injuries is good with symptom regression generally occurring spontaneously within days or weeks. If bleeding is severe, an axonotmesis could occur. Axonotmesis recovery, although good, is often longer and symptoms can last for months.

Research validating needle placement in relationship to target tissues using cadavers has been done but it is uncertain whether such knowledge obtained in vivo can be helpful in guiding practitioners on how to avoid structures such as nerves.[28-30] The use of fluoroscopy or ultrasound imaging to verify needle placement during DN is impractical.[31] Research is also continuing to determine if patient positioning can help reduce the risk of injury to nerves or other underlying tissues.

If a patient experiences a sharp electrical-type sensation distal to the needling site during DN, a nerve may have been encountered. Peuker[22] has described several peripheral nervous system injuries associated with acupuncture and notes that peripheral nerves often have a variable anatomical course. For example, peroneal nerve palsy with a resultant foot drop has occurred after needling the area around the fibular head.

More recently, McManus and Cleary[32] described a case of a 27-year-old woman who developed a neuropraxia of her left radial nerve (at the level of the spinal groove) after DN intervention for shoulder pain. She developed a left-hand muscle spasm after a needle insertion and a subsequent left wrist drop. Despite intensive hand therapy and splinting, the patient continued to present with profound weakness. Follow-up nerve conduction and EMG testing showed no sign of nerve recovery.

In addition to peripheral nerve injuries, cases of injury to the spinal cord or spinal nerve roots associated with acupuncture and DN have been reported. Peuker[22] reviewed 10 cases of injury that were the result of direct injury to nerves or the result of needle fragments that occurred in the cervical and lumbosacral regions. The severity of injury varied from focal neurological signs to paraplegia. The authors noted that the distance from the skin to the nerve roots or spinal cord varies from 25 to 45 mm depending on the size of the person.

Forgotten needles or broken needles

Practitioners must be meticulous in ensuring that no needles are forgotten during an intervention. As most DN does not involve needle retention, this is less of a concern than acupuncture, which involves numerous needles and longer retention times. Maintaining and documenting accurate counts of needles "in" and "out" helps. Practitioners should keep used, empty needle packaging until the end of the intervention session to help maintain a correct needle count.

Needle breakage is rare now that single-use disposable needles are the standard of practice. Prior to this, metal fatigue was a concern when needles were repetitively used and sterilized with an autoclave. The most common area for a needle to break is at the root of the needle where the shaft and the body meet. When inserting a needle, one-quarter to one-third of the shaft should always be kept above the skin level. This requires the practitioner to use the correct needle length for the patient size and the area of the body that is being treated. Breakage may occur if there is a crack in or erosion of the needle, which may be a factor when using needles of poor quality. Breakage could also occur if the patient suddenly moves or has a strong muscle spasm, an external force hits the needle, or if a practitioner tries to forcibly remove a bent needle.

Leow et al[33] studied the mechanical compression forces needed to break a filiform acupuncture needle. A variety of needle diameters and lengths (.25 x 40 mm, .30 x 25 mm, .18 x 13 mm) were bent using an Instron 3343 single column universal testing system. The authors were unable to break the needles but permanent bending did occur with high loads. They concluded that needle breakage is unlikely to occur with muscle spasm or sudden movement of a patient but recommended avoidance of excessive force when manipulating needles.

If a needle does break during intervention, it is important for the patient and practitioner to stay calm and the patient to remain still. If part of the needle is visible above the skin, it should be gently removed with forceps. If it is at the skin level, the tissue around should be gently pressed until the broken end is exposed and can then be removed. If removal is not possible, the needle's point of entry on the skin should be marked and medical transportation to the hospital arranged.

Case studies have illustrated the danger of needles breaking or being forgotten during interventions. Chaput and Foster[34] reported of a healthy 46-year-old woman went to an emergency room and complained of a foreign body sensation after eating some potato chips and feeling one lodge in her throat. An x-ray and a subsequent laryngoscopy showed a needle in the wall of the esophagus. Six months prior she had been receiving acupuncture for a whiplash injury. She could not recall if one of the needles had broken but she had continued neck pain, which she had attributed to the motor vehicle accident. Snyder also described the case of a 52-year-old man who had acupuncture treatments for chronic neck pain while out of the country on a business trip. During the session, one of the needles inserted in the upper cervical region broke. The acupuncturist was unable to remove the needle segment and the patient was transported to the hospital for x-rays. The radiography showed that in addition to the needle near the C1-2 junction another needle was discovered at the C6-7 level, presumably from a previous acupuncture session. It was determined that both needles did not pose an immediate threat and the patient boarded a plane back to the United States. During the flight, however, the upper cervical needle migrated over 3 centimeters. Upon landing, further imaging was done and the upper cervical needle was found only 2 millimeters from the vertebral artery. Surgical removal of the needles was required followed by extensive physical therapy to regain cervical mobility.[35]

USING NEEDLING MODALITIES DURING PREGNANCY

There is little published evidence on the safety of treating pregnant women with DN. Physical therapists may be uncertain about using the modality during pregnancy and may be concerned about the potential risks to the unborn fetus or the mother. However, lower back and pelvic girdle pain are common ailments during pregnancy. Dry needling is an intervention that may be helpful in symptomatic relief of pain since pharmaceutical intervention is often not an option.

It is noted that physical therapists are often reluctant to treat pregnant women with needling modalities as a defensive practice. Miscarriage occurs in over 10% of all pregnancies with 80% occurring in the first trimester. The Fanslow study, a random sample of 2,391 New Zealand women, reported that a spontaneous abortion had affected almost 1 in 3 women.[36] If a patient has a DN treatment and has a spontaneous abortion soon afterwards, the therapist and the intervention may be suspected of causing the event.[37] The "fear of blame" for a potential miscarriage may influence physical therapists to choose not to treat pregnant patients with DN.[38]

CONCLUSION

Although there are few recorded serious AE associated with DN, there is an absence of national or international standards in the training of physical therapists in DN interventions. In the United States, there is considerable variation in DN training standards and the efficacy of the training is not regulated. The length of a program is not necessarily a valid measure of competency. The DN educational programs and federal and state professional regulatory agencies must ensure the competency of practitioners who needle these vulnerable areas. Some individual states have mandated initial competency requirements, since profession-wide national standards do not exist. Individual physical therapists performing DN must always comply with the standards of their own state regarding the educational and competency requirements.

At the present time, there is no consistent tracking of the AE associated with DN. The ability to systematically report AE associated with DN in a blame-free and voluntary way can help the profession to focus on reducing accidents.[39]

Dry needling education must emphasize anatomical knowledge with advanced training when needling the trunk, thorax, head, and cervical regions. It is essential that practitioners screen for individual risk factors associated with each patient, practice strict adherence to sterile needle practices and be able to recognize acute AE complications. It is also important to obtain informed consent prior to treatment, document treatments well, and have adequate follow-up of any AE. This article contributes to the literature on DN to inform the reader of potential AEs to consider.

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The Clinical Influence of a Collaborative Partnership for Physical Therapy Residency Training in Kenya: Perspectives of Graduates and their Employers

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ABSTRACT

Background and Purpose: Collaborative partnerships have been formed with academic institutions in resource-limited countries to elevate the care provided to individuals with disabilities. However, few studies have explored the influence of these programs on clinical practice. The aim of this qualitative study was to explore the influence of an international partnership developed to provide advanced education to physical therapists in Kenya and the impact of the program on clinical practice. **Methods:** Individual interviews were performed with graduates of the residency program and their employers to explore the influence of the advanced education on clinical practice. **Findings:** Five interrelated themes were discovered through the interviews offering a conceptual model for the relationship between clinical reasoning development and enhanced clinical practice. **Clinical Relevance and Conclusion:** The collaborative partnership for advancing the practice of physical therapists in Kenya positively influenced the development of clinical reasoning skills and clinical practice.

Key Words: clinical practice, clinical reasoning development, residency training

BACKGROUND AND PURPOSE

The majority of the world's population with disabilities reside in resource-limited countries.[1] To assist in elevating the quantity and quality of rehabilitation providers, non-governmental organizations and academic programs have engaged in collaborative partnerships with institutions in those countries.[2] However, there are few studies that have explored the influence of these collaborative efforts.[3-6] The current outcomes have focused on the number of graduates and cultural competency of the participants.[2-6] There has been limited focus on the long-term impact of these programs on clinical practice or patient outcomes.[2-6] It has been suggested that partnerships for global health training need to be evaluated based not only on the number of graduates, but also the access to clinical services and improved health outcomes related to the training.[3]

Physical therapists in Kenya currently have the opportunity to obtain a 3-year technical diploma or Bachelor's degree in Physiotherapy. To promote rehabilitation in the country of Kenya, a post-graduate physical therapy orthopedic residency program was introduced to Nairobi in 2012. The program is a collaborative effort between the Jackson Clinic Foundation (United States) and the Kenya Medical Training College. The residency program in Kenya was based on the current residency model for physical therapists in the United States.[7,8] The 18-month program consists of 12 weeks of onsite didactic and practical education, online education, and clinical mentoring. The mission of the residency program is to graduate physical therapists who can guide their communities and profession in the advancement of quality patient care and education.

Post-graduate physical therapy residency programs have been recognized by graduates in the United States as a valuable resource for advancing clinical reasoning and promoting career advancement.[9,10] Survey studies performed in the United States have noted a positive impact of residency education on the ability to execute a comprehensive evaluation, employ clinical reasoning in the examination of patients, and use scientific literature to develop treatment plans.[9,10] Furthermore, Robertson and Tichenor proposed increased efficacy in patient care and confidence in implementing evidence informed practice may contribute to the residency graduate's professional satisfaction and a dedication to lifelong learning.[11] Although accepted from a theoretical perspective, limited studies have investigated the influence of physical therapy residency programs on practice patterns and patient outcomes.[12]

Although physical therapy residency graduates value the advanced education for development of expertise, the self-perceived improvements in clinical reasoning may not generate improved patient outcomes.[9,10,12] Furthermore, the clinical impact of partnerships to provide health care education in resource-limited countries has not been widely investigated.[2-6] Providing education to enhance patient care, without understanding the eventual impact of the education, may present ethical challenges. The aim of this qualitative study was to explore the influence of an international partnership developed to provide advanced education to physical therapists in Kenya and the impact of the program on clinical practice.

METHODS

Twenty-seven graduates of the first and second cohorts of the residency program in Kenya were contacted 2 years following graduation to request their participation in an interview. The graduates were chosen based on their physical proximity to Nairobi, Kenya. All graduates contacted worked within 3 hours of the capitol city. In addition to requesting one-on-one interviews with the graduates, permission was requested to contact their employers or supervisors to participate in interviews. A total of 14 residents and 6 employers agreed to take part in the study. Approval for this study was received from the Kenya Medical Training College Ethics and Research Committee and the Institutional Review Board of Radford University. Informed consent was obtained prior to initiation of the study and the rights and confidentiality of the participants were protected throughout the study.

Interviews were conducted in September and October 2016. The primary investigator (PI) traveled to each participant's place of work to perform the individual, face-to-face interviews. The PI had completed graduate training in qualitative research methods and had been mentored by an experienced qualitative researcher in interviewing techniques. Graduates were familiar with the PI as an individual collecting data regarding the outcomes of the program and also from participation in two previous studies. Other than that,

there was no relationship with the researcher. Prior to participating in audiotaped, semi-structured interviews; each participant provided informed consent and completed a brief demographic questionnaire. Interviews with both the graduates and employers lasted approximately 40 minutes each.

A qualitative research design was chosen for this study to explore the perspectives of the graduates of the residency program and their employers. The graduates and their employers were chosen for the interviews in order to gather multiple interpretations of the phenomenon within the context of clinical practice. An interview guide was developed with open ended questions to encourage the participants to explore their experience. The interview guide can be found in **Table 1**.

