2020 / volume 32 / number 3

ORTHOPAEDIC PHYSICAL THERAPY PRACTICE

The publication of the Academy of Orthopaedic Physical Therapy, APTA

TISSUE TOLERANCES

Independent Study Course 30.2

Description

This course will provide the clinician with an appreciation of the structure and function of tissue and its tolerance for injury and its potential for healing. Physiological concepts and biomechanics are covered for muscle and tendon, ligament and capsule, and articular cartilage. Each author brings a unique perspective for how to integrate basic science to clinical scenarios. An interesting array of cases accompanies each monograph. The cases serve to facilitate clinical decision-making and to provide examples of evaluation and treatment. This is a unique course series that should satisfy the scientific and clinical curiosity of every clinician.

Learning Objectives

1. Understand muscle and tendon anatomy and biomechanics.
2. Interpret the physiological mechanisms and processes associated with pathologic muscle and tendon tissue to clinical care.
3. Describe clinical and diagnostic tools used in identifying muscle-tendon abnormality.
4. Apply the current body of evidence underlying the physical therapy management for injury to the muscle-tendon unit.
5. Know how to apply concepts to improve the tolerance of muscle-tendon tissue to load, and implement such concepts to injury prevention strategies.
6. Describe the anatomy and physiology of a healthy ligament and capsular tissue.
7. Describe the pathophysiological processes that occur in the event of an injury to ligament or capsule.
8. Identify the phases of healing following a ligamentous injury.
9. Apply pathophysiological concepts of ligamentous integrity to the examination and treatment of specific conditions for the extremities.
10. Understand the structure and functional rigor of articular cartilage.
11. Appreciate the scientific basis of why cartilage regeneration is limited.
12. Describe the most common mechanisms for articular cartilage damage.
13. Describe the link between articular cartilage damage and early osteoarthritis.
14. Describe the medical interventions currently used in the repair of articular cartilage.
15. Specifically apply rehabilitation goals and precautions for patients who have undergone patellar and femoral articular cartilage repair.

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Tissue Tolerances of the Ligament and Capsule
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Tissue Tolerances of the Articular Cartilage
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President's Corner

"Back in the Saddle"

Joseph M. Donnelly, PT, DHSc, FAPTA

I want to start this President's update with a big thank you to Lori Michener, Vice President of the Academy of Orthopaedic Physical Therapy (AOPT) for her tireless efforts in carrying out the duties and responsibilities of President during my medical leave. I want to thank the Orthopaedic Academy Board of Directors and staff for their unwavering support during this time as well. I am so proud to work with this amazing group of individuals. On April 1, 2020, I transitioned back into my leadership role as the AOPT President 12 weeks post emergency L5 decompression on January 7, 2020, and L5-S1 spinal fusion and reconstruction on January 8, 2020, for Cauda Equina Syndrome. I distinctly remember asking the neurosurgeon on the morning of January 9th if I would be able to go to Denver for CSM? Obviously he said absolutely not! Missing CSM was more difficult than I could have ever imagined.

I began my physical therapy controlled mobility rehabilitation program at week 4 with some hesitation from the surgeon but I promised to behave (and I did). At week 10, I was ready to return to my professional role and was notified that I would be working virtually due to the COVID-19 pandemic. It was disappointing but necessary, however my first thought was about my own physical therapy treatments and progression. I needed to get moving; I would be off spinal pre-cautions at week 12. I was so ready to get back to life.

The COVID-19 virus was really novel in the United States at this time and there was a lot of dialogue happening on social media; some good and some very embarrassing for our profession. Were we essential or non-essential? Who should be open? Who should be closed? I was very determined that I was going to get my physical therapy. On March 20, 2020, APTA President, Sharon Dunn demonstrated strong leadership and addressed COVID-19 head on with a letter to APTA members. There were two sentences in this letter that triggered a significant opportunity for reflection; *"I hope that this uncertain time brings us together—as a nation, as a community, as an association—by showing us how connected we are, and how much we depend on each other. And I hope that our profession will do what it does best: help our society move on from a period of suffering, by restoring function, independence, and dignity to survivors."* A call to action to make sure we did not lose sight of who we are for society. I was viewing this letter through the lens of a patient and that is exactly what my physical therapist was doing for me. I will share with you my experience as a patient during these unprecedented times.

I was a patient in physical therapy (Mercer University Physical Therapy) at the time of "shelter in place" orders and was observing the changes that were happening in the clinic to provide safe, effective, and efficient care. These changes were being driven by physical therapists who knew patients like me could not be abandoned during these unprecedented (new favorite word) times. Discussions and meetings took place, signs went up, and physical therapy services were being delivered. I was treated just like every other patient entering the clinic each visit. I was asked the same 5 questions, my forehead temperature was taken with a laser thermometer, physical therapists were in masks, I was washing my hands and physical therapists were washing their hands before treatment, and all equipment was being cleaned while the patient observed the process at the end of their visit. Both the patient and his or her physical therapist were washing their hands at the end of the visit. I felt safe and continue to feel safe as it is May 15, 2020, and I am still receiving physical therapy two times weekly and progressing very nicely according to my physical therapists. And I am still behaving! I am sharing this story with you to support the notion that we are always essential to someone in society, and individuals like me depend on our services so we can return to function and life.

It is now July and my hope is that we have learned so much more about COVID-19 and how to minimize its effects in our lives. I wear a mask for you; I wash my hands for you and me, and I avoid taking risks that would expose me and those I love to the virus. My hope is that during this pandemic and on the other side of it that we are a kinder, gentler society that has empathy and compassion for those who are suffering. I strongly believe as a profession we need to be as flexible and adaptable as possible to get through this together. Continued advocacy for telehealth services and payment for this delivery of care will be necessary. The art and science of Physical Therapy must prevail.

The AOPT BOD have been actively engaged in the COVID-19 multi-Section/Academy Task Force and supported these efforts to provide resources to members through the APTA Learning Center and Communities. We know that many members have been affected by COVID-19 personally, professionally, and financially. We have been discussing strategies to help our members and hope to finalize some of these initiatives this month at our BOD Meeting. We will meet virtually to protect each other and the Orthopaedic Academy's financial resources. The AOPT staff have developed initiatives to provide continuing education resources at reduced costs and will continue to investigate opportunities to assist AOPT members.

Remember that the slate of candidates for AOPT BOD and Nominating Committee will be presented in July and AOPT **voting will now be in August**. Special Interest group elections will take place in November as usual. Stay well and safe!

Editor's Note | 3 sets of 10 reps

I was recently invited to review a legal case as an expert witness and without going into all the specifics (which are now public), I wanted to highlight a concern. I have been involved in 8 legal cases and each time, the same concern is evident. The concern that I speak of also occurs in DPT entry-level students and in practicing therapists of various ranges of experience. That concern is the pervasive use of 3 sets of 10 repetitions in exercise. The concern I have is that 3 sets of 10 repetitions without modification is terribly wrong.

There are all kinds of resistance variables that can be manipulated. Load, the amount of mass lifted. Volume, the total number of repetitions in a session multiplied by the resistance used. Even the order of exercises within a session contributes to benefits to the patient. There are several approaches to progressively overload muscles besides defaulting to 3 sets of 10 repetitions. By increasing the resistance, increasing the volume through increasing repetitions, sets, number of exercises performed, altering resting time between sets or by increasing the repetition velocity during submaximal resistances as suggested by excellent authors.[1] In the legal case that I reviewed, a patient was being treated by a therapist for 6 months and I reviewed all of the patient's notes. As you might guess, the patient was still doing the same number of sets, repetitions, and weight for over 4 months of therapy. I have taught in 4 different DPT programs and have observed a similar mindset in students, of defaulting to 3 sets of 10 reps. I am certain the use of Holten's curve is taught, which suggests finding a 1 rep maximum for an exercise for a healthy client. This approach is contraindicated for a patient who is being seen for rehabilitation of an injury.[1] DeLorme, way back in 1945, suggested 3 sets of 10 reps BUT qualified this by suggesting that progressive loading must occur to reach strength gains.[2] For some reason, this latter idea has been lost in translation.

In this editorial, I would like to have the reader consider the use of the OMNI-RES first introduced by Robertson.[3,4]

By observation, the OMNI-RES scale appears similar to the Wong-Baker FACES® for pain scale. The OMNI-RES is used to determine when to increase intensity. This scale is applied when the individual initially performs the exercise with resistance or theraband or tubing and is asked to rate the level of difficulty for the exercise using the OMNI-RES scale.[4] When the individual is able to perform the exercise with 3 sets of 15 repetitions and the OMNI-RES score falls below a 5, resistance is increased by one pound or resistance of the tubing or band is increased. Obviously, if the therapist is trying to work on strength vs endurance, the number of repetitions and resistance is modified.