A combination of the phenomenological and grounded theory approach was used to analyze the qualitative data. All interviews were transcribed by an independent transcriptionist to ensure accuracy. To maintain confidentiality, each consenting resident and employer were assigned a pseudonym for identification purposes. The primary investigator analyzed the data collected from the interview by identifying significant statements. The constant comparative method was utilized for primary coding followed by secondary cycle coding to identify patterns and themes. The qualitative data analysis software NVivo Mac, distributed by Scolari, was used to arrange codes. Thick descriptions and narratives of the participants have been provided to inform the themes. As the themes developed, a relationship was discovered between the themes as the participants discussed their experience on a continuum. This resulted in the progression of data analysis towards a grounded theory approach to develop a model to frame the findings. Member checks for accuracy of the themes were performed with seven of the participants to improve validity. The 7 participants (6 graduates and 1 employer) were offered the themes with narratives to read and confirm that their views were correctly represented. Furthermore, the themes were provided to one of the original developers of the residency program and an instructor in the program for a formal critical evaluation of the findings.

Table 1. Interview Guide for Graduates and their Employers

Graduate Residents

1. Could you describe your experience in the residency program?
2. Has your clinical practice changed since the completion of the program?
3. Has completion of the residency program affected patient outcomes?

Employers

1. How many residency graduates are practicing in the clinic?
2. Have you noticed a change in their clinical practice?

Closure

Is there anything else you would like to discuss before we end this interview?

FINDINGS

Graduates participating in the interviews demonstrated a median age of 29.0 years (SD 10.3 years) with 8.2 years of experience in clinical practice (SD 9.8). Five themes were discovered through the interviews: (1) clinical reasoning development, (2) increased efficacy in patient care, (3) consultations for complex patients, (4) enhanced clinic reputation, and (5) increased clinic income. Each of the themes built upon each other to result in a transformation of clinical practice (**Figure 1**). As the residency graduates' clinical reasoning developed, their treatment efficacy improved. The improvement in patient outcomes were recognized by their colleagues and consultations for difficult patients were requested of the graduates. In this manner, the graduates began to provide mentoring to their peers. Not only did the physical therapists notice a change in practice, the patient progress was also recognized in the medical community. This recognition as expert clinicians, resulted in increased referrals to the clinic, enhanced clinic reputation, and improved clinic income.

Clinical Reasoning Development

The graduates noted the personal change in their practice as the result of their clinical reasoning development. Their confidence in patient care and patient outcomes had improved as they integrated the knowledge and examination techniques taught throughout the residency. As stated by one graduate, "Clinical reasoning is the best way to do your examination, determine a diagnosis, your prognosis. Then at the end of the day, you know this patient has this problem and you are going to give a correct intervention." The ability to determine a hypothetical diagnosis was further supported by another graduate,

> Prior to residency, I was not going deeper to really establish the cause of pain, but now I have the ability to do that. I can confidently do it and distinguish between hypotheses and come up with the right one. I also positively identify the functional limitations and impairments that the patients have.

Graduates reported that determining a hypothetical diagnosis and list of impairments specific to the patient provided guidance to the treatment plan and resulted in the perception of improved patient outcomes.

Increased Efficacy in Patient Care

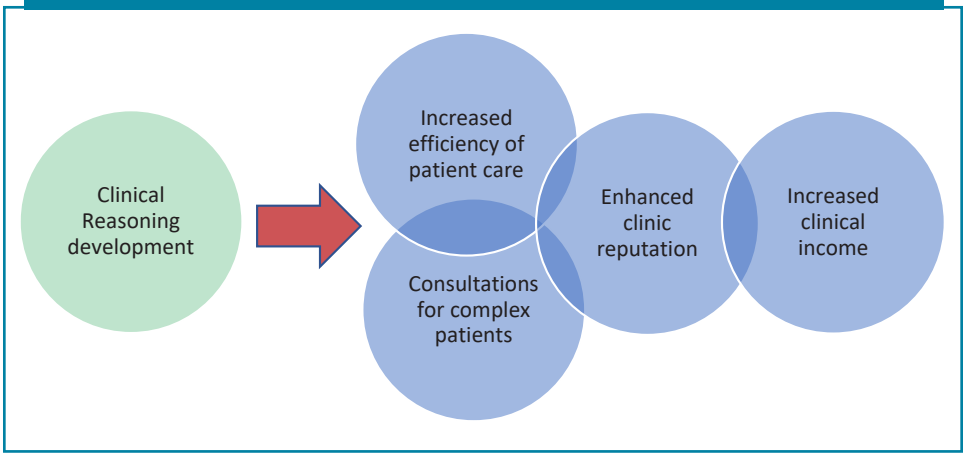
In addition to the development of clinical reasoning skills, graduates of the residency program and employers noted that the treatment efficiency had improved. One graduate noted, "I am seeing patients for a shorter period and getting tremendous results." Another graduate noted that this increased efficiency was resulting in financial savings for the patient as well, "You understand the patient's condition better, instead of just guessing and doing everything which was very unnecessary. So you do not waste the patient's time and also the money." This improved efficiency was not only recognized by graduates, but also commented on by the employers,

> I have seen them change in terms of examining patients, documenting what the patients are being seen for, and also documenting their examination process. I have seen them take a shorter period with their patients. From the patients, we also get feedback. Those patients are appreciative of the results and the short timeframe.

This change was reinforced by another employer,

> There is a big change in those that have done the program and those who have not done the program. If you look at their practices as an employer, you find that those that have not done the program are still in the old way of doing things (electrophysical agents). It is a routine thing that they do and

Figure 1. Progression From Individual Professional Development to Enhanced Clinical Practice



> they tend to keep the patients coming to the clinic for a longer time. And I like what I am seeing with the persons who have done the residency program, take shorter time with the clients. [sic]

Consultations for Complex Patients

The graduates discussed providing consultations to their peers for the treatment of difficult patients. Through this consultation they provided one-on-one mentoring to their colleagues. As stated by one graduate, "It has reached the point where most of my colleagues come to me for advice on what to do for the patients, which is something they were not doing before." This was reinforced by another graduate, "When they are seeing a difficult patient, they call me in to see the patient together. They can see the kind of manipulations I am doing. And they learn more deeply and they know this is what is done." The ability to use consultation as a form of mentoring was emphasized in other interviews, "When they have a patient, they will tell you. Kindly ask you to assess the patient. You want to systematically go through some assessment with them." The enthusiasm to share knowledge was repeated, "So we are going one day at a time. If they are open to learning, we are really open to sharing knowledge. I am really ready to share my knowledge." By sharing knowledge and providing mentoring to colleagues, the programs influence was extending beyond the graduates to clinical practice as a whole.

Enhanced Clinic Reputation

The positive change in practice has led to an enhanced clinic reputation where the residents are employed. The patients are leaving positive feedback regarding their treatment in the clinics compliment books and referring others to the clinic. Compliment books serve a similar function as patient satisfaction surveys in the United States.

> The patients are writing in the compliment book. Most patients are writing that they are happy with my management or our management of people who have done the (Orthopedic Manual Therapy) OMT program. Most people say they have been referred to people who have done the OMT.

Employers have also seen the change, "Once I have referred the patient to them, within no time the patient pass through here (management office) and tells me he has noted tremendous improvement and it goes back to the doctor. So the doctors keep sending patients to me and I allocate them to the few who are very confident." Other employers noted the same change in referrals, "We get more referrals. Now the doctors want to know whether we are doing OMT. So they are sending patients for manual therapy." This was reinforced by an employer, "We have also experienced some increase in referrals. So that in itself has also created a positive image of the hospital and in particular the department."

Increased Clinic Income

As clinics saw a positive change in referrals and reputation, the result was an increase in income. The change in clinical income was noted by all employers. "The change has been remarkable, more revenue than I have ever done." Another employer directly associated the changes in clinical practice to increased revenue generation.

> The practice in the clinic has changed tremendously. There are things I forgot to mention with the revenue, with the increase revenue. That is a point to the fact that so many people are now coming in and out.

> This increased income has allowed employers to partially fund or fully fund the residency training for additional therapists in their respective clinics interested in advanced training.

There were several limitations to this study. The study was based solely on interviews with residency graduates and their employers from a single program for the professional development of physical therapists in Nairobi, Kenya. The results of this study may not be generalized to collaborative health care programs in other resource-limited countries. Nonetheless, the findings and resulting model may be transferrable to similar collaborative relationships to provide advanced health care education to physical therapists in resource limited countries. Limited health care documentation and outcome measurement in Kenya restricted the analysis of quantitative measures over time. However, efforts to gather this information through qualitative interviews has provided insight into the influence of the education on clinical care.

CONCLUSION

The themes discovered through the interviews with graduates and their employers were interrelated. As graduates improved their individual clinical practice through the application of clinical reasoning, they were able to provide mentoring to colleagues resulting in the increased efficacy of the clinical practice. This helped improve the clinic reputation, increased referral sources, and increased clinic income. This transformation in practice was recognized by the residency graduates and their employers alike, thus resulting in increased value being placed on the advanced education.

Similar to research on graduates with advanced degrees in allied health professions in the United States, the residency graduates reported increased confidence with their patient examinations and treatment plans.[13] This has also been reported by physical therapists in the United Kingdom following completion continuing professional development courses.[14] The motivation to improve patient outcomes and increased confidence in patient care resulted in increased job satisfaction.[14] Not only did the Kenyan residency graduates note their personal increased confidence, the improvements in patient care were recognized by their colleagues. The residents were

asked to perform consultations and assist with difficult patients. The experience of discussing client care and mentoring colleagues following professional development activities has also been reported by physical therapists in the United Kingdom.[14] The encouragement of colleagues to complete professional development activities through the invitation to share new knowledge became a motivator to pursue future learning opportunities.[14] The Kenyan graduates interviewed sought opportunities to share knowledge with their colleagues and thus extended the reach of the program beyond the participants.

Through this ongoing professional development, Kenyan residency graduates and their employers noted increased clinical efficiency. This is in contrast to research by Rodeghero et al who found decreased efficiency in treatment following physical therapy residency education.[12] The difference in entry-level education of physical therapists in Kenya and the United States may account for the discrepancy in outcomes between the two countries. The residency education provided the physical therapists in Kenya the opportunity to explore the patients' unique impairments and apply the evidence to determine the optimal treatment approach. This is in contrast to the protocol-based therapy that Kenyan residents have described as their previous practice pattern prior to residency education. The Kenyan residents also reported there had been no prior opportunity for continuing education specific to physical therapy following entry-level education limiting their ability to incorporate new evidence into practice.

As noted by the participants in this study, the graduates of the residency program were often asked to consult on complex patient presentations. Although the number of actual visits with each patient was not documented, complex patients may have needed additional time to meet functional outcome goals. However, graduates and employers reported the patients and referral sources were pleased with the care provided by the residents and there was a general perception of increased efficiency.

CLINICAL RELEVANCE

The improvement in clinical care following participation in a physical therapy orthopedic residency program in Kenya has extended beyond the graduates themselves as they provide mentoring to their colleagues that have not had the opportunity to access continuing professional development activities. As new programs are created in resource limited countries to advance the profession of physical therapy, attempts to evaluate the short and long-term outcomes should be made. This can be difficult in rehabilitation services when functional outcomes measures have not been widely adopted in these countries. Future research should be performed to further measure the clinical outcomes associated with collaborative partnerships to promote physical therapy in resource-limited countries.

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Regression of Cervical Disc Extrusion Following Conservative Treatment: A Case Report

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ABSTRACT

Background and Purpose: Spontaneous regression of disc herniation in the lumbar spine has been well documented. However, the clinical course of cervical disc herniation remains poorly established. The purpose of this report is to describe a case of cervical disc herniation with spinal cord compression that spontaneously regressed following conservative treatment. **Case Description:** A 34-year-old female presented to her primary care physician with recurrent, nontraumatic neck pain and a new onset of right upper extremity radicular symptoms. Magnetic resonance imaging of the cervical spine revealed a disc extrusion at C6-7 with spinal cord compression. **Outcomes:** Six months following initial onset and physical therapy interventions, MRI revealed spontaneous regression of the herniation with no evidence of spinal cord compression. **Clinical Relevance:** Currently, patients with symptoms of cervical cord compression are routinely referred for surgical stabilization. Anterior cervical disc fusion remains the gold standard; however, paralleled with physical therapy, the risk and financial burden can be significant. **Conclusion:** Physical therapy may result in spontaneous disc regression in the cervical spine, even in cases with spinal cord compression.

Key Words: compression, myelopathy, radiculopathy, spontaneous

INTRODUCTION

The clinical course of lumbar disc herniation and spontaneous regression have been well documented in the literature; however, the clinical course of cervical disc herniation is not well established.[1-3] Kreiger et al[4] published the first known case of a documented cervical disc regression evident on magnetic resonance imaging (MRI) in 1992, shining light on the possibility of cervical disc healing. Cervical disc herniation is categorized in order of severity using the terms bulge, focal protrusion, broad-based protrusion, extrusion, and sequestration, according to the Combined Task Forces Classification System.[5] Disc herniation that contacts the spinal cord can cause a condition known as myelopathy. Myelopathy is considered more severe than radiculopathy, a compression of a spinal nerve root, due to the potential of severe motor function deficits in the bilateral upper and lower extremities. Due to the lack of evidence supporting cervical disc regression as well as a concern for spinal cord injury with detrimental long-term effects, patients with signs of myelopathy are often referred for surgery.[2] However, with current evidence of lumbar disc spontaneous regression being vast and positive, one must consider the possibility of spontaneous regression in the cervical spine and question whether surgery versus physical therapy produces the best long-term outcomes. The purpose of this report is to describe a case of cervical disc herniation with spinal cord compression that spontaneously regressed following physical therapy interventions.

CASE DESCRIPTION

The patient was a 34-year-old female physical therapist seen by her primary care physician (PCP) for constant neck pain and intermittent right upper extremity paresthesia. Neck pain was rated 6/10 on a visual analog scale. Numbness, tingling, and pain in the right upper extremity occurred from the axilla along the T1 dermatome extending to her 4th and 5th digits. She had a nontraumatic history of intermittent episodes of severe neck pain for the previous 10 years. The right upper extremity symptoms were new to her history and began one month prior to her PCP visit.

The PCP's examination included a patient history, cervical active range of motion, and upper extremity reflexes. After the examination, the PCP prescribed an oral steroid and ordered an MRI of her cervical spine.

IMAGING

The MRI, performed one month after initial onset of right upper extremity symptoms, revealed a large right paracentral disc extrusion at C6-7 (**Figure 1**). The radiologist reported the herniation extended 4 mm posterior to the C6 vertebral body and superiorly along the posterior aspect of the vertebral body. The extruded disc contacted and flattened the spinal cord on the right side. The PCP referred the patient to a specialist in neurosurgery due to the findings of spinal cord compression.

INTERVENTION

Examination by a neurosurgeon occurred 3 months after initial PCP visit. At the time of this visit, the patient's right upper extremity symptoms had resolved. Cervical pain was now intermittent and rated a 2/10. Physical examination revealed a positive Hoffmann's reflex bilaterally.

Following the physical examination and review of MRI, a recommendation for surgical intervention was made due to concern for integrity of the cervical spine and risk of spinal cord injury with future trauma. The patient denied surgical intervention electing to manage her symptoms conservatively using physical therapy interventions. Interventions used by the patient included the oral steroid medication prescribed by the PCP, activity modification, and self-directed postural strengthening, cervical stretching, and nerve gliding exercises.

OUTCOME

Seven months following the onset of right upper extremity symptoms and 6 months following the first MRI, the patient had a second MRI at the same facility. The radiologist's report revealed C6-7 herniation had decreased to 2 mm posterior to the C6 vertebral body. This was described as a paracentral disc protrusion at C6-7, mildly effacing the anterior thecal sac (**Figure 2**). At this time the patient's right upper extremity symptoms continued to be resolved, and neck pain was rated 2/10 with intermittent frequency.

The patient's neck pain and right upper extremity paresthesia both demonstrated significant improvement with conservative care, the most notable improvement occurring in the first 2 months. Cervical disc herniation was described initially as a 4-mm extrusion with flattening of spinal cord and decreased to a 2-mm protrusion with no evidence of spinal cord compression.

DISCUSSION

Current evidence on the natural history of lumbar disc herniation is well established to support the occurrence of spontane-

Figure 1. Initial MRI

Figure 2. Follow-up MRI

ous regression within the first year, notably in the first 2 to 3 months.[5,6] Evidence also supports the larger the lumbar disc herniation, the greater the likelihood of regression, therefore the greatest improvements are seen in disc extrusions and sequestrations.[6,7] Chiu et al[5] published that in patients with lumbar disc extrusion, 70% of the disc extrusions regressed and 15% completely resolved. This case study describes an extruded, cervical disc that regressed spontaneously similarly to what has been described in the lumbar spine. Currently, a high likelihood of lumbar herniation to regress has been established, therefore warranting physical therapy as a first line of treatment for disc-related symptoms. This case report underlines the question of spontaneous regression of cervical disc herniation following management with physical therapy.

Wong et al[1] suggested cervical disc healing is indeed similar to lumbar disc healing with the most significant improvements in radicular symptoms occurring in the first 4 to 6 months and complete recovery occurring between 24 and 36 months. The authors also note minimal long-term pain and disability following cervical disc herniation that has also been established in the lumbar spine. However, Mochida et al[8] suggest that cervical disc herniation may differ due to the presence of end plate cartilage in extruded material in cervical discs, which is harder for the body to resorb. The authors suggest the phase of healing, position of the herniation, and composition of disc material may affect the ability of the disc to regress. Another difference in cervical disc herniation as compared to lumbar is the risk of cervical myelopathy with detrimental long-term effects on motor function. This patient did exhibit signs of myelopathy including MRI confirmed spinal cord compression as well as a positive Hoffmann's reflex bilaterally. However, she did not report any symptoms of myelopathy.

Currently, patients are commonly referred for surgical stabilization as a prophylactic measure against the potential of quadriplegia[1,2,4] when the patient reports symptoms of myelopathy that have not improved with conservative treatment after 6 to 12 weeks, progressive motor deficits, and if the patient does not have symptoms of myelopathy but has positive MRI findings of cord compression. Anterior cervical disc fusion remains the gold standard for treatment of symptomatic cervical disc herniation.[9,11] In addition to standard complications of surgery including infection, cardiopulmonary events, and even death, anterior cervical disc fusion documented complications include joint hypermobility, pseudoarthrosis, dysphagia, and adjacent segment degeneration.[10] Anterior cervical disc fusion is also quite costly, averaging $39,528 – $47,330 per patient.[11]

This case report adds to the growing body of evidence of spontaneous regression of cervical disc herniation following conservative treatment. Wong et al[1] in their systematic review of the literature reported that patients with cervical disc herniation and radiculopathy had significant improvements in pain and disability within the first 4 to 6 months with complete recovery in 24 to 36 months. Orief et al[7] in their study, reported 5 cases of lumbar and one case of protruded cervical discs that regressed resulting in symptom improvements following conservative treatment, and that all patients in this study recovered from radicular pain in 3 to 6 weeks with resorption of sequestration at 4 to 9 months as demonstrated by MRI. Gurkanlar et al[12] published 6 cases of patients aged 32 to 49 who exhibited spontaneous regression of cervical disc extrusion evidenced on MRI.

CONCLUSION

Physical therapy interventions for cervical disc herniation may result in spontaneous regression, even in cases with spinal cord compression. This case report is consistent with lumbar studies that reveal disc herniations are likely to regress conservatively, that larger disc herniations have a greater likelihood to regress, and the greatest symptom resolution occurs in the first 2 to 3 months.[5-7] Future studies are warranted to understand the natural history of cervical disc herniation. MRI has been shown to be a prognostic tool in disc herniation and should continue to be used as a reliable measure of disc herniation and healing.[2]

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Primary Spontaneous Pneumothorax in a High School Athlete: A Case Study

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ABSTRACT

Background and Purpose: Pathophysiology of primary spontaneous pneumothorax (PSP) involves separation of the visceral pleura of the lung from the parietal pleura of the thoracic cavity with entrance of air into this space causing collapse of the lung. This condition has the potential association with rupture of sub-pleural blebs and bullae. The present case study involves a female teenage athlete who presented to out-patient physical therapy with the chief complaint of thoracic pain of apparent musculoskeletal origin. The patient was treated with therapeutic exercise, manual therapy, and modalities with a resolution of symptoms. She sustained a PSP approximately 13 days post-discharge from physical therapy while playing in a basketball tournament. The purpose of this case study is to review the literature concerning PSP, as well as this patient's case, to ascertain any potential relationship between this patient's symptoms and the onset of PSP. **Methods:** A literature review was performed using PubMed, CINAHL and EBSCOhost, searching for pertinent information regarding signs, symptoms, and diagnostic testing for PSP. **Findings:** Primary spontaneous pneumothorax is typically seen in young males and less common among females. Risk factors include ectomorphic body structure and smoking, among others. Activity levels are not contributory. Symptoms include chest or thoracic pain and dyspnea. Examination findings can include reduced breath sounds, tactile fremitus, and hyper-resonant percussion. Diagnosis is confirmed via chest radiograph. Primary spontaneous pneumothorax has low morbidity rates but early recognition allows for prompt treatment reducing potential progression to more serious complications such as tension pneumothorax. **Clinical Relevance:** Primary spontaneous pneumothorax symptoms could mimic a typical musculoskeletal pathology. Patients presenting with thoracic pain without a clear history of injury should be referred for radiographs to rule out PSP.

Key Words: chest, lung, pain, thoracic

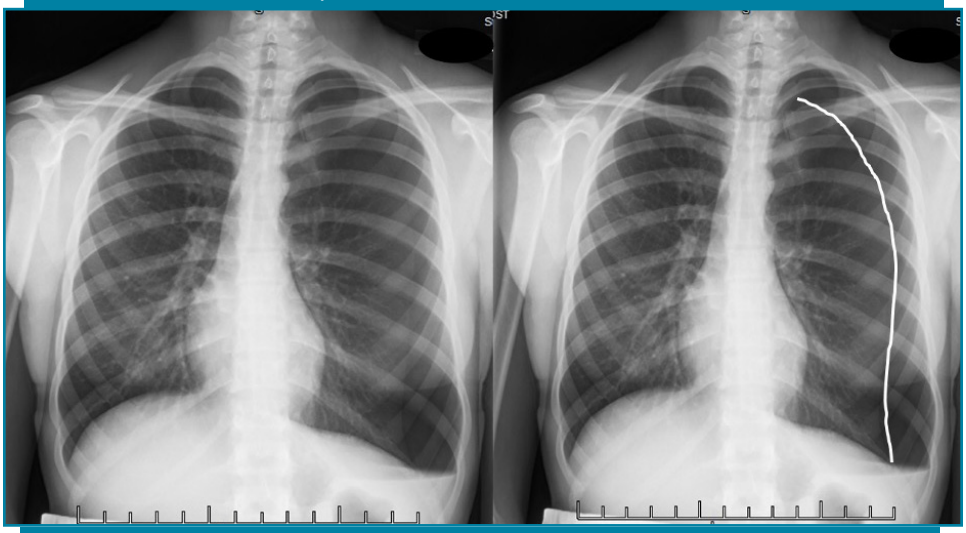
BACKGROUND AND PURPOSE

Primary spontaneous pneumothorax (PSP) is a condition in which the visceral pleura of the thoracic cavity becomes separated from the parietal pleura. This creates space into which air can flow and results in collapse of the lung. The occurrence of PSP is more common among tall, ectomorphic males[1] in their late teens and early twenties.[2] It is less commonly seen among females.[3]

The present case involves a 17-year-old female basketball player who presented to outpatient physical therapy with the chief complaint of right posterior thoracic pain. The patient described a mechanism of injury that involved bending over from a seated position, at which point she noted upper back pain along with difficulty breathing and turning. No other significant mechanism of injury was reported, including motor vehicle accident and there were no other comorbidities per the patient's past medical history. She had pain with deep inspiration, also noting pain at rest in the thoracic spine around to the anterior chest wall. The patient reported no previous history of dyspnea. She denied tobacco or electronic cigarette use. Subjectively, the patient reported pain rated at 6/10 on the Numeric Pain Rating Scale. The physical therapy examination revealed a 20% loss of thoracic flexion and extension in sitting and noted pain with thoracic rotation left only. Inspiration was painful at the left T6-7 costovertebral junction and there was some crepitus noted upon grade 2 mobilization of this area. Initial oxygen saturation rates were 99%. Tactile and vocal fremitus were not assessed on initial examination. Her initial impairments were noted as pain and loss of motion into trunk flexion and extension. No significant difficulty with breathing was noted by the patient or observed by the therapist. Functional deficits included difficulty with activities of daily living with her primary participation limitation being inability to play basketball. She was started on a treatment regimen of pulsed ultrasound at 50% duty cycle for 8 minutes at 1.5 w/cm^2 using a 5 cm^2 head to the T6 costovertebral and paraspinal muscle region. Thoracic range of motion, and manual therapy, including joint mobilization of the mid-thoracic spine were also performed. Ultrasound was utilized as a preparatory intervention to increase tissue temperature in order to improve effectiveness of manual therapy techniques.[4] Manual therapy was performed over two visits consisting of posterior-anterior glides of the T-6 segment as well as anterior rib mobilization at the same level. During this time, thoracic mobility exercises to improve flexion and extension were performed consisting of cat-camel and rotational stretching. Pain reduced over these two visits to 2/10 therefore, ultrasound was discontinued and she was advanced to conditioning, strengthening, and sports-specific exercises. This program consisted of elliptical training, step ups, and core stabilization with progression to lateral slides and chest passing by her fourth visit. The focus of conditioning was to increase cardiovascular load in preparation for return to play. Over the course of the last two visits, pain resolved completely. During the program, the patient's vital signs were monitored and remained stable and unremarkable with expected results due to exercise, including mildly elevated blood pressure and heart rate. Pulse oxygenation remained strong at 99% with interval testing. Occasional exertional breathing was noted with conditioning exercises, but again, there were no abnormal responses regarding vital signs. The patient was seen for 4 visits over 8 days with complete resolution of symptoms and ability to return to full participation in competitive basketball.