I am not sure why the OMNI-RES is not more commonly used and that very few therapists have even heard of it, but it has construct validity with the RPE scale and provides objectivity to a subjective measure of intensity. Recently, a therapist friend of mine told me of an incident in which he was covering for another therapist and asked the patient to perform the exercise for the same amount recommended by the absent therapist. My friend asked the patient to go until fatigue on the last set much like what is recommended in the daily adjustable progressive resistance exercise technique (DAPRE).[5] She was doing straight leg raises for 4 minutes before he stopped her from doing any more and added resistance. This has got to stop. We are underdosing our patients.

Intensity has been suggested by authors to be the most important aspect of gaining strength. After watching the fantastic documentary *"The Last Dance"* I think it would be safe to say that Michael Jordan's approach to intensity in practice, games, and in everything in his life resulted in his success. I believe that for a successful outcome with a patient, both the patient and the therapist must do their part. As physical therapists, we can do a better job of prescribing exercise with the proper intensity AND we can ask our patients to do their part by following through with the personalized program we prescribe. Exercise is medicine. Perhaps tools like the OMNI-RES will help bring about this success on both sides.

Professionally,
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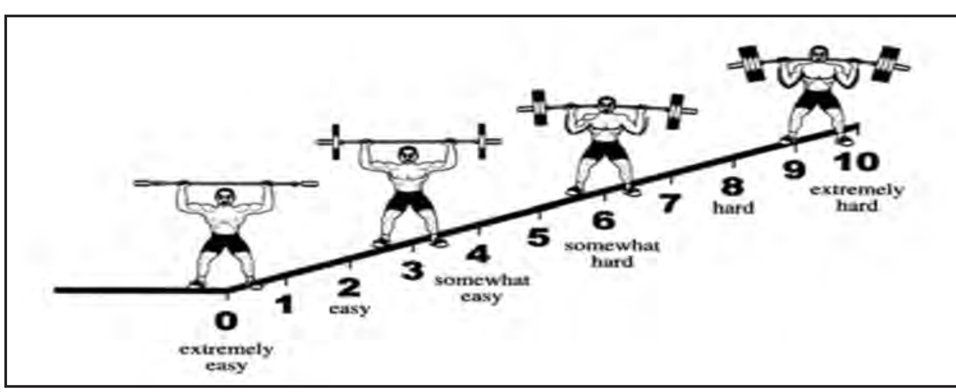

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Physical Therapists in the Patient Centered Medical Home: Improving Cost, Quality, and Access

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The opinions and assertions expressed herein are those of the author and do not necessarily reflect the official policy or position of the United States Army or the Department of Defense.

ABSTRACT

Background and Purpose: Musculoskeletal (MSK) conditions are the most common reason patients seek care in the Military Health System (MHS). This demand is a significant burden on the MHS, accounting for over 4 million ambulatory visits in 2018. The purpose of this paper is to describe the impact on access, cost, and quality of care by embedding physical therapists into a developing Patient Centered Medical Home (PCMH) within a community-based military hospital. **Methods:** The hospital moved an existing full-time physical therapist from the physical therapy clinic directly to the PCMH within family medicine. Data regarding network purchased care costs, number of physical therapy consults deferred to the non-military care network, and quality metrics regarding low back pain imaging were assessed. **Findings**: One year after embedding the physical therapist, the hospital realized a 38% reduction in private sector physical therapy costs, a 35% reduction in network physical therapy deferrals, and improved low back pain imaging quality measures. Patient satisfaction metrics exceeded national standards. **Clinical Relevance:** Embedding physical therapists in a PCMH can improve cost, quality, and access to care for patients with MSK conditions. **Conclusion:** Integrating physical therapists within a PCMH model in a military hospital improved access to care, lowered costs, and decreased use of health care resources.

Key Words: direct access, primary care, musculoskeletal, military health system

BACKGROUND AND PURPOSE

Musculoskeletal (MSK) conditions are the most common reason active duty service members seek care in the Military Health System (MHS), accounting for over 4 million ambulatory visits in 2018. This is more than double the number of behavioral health visits, which is the second leading cause of ambulatory encounters in the MHS. Furthermore, 53.4% of all ambulatory visits related to duty limiting conditions for active duty service members are due to MSK related conditions.[1] This high volume of MSK conditions presents a considerable burden on the MHS and impacts the overall readiness of the military.

The Patient Centered Medical Home (PCMH) is a care delivery model developed to shift care from a reactive, physician-centered model of care to a proactive, patient-centered model that provides improved access and quality of care at a lower cost while enhancing the overall patient experience.[2]

Direct access to physical therapists without physician referral has been shown to result in fewer overall patient visits, lower costs, less imaging and medication use, and fewer additional non-physical therapy related visits, while demonstrating excellent patient satisfaction and outcomes with no evidence of harm.[3-9] Furthermore, physical therapists are ideally suited and trained to be primary managers of MSK conditions. The diagnostic accuracy of physical therapists has been shown to be similar to orthopedic surgeons and better than non-orthopedic or primary care providers, including nurse practitioners, physician assistants, family practitioners, and internal medicine providers.[10,11]

Given the strong evidence of effectiveness for early access to physical therapists for patients with MSK conditions, the director of physical therapy services at a community-based military hospital advocated to hospital administrators for the integration of physical therapists within a developing PCMH. The purpose of this paper is to describe the impact on access, cost, and quality of care by embedding physical therapists into a developing PCMH within a community-based military hospital.

METHODS

The director of physical therapy services at the military hospital provided the chief medical officer and chief executive officer of the facility with a thorough review of the evidence of effectiveness, impact on cost, quality, patient satisfaction, and low risk of harm when patients access physical therapy directly. After learning of the published evidence on improved cost, quality, and access as well as projected impact on enhanced patient experience, the hospital agreed to a trial of moving an existing full-time physical therapist from the physical therapy clinic directly to the PCMH within family medicine. An examination room was provided for the physical therapist adjacent to the PCMH providers and existing administrative support from the PCMH staff was used for the physical therapist. Workflow details were coordinated, which included patients with MSK complaints being provided the option to see the physical therapist rather than the primary care provider. Data regarding network purchased care costs, number of physical therapy consults deferred to the non-military care network, and quality metrics including Healthcare Effectiveness Data and Information Set (HEDIS) for low back pain imaging were assessed. The HEDIS is a widely used set of performance measures in the managed care industry, developed and maintained by the National Committee for Quality Assurance.[12]

RESULTS

Cost

The year prior to embedding a physical therapist into the PCMH, the facility spent $2.5 million in private sector physical therapy care delivered outside of the military hospital. This amount was just below the $2.7 million combined costs for private sector physical therapy services spent by 3 nearby military hospitals. One year after embedding the physical therapist, the hospital realized a cost avoidance of $944,855, equal to a 38% reduction in private sector physical therapy costs.

Network Deferrals

The number of patients deferred to network private sector care decreased from 2,632 the year prior to embedding the physical therapist to 1,706, a reduction of 35% during the first year of implementation. The hospital continued to see reductions in network deferrals the following year, with 1,076 patients deferred, an additional 36% reduction.

HEDIS Low Back Pain Imaging Metric

Diagnostic imaging of patients with low back pain prior to 28 days of symptoms in the absence of red flags is unlikely to provide additional patient benefit.[13] The HEDIS low back pain imaging metric measures the percentage of patients, without red flags, between the ages of 18 and 50 with a primary diagnosis of low back pain who did not have an imaging study, including radiograph, magnetic resonance imaging, or computed tomography, within 28 days of the diagnosis.[12]

At the time this program was implemented, none of the 28 Army hospitals within the MHS were above the 50th percentile for this HEDIS metric. Embedding the physical therapist in the PCMH increased the HEDIS low back pain imaging within this facility to above the 75th percentile, and this improvement was sustained for the next 2 years. One year after embedding the physical therapist in family medicine, a physical therapist was also embedded within the internal medicine PCMH. The internal medicine PCMH subsequently performed above the 90th percentile for this metric.