Thirteen days after discharge from physical therapy, the patient was participating in a weekend basketball tournament, when she noted the return of thoracic pain along with shortness of breath with exertion during play. Symptoms became marked with vomiting. She was taken to a local emergency department where radiographs revealed a moderate to large left-sided pneumothorax (**Figure 1**). She was admitted and treated with insertion of a chest tube to allow for re-inflation. She was discharged two days later without reoccurrence of symptoms.

Figure 1. Primary Spontaneous Pneumothorax of the Left Lung in the 17-year-old Patient from this Case Study



The image on the right shows the visceral pleural line with resultant air space.

In retrospective analysis of this case, it is logical to consider that perhaps her initial symptoms with which she presented to physical therapy were indicators of the development of a PSP. The purpose of this case study is to review the literature concerning PSP, as well as this patient's case, to ascertain any potential relationship between this patient's symptoms and the onset of PSP.

METHODS

Before beginning research, proper patient consent was obtained along with approval of research by the Alvernia University Institutional Review Board. A literature review was performed through PubMed, CINAHL, and EBSCOhost databases to investigate signs and symptoms of PSP to ascertain if there are typical precursor signs and symptoms that might alert a physical therapist to the presence of a PSP. Search terms used across all data bases were primary spontaneous pneumothorax and pneumothorax. This information was applied to the patient case, noting all relevant signs and symptoms and the course of care from the patient's medical record.

FINDINGS

Occurrence of PSP has a higher incident rate in men (7.4/100,000 per year) than women (1.2/100,000 per year).[3] In one study this incident peaked at 17 years of age, with a high risk noted between the ages of 15 and 22.[2] Other key physical findings include tall, thin men displaying an ectomorphic body type.[1] Additional risk factors include smoking with a noted 9-time and 22-time increase in PSP among men and women, respectively.[5] Recent case studies have drawn a possible association to vaping, or electronic cigarette use.[6,7] As per the name, a PSP is spontaneous and is usually unrelated to injury or physical activity level and often occurs at rest.[1] Individuals who present with PSP are generally healthy individuals with no contributory medical history, although there has been some correlation with inherited disorders including Marfan Syndrome[8,9] and Birt-Hogg-Dube syndrome.[10] Other factors that are related to the occurrence of PSP include loud music, playing a brass instrument,[11] blowing up multiple balloons,[11] atmospheric pressure changes,[12] anger,[13] and sneezing. The apparent commonality in these factors appears to be increased intrathoracic pressure. There appears to be a hereditary link as well with 10% of patients reporting a family history of PSP.[14] Another condition known as secondary spontaneous pneumothorax can occur in individuals with a contributing medical history, including lung conditions such as chronic obstructive pulmonary disease.[15] Bintcliffe et al suggested that the presence of underlying lung abnormalities, such as blebs and bullae, may be cause for reconsideration of these cases as being less spontaneous, which may better direct intervention.[16]

The cause of PSP is not clearly understood, but there is some evidence to suggest the rupture of sub-pleural blebs and bullae is involved. Blebs and bullae have been found ipsilaterally in up to 88% of patients presenting with PSP,[17] with a prevalence of these anomalies having been found more in the apical segments of the lungs.[15,18] A bullae is described as an emphysematous distended air space within the lung[19] and a bleb is a "blister-like formation" on the surface of the lung.[15] Both may be related to the degradation of elastic fibers in the lungs that can be evoked by smoking.[20,21] The formation of blebs in taller, ectomorphic individuals may also be related to an increased chest length with a subsequent change in the gradient of pressure from the base of the lung to the apex, possibly due to the weight of the lungs and caudal gravitational forces.[22] This is particularly thought to be the case in rapidly growing individuals, if vertical growth outpaces horizontal growth.[23] The resultant negative pressure in the apex of the lung may cause enhanced formation of blebs due to thinning of the apical alveoli, thus causing an increased risk of localized rupture. This can lead to dissection of air through the peripheral portion of the lung into the pleural space, resulting in a pneumothorax.[18] Despite the prevalence in patients diagnosed with PSP, there is not full consensus regarding blebs as the primary cause of this condition.[20,24] Another suggested cause of a PSP is the presence of diffuse areas of weakness of the visceral pleura described by Noppen as "pleural porosity", which may allow spontaneous leakage of air into the pleural cavity.[25]

Patient Presentation

When a patient is suffering from a PSP, they will often present with sharp thoracic or chest region pain along with dyspnea as the primary chief complaints.[1,15] Severity of dyspnea is often proportional to the size of the pneumothorax.[15] Chest pain is typically on the same side of the pneumothorax and oxygen saturation rates are often within normal range, especially in those patients with a pneumothorax that fills less than 25% of the pleural cavity with air.[26] Small pneumothoraxes may not cause symptoms and may heal without treatment.[15] In other cases, symptoms may be mild, causing patients to delay care.[18] A pneumothorax can progress in size and lead to a tension pneumothorax, which is essentially the production of a one-way valve from the lung into the interpleural space.[27] A greater degree of lung collapse is noted with a tension pneumothorax. These patients will typically present with increased dyspnea, cyanosis, profuse diaphoresis, hypotension, and tachycardia.[28] A tension pneumothorax can occur in any type of pneumothorax (traumatic or spontaneous),[27] but is generally considered rare in the case of a PSP.[29,30]

Examination, Diagnosis, and Treatment

Physical examination may reveal dyspnea. Mild tachycardia may also be present on physical examination with severe tachycardia more indicative of secondary spontaneous pneumothorax.[18] Presentation may include the appearance of a larger chest size, as well as reduced chest movement on the side of the PSP with breathing.[18] Additionally, hyperresonant percussion may be present along with the absence of tactile fremitus, particularly in cases of a larger PSP.[1,31,32]

Diagnosis is typically made via an upright posteroanterior radiograph and can be combined with lateral views if diagnosis is difficult.[33,34] If the PSP is small, computerized tomography may be necessary.[1] Imaging allows visualization of air in the pleura, with a noted displacement of the pleural line away from the chest wall along with the absence of lung markings[15,18,33] **(Figure 1)**.

Medical management of a PSP is often based on size and recurrence. Several classification systems exist including one by the American College of Chest Physicians, who classify the size of a PSP by the distance of the lung to the ipsilateral cupula of the thoracic cavity, and another by the British Thoracic Society, who size a PSP by the distance of the lung from the parietal pleura at the level of the hilum.[16] Generally, a PSP is classified as small (<15% lung collapse), moderate (15-60%), and large (>60%).[15] If small, a PSP may show spontaneous improvement and is usually treated conservatively with observation and administration of oxygen.[15,35] More remotely, there has been some consideration that non-invasive, conservative care in uncomplicated, younger patients might allow for more natural healing of the parenchymal tissue to reduce the risk of recurrence.[16,36] In more severe cases, manual needle aspiration is performed.[35] Chest tube placement may be necessary if the patient is unstable or if the pneumothorax enlarges.[15,35,37] Small-bore versus large-bore chest tubes are inserted in less complicated cases.[37] Recurrence rates for PSP are reported at 32%[35] and up to 52%[15] if treated with observation alone. Recurrence rates increase after second and third incidences if not treated with thoracotomy.[15] Surgical interventions used via video-assisted thoracoscopic surgery include bullectomy, pleurectomy, as well as mechanical and chemical pleurodesis. Pleurodesis involves irritation of the parietal pleura either with a sclerosing agent such as talc or doxycycline (chemical) or via direct abrasion using a dry surgical sponge (mechanical).[15] These techniques will cause formation of adhesions between the parietal and visceral pleura. The use of pleurodesis is associated with lower recurrence rates.[15,35] Patients are typically released from hospitalization once lung re-expansion has occurred and there are no immediate signs of recurrence via radiographs.[15,35]

Return to normal activity, even sports participation, is expected for most people who sustain a PSP, particularly if no deficits are noted in pulmonary and cardiac function after recovery.[24] A long-term follow-up study noted only minimally impaired pulmonary function and mild pleural thickening 22-35 years after treatment of PSPs with either talc pleurodesis or pleural drainage.[38]

CLINICAL APPLICATIONS

Primary spontaneous pneumothorax is a relatively rare condition most commonly seen in young males. Recognition and diagnosis can be confounding as there does not appear to be any particularly predictive precursor signs and symptoms and, many times the patient presentation is not obvious or may be occult. In the current case, the patient presented to physical therapy with symptoms that appeared to be a mid-thoracic sprain. There were no other obvious signs or symptoms that would indicate an emergent need for referral. Physical therapy treatment to this region successfully assisted in the resolution of the patient's symptoms. The question remains: could this presentation have been the initial onset of her PSP? This is a definite possibility. The difficulty for the assessing therapist is, in the presence of these types of symptoms without other defining signs, such as predictably elevated blood pressure or a drop in oxygen saturation levels, ascertaining the presence of a PSP is difficult.

After review of the literature, the authors have made several conclusions. Common signs and symptoms that should be on a physical therapist's radar for potential differential diagnosis should include tall, ectomorphic males between the ages of 15 and 25 years old who present with thoracic pain, particularly of non-traumatic origin. Any history of shortness of breath would add a greater degree of concern. Additionally, individuals should also be questioned for a history of smoking or vaping. In these patients, particularly in the case of a direct-access referral, a physician consult for radiographs to rule out PSP is warranted. Given this patient case, it is also logical to include female patients in this grouping as well, as the need for follow-up care is pressing, particularly if the diagnosis of a PSP is confirmed.

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President's Message

Rick Wickstrom, PT, DPT, CPE, CME

Our first virtual Combined Sections Meeting was a pivot that inspired new learning and networking options for students and physical therapy professionals to move forward. Its reasonable registration cost and flexibility allowed me to experience more programming than usual. For example, I was interested to learn about similarities and differences in applications for core tests of physical performance across sections and academies. Our OHSIG sponsored a timely presentation, "Therapy at Work for Total Worker Health®: Making Magic for the Next 100 Years". The speakers, L. Casey Chosewood, MD, MPH (Director, Office of Total Worker Health at NIOSH) and Kathy Malchev, OTR/L, MPH (Health Services Manager at Disney), provided a refreshing vision of practice opportunities for therapists to meet the needs of business and worker clients. This was relevant to one of our primary OHSIG initiatives to implement an advanced practice educational credential program to recognize expertise of therapists who specialize in occupational health. In the short article that follows, our OHSIG Practice Committee Chair, Lorena Payne describes OHSIG's process to create the Optimizing Worker Performance Clinical Practice Guideline. This has been a 6-year, monumental effort by OHSIG AOPT members. It provides an evidenced-based foundation for the occupational health practice niche, but also provides guidance to supplement CPGs for specific health conditions to reduce the personal and society cost of work disability. Enjoy!

Building A Clinical Practice Guideline

Lorena P. Payne, PT, MPA, OCS

ASKING THE RIGHT QUESTIONS

What are the components of physical therapy treatment that lead to optimal participation in work by the worker with activity limitations? What tools can be used to estimate the risk of delayed return to work? What interventions are indicated when there is an estimated risk of prolonged disability? What are the unique factors, related to a work-limiting injury or illness, that should be assessed at initial evaluation? When is it appropriate to initiate active intervention to return the worker to optimal functioning? Does a brochure lead to better rate of return to work? A group of physical therapists has sought to answer these questions and more by building a clinical practice guideline (CPG) related to the process of returning the worker to optimal function after injury or illness. Clinical practice guidelines published under the guidance of APTA and various components typically are grounded in the description of body functions and structure and a health condition (disorder or disease). In addition to body functions and structures, physical therapists considering a treatment plan and goals to return the worker to optimal functioning, must place a greater emphasis on contextual factors (environmental and personal factors) and participation in activity, specifically related to employment or occupation. This CPG, ***Optimizing Work Participation After Illness or Injury: The Role of the Physical Therapist,*** with an anticipated publishing date later this year, is meant to give evidence-based guidance to physical therapists in these functional domains. It is meant to be used in conjunction with other published CPGs that describe best practice related to specific health conditions.

BUILDING A CPG

Steps in completing a CPG include identifying individuals to participate in a development group; a thorough literature search (3 have been completed for this CPG); abstract review; extraction of data from each of the studies (over 300 references are included); draft the outline; grade the evidence; develop guidelines based upon the literature; write the body of the document; ask for expert, stakeholder, and peer review; edit the CPG related to comments; and submit for publishing. That is a long list; however, the work is not yet done until a plan for dissemination of the information is carried out.

DISSEMINATION OF INFORMATION

The information contained in this CPG will be available for APTA components (state chapters and academies) and stakeholder groups (ie, therapy providers, employers, payers, case managers, adjustors, medical providers, regulatory agencies). Individual practitioners will have access to self-assessment tools and continuing education opportunities. The information provides the foundation for advanced practice credentialling coursework to be made available within the next year.

ELEVATE YOUR PRACTICE

Look for your opportunity to review the CPG, ***Optimizing Work Participation After Illness or Injury: The Role of the Physical Therapist,*** and provide comments. The publishing date is anticipated during this summer 2021, in the *Journal of Orthopaedic and Sports Physical Therapy*. Read and share the published CPG with peers and stakeholders. Participate in advanced credentialling course work through the Occupational Health Special Interest Group of AOPT, for which the CPG serves as a foundation. Invite speakers, designated by the CPG authors, to present the information at component meetings, your state department of labor, or other stakeholder groups.

ACKNOWLEDGE THE PROCESS

Researching, writing, publishing, and disseminating this clinical practice guideline is a process that has required the help of a large group of experts. Acknowledge those that invested thousands of hours over the past 6 years to see this project through. Upon reading through the published document, seek out the list of individuals that gave their time to be a part of the CPG development group. They are additional resources and mentors, available to elevate your practice in occupational health. Consider participation in the constant update of this living document by joining the group that will add to the evidence as more research is available. Become part of the OHSIG practice or research team. Most of all, consult this guideline as it becomes available and practice with evidence, to return individuals to optimal work ability.

President's Message

Laurel Daniels Abbruzzese, PT, EdD

CSM Update

The 2021 Combined Sections Meeting, held virtually for the first time, offered access to high-quality continuing education courses and research through a combination of on-demand recordings and synchronous Zoom presentations and discussions. Thank you to our VP, Rosie Cazinares, for securing such great content each year. We want to thank Stephanie Jones Greenspan, PT, DPT; Luc Fecteau, PT, DPT; Dawn Muci, PT, DPT, ATC; and Evert Verhagen, PhD, for their educational session, "From the Clinic to the Big Top: Interprofessional Management of the Circus Artist!" We co-sponsored a post-conference course with the Imaging SIG, "Next Level Clinical Reasoning: Integration of Diagnostic Ultrasound into Physical Therapy Practice" featuring Mohini Rawat, PT, DPT, MS; Jon A. Umlauf, PT, DPT, DSc; and Colin Thomas Rigney, PT, DPT. We hope to schedule the lab component of the course with performing arts applications when we can gather again in person.

In addition to our business meeting, the PASIG also organized a March Q&A session with the PASIG poster presenters. Thank you to all who presented performing arts research this year.

Abigail Skallerud, Aaron Brumbaugh, Tiffany B. Parker, Stephanie Fudalla, Marie-Eve S. Pepin. "Comparing Functional Lumbar Lordosis in Collegiate Dancers with and without Low Back Pain"

Hilary Busick, Allison Marie Ventola, Aimee Fries, Margaret Adeline Bryant, Shilamit Mikhaylov, Joanna Raine Binney, Jessica Boyle, Zoe Tawa, Kynaston Schultz, Laurel Daniels Abbruzzese. "Compensated Turnout Can Predict Injuries in Adolescent Dancers: A Prospective Pilot Study"

Pamela Mikkelsen, David Ortiz, Hai-Jung Steffi Shih, Amanda Christine Yamaguchi, Kornelia Kulig. "Dancers Alter Ground Reaction Force Profiles to Maintain Impulse with Perceived Exertion during Dance-Style Hopping"

Deah McRae, Erin Ogden, Alexander Nathaniel Durland, Chia-Cheng Lin. "Using Computerized Balance Error Scoring System as Baseline Concussion Testing in Collegiate Dance Majors"

Patricia Cavaleri. "Nonsurgical Management of a Pre-Professional Contemporary Dancer with Hypermobile Ehlers-Danlos Syndrome Following Recurrent Shoulder Dislocations"

Sonali Sethi, Rosalinda Cacha Canizares, Bradley James Myers. "Severity and Impact of Injuries in Competitive Bhangra Dancers"

Jessica M. Smith, T Kevin Robinson. "A Kinematic Analysis of a Series of Jumps in Professional Ballet Dancers"

Brooke Renee Winder, Kari Marie Lindegren, Amanda M. Blackmon. "Prevalence of Urinary Incontinence in Female Professional Dancers"

Hanz Tao, Michelle Marie Reilly, Avery Beth Allen, Allison Nichole Deering, Stephanie Prinsen. "Reliability Analysis of a Modified, Ballet-Specific Balance Error Scoring System for High School Dancers"

T Kevin Robinson, Jessica M. Smith, Justin Brothers, Amy Henson, Tyler Brazelton, Tammy Joe, Ashley Karadeema, Pat Sells, DA, Natalie Norman Michaels. "A Kinematic Analysis of Non-Injured and Injured Professional Ballet Dancers Performing Fundamental Dance Tasks"

Ashley Lea, Laura Ann Guy, Carley Alexandra McQuain, Tyler Wade Ray, Mikela Nylander-French, Corey B. Simon, Rosalinda Cacha Canizares, "Treatment and Rehabilitation of Os Trigonum Syndrome: A Systematic Review"

PASIG CSM Scholarship Winners

This year the entry level DPT PASIG scholarship winner was Abigail Skallerud and our Performing Arts fellowship scholarship winner was Patricia Cavaleri. Abigail graduated from Wayne State University Department of Physical Therapy with the Class of 2020. Patty is a graduate of Columbia University Programs in Physical Therapy. She just completed the NYU Langone Harkness Center for Dance Injuries - Performing Arts Physical Therapy Fellowship.

Photos of our scholarship winners:

PASIG Entry Level DPT Scholarship

The entry level DPT scholarship winner is Abigail Skallerud, SPT
with Aaron Brumbaugh, SPT; Stephanie Fudalla, SPT; Tiffany Parker, SPT; and mentors, Dr. Marie-Eve Pepin and Dr. Kristen Robertson

Abstract Title: "Comparing Functional Lumbar Lordosis in Collegiate Dancers With and Without Low Back Pain"

Wayne State University Department of Physical Therapy, Class of 2020

PASIG Fellowship Scholarship

The fellowship scholarship winner is Patricia Cavaleri, PT, DPT

Abstract Title: "Nonsurgical Management of a Pre-Professional Contemporary Dancer with Hypermobile Ehlers-Danlos Syndrome Following Recurrent Shoulder Dislocations"

NYU Langone Harkness Center for Dance Injuries - Performing Arts Physical Therapy Fellowship

Performing Arts Fellowship Update

We are excited to announce that both the Johns Hopkins Hospital Performing Arts Fellowship and the NYU Langone-Harkness Center for Dance Injuries Performing Arts Fellowship were accredited by ABPTRFE in the fall of 2020! Congratulations on this well-deserved achievement. Physical therapists with an OCS, SCS, or completion of an orthopedic residency may choose from 1 of 4 performing arts fellowship programs for advanced training and specialization in performing arts. If you have questions about starting a performing arts fellowship program, contact our Chair, Tiffani Marruli at tiffany.marulli@osumc.edu. For specific program questions, contact the program directors.

- **Columbia University Irving Medical Center and West Side Dance Performing Arts Fellowship**
  - Program Director: Laurel Daniels Abbruzzese la110@cumc.columbia.edu
  - https://www.ps.columbia.edu/education/academic-programs/programs-physical-therapy/performing-arts-fellowship
- **NYU Langone-Harkness Center for Dance Injuries Performing Arts Fellowship**
  - Program Director: Angela Stolfi harkness@nyulangone.org
  - https://med.nyu.edu/departments-institutes/orthopedic-surgery/specialty-programs/harkness-center-dance-injuries/education/professional-development-students-healthcare-practitioners/academic-observation-fellowship
- **The Johns Hopkins Hospital Performing Arts Fellowship**
  - Program Director: Andrea Lasner danceFIT@jhmi.edu
  - https://www.hopkinsmedicine.org/physical_medicine_rehabilitation/education_training/therapy-residency/physical-therapy/performing-arts-pt-fellowship.html
- **The Ohio State University Wexner Medical Center Performing Arts Fellowship**
  - Program Director: Tiffany Marulli tiffany.marulli@osumc.edu
  - https://hrs.osu.edu/academics/graduate-programs/clinical-doctorate-in-physical-therapy/residencies-and-fellowships/performing-arts

Officer Transitions

We welcome newly elected Kimberly Veirs to the PASIG leadership team. Kim will join Pamela Mikkelsen, and Duanne Scotti (Chair) on our Nominating Committee. We want to thank Marissa Hentis for her 3-year term on the Nominating Committee. She will be transitioning to the role of Performing Arts/Dancer Screening Chair. We also want to thank Mandy Blackmon, who has served the PASIG for many years in this role. A full list of PASIG leaders is on our website: https://www.orthopt.org/content/special-interest-groups/performing-arts/pasig-officer-listing

Strategic Planning

The PASIG will be working on the following goals for 2021 that are part of the larger AOPT 3-year Strategic Framework.

1. Update all of the educational resources on the PASIG Website and rebrand at least 80% of the documents with our new diverse logo by June 2021.
2. Publish 2-3 success stories featuring PASIG clinicians by December 31, 2021.
3. Create 2-3 educational topic presentations (10-20 minutes in length) added to membership meetings by June 30, 2021.
4. Create 1-2 podcasts for programs and faculty by June 30, 2021.
5. Create 1-2 micro learning products for the Learning Management System by December 31, 2021.
6. Create 2-3 YouTube videos on the professional roles of performing arts physical therapists by September 30, 2021.
7. Create, disseminate, and summarize a Survey to programs about mentorship by June 30, 2021.
8. Create and publish ABPTRFE 8-12 "Q & A's" document as a resource for Fellowship program education and support by March 30, 2021.

In addition to these goals, the AOPT Board has approved our proposal for an Independent Study Course focused on Circus Arts. The PASIG has committed funds to support this project, with an anticipated publication date in the summer of 2022.

If you would like to join a committee to help us meet these goals, do not hesitate to reach out. Contact the PASIG President: labbruzzese@orthopt.org.

You can also reach out to share your success stories. We are particularly interested in highlighting the diversity within our SIG. We want to hear from therapists of all ages and backgrounds, representing the full array of the artists that we treat. Contact PR Chair: dawnd76@hotmail.com

Research Citation Blasts

The Research Committee continues to serve our membership by producing Citation Blasts on a diverse array of topics that are sent directly to members and posted to the web. We can always use more authors. If interested, please contact our Research Committee Chair, Mark Romanick at mark.romanick@und.edu. Thank you to the following authors for your contributions this winter:

January

Diagnosis and Management of Sacroiliac Joint Disorders
Chloe Terrell, SPT
Michelle Dolphin, PT, DPT, OCS

February

Microinstability of the Hip in Performing Artists – A New look at an old problem
Sarah Kate Peterson, PT, DPT, SCS

Communications Committee Update - Dawn Muci

The Communications Committee, led by Dawn Muci, continues to keep our members connected through the AOPT social media accounts. Be sure to follow Twitter handle: @OrthopedicAPTA, Instagram handle: @APTA_Orthopaedic, and Facebook: @PT4Performers.