Net Promoter Score

In an effort to gauge patient experience with the physical therapist in the PCMH, we calculated the Net Promoter Score (NPS). The NPS is an indicator of company growth and customer loyalty.[14,15] The industry average is 16%, with exceptional companies scoring 75-80%. The NPS question is, "How would you rate your overall experience today?" It is scored on a Likert scale of 0 to 10 with 0 being the worst experience, 5 being neutral, and 10 being the best experience ever. "Promoters" are considered those that score 9 or 10 while those that are "passively satisfied" score 7 or 8. "Detractors" are considered those that score 6 or below.[14,15] The total NPS score is derived by subtracting the number of detractors from promoters.[14,15] Seventy-eight percent of patients surveyed during the first year of embedding the physical therapist in the PCMH were "promoters" and none were "detractors," resulting in an NPS of 78%.

Patient Satisfaction

A convenience sample (n=179) of patients who accessed physical therapy through the PCMH during the first year were also surveyed using a 1-5 Likert scale (1 = not at all, 5 = absolutely), regarding their confidence in the physical therapist's knowledge, explanation by the physical therapist on their diagnosis, interest and concern shown by the physical therapist, overall satisfaction with their experience, and preference for seeing a physical therapist first for their MSK condition. All patients surveyed responded with either a 4 or 5 on the scale. Ninety-six percent of patients seen in the PCMH clinic during the first year were satisfied with their access to care while only 74% of patients were satisfied with their access to care in the main physical therapy clinic.

DISCUSSION

Overall, patients accessing physical therapy through the PCMH were very satisfied with the care they received, as evidenced by NPS ratings similar to exceptional companies. Consistent with previous studies, we also found that early access to physical therapists resulted in cost savings, lower use of other health care resources such as diagnostic imaging, and no incidents of harm. It is important to note that these initial results were obtained without increasing staffing but rather using existing resources in a different way to meet patients' needs at the entry point of the health care system.

The initial success of the physical therapist in the family medicine PCMH led to the decision to embed another physical therapist in the internal medicine PCMH. Despite a substantial reduction in network provided physical therapy services, there was still considerably more demand for MSK services than could be met with the existing military facility physical therapy personnel on hand. The value of embedding physical therapy services in the PCMH led to additional physical therapists being hired and aligning a physical therapist to each PCMH team to manage the high volume of MSK conditions. Two of the three other military health care facilities within the market also began to incorporate physical therapy within primary care.

An important element to the success of this model of care delivery includes fully integrating physical therapy within the primary care team rather than simply co-locating a physical therapist or physical therapy team with primary care providers. Having a primary care provider who advocates for and sees the value in integrating care, consistent with the PCMH model, is critical to successful implementation.

Depending on the setting, staffing, space allocation, and equipment are factors to consider when establishing physical therapy within a PCMH. For the hospital setting described here, the physical therapist assumed an examination room similar to other providers on the primary care team. This space was considerably smaller than that of a typical physical therapy examination room, and access to an open "gym" area was not feasible. As such, the physical therapist focused primarily on initial evaluations, acute MSK management, and home exercise programs with periodic follow-up visits. An alternative format that could be considered by the hospital is if sufficient staffing exists, a physical therapist could potentially rotate each day of the week in the PCMH as a primary mechanism to improve access to patients, with follow-up visits completed in the traditional physical therapy clinic setting.

CONCLUSION

Physical therapists are ideally suited to serve as primary managers of clients with MSK conditions. Integrating physical therapists within a PCMH model in a military hospital improved access to care, lowered costs, and decreased use of health care resources. This is another example of how direct access and physical therapists in primary care settings can demonstrate value. Future research looking at prospective, randomized clinical trials of physical therapists working in direct access settings that assess patient-reported clinical outcomes in addition to cost, quality, and access to care metrics is warranted.

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Clinical Decision-making Considerations for the Integration of Manual Therapy as an Intervention for Patellofemoral Pain

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ABSTRACT

Background and Purpose: Patellofemoral pain syndrome (PFPS) is a common condition seen in the orthopaedic and sports physical therapy settings. Despite the emergence of high-quality evidence and clinical practice guidelines, a substantial percentage of individuals with PFPS have persistent symptoms and functional impairment at long-term follow-up. The purpose of this commentary is to review and discuss current evidence related to manual therapy for PFPS and guide specific prescription decision-making regarding the use of manual therapy in this population. **Methods:** Narrative literature review. **Findings:** While manual therapy is not typically useful in isolation, manual therapy appears to have an additive effect on outcomes when coupled with other interventions. **Clinical Relevance:** Soft tissue and joint mobilization/manipulation can be effective in down regulating pain and nervous system sensitization. Beyond describing current evidence, this article attempts to hasten knowledge translation through offering clinical decision-making considerations. **Conclusion:** Manual therapy can be helpful in decreasing pain and improving self-reported function for individuals with PFPS. Matching the mode of delivery to the patient's specific presentation including modified positions of application may assist in optimizing effects of manual therapy for PFPS.

Key Words: clinical reasoning, manipulation, mobilization, patellofemoral pain syndrome

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is one of the most common conditions of the lower extremity characterized by diffuse anterior retropatellar and/or peripatellar pain, affecting adolescent and young active women more than men.[1,2] The condition is associated with pain with prolonged sitting and with functional activities such as squatting, stair negotiation, running, kneeling, and jumping.[3] It has been suggested that some individuals with PFPS experience persistence of anterior knee pain for 2 years following initial onset.[4] Recurrence of PFPS is high, and it was reported that patients with PFPS demonstrate unfavorable outcomes 5 to 8 years following initial onset of symptoms.[5] The high incidence of the condition coupled with a persistent and recurrent nature suggests further investigation into best practice is warranted.

Though there are many interventions that target PFPS, there is no universally-accepted treatment approach for patients with PFPS. A recently published clinical practice guideline (CPG) on PFPS suggests that effective interventions include exercises targeting the hip and knee, patellar taping, foot orthoses, running gait retraining, manual therapy as an adjunct to treatment, and patient education.[6] The CPG prioritizes the use of therapeutic exercises combined when necessary with additional interventions to address PFPS. However, selecting appropriate treatment for PFPS can be challenging due to varied response to aforementioned interventions across individuals. While high-quality evidence continues to emerge to guide interventions, in excess of 50% of individuals with PFPS report persistent knee pain at long-term follow up.[5,7,8] It is possible that the ongoing fair outcomes despite high-quality evidence regarding PFPS could be related to challenges with clinical decision-making and intervention selection.

Four impairment-based classifications of PFPS, based on expert opinion have been proposed: (1) overuse/overload without other impairment, (2) muscle performance deficits, (3) movement coordination deficits, and (4) mobility impairments.[6] Rarely do patients fit discretely into a single classification, leading to multimodal treatment approaches. The CPG emphasizes that while manual therapy may enhance outcomes for PFPS, it should not be used as a stand-alone intervention to promote recovery and that it should not take away time from exercise interventions.[6] The recommendation is supported with Grade A evidence, described as a preponderance of level I and/or level II studies.[6] However, if mobility deficits are present it stands that restoring joint mobility and range of motion (ROM) should be a priority of treatment, as persistence of mobility deficits could theoretically lead to altered biomechanics, persistence of symptoms, and lack of improvement. Manual therapy can have a positive influence on joint motion, pain and self-reported function in a variety of musculoskeletal conditions[9] including PFPS.[10,11] Despite the classification of PFPS with mobility deficits, recommendations and decision-making assistance for implementation of manual therapy for PFPS is limited.

In addition to mobility deficits, increased pain sensitization has been associated with PFPS and may contribute to longevity of symptoms and functional decline. Central sensitization has been recognized in patients with osteoarthritis, suggesting that despite a localized peripheral report of pain, numerous pain mechanisms could be at fault.[12] A recent systematic review demonstrated that patients with PFPS may have local and widespread hyperalgesia compared to healthy controls.[13] Additionally, PFPS has been correlated to a number of psychological impairments such as higher levels of mental distress, lower levels of self-perceived health, anxiety, depression, catastrophizing, and fear of movement.[14,15] Bialosky et al suggested that manual therapy modulates pain by initiating a neurophysiological cascade at the peripheral, spinal, and supraspinal levels,[9] thus reasoning to incorporate manual intervention in patients with PFPS.

While the CPG for PFPS provides a strong recommendation against using manual therapy in isolation, it does not recognize clinical circumstances in which manual therapy may be a preferred intervention, such as in the presence of mobility deficits or pain sensitization. The purpose of this commentary is to review and discuss current evidence related to manual therapy for PFPS and guide specific prescription decision-making regarding the use of manual therapy in this population.