(Continued on page 116)

Hello AOPT and Foot and Ankle SIG members, and Happy Spring!

The FASIG continues to be energized by some great initiatives in 2021. These are well aligned with the newly developed AOPT strategic plan that is now fully executed by the AOPT. We will highlight a few here in this newsletter but would also encourage anyone who would like to get more FASIG news to make sure you are signed up as a FASIG member (easy and free to join at www.orthopt.org) and also join our Facebook page: www.facebook.com/groups/FASIG/

As always, the Combined Sections Meeting (CSM) this past February was a great meeting and had the opportunity for sharing lots of foot and ankle content. But the virtual format certainly was a change from our normal. Hopefully, we can take away from the experience and look to the future as we continue to plan in person and virtual events.

Next up – the American Orthopaedic Foot and Ankle Society (AOFAS) and the FASIG continue to partner to develop webinar content. Our next educational collaboration is scheduled for about the same time this issue of OPPT might land on your desk – April 23rd. If you have not already, check out the content at https://www.aofas.org/education/online-learning/foot-ankle-focus to see the topic for the next live webinar. In addition to this webinar keep an eye out for our own AOPT/FASIG hosted webinar coming out this year.

The FASIG continues work on the development of a foot and ankle fellowship specialty area of practice. This is an exciting opportunity that will help to inform the future of advanced foot and ankle care. Our pilot practice analysis will be submitted to the American Board of Physical Therapy Residency and Fellowship Education (ABPTRFE) for review during the first quarter of 2021. We anticipate the final steps will occur during the remainder of 2021 to complete the process. Please stay-tuned for updates on this initiative as the FASIG and the AOPT are eager to move this process ahead.

Finally, throughout my tenure as President of the FASIG, I have come to appreciate the strengths, value, impact, and resources the SIG has to offer. It has truly been a rewarding experience to share my time with the whole FASIG community and especially with the amazing leadership group that continually pushes the ideas and works forward. But I am writing now, in the last year of my final term as President, to ask for the next leader to step forward. The formal election will begin this Fall for open positions but I would welcome the opportunity to share my final year with any who are interested. Please contact me directly (cneville@orthopt.org) if you are considering a position in the FASIG, or if you would like more information. The time and energy is truly rewarding and the network of incredible individuals gained from the experience is invaluable. I would welcome the chance to begin the transition process to the next leader to make the process as easy and efficient as possible. What better way to start but to get involved now!

Christopher Neville and the FASIG leadership
https://www.orthopt.org/content/special-interest-groups/foot

PA SIG

(Continued from page 115)

PASIG Merchandise Update

The PASIG merchandise has finally arrived! Orders can be placed through the AOPT website to order your PASIG half-zip, slub shirt, mask, tumbler, and pinkey balls. Show your PASIG pride! All PASIG merchandise features our new logo designed by Victoria Lu. The revenue generated will support PASIG strategic initiatives. Thank you to our Membership Chair, Jessica Waters for organizing.

PRESIDENT'S MESSAGE...THE FUTURE OF THE PAIN SIG

Nancy Robnett Durban, PT, MS, DPT

Hello All…I hope this report finds you well and safe.

The future of the Pain SIG looks bright. It is what we make it. This is a big year for the Pain SIG. We have a committee that has diligently and feverishly written a Pain Education Manual and another working on Pain Specialization. We are currently working on our 2021 strategic plan that will help map our direction to the future. As goes the future of pain management, so goes the future of the Pain SIG. Our strategic plan will include the 4 domains of pain management—Education, Research, Practice, and Business and will reflect the results of the membership survey. There are many ways for you to be a part of this movement.

THANK YOU

We owe a debt of gratitude to our outgoing leaders: Vice President, Mark Shepherd, PT, DPT, OCS, FAAOMPT, and Nominating Committee Chair Brett Neilson, PT, DPT, OCS, FAAOMPT. Thank you for all your hard work. We wish you well in your future endeavors.

CONGRATULATIONS

Congratulations to newly elected officers: Vice President, Eric Kruger, PT, DPT, PhD, and Nominating Committee member, Meredith Perny, PT, DPT, OCS. Thank you for your wiliness to serve as a Pain SIG leader.

CSM

The Pain SIG sponsored the presentation entitled, 21st Century Pain Education – Meeting Recommended Core Competencies and Implementation into DPT Curriculum. This was presented by Mark Shepard, PT, DPT, OCS, FAAOMPT; Shana Harrington, PT, PhD; Meryl Alappattuu, PT, PhD; Marie Bement, PT, PhD; Craig Wassinger, PT, PhD; Kathleen Sluka, PT, PhD, FAPTA; and Kory Zimney, PT, DPT. The program was viewed by 349 participants. The post-session discussion was motivating and thought-provoking. The Pain SIG will continue to support this amazing effort.

CLINICAL PEARLS ARE BACK

In case you missed it, our very own Pain SIG past president, Carolyn McManus, MPT, MA, presented a clinical pearl entitled, The Brain on Stress and What We Can Do About It. It was released on February 18th by the AOPT. Thank you Carolyn for your continued support of the Pain SIG. Stay tuned for more clinical pearls this year.

OFFICER REPORTS: FEBRUARY 2021

Vice President: Mark Shepherd, PT, DPT, OCS, FAAOMPT

- Dr. Shepherd: "Some outgoing thoughts - My time as VP of the Pain SIG has been some of the most rewarding since serving within the AOPT. The people part of the SIG are so special and dedicated to advocating for those treating and suffering from pain. I want to thank Carolyn McManus who supported me for the first few years I was in this position. Carolyn was patient, kind, and driven and opened up opportunities for the SIG to grow and make an impact. I want to thank Colleen Louw for inspiring me to take on this position. Finally, I want to thank Nancy Durban and the current Board for the work you all have done and will continue to do. Thank you all!"

Nominating Committee Chair: Brett Neilson, PT, DPT, OCS, FAAOMPT

- Dr. Neilson: Outgoing message - "It has been a wonderful pleasure serving the SIG and I look forward to remaining involved."
- Incoming Nominating Committee Chair Rebecca Vogsland, PT, DPT: Next year we will have an opening for 1 Nominating Committee member.

Research Chair: Dana Dailey, PT, PhD

- Dr. Dailey has a list of volunteers willing to work on the SIG Clinical Pearls and research blasts. Stay tuned for more Clinical Pearls and Research blasts coming your way soon in 2021.

Public Relations Committee Chair: Derrick Sueki, PT, DPT, PhD, GCPT, OCS, FAAOMPT

- Dr. Sueki: Outgoing message - "I would like to thank Nancy and the whole SIG leadership for allowing me to be a part of this amazing team. I know the SIG is in solid hands moving forward. I will continue to be involved in the SIGs project and will endeavor to be a contributing member of the SIG. My role on the AOPT Board allows me to continue to work and contribute to the SIG, just not in a leadership role. Thanks again for the opportunities provided and I look forward to the changes that will come in the next couple years and PT grows into its role as pain specialists."
- Incoming PR Committee Chair, Katie McBee: In the future, SIG PR Committee will be responsible for the creation and maintenance of a private Facebook page and a Pain Website. Please reach out to Katie McBee, DPT, OCS, if you would like to help the Pain SIG as a member of the PR Committee.

Residency and Fellowship Chair: Katie McBee, DPT, OCS

- For the Pain Specialty/Fellowship, we received approval from ABPTFRE and ABPTS to pilot our survey this week and will be sending it out shortly to 25 previously identified subject matter experts. The results from the pilot will be analyzed to shape our final survey. Things are moving forward. Our team recorded a CSM session and the LIVE Q&A was February 18th at 9pm ET.

Pain Education Manual Update:
Mark Shepherd, PT, DPT, OCS, FAAOMPT

As you all know, the PSIG has dedicated a Pain Education

(Continued on page 119)

In Gratitude

First, we thank Jim Elliott for his work as SIG Vice President over the past 5 years and Marie Corkery for very capably filling the final year of Jim's term. Marie did a marvelous job coordinating the educational effort at CSM under perpetually evolving and novel circumstances. We also thank Mohini Rawat for her work as Nominating Committee Chair and for bringing us a particularly robust slate of candidates for our election in November 2020.

CSM 2021

At the time of this writing, CSM 2021 was still on-going. We expected the SIG sponsored educational session pairing evidence and advocacy to attract immediate and lasting attention. That session was entitled "Advances in Imaging Referral: Generating a New Pulse in Autonomous Physical Therapist Practice" and moderated by Marie Corkery with speakers Aaron Keil, Evan Nelson, Stephen Kareha, Marcus "Kip" Schick, and Michelle Collie. Those states formulating strategies toward gaining imaging referral privileges will likely find value in this session immediately and in the future.

With the change to the virtual format, the planned 2-day preconference course was adapted to a 1-day post-conference course. "Next Level Clinical Reasoning: Integration of Diagnostic Ultrasound into Physical Therapy Practice" was presented by Mohini Rawat, Jon Umlauf, and Colin Rigney as an introduction to the technical aspects of diagnostic ultrasound along with the value of ultrasound in practice. At the time of this writing, the early registration for the post-conference course was very robust, reflecting the rising interest in ultrasound augmenting the clinical examination.

CSM Scholarship

For the fourth year, the Imaging SIG recognized excellence in research with awarding Brian Honick the CSM scholarship for the platform presentation for his study "Patients with Achilles Tendinopathy and Neovascularization Have Worse Tendon Structure and Function." Additional authors/investigators on the project were Haraldur Sigurðsson and Karin Grävare Silbernagel.

Please keep this scholarship in mind year-round. Encourage your colleagues and students to consider working toward this in the future. Once CSM acceptances are issued, the application process can be initiated. Details of the application process are available on the Imaging SIG webpages under "Imaging SIG Scholarship."

CSM 2022

By the time you read this, submissions for CSM programming in 2022 will be complete. Certainly, we all are hopeful to be back to the informative and personally interactive conference format we have all missed over the past year. As noted above, we originally had planned a 2-day preconference course for diagnostic ultrasound in the upper quadrant. With the change to the virtual format, the content was adapted with the plan to resubmit the 2-day course again for 2022 in San Antonio.

Our educational session for 2022 will likely focus on how to plan and conduct educational initiatives consistent with expanding imaging referral privileges. With most curricula now increasing their efforts to better educate future physical therapists, educational programming for existing practitioners now becomes a priority for jurisdictions seeking or having just obtained imaging referral privileges. This includes not just the technical aspects of which patients should be imaged (or not) and the appropriate modality, but also the communication and individual jurisdictional aspects of imaging referral. The specific details of this are still evolving at the time of submission of this story.

The Horizon for Imaging Referral Among Jurisdictions

In a poster presentation at CSM, Leah Lawson and Molly Mathistad, 3rd year University of Kentucky DPT students reported on a survey of jurisdictional priorities in seeking imaging referral privileges for physical therapists. While approximately half of the leaders in APTA affiliated chapters responded, among those were 17 states that indicated plans to seek imaging referral privileges within the next 5 years. Data on diagnostic ultrasound imaging were also obtained with state associations being generally less knowledgeable with their methodological approach to this form of imaging. While state chapters are required to balance multiple priorities of their members, the number of states with imaging referral as parts of their strategic plans foretells major changes potentially on the horizon.

Ultrasound Reimbursement Survey

In September and October 2020, a survey of diagnostic ultrasound users within the Imaging SIG collected data on the experiences of users with success or the lack thereof in being reimbursed for ultrasound. In December and since, Imaging SIG leaders have been communicating with APTA and AOPT payment personnel in follow-up to this survey. More information about the measures evolving from this data will be forthcoming.

Infographics in Development

The Imaging SIG is in the process of developing infographics for multiple purposes, but all with the common theme of supporting imaging in physical therapist practice. The infographics will be directed at various audiences, including serving the roles to supplement advocacy for imaging referral privileges and payment. Future infographics will include support of physical therapist use of diagnostic ultrasound. Once these are developed, they will be available from the Imaging SIG webpages for download and member use.