SOFT TISSUE MOBILIZATION

Authors suggest that tissue restrictions surrounding the knee joint may contribute to altered compressive load at the knee.[16] Piva et al described decreased muscle length or inhibition of the hamstring, gastrocnemius, iliotibial band, and/or quadriceps as factors that can direct or indirectly increase compressive forces at the joint.[17] Soft tissue mobilization (STM) is a commonly used intervention for improving soft tissue restrictions,[18] willingness to move,[19] and muscle activity, all of which may enhance an individual's capacity to perform functional activities without dysfunction. Common STM techniques include myofascial release, trigger point release, and transverse friction. Although there is a paucity of literature describing the use of STM in the management of PFPS, given the common soft tissue mobility restrictions and related impairments associated with PFPS, STM may be a logical and appropriate intervention for the condition.

Current Evidence Related to STM for PFPS

Restrictions in the lateral knee, such as the lateral retinaculum or iliotibial tract, may contribute to excessive lateral loading of the patellofemoral joint (PFJ). van den Dolder et al used transverse friction to the lateral retinaculum as a part of a multimodal manual therapy program for individuals with anterior knee pain.[20] This intervention was performed with the patient in supine, both with the knee fully extended and fully flexed for 6 sessions. When compared to the control group, the manual therapy group demonstrated significantly greater improvements in active knee flexion ROM, ability to perform step ups/down, and decreased pain.

In addition to mobility restrictions, muscle inhibition is commonly associated with PFJ dysfunction.[21] Specifically, literature highlights the contribution of a dysfunctional vastus medialis obliquus (VMO) muscle[16,21] and its relation to abnormal patellar tracking and resultant PFPS.[22] In a double-blind randomized trial, Behrangrad et al compared ischemic compression to the VMO with lumbopelvic manipulation for individuals with PFPS.[23] At each session, ischemic compression was performed 3 times with a 30-second rest break between applications. The amount of pressure was standardized using a pressure algometer and VAS, aiming to keep pain level at target value of 70/100. While both groups demonstrated significant improvements in pain, function, and pressure pain thresholds, the ischemic compression group attained better outcomes immediately and at follow-up.

Clinical Considerations for STM for PFPS

Clinically, muscle inhibition, pain, and/or muscle stiffness related to PFPS are indications for use of STM. Trigger point release and cross friction massage can be aggressive techniques, which may be appropriate for individuals with a low symptom irritability and a localized location of pain or dysfunction. For individuals with heightened pain, it may be necessary to start with a desensitization technique or gentle effleurage/petrissage to improve tolerance and effectiveness of additional rehabilitative interventions (Figure 1). These gentler techniques help with the down regulation/modulation of pain.[19,24] In the presence of mobility deficits, STM aimed to improve soft tissue extensibility may be appropriate before strengthening exercises. Incorporating these interventions may allow individuals to improve their motor performance through their new ROM, rather than strengthening muscles in a limited range. Techniques should be modified for patient comfort and, if tolerable, performed at the end limits of their existing ROM. Clinicians may also perform instrument-assisted techniques that can decrease clinician burden and effort.

PATELLAR MOBILIZATION

Similar to STM, PFJ mobilizations may be beneficial as part of a larger comprehensive plan of care.[6] Joint mobilization performed locally at the PFJ is suggested to assist with mobility and maltracking issues, in addition to pain modulation when combined with therapeutic exercise.[25,26] As previously stated, individuals with PFPS may present with mobility deficits and peripheral or central sensitization.[6,13] Recent systematic reviews found joint mobilizations to improve pain and function for individuals with PFPS.[10,11] One review noted that joint mobilization performed locally at the PFJ can be more effective than lumbar manipulation or soft tissue mobilization.[10] Patellofemoral joint glides can include superior, inferior, lateral, medial, and tilting motions of the patella on the femur.[27] Mobilizations can be performed in various positions, with differing grades of mobilization to target specific interventional goals. While there is some evidence to support the use of joint mobilization to improve outcomes in PFPS, there are also studies suggesting manual therapy is not additive in treatment plans for the condition.[28,29] In the presence of conflicting evidence, clinicians must rely more heavily on the specific patient needs to inform decision-making.

Current Evidence Related to Patellar Mobilization for PFPS

Few studies have investigated the use of PFJ mobilization for PFPS. Rowlands and Brantingham performed a randomized controlled trial (RCT) to determine the efficacy of PFJ mobilization in the treatment of PFPS.[26] An intervention group receiving PFJ mobilization was compared to a group receiving detuned ultrasound. The interventions were performed 8 times within 4 weeks. Participants receiving PFJ mobilizations demonstrated statistically significant differences in all subjective and objective measures compared to the control group. Though PFJ glides were used in isolation, this study demonstrates the benefit of the manual therapy intervention in comparison to a placebo in the management of pain related to PFPS.

As compared to the previous study evaluating PFJ mobilizations in isolation, PFJ mobilizations can be part of a comprehensive treatment plan. In an RCT, Crossley et

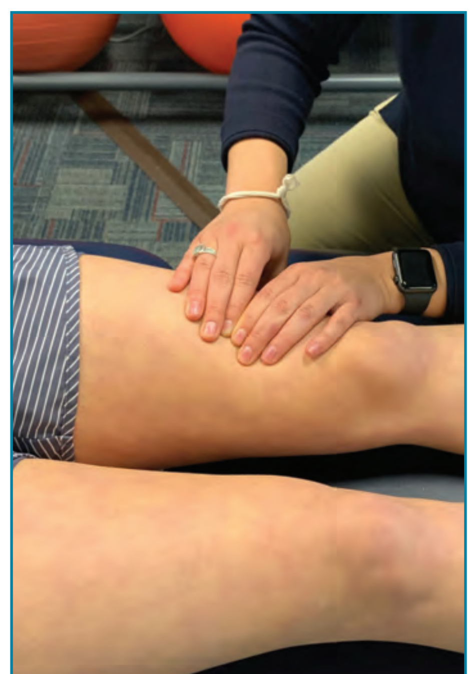

Figure 1. Soft tissue mobilization of the quadriceps.

al investigated the use of a comprehensive therapy program of PFJ mobilization with quadriceps strengthening, daily home exercises, and patellar taping in comparison to a placebo, which consisted of taping and sham ultrasound.[25] Patellofemoral joint mobilization included mediolateral glides/tilting and was performed for 60 seconds, 3 times. Both groups received treatment for 6 sessions, over 6 weeks. At the end of the study, researchers found significantly greater improvements in pain, self-reported disability, physical impairment, and function for the intervention group as compared to the placebo group. As noted by the outcomes of Crossley et al, when used as part of a comprehensive plan of care, PFJ glides may be beneficial in improving body-structure function, activity, and participation impairments.

Clinical Considerations for Patellar Mobilization for PFPS

Abnormal movement and decreased mobility of the patella on the femur may increase load on the PFJ, potentially leading to increased pain. Patellofemoral joint mobilizations may assist with these stated impairments, and suggestions for mobilization prescription are presented in Table 1. Patellofemoral joint mobilization is typically performed in full knee extension where mobility is most easily assessed. Patellofemoral joint glides can be performed in both open and closed packed positions, from full knee extension to varying degrees of knee flexion, and in both weight-bearing and nonweightbearing positions (Figure 2). Grade I and II joint mobilizations are typically used for pain reduction, whereas grades III and IV are typically used to improve mobility of a hypomobile joint. Grade I-II mobilizations may be useful for individuals with high symptom irritability, decreased willingness to move, and greater pain sensitization.[27] In comparison, grade III-IV mobilizations may be used to improve mobility for individuals with altered functional movements and typically less pain irritability. For PFPS, higher grade mobilizations could theoretically decrease load on the PFJ and improve mobility to normalize functional movement.

Similar to STM, mobilizations used to improve mobility should be followed by therapeutic exercise to optimize muscle performance within the new ROM. When individuals are able to perform normal activities but higher-level functional tasks remain difficult, PFJ mobilization may still be relevant with modification. As an example, performing a medial or lateral glide as a patient performs a squat could be useful for impaired patellar tracking related to PFPS. Although manual therapy in isolation is not indicated as recommended by the recent clinical practice guideline,[6] when combined as part of a comprehensive rehabilitation program, mobilizations may be efficacious.