Ultrasound Studies of Pedagogy

The Research Committee continues to do excellent work and has recently undertaken a project to identify the best pedagogical approaches for ultrasound education for physical therapists. Specifically, they are seeking to be able to find the best approaches in development, implementation, and impact of an expert-informed pedagogy for teaching physical therapists musculoskeletal diagnostic ultrasound imaging. This work is being undertaken by George Beneck, Lorna Hayward, Alycia Markowski, Maureen Watkins, Rob Manske, and Murray Maitland. This group recently obtained grant funding to assist in achieving their objectives.

Imaging SIG in PTJ

Did you happen to notice the articles in each of the January and February issues of P*hysical Therapy Journal*? The article entitled "Survey of Physical Therapists' Attitudes, Knowledge, and Behaviors Regarding Diagnostic Imaging" was written by Sean Rundell, Murray Maitland, Robert Manske, and George Beneck and appeared in the January issue. This manuscript was the direct result of a project undertaken by the Research Committee. The next month "Referral for Imaging in Physical Therapist Practice: Key Recommendations for Successful Implementation" was published as the continued effort from the educational session at CSM 2019 in Washington, DC. Authors on that project included Aaron Keil, Amma Maurer, Connie Kittleson, Daniel Watson, Brian Young, Scott Rezac, Scott Epsley, and Brian Baryani. Both articles evolved out of Imaging SIG activities to be published in our main journal of the profession and will make substantial impact.

AIUM Webinars

Our webinars, in conjunction with the American Institute for Ultrasound in Medicine (AIUM), continue with more webinars planned through 2021 and early 2022. The next scheduled webinar conducted by a physical therapist is Karin Grävare Silbernagel presenting "Optimizing Treatment of Patellar Tendon Injuries with Ultrasound Imaging" on April 28. As you may recall, Karin led another webinar in December 2019 on Achilles tendinopathy (co-sponsored with the Foot and Ankle SIG) that was very well received. Both AIUM and the Imaging SIG very much wanted an encore.

Announcements of these webinars, including the links for registration, are through email to all Imaging SIG members 4-5 weeks in advance of the date of presentation and then also promoted through the various AOPT social media platforms. One can also stay informed of these webinars along with all other AIUM programming by going to www.aium.org and searching under "Learning Center." If ultrasound is of significant interest for you, please consider joining AIUM as a multi-disciplinary organization, supportive of physical therapists pursuing excellence in practice with the utilization of ultrasound imaging. As has been announced earlier, the resources available from AIUM and linked on the Imaging SIG web pages are consistent with the prerequisites of earning the Registered in Musculoskeletal Sonography credential as offered by Inteleos.

Imaging Education Within the SIG and Across AOPT

Brian Young is the new Imaging SIG Vice President and in that role is also the Education Chair. Watch for new educational initiatives to get underway this year in a variety of undertakings. More information on these will be forthcoming.

PAIN SIG

(Continued from page 117)

Committee that I have been working with to help develop a Pain Education Manual to provide to DPT faculty to help implement the IASP guidelines. We are now at a point where we are ready for key stakeholders to review our draft. The goal is to have the final draft ready for the AOPT to brand and copyedit by April.

Pain Specialization Update: Derrick Sueki, PT, DPT, PhD, GCPT, OCS, FAAOMPT, Workgroup Chair

The pain specialization process continues to move forward. We have completed our pilot survey to determine the elements of specialty practice and it has been approved for distribution to our sample group. We hope we will have the results back by mid-March and will be able to modify the survey for general release by mid-April. When we have the results from the survey, we will have the information necessary to complete an analysis for the Specialty Board. If approved, we will prepare the Description of Specialty Practice (DSP). The DSP is the guide for what Pain Specialization entails and provides the framework for a specialty certification examination and any post-professional residency efforts. Once the DSP is completed, we will petition the Specialty Board for approval and if they approve, it will move to the House of Delegates. Our goal is to have the petition prepared and before the Board within this next year. Derrick Sueki continues to oversee this process with Marlon Wong directing the pain specialization track and Katie McBee leading the residency and fellowship efforts.

In closing…

The Pain SIG would like to thank the all the AOPT office personnel and President, Joseph M Donnelly, PT, DHSc, for their continued support and guidance.

We presently have multiple opportunities for SIG involvement on the membership, public relations, and research committees. Please contact me or any other Pain SIG leader to volunteer to help our initiatives and our future.

DID YOU KNOW?

As an Academy of Orthopaedic Physical Therapy member, we support you with:

- **Member pricing on independent study courses**
- **Subscriptions to *JOSPT* & *OPTP***
- **Clinical Practice Guidelines**
- **Advocacy of practice issues**
- **Advocacy grants**
- **Mentoring opportunities**

Visit orthopt.org

ORF-SIG Dashboard:

Total Members: 369 (+13)

- **Facebook Group: 150 (+4)**

ABPTRFE ACCREDITED PROGRAMS:

- Residencies:
  - **Orthopaedic: 119 (+4)**
- Fellowships:
  - Hand: 0
  - Movement: 2
  - OMPT: 23 (-1)
  - Performing Arts: 3 (+2)
  - Spine: 3
  - Upper Extremity: 3

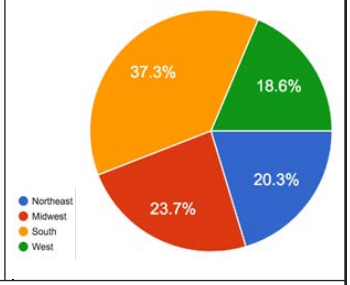
ACOMPTE ACCREDITED PROGRAMS

- OMPT: 34 (-/+ 0)

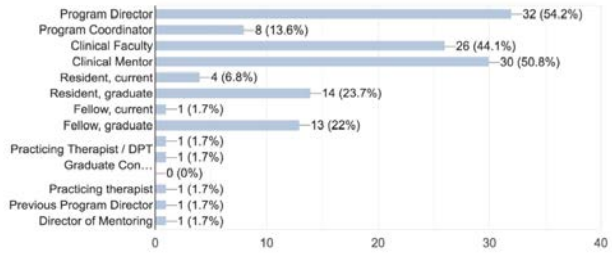
(+/- in members/programs since last quarter)

Current Member make up:

Demographic Regions:



Who We Are



Please Scan the QR Code or go to: bit.ly/orfsig-membersurvey and complete the survey if you have not already:

President's Message

ORF-SIG Members,

By the time you receive this message, we will have moved through our first all virtual APTA Combined Sections Meeting. While I admit I was looking forward to attending some of the courses from home while sleeping in my bed, I quickly realized I truly missed the opportunity of meeting and dialoguing with our members face-to-face. The virtual option of CSM allowed me to attend a few more courses than what I am typically able to as I run from meeting to meeting at CSM. So, in the end, a little different focus than years past which will hopefully open new doors in the future. I do look forward to more face-to-face interaction in the future while embracing the new opportunities provided this year.

Along with 2021's new opportunities, the ORF-SIG is also guided with new leadership. In our last message we thanked Kathleen Geist and Mary Derrick for their leadership within the ORF-SIG as elections were held for our Vice President and Nominating Committee openings. The ORF-SIG is now happy to announce Kirk Bentzen as the incoming Vice President and Molly Malloy as the incoming Nominating Committee member.

Dr. Bentzen is no stranger to residency and fellowship education or the ORF-SIG as he currently serves on the American Board of Physical Therapy Residency and Fellowship Educations (ABPTRFE) Accreditation Services Council since 2017 and Committees since 2010. Additionally, Kirk has served in many committee and sub-committee roles within the ORF-SIG supporting the growth and development of the special interest group. Dr. Bentzen is currently pursuing a PhD in Leadership Studies with an emphasis in Health Sciences at the University of the Cumberlands with a special interest in evaluating mentorship within physical therapy residency and fellowship education. Dr. Bentzen currently is a part-time Associate Professor of Anatomy at Occidental College and holds a full-time position at Adventist Health Glendale where he is the manager of the Therapy & Wellness Center as well as the residency Program Director for the Orthopedic Residency (2009) and the Sports Residency (2013). We look forward to the experience and leadership Kirk will be bringing to the ORF-SIG in 2021.

Alongside Kirk's leadership, we are happy to welcome Molly Malloy as the incoming Nominating Committee member. Dr. Malloy too has been an active member in the ORF-SIG and AOPT as she serves as the liaison to the AOPT Practice Committee regarding residency and fellowship education and curricular developments for the AOPT Residency Curriculum. Additionally, Molly has reviewed and contributed to the Education Section's Residency and Fellowship SIG's "Think Tank" that provides shared resources for residency/fellowship programs across the country. Molly is the current orthopaedic Residency Director and an Assistant Professor for the DPT program at Arcadia University. Prior to starting at Arcadia University in 2019, she previously served as the orthopaedic and pediatric Residency Director at the University of Chicago walking the programs through the initial ABPTRFE credentialing and re-credentialing process. Dr. Malloy's experiences will be a great addition to the ORF-SIG.

Finally, there is one more member and AOPT leader I would like to formally thank for her great leadership. Dr. Aimee Klein has served as the ORF-SIG's Board liaison nearly since the inception of the special interest group. Over the past several years, Aimee has been instrumental in the growth of the ORF-SIG assisting in identifying program director barriers to new and developing accreditation standards, the use of primary health conditions while still encouraging the growth of residency and fellowship education. Aimee was one of the pioneers in developing the AOPT Residency Curriculum as well as the Developing Residency/Fellowship Grant program to assist in the development of new programs. Dr. Klein has been no stranger to the leadership of the APTA and AOPT which are just a few of her accomplishments that will be greatly missed as Aimee steps down from the AOPT Board.

- APTA: Director - Board of Directors (2006-2012) AOPT liaison (2009-2011) Spokesperson Media Corps (2011-present), and Advisory Panel on Practice (1998-2001/Chair 2000-2001)
- ABPTS: Orthopaedic Specialty Council - Test Item Coordinator (2004-2006), Clinical Content Expert SACE (2002-2004)
- ABPTRFE: Accreditation Services Council (2014-present) and Committee (2011-present)
- AOPT: Practice Committee (2002-2006/2013 present), liaison to Residency/Fellowship Education
- Chapter: APTA of MA Chief Delegate (1999-2002), Legislative Committee (1987-1990/1999-2012); FPTA Practice Committee (2013-present)

What will be most missed about Aimee does not come just from her experience but from her tenacity to move the profession forward. Much like the GOAT Tom Brady, Aimee's east coast work ethic is one to be admired. No matter what team Aimee moves onto next, we know that she will continue to inspire, impress, and be an innovator in the physical therapy profession. Thank you Aimee for all that you have done and will continue to do. I hope the Tom Brady reference brings a smile to your face!

Thank you!

Matt Haberl
President, ORF-SIG

Here is an update of what our current Committees and Subcommittees are working on. If you would like to Get Involved within the SIG make sure to reach out to mhaberl@orthopt.org.

Committee Updates

Research: Kathleen Geist, Mary Kate McDonnell

Thank you to those individuals who have submitted a poster for the **Resident and Fellow 2021 CSM Poster submissions** for publication in Orthopaedic Practice and **an opportunity to win a cash prize of $250.** Presenters will have an opportunity to present their poster virtually and the first and second place poster winners will win $250 upon submission to OPTP. Members of the research subcommittee will contact everyone who submitted a poster to sign up for a virtual presentation time the week of February 22nd. Each presenter will have 15 minutes to present their poster, 10 minutes to present the poster, and 5 minutes for follow-up questions. Please make sure to consider submitting your poster for CSM 2022 to https://www.orthopt.org/content/special-interest-groups/residency-fellowship/poster-award. Please access the website for submission due dates Please contact kgeist@emory.edu

Practice/Reimbursement: Darren Calley and Kirk Bentzen

During the development of a mentorship survey, Dr. Kirk Bentzen was in the process of developing his dissertation for his PhD studies. Due to these common interests around the topic of mentorship, it was decided to conjoin these two projects. Recently, Dr. Bentzen completed his review of the literature, including the exploration of mentorship across a variety of professions and levels of education.