LUMBOPELVIC THRUST MANIPULATION

A number of studies have examined the effects of lumbopelvic manipulation for patients with PFPS. Joint manipulation has been suggested to affect peripheral and central systems to decrease pain and spasm, enhance descending pain modulation, and improve muscle performance and ROM.[9] Individuals with PFPS may present with mobility deficits,[6] widespread hyperalgesia,[30] impaired pain modulation,[31] pain sensitization,[13] decreased quadriceps activation, and atrophy;[6] all of which may benefit from the described effects of joint manipulation. Based on available literature, spinal manipulation for PFPS is most commonly used to decrease pain or sensitivity, to increase output of the muscles surrounding the knee and/or hip, and to improve functional outcomes. Despite the theoretical effects of manipulation, recent systematic reviews reported mixed results on the use of spinal manipulation for pain and function related to PFPS.[10,11]

Current Evidence Related to Lumbopelvic Manipulation for PFPS

A number of studies have considered the efficacy of spinal manipulation for PFPS. Nambi et al suggested that spinal manipulation may be appropriate in reducing pain for individuals with chronic PFPS.[32] This RCT divided participants into 3 groups: group 1 received lumbopelvic manipulation and exercise, group 2 received PFJ mobilization and exercise, and group 3 received exercise alone. Manipulation was performed ipsilateral to the painful knee, with a posterior-inferior force delivered through the opposite ilium (Figure 3). Manipulation was performed 3 times per week for 6 weeks. Results demonstrated significantly greater improvement in pain and self-reported functional disability in the lumbopelvic manipulation and patellar mobilization groups. The article suggests that both lumbopelvic manipulation and local PFJ mobilization may modulate pain perception in those with PFPS.

Suter et al found that manipulation decreased muscle inhibition and increased knee extensor torques and muscle activation in individuals with anterior knee pain.[33] Sacroiliac joint manipulation was performed in a sidelying position. Quadriceps inhibition, activation, and torque was measured pre- and post-manipulation. Following manipulation, a decrease in muscle inhibition and increases in quadriceps torque and muscle activation were observed. However, while results demonstrated positive effects of manipulation, the lack of a control group limits the generalizability of the findings.

Though the above articles point towards the use of spinal manipulation for PFPS, there is research to suggest it may not be additive. Stakes et al compared PFJ mobilization alone to PFJ mobilization and spinal manipulation via sidelying lumbar thrust technique.[34] Pain outcomes were assessed both subjectively with self-reported outcome measures and objectively with pain algometry. Significant improvements in pain outcomes were reported for both groups, with no significant between-group differences. Based on this study, spinal manipulation may not be additive towards a comprehensive treatment plan for PFPS related pain.

Grindstaff et al examined the impact of lumbopelvic joint manipulation on quadriceps activation for individuals with PFPS.[35] Manipulation was compared to 2 groups, one receiving passive lumbar flexion/extension ROM for one minute, and the other performing static prone extension on elbows for 3 minutes. The lumbopelvic manipulation was performed on the ipsilateral side of the affected knee (Figure 3). Quadriceps maximum isometric force output and activation was assessed with a load cell and with a burst superimposition technique on a maximal voluntary isometric contraction (MVIC). Researchers found no differences between groups across all time points for quadriceps force output and activation, suggesting quadriceps function may not immediately be altered by lumbopelvic manipulation.

Clinical Considerations for Lumbopelvic Manipulation

Increased pain, heightened sensitivity, and quadriceps inhibition may all be associated with PFPS. Muscle inhibition and pain may lead to excess use of surrounding structures, including the PFJ, resulting in aberrant movement patterns. Spinal manipulation requires a high velocity, low amplitude thrust, requiring clinician experience and comfort with the intervention. As authors suggest, manipulation can be considered for patients with heightened pain responses or for patients with quadriceps inhibition.[32-34,36] If the goal is to improve muscle output, it

Table 1. Joint Mobilization Prescription Considerations

Indication	Patient Position	Grade	Dosage	Example
Pain	Position of comfort Commonly NWB, open-packed position	Grade I and/or II joint mobilizations	Short duration bouts Rest between bouts	Patient case: 4/10 resting pain, 8/10 pain with stairs, unable to assess full knee ROM due to pain Possible mobilization: patient supine, knee bent on pillow to 20°, 4 x 15" PFJ grade I medial glides, 30" rest between bouts
Mobility deficits	Position of restriction, often end-ranges of available motion Commonly NWB or WB positions, end ranges when tolerated	Grade III and/or IV joint mobilizations	Performed until therapist perceives improvement in tissue resistance	Patient case: 1/10 resting pain, 2/10 pain with stairs, flexion limited to 115° Possible mobilization: knee flexed to 115°, grade IV inferior PFJ glide x 3 min (or when less restriction to glide is noted)
Impaired functional movement	Position of functional restriction Commonly performed in WB positions	Grade III and/or IV joint mobilizations	Can be performed as MWM	Patient case: 0/10 resting pain, 2/10 pain at 75° flexion into deep squat, normal knee ROM Possible mobilization: sustained medial PFJ glide while patient performs squat to make the task pain free. Perform 3 sets x10 repetitions
Abbreviations: MWM, mobilization with movement; NWB, nonweight bearing; PFJ, patellofemoral joint; ROM, range of motion; WB, weight bearing				

is suggested that treatment sessions are initiated with thrust manipulation techniques and then followed by quadriceps targeted therapeutic exercise to increase muscle control and strength to capitalize on the newly improved muscle capacity.[36] Increasing output of the surrounding musculature could possibly improve strength of surrounding musculature and PFPS symptoms, making manipulation a viable option in managing the condition.

Although the evidence is conflicting, in the presence of pain or arthrogenic muscle inhibition, commonly present in persistent PFPS, manipulation could be incorporated. The manipulation technique and position may be best determined by patient comfort in end range positions, in addition to clinician comfort with specific techniques. Many studies used a supine lumbopelvic manipulation. While neurophysiological effects are possible with this technique, some would argue the segmental level of neurologic involvement (in this case, L2-4) should be targeted to localize a treatment effect. If this is the case, a sidelying lumbar manipulation may be

Figure 2. Patellofemoral joint mobilization in A, nonweight-bearing knee flexion. B, weight-bearing knee flexion.

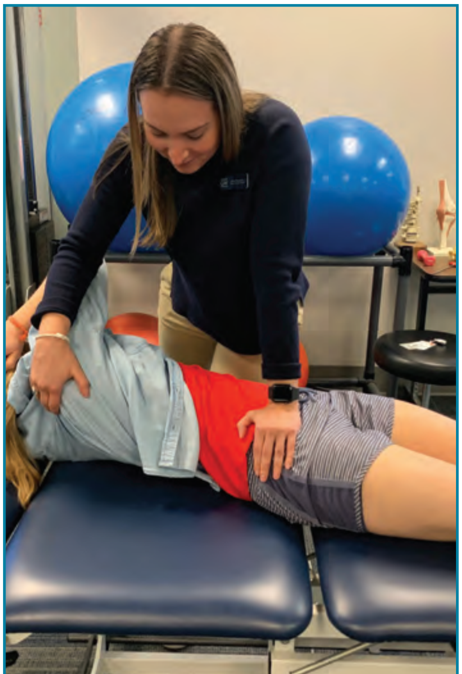

Figure 3. Supine lumbopelvic thrust manipulation.

Figure 4. Sidelying lumbar thrust manipulation.

more appropriate (Figure 4). It is important to note that in some studies, researchers performed the manipulation until cavitation was heard or felt by the clinician or patient for up to 4 times. Several other studies have suggested that cavitation is not necessary for an effective manipulation.[37,38] Therefore, if spinal manipulation is deemed appropriate for the patient, when performed correctly, the intervention can be completed once per session.

DISCUSSION

Patellofemoral pain syndrome is a common condition frequently associated with substantial self-reported functional disability. Recent high-quality publications have attempted to identify best-practices in evaluation and treatment for PFPS.[6,39] As is frequently the case, evidence does not easily become implemented into clinical practice, and as such, knowledge translation has become a priority for many researchers. One challenge with knowledge translation in physical therapy particularly is the limited capacity to apply general or wide-ranging conclusions to specific patients, who have vague and complex clinical characteristics, psychosocial, personal, and environmental factors impacting their activity level. Subsequently, attempts to bridge the gap between the laboratory and the clinical settings are necessary.

As noted previously, a recent CPG provided grade A level evidence recommendation suggesting manual therapy could be used as a useful adjunctive intervention, but should not be used in isolation. While the authors agree that plans of care using single interventions are infrequently effective for complex presentations, the recommendation does highlight important gaps in the evidence. For example, many PFJ mobilizations are performed in the open-packed position of knee extension, where the patella most easily moves through its motion but is less relevant to functional limitations (typically a knee flexion position). Resultantly, it was recently suggested that PFJ mobilizations be matched either to the position of mobility restriction, functional position of pain, or both, to optimize effectiveness of manual therapy.[40] Additionally, if recommendations suggest which interventions should not be used in isolation rather than which interventions may be useful in some cases, readers are left with fewer options to guide decision-making. Although the recommendation for manual therapy is not strong, using manual therapy for individuals with PFPS and mobility deficits is appropriate.

Evidence suggests that when manual therapy is provided for treating patients with PFPS, local joint mobilization is likely to be most effective.[10] In the presence of mobility deficits, knee joint or soft tissue mobilization would be the most appropriate to potentially enhance the arthrokinematics motion of relevant joint complexes. Based on theoretical mechanisms and available evidence, lumbopelvic manipulation appears most useful for PFPS in the presence of increased pain sensitivity or impaired quadriceps output. In order to enhance clinical utility, manual therapy needs to be prescribed based on the patient's specific presentation, rather than arbitrary incorporation. The suggested method to determine the efficacy of the interventions would be to perform an assessment, provide the intervention, and immediately perform a re-assessment. It is additionally expected that exercise interventions would follow manual therapy interventions to reinforce and optimize improvements in pain and/or mobility.

While a number of biomechanical faults may contribute to the development and persistence of PFPS, there may also be alterations in individuals' psychological variables and central pain processing. It was reported that anxiety, depression, catastrophizing, and fear of movement may be present in persons with PFPS, and may be correlated to increased pain and self-reported disability.[14] Individuals with PFPS have been noted to demonstrate increased temporal summation of pain,[31] impaired conditioned pain modulation,[41] widespread hyperalgesia,[30] somatosensory alterations,[42] and bilateral tactile sensitivity deficits.[43] Manual therapy has been reported to affect all of the noted impairments in pain processing.

Appropriate intervention selection for PFPS can be challenging, and the high rate of chronic PFPS is indicative of the need for ongoing investigation. To best treat these individuals, clinicians need to integrate best available evidence with patient specific decisions. It is the hope of the authors that this paper briefly presents the evidence and possible uses for manual therapy for PFPS, improves clinical decision-making and stimulates additional research for the challenging condition.

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Clinical Reasoning Considerations for the "Flexible" Patient: A Ligamentous Laxity Overview

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ABSTRACT

Background and Purpose: Individuals with excessive joint hypermobility often seek physical therapy care. Despite the common clinical occurrence, a consensus is lacking on how to best conservatively address the specific needs of this poorly understood population. The aim is to explore concepts and clinical reasoning considerations when treating a person with a joint hypermobility syndrome (JHS). **Methods:** A pragmatic outline was established including clinical manifestations, evaluation, prognosis, and clinical reasoning processes to determine intervention. The literature was identified through PubMed and CINAHL. **Clinical Relevance:** Only a subset of individuals with joint hypermobility become symptomatic. Joint hypermobility syndrome includes many ligamentous laxity conditions requiring the clinician to appreciate different disease characteristics. There are questionnaires and objective evaluation tools available to assist with developing individualized treatment. **Conclusion:** The evaluation and construction of a meaningful treatment plan for individuals with JHS can be challenging. Combined clinical knowledge and sound clinical reasoning processes can assist with optimizing outcome.

Key Words: Ehlers-Danlos, generalized hypermobility, joint hypermobility

INTRODUCTION

Joint hypermobility is defined as the ability of a joint to move past the clinically defined normal standards for range of motion (ROM).[1] It can occur at one joint or at multiple joints throughout the body. When excessive motion occurs in multiple joints, it is characterized as generalized joint hypermobility (gJHM). Generalized joint hypermobility is asymptomatic with no functional loss despite having increased ROM. Identifying an individual with gJHM is often made using the Beighton score.[1] The cut-off scores for the Beighton assessment are inconsistent and lack a consensus on how to best identify individuals with gJHM.[1,2] This is further supported by a large prevalence range from 2-57% for individuals with gJHM indicating inclusion criteria remains uncertain.[3] Typically, a Beighton score of 4 out of 9 indicates gJHM in a general adult population.[1] There are some additional studies indicating gJHM is present in women if a score of 5 of 9 is achieved, and a score of at least 6 out of 9 is needed to determine the presence of gJHM in children.[1,2]

Joint hypermobility syndrome (JHS) occurs when joint hypermobility becomes symptomatic. These symptoms were previously believed to be only limited to localized pain, instability, and decreased proprioception. However, a progressive understanding appreciates this condition is much more complex. Due to the nature of the tissues affected, the condition can present in a variety of ways. In addition to the musculoskeletal complaints, such as increased likelihood for joint sprains, meniscal injuries, and stress fractures, other body systems are affected manifesting as disturbances in pain perception, anxiety, fatigue, and gastrointestinal interruptions.[4-7] Congenital conditions that present with ligamentous laxity and subsequent joint hypermobility are Down's syndrome, Marfan syndrome, Loeys-Dietz syndrome, and Osteogenesis imperfecta.[8-10] Joint hypermobility syndrome is considered by some sources to be a mild form of Ehlers-Danlos syndrome (EDS) hypermobility type while other sources indicate JHS is a diagnosis of exclusion and separate from EDS.[8]

Conservative management by a physical therapist is often the preferred first method of treatment for these conditions due to their musculoskeletal nature. Treatment can vary from stability exercises, proprioception training, and patient education. Patient education is focused on modifying movement, lifestyle changes, and addressing persistent pain.[11] Unfortunately, there is little consensus for the best way to manage individuals with a joint hypermobility condition; therefore, an increased awareness and understanding of JHS is important as physical therapists are the best health care provider to appreciate the specific needs in this hypermobile population.

The aim of this article is to present a review of the literature regarding JHS and offer clinical information to conservatively manage individuals with suspected or confirmed joint hypermobility syndromes. Lastly, the article could serve to identify knowledge gaps and areas for future research.

JOINT HYPERMOBILITY CONDITIONS AND CLINICAL MANIFESTATIONS

Individuals with joint hypermobility often present to physical therapy due to joint pain.[6] Physical therapists must recognize the patient's underlying condition and how it is contributing to their current complaint. The physical therapist should appreciate the various characteristics these conditions present with in order to properly address the individual patient's needs.

The common characteristics of EDS, Marfan syndrome, Osteogenesis imperfecta, and Down's syndrome are listed in Table 1. Table 1 identifies the most common condition characteristics that may help construct a differential diagnosis, although it is not a complete list of symptoms related to joint hypermobility. Ehlers-Danlos syndrome presents with many different types. Ehlers-Danlos syndrome, hypermobility type III is the most common and has an almost identical clinical presentation to JHS.[4,12] Unfortunately, JHS can often be considered a diagnosis of exclusion.[8]

In addition to musculoskeletal complaints, many individuals may report high levels of fatigue, depression, and anxiety with any ligamentous laxity condition.[8] Other clinical observations may include a lack of proprioception, generalized hyperalgesia, various neuropathies including tarsal tunnel and carpal tunnel syndrome, ptosis, varicose veins, low bone density, and postural orthostatic tachycardia syndrome. Patients may present with bowel and bladder dysfunction, including pelvic organ prolapse.[8,13]

CLINICAL EVALUATION

Individuals may arrive to physical therapy with an undiagnosed ligamentous laxity condition. It would be prudent for the physical therapist to properly screen for ligamentous laxity and consider referral to the proper medical provider for diagnosis and additional management.

A thorough subjective history is recommended during a clinical evaluation for an individual with suspected JHS. The subjective intake should aim to gain an understanding of the current and past injury and health history, mechanism of injury, and aggravating and alleviating factors. Identifying how these complaints influence functional loss is important.

The objective evaluation should include ROM measurements while noting if these are outside of typical norms. Strength measures and a general neurological screen should be assessed. Blood pressure and heart rate measurements within the initial session is advisable due to the common occurrence of related hypotension. Functional tasks should be observed to understand the individual's movement strategies, motor control, and compensations. Both daily functional tasks and sport specific tasks should also be observed.