A **mentorship survey** has since been developed to identify how mentoring is delivered across orthopaedic residency and fellowship programs. It recently received IRB approval at Dr. Calley's institution and was sent out to program directors. With this survey data, we hope to better understand how mentoring is implemented across programs, which will give ORF-SIG programs ideas for how others are delivering mentoring and future content development. To date, 25 program directors have completed the survey. For those program directors who have not completed this survey and are interested in doing so, please look for one additional opportunity to complete this survey in an upcoming email. Thank you to the members of the Practice/Reimbursement Committee for their efforts in developing this survey and to all who have participated.

Additionally, Dr. Bentzen would like to thank all members of ORF-SIG that participated in his dissertation data collection over the past 6 weeks. Across all residency programs, over 200 responses were recorded thereby providing a robust data set with which he can begin his analysis. The dissertation is looking at the site visit rubric accreditation reviewers utilize when observing the onsite mentoring session.

Communication: Kirk Bentzen, Kathleen Geist, Darren Calley, Megan Frazee, Sarah Nonaka, Chrysta Lloyd, Steve Kareha

ABPTRFE Frequently Asked Questions Documents: Recently the American Board of Physical Therapy Residency and Fellowship Education (ABTPRFE) released updates to their Policies and Procedures including some changes to the Primary Health conditions and CoVid-19 accreditation recommendations. The ORF-SIG was able to work with the Chair of ABPTRFE, Mark Weber, and the Lead Accreditation Specialist, Linda Cisza where they provided some further elaboration on several Frequently Asked Questions. Keep an eye open for the release of these upcoming documents:

- Policy 13.5 Addition of Practice Sites FAQ
- Primary Health Conditions / Medical Conditions List FAQ
- CoVid-19 Temporary Guidance FAQ
- Program Sustainability: Applicant Sharing and Recruitment FAQ

Membership: Bob Schroedter, Tyrees Marcy

Some of you may have received emails regarding your membership status with the ORF-SIG and AOPT Please make sure to renew your AOPT and ORF-SIG status when you renew your APTA membership as this does not automatically occur unless you are set up for auto renewal. Moving forward in 2021 we will be creating more member-only access to several of our great resources. We are reaching out to congratulate new and developing programs and to increase awareness of the membership benefits and highlight that membership is included to all Academy of Orthopaedics members. Please make sure to share the benefits of the ORF-SIG with your colleagues!

- Communication of up-to-date changes and developments in Residency and Fellowship Education
- Access to Collaborate with other ORF-SIG Members engaged in Residency and fellowship Education on our Facebook group page
- Program Resources for members including program directors and coordinators, faculty, mentors, and prospective residents/fellows
- Scholarship Awards for residents and fellows in training
- Grant Funding and Curricular options for programs and faculty
- Opportunities to Get Involved with various leadership roles within the SIG

Take advantage of our member-only communication forums to share and develop ideas.

ORF-SIG Facebook group
bit.ly/orfsig-fbgroup

AOPT ORF-SIG Communities HUB
bit.ly/orsig-communityhub

Nominating: Bob Schroedter, Tyrees Marcy, Molly Malloy

Thank you to those who agreed to be slated for the ORF-SIG Vice President and Nominating Committee openings. By the time this is published, we will know who these wonderful individuals are and look forward to building our community of excellence in residency and fellowship education.

Additionally, the ORF-SIG will be trialing the use of Microsoft Teams to enhance our committee and subcommittee communication for project development. We are excited to continue to bring our membership new and exciting things in 2021.

Subcommittee Updates:

RF-PTCAS: Kirk Bentzen, Steve Kareha, Megan Frazee, Carrie Schwoerer, Christina Gomez

We as a leadership team have heard the frustration that programs have with using the RF-PTCAS portal. We recognize these processes occur only once a year and are looking for ways to support our membership in optimally leveraging RF-PTCAS. Please contact Carrie Schwoerer (cschwoerer@uwhealth.org) if there are particular aspects of RF-PTCAS you would like a greater understanding of as the ORF-SIG in collaboration with Ryan Bannister from RF-PTCAS and Sara Kraft and Christina Gomez of the Educations Sections RFE-SIG will be hosting a webinar answering many common questions.

Program Sustainability: Steve Kareha, Matt Haberl, Kirk Bentzen, Carrie Schwoerer

One big problem facing programs is the ability to sustain consistent applicant bases despite using, or not using, RF-PTCAS. Based upon your feedback, we have created 2 surveys to aid in this effort. The first is to become a contact list library for our member programs of physical therapists and physical therapist students interested in learning more about orthopaedic residency and fellowship programs. The second is specifically for those qualified applicants who are good and have already been vetted but applied to a program that does not have any additional spots available. The program denying admission may then provide the applicant with a flyer explaining the database and providing them the option to participate. Member programs may then access these qualified, vetted applicants as needed by contacting Steve Kareha (stephen.kareha@sluhn.org) and updates on numbers of candidates in this list will be provided quarterly to the membership.

Residency & Fellowship Interest
http://bit.ly/2OH6zdX

Residency & Fellowship
Qualified Applicants
http://bit.ly/3u0JR0s nityhub

Program Highlights: Caitlyn Lang, Kristine Neelon, Bob Schroedter

New things to come in 2021! The ORF-SIG recognizes that the CoVid-19 pandemic has placed a lot of stress on Residency and Fellowship programs with the future of some programs being in jeopardy. To assist programs, the ORF-SIG is working on developing a Monthly Program Highlight for its members to spread the word regarding the benefits of residency and fellowship education. More to Come!

Liaison Updates:

ORF-SIG-AAOMPT Updates: Bob Schroedter

ORF-SIG and AAOMPT are joining forces to brainstorm potential avenues for collaboration in the future. Be on the lookout for innovative ideas to bring together these two organizations and engage both memberships. More to come!

Other Resources

bit.ly/orfsig-covidresourcemanual

If you have not already done so, please make sure to review the continually evolving ORF-SIG **CoVid-19 Resource Manual**. This manual provides further information on how residency and fellowship programs are overcoming accreditation challenges, ensuring patient participation, and program sustainability.

aptaeducation.org/special-interest-group/RFESIG/

You can also find more great information from the Academy of Education's Residency and Fellowship SIG (RFESIG). Here you will find a variety of Podcasts they have completed for Residency and Program Directors. Please make sure to check these out as well as the Think Tank resources.

President's Message

Francisco Maia, PT, DPT, CCRT

I wanted to start this letter by sending a big thank you to all of you who attended CSM 2021! Of course, I missed the networking component and getting to meet hundreds of physical therapists and students interested in the field of animal physical therapy, but we had a great turnout for our virtual sessions. I am very much looking forward to seeing you all next year in San Antonio, Texas.

With that in mind, I was reflecting on previous CSM conferences and thinking about what were the most common questions I would get about our field. One of them was always regarding legislation and our ability to practice with animals in certain states. There are 50 different answers to that question based on where you live in the United States, but I was glad to have Kirk Peck submit the article for this month's newsletter highlighting some of those states along with updates on legislation and guidance on what to do if you wish to initiate changes in your state. If I may be blunt, change never happens unless we are willing to fight for them. If you live in a state where animal physical therapy is a "gray area", then I would highly encourage you to get involved in making that change instead of waiting for the change to happen. Someone needs to get that started, so why not you? If needed, reach out to the Animal Physical Therapy SIG and we will provide you with support and resources.

The second question I would commonly get would be regarding what to do to prepare to be an animal physical therapist when that person would know they were years away from even going through the certification courses. Of course, that was often asked by students, but it was always a common question among practicing clinicians as well since the coursework can take months, and sometimes even over a year, to get completed. There were always 2 main things that I would recommend to anyone in that position:

1. Start spending some time learning about animal behavior and body language. Yes, animals do communicate with us, but they do so in a different way, and often physical therapists struggle initially to understand how to communicate with them. There are numerous courses, textbooks, and other resources on this topic. I would also highly recommend learning about positive reinforcement training. You will need a basic understanding to be able to develop a bond with your animal patients while getting them to do the exercises that you want them to do.
2. In addition to learning about behavior and body language, make sure you are spending some time getting used to handling animals of all shapes and sizes. We are often comfortable with handling our pets, but how about an animal who might be anxious, nervous, or has behavioral issues? How about an animal that does not know you and has had numerous veterinary visits that were not pleasant to them? While I was getting certified as a canine rehabilitation therapist, I spent 2-3 hours a week volunteering as a dog walker at a local dog shelter. This was a win-win because those pups got the tender loving care they needed and I got experience handling dogs of all different shapes and sizes.

Thank you,
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The Legalese of Animal Physical Therapy

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I would like to share a brief scenario many of you probably can relate to as part of your career path in physical therapy. You graduated from physical therapy school, acquired a few good years of clinical practice, and eventually decided you would like to get certified in animal physical therapy as a way to satisfy a personal desire to treat our wonderful human companions. To achieve this goal, you enrolled in a certification program for animal rehabilitation, got super excited about collaborating with both physical therapist colleagues and veterinarians in the same learning environment, and finally you successfully passed all required examinations. Then you returned to your home state and realized no laws allow physical therapists to legally treat animals.

I share this scenario only because I have heard the story too many times over to remember. As past president of the APTSIG I received numerous questions from physical therapists, both pre- and post-certification in animal rehabilitation inquiring if their state laws allowed physical therapists to treat animals. One of my standard replies was for the inquirer to seek direct advice from their own state's physical therapy licensure Board as the appropriate entity for regulatory interpretation. After 6 years of repeating myself, I decided it was time to speak in a more public venue with a targeted audience representing all state regulatory agencies--the Federation of State Boards of Physical Therapy (FSBPT).

During the annual FSBPT fall meeting in 2019, I presented the current state of regulation guiding the practice of animal physical therapy in the United States. The presentation was summarized into an article published online in the FSBPT Forum in 2020. The article is entitled, ***"A Political Dog and Pony Show: Policy Making in Support of Animal Physical Therapy"*** and may be accessed at:

https://www.fsbpt.org/Free-Resources/FSBPT-Forum/Forum-2020/A-Political-Dog-and-Pony-Show

I encourage any physical therapist with an interest in treating animals as part of physical therapist practice to read the article posted on the FSBPT website. The narrative covers a brief history of animal physical therapy, in addition to current state laws and regulations, sample barriers to practice, and suggested negotiations to support regulation for physical therapists seeking to collaborate with veterinarians. It is imperative that physical therapists learn about appropriate state laws regarding animal practice, and do so *"before"* making a substantial financial commitment to an educational endeavor that may lead to personal frustration when they learn they cannot legally treat animals in their state.

Finally, it is worth restating the current position of the American Physical Therapy Association on physical therapists treating animals. In 2018, the APTA House of Delegates unanimously passed the following position statement:

RC 26-18 AMEND: VETERINARIANS: COLLABORATIVE RELATIONSHIPS (HOD P06-03-23-20) COLLABORATIVE RELATIONSHIPS BETWEEN PHYSICAL THERAPISTS AND VETERINARIANS

"The American Physical Therapy Association supports the collaborative relationships of physical therapists and veterinarians and the evolution of specialized practice by physical therapists who are addressing the rehabilitation needs of animals. Where allowable by state law and regulation, and consistent with a physical therapist's knowledge and skills, physical therapists may establish collaborative, collegial relationships with veterinarians for the purposes of providing professional consultation and expertise in movement impairment, fitness, and conditioning for animals".

This particular APTA Position is important for the practice of animal physical therapy in that it serves as an excellent reference for political advocacy and educating other physical therapists and veterinarians who may be unaware of this unique niche practice. Support from the APTA in addition to an active Special Interest Group through the Academy of Orthopaedic Physical Therapy serve as excellent resources for physical therapists with interests in the field.

Treating animals as part of clinical practice can be very gratifying and an excellent way to highlight the value physical therapy adds to the physical therapist and veterinary team in restoring physical well-being to animals of all kind. However, physical therapists need astute knowledge of their respective state laws to ensure they have legal ground to expand their services beyond just human care. So again, if you are serious about pursing animal physical therapy as a practice option, I urge you to please read the comprehensive article on the FSBPT website. It addresses several important topics that all physical therapists should know if treating animals is a career goal.

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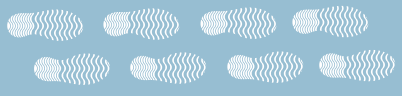

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APTA American Physical Therapy Association

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