Table 1. Review of Specific Joint Hypermobility Syndromes Along with Common Characteristics to Assist with Recognition

Joint Hypermobility Syndromes	Common Clinical Presentations
Ehlers-Danlos syndrome[8] • Classic Type (I) • Vascular Type (IV) • Kyphoscoliotic Type (VI-A) • Musculocontractural Type (VI-B) • Dermatosparaxis Type	Bilateral clubfoot Developmental delays Dysmorphic facies Extensive and easy bruising Large hernias Marfanoid habitus Muscle weakness Scleral fragility Scoliosis Sensory neural hearing loss Severe muscle dystonia Severe muscle hypotonia Skin hyperextensibility Thin translucent skin Velvety skin texture
Marfan syndrome[8]	Ascending aorta dilation Fingers and toes abnormally long and slender Funnel chest High palate Muscle hypoplasia Scoliosis
Osteogenesis imperfecta[10]	Aortic root dilation Conductive deafness Decreased pulmonary function Heart murmurs Scoliosis Teeth discoloration
Down's syndrome[9]	Brachycephaly Flat nasal bridge Folded ear Gap between 1st and 2nd toes Incurved 5th finger Muscular hypotonia Narrow palate Nystagmus Oblique eye fissure Short neck

Subjective Examination

The Hakim and Grahame questionnaire (Table 2) and musculoskeletal and non-musculoskeletal screening questions (Table 3) can assist with developing a list of differential diagnoses.[8,13,14] It is important to investigate the timeline of symptom development, especially childhood presentations, to determine a progression or long-standing presentation of related injuries or pain. The individual may describe multi-system involvement, including gastrointestinal, vascular, and bowel/bladder issues. They may report clumsiness, unsteadiness, or coordination deficits. After ruling out more serious pathologies, these responses can increase suspicion of a JHS diagnosis. The patient responses to the Hakim and Graham short questionnaire will assist in development of a thorough objective examination and patient centered goals.[14]

Objective Examination

The Beighton score is a widely used measure of gJHM and is helpful in quickly observing if excessive ROM is present in multiple joints. An adult individual is considered positive for gJHM with a score of 4 out of 9 or greater; for children 6 out of 9 or greater (Table 4).[15] Positive responses to questions from Table 2 can lead the clinician to perform movements described in the Beighton score during the examination for additional objective data. This information can then be incorporated into the Brighton score (Table 5) to determine if a JHS diagnosis is suspected.[16] Joint hypermobility syndrome is considered present when the individual presents with one of the following: (1) 2 major criteria, (2) 1 major and 2 minor criteria, and/or (3) 4 minor criteria (Table 5).[16] Recall, symptomatic complaints limiting function is a key characteristic difference between gJHM and JHS.

Additional static and dynamic balance measures may be helpful in developing a complete clinical picture. This is because individuals with JHS frequently have vestibular and somatosensory dysfunction.[17,18] Static measures may include single leg stance with eyes open, eyes open with cervical extension, and eyes closed.[17,18] Dynamic measures may include single leg squat, single leg hop tests, Y-balance test, or star excursion balance test.[1,17] Impairments may be found in some or many of these measures to help with development of the individual's plan of care. Typical outcome forms, such as the Hip Outcome Score, may be used to periodically assess functional progress, or decline, during the plan of care.[19]

This is not an exhaustive list and additional objective measures may be needed to address a specific individual's complaint and goals.

Table 2. Five Question Screening Questionnaire to Assist Clinicians to Identify Individuals with Joint Hypermobility[14]

Patient Questions to Ask if Joint Hypermobility is Suspected
- Can you now (or could you ever) place your hands flat on the floor without bending your knees? - Can you now (or could you ever) bend your thumb to touch your forearm? - As a child, did you amuse your friends by contorting your body into strange shapes or could you do the splits? - As a child or teenager, did your shoulder or kneecap get dislocated on more than one occasion? - Do you consider yourself double jointed?
A "Yes" answer to 2 or more of the above questions has 80% sensitivity and 90% specificity for indicating the individual has joint hypermobility.[2]

Table 3. Multi-system Screening Questions for Individuals with JHS (Adapted Questions)[8,13]

Subjective Questions	Common Responses
1. Did you have any injuries or notable periods of pain as a child?	Periods of joint pain commonly occur in the posterior knees. Also, the patient may report a history of benign paroxysmal nocturnal leg pain (growing pains).
2. Did your subluxation/dislocation and/or fracture occur without great provocation?	Minimal impetus is needed for the fracture or subluxation/dislocation to occur.
3. Do injuries take a long time to heal?	Injuries may heal more slowly than standard tissue healing timeline.
4. Do you have a family history of joint hypermobility?	Often times there is a positive family history.
5. Can you describe your pain?	Pain is often reported as dull.
6. When do you have your pain?	Reports baseline pain but symptoms are made worse with activity. Symptoms typically feel the best in the morning and worst at the end of the day. Activities that use the involved joint influences pain.
7. Do you feel fatigue?	Fatigue, sometimes severe, is a common symptom, as well as sleep disturbance.
8. Do you have headaches?	Headaches are a common symptom; these may be migraines or other.
9. Do you ever feel lightheaded?	Reports feeling lightheaded or dizzy at various times. Low blood pressure, a fast heart rate, and increased sympathetic tone are common symptoms.
10. Do you have any stomach discomfort?	Commonly reports bloating, nausea, or vomiting after meals. Often encourages eating less.
11. Do you feel uncoordinated or clumsy?	Balance deficits, unsteadiness and clumsiness are symptoms are often reported.
12. Are you experiencing any symptoms that you feel are unrelated to the incidence bringing you to physical therapy?	Symptoms may include bowel and bladder dysfunction and prolapse of pelvic organs.

PROGNOSIS AND CLINICAL REASONING PROCESS FOR DETERMINING INTERVENTION

The prognosis for JHS is generally considered good since it is a nonprogressive and noninflammatory condition. Joint hypermobility tends to naturally decrease as the individual ages providing a natural "protection" to the joint.[8] Common sense reasoning indicates preserving the joint will ultimately promote and sustain function; however, available data to support this concept is lacking. Longitudinal studies are needed to ultimately determine long-term prognosis associated with the recommended management strategy, but it is recognized there are short-term benefits to conservative management including pain control and functional capacity.

While it is necessary to address the individual's area of primary concern, it is likely the individual will have, or currently has, multiple areas of pain or dysfunction. Areas of pain and dysfunction should be addressed directly while also incorporating general exercise strategies. The hypermobile person may benefit from an individualized exercise program but detailed information on a well-rounded program is not well established.[20,21] Clinicians may incorporate aerobic capacity, strength, coordination, and motor control training that address all systems rather than only the direct areas of pain. This approach may also assist with long-term self-management of symptoms. For those individuals with high irritability or difficulty participating in full weight-bearing activities, low impact training like water aerobics, modified swimming strokes, water treadmill, body weight supported treadmill, or elliptical may be beneficial to begin an exercise program.

Fatigue must be considered when developing an exercise program since it is a very common symptom within the JHS population. Clinicians should ensure proper education on a gradual increase in duration of activity with greater rest times to allow for proper recovery and joint protection. A common complaint can also include disturbance in restful sleep. If there is a disturbance in sleep reported, guidance on proper sleep hygiene and education on sleep positioning may assist to promote successful sleep.

The proprioceptive impairments typically observed in the JHS population can be addressed with closed kinetic chain strengthening and training on dynamic surfaces.[22,23] These individuals will likely need postural education during functional tasks that may include use of tactile cues, taping, and mirror

Table 4. The Beighton Score is a Clinical Objective Test for Joint Hypermobility. Variability exists for cut-off scores.[1]

Beighton Score	Scoring
- Passive flexion of the thumb allows the touch of the volar aspect of the forearm (repeat on both sides)	1 point per side
- Passive hyperextension (>90°) of the fifth finger with the palm and wrist touching a solid surface (repeat on both sides)	1 point per side
- Active hyperextension (>190°) of the elbows with the upper limb extended and the palm turned up (repeat on both sides)	1 point per side
- Active hyperextension (>190°) of the knees while the subject stands up (repeat on both sides)	1 point per side
- Active hyperextension of the lumbar spine by inviting the subject to touch the floor with both palms but without flexing the knees per side	1 point
Generalized joint hypermobility: ≥4 for adults[1,2,15] **Children:** ≥5, 6 or 7 is remarkable for joint hypermobility[15] **Female Adults:** ≥ 5 is remarkable for joint hypermobility[15]	

Table 5. The Brighton Score for Joint Hypermobility Syndrome and Classification Criteria[16]

Brighton Score for Joint Hypermobility Syndrome
Major Criteria
1. Beighton score of 4/9 or greater 2. Arthralgia for more than 3 months in 4 or more joints
Minor Criteria
1. A Beighton score of 1, 2, or 3 out of 9 (0-3 if over age 50) 2. Arthralgia for ≥ 3 months in 1-3 joints, or back pain ≥ 3 months, or spondylosis, spondylolysis, spondylolisthesis 3. Dislocation or subluxation in more than one joint, or in one joint on more than one occasion 4. Soft tissue rheumatism in ≥ 3 locations (eg, epicondylitis, tenosynovitis, bursitis) 5. Marfanoid habitus 6. Abnormal skin (eg, striae, hyperextensible, thin, papyraceous scarring) 7. Eye abnormalities (eg, drooping eyelids, myopia and mongoloid slant) 8. Varicose veins or hernia or uterine/rectal prolapse
Remarkable for Joint Hypermobility Syndrome if: - Two major criteria are present **OR** - One major and two minor criteria are present **OR** - Four minor criteria are present

feedback due to impaired proprioceptive awareness.[13]

Medical management including nonsteroidal anti-inflammatory medication could assist in reducing acute symptoms; however, this is not recommended as a long-term management strategy.[13] The physical therapist should screen for the presence of anxiety and depression as these are frequently observed in this population.[24] Consider a mental health referral if screening is positive and especially if the individual's mental health is promoting fear-avoidance behavior. Cognitive behavior therapy may be recommended to assist with coping strategies and to address any associated fear and anxiety of future injury in these individuals.[8]

Most individuals with JHS can be conservatively managed; however, if there are repeated joint subluxations or dislocations with related pain and functional loss, a surgical referral should be considered.[25] The common goal should be to preserve the longevity of the joint by reducing repeated injury.

Individuals with JHS will likely need long-term follow-up with a physical therapist due to fluctuations in symptoms and potential involvement of multiple joints and body systems. Once the individual's acute symptoms have stabilized and an individualized exercise program has been developed, less frequent visits are recommended with continued monitoring. Deductive clinical reasoning processes must be incorporated to best direct the patient.[26] These individuals may also benefit from use of telehealth services or other remote communication media for ongoing monitoring to eliminate the need for frequent in-clinic visits.

CONCLUSION

It is important to appreciate the difference between asymptomatic gJHM and symptomatic JHS. Only when individuals with joint hypermobility become symptomatic is it important to consider the varying possible diagnosis associated with JHS. Proper conservative management at any stage of the hypermobile condition can be meaningful. Earlier intervention would be optimal as education and intervention could influence the trajectory of the individual's condition to best preserve overall joint health.

It is advisable to subjectively screen individuals with suspected ligamentous laxity issues while considering specific objective tests, such as the Beighton and Brighton score, to quantify the overall joint hypermobility. The combined subjective and objective information will help develop an individualized treatment plan and estimate prognosis. Conservative management recommendations can and should include low impact aerobic exercise, proprioception and balance training, and strength building activities. Addressing any mental health needs may also be necessary, especially if functional progress is impeded. Lastly, stepping away from a "joint only" treatment approach is necessary when working with individuals with JHS. The clinician much appreciate JHS is a multi-system issue in order to optimize both short-term and long-term outcomes. Sound clinical reasoning can assist with development of an effective conservative management strategy to best match the patient's needs. Addressing single joint flare-ups or localized injury associated with a ligamentous laxity syndrome may be necessary in the short-term, but if a person with multi-joint, non-traumatic issues seeks care, then a comprehensive approach should be considered to guide the patient to a long-term optimal outcome. This literature review identified future research could include systematic reviews on conservative management for individuals with JHS. Recognizing the unique characteristics and special needs of this under-recognized and under-studied population is necessary to best promote optimal care for the "flexible" patient.

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Establishing An Interdisciplinary Team of Engineering and Physical Therapy Faculty and Students to Improve Rehabilitation Technology: A Single-Site Example

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ABSTRACT

Background and Purpose: Barriers of interdisciplinary work between physical therapists and engineers persist including limitations in understanding each other's professions, time, and perceived value. The purpose of this paper is to offer a stepwise approach to establishing interdisciplinary work. **Methods:** Phase I: Physical therapy faculty and students held a roundtable discussion and simple project discussions during engineering coursework. Phase II: Year-long human-centered problem-based design in an engineering capstone course with consultation from physical therapy faculty and students. **Findings:** Positive student feedback ensured mutual value in collaboration, followed by robust problem-solving to design a clinically useful device. **Clinical Relevance:** A single site, stepwise progression in an academic setting is offered to introduce the value of physical therapy to engineers as part of an interdisciplinary team to design clinically useful devices. **Conclusion:** Physical therapists can successfully engage with engineers as part of an interdisciplinary team in developing clinically useful technologies that accurately measure the intended activity, are purposeful, and are easy to use.

Key Words: bioengineering, biomedical, multidisciplinary

INTRODUCTION

Technology is advancing at an exponential rate. Wristwatches and smartphones that tell users how many steps they take each day and collect metadata on places that people patronize are now widely available and used. As technology advances, so do the possibilities in the medical profession. Cameras, accelerometers, microchips, and miniaturized robots that can measure joint movement as well as community navigation are becoming more and more prevalent in clinical practice. In the orthopaedic setting, it is more important than ever for the engineers designing the next technological innovation to become familiar with the physical therapy profession. Physical therapists with their knowledge and expertise in human movement are well poised to assist in the development and implementation of technology. By including physical therapists in an interdisciplinary team to design new devices, the effectiveness of our ability to measure, assess, and intervene to optimize movement strategies in patients can be highly improved.

Understanding the reciprocal benefit of collaborative initiatives has led to several calls to increase interdisciplinary education and community outreach programs. Norland and colleagues demonstrated the lack of awareness of regenerative rehabilitation among physical therapists and called for physical therapy programs to establish an active approach to learning new technologies.[1] Trumbower and Wolf highlighted the importance of collaborations between physical therapy and engineering disciplines. They encouraged educational programs to support partnerships as a means to simultaneously accelerate biotechnologies and the profession of physical therapy.[2] While the Commission on Accreditation on Physical Therapy Education (CAPTE) Standards and Required Elements for Accreditation of Physical Therapy Education Programs requires interprofessional education, incorporation of engineers as an interdisciplinary team member continues to remain sparse.

Some physical therapy programs have been able to bridge the academic silos within institutions and have successfully established interdisciplinary events and projects. Faculty at the University of North Florida established a successful relationship between the School of Engineering and Physical Therapy program, designing rehabilitation technology for children with disabilities.[3] Emory University established an interdisciplinary course involving lecture and team-based design challenges to those with functional mobility limitations.[4] While these exemplars are laudable, there are limitations in the capacity to model these programs due to challenging constraints.

For an academic partnership to be viable, it is ideal that the academic physical therapy program and the academic engineering program be located in the same institution. Though physicality is a significant barrier, both partners must see value in establishing an interdisciplinary relationship.[5] If an engineering program is unfamiliar with the profession of physical therapy, willingness to collaborate may be low. Perhaps the most extensive availability of engineering students is at the undergraduate level, while physical therapy degree earners are at the post-secondary level. This educational mismatch may be a challenge to establish a mutual curriculum that offers similar levels of value for each partner. Scheduling and course rigor are barriers to successful interdisciplinary work.[6] Physical therapy students may have high levels of anxiety[7] due to an already intense curriculum and the faculty may be less likely to increase student burden by adding yet another activity or project.

While the barriers exist, academic institutions should emphasize the benefits of teamwork to both physical therapists and engineers alike. Interdisciplinary education improves perceptions of one's profession and the ability to work with others.[8] Surveys of faculty in academia, including the health sciences, have a favorable opinion of teamwork and interdisciplinary education.[6] Authors suggest that previous positive experiences,[9] and an understanding of other professions,[5] lead to optimal interdisciplinary conditions.

It is the view of the authors that physical therapists can capitalize on the academia-wide optimism by physical therapists being the first to cross the bridge to engineering. The authors of the current study feel it is essential to establish physical therapists as the provider of choice in consultation of design user interface for technology intended to assess, track, and provide feedback regarding human movement.

In this article, the authors describe a stepwise approach to collaborations between physical therapy and engineering programs. In these first two phases, the progression of physical therapy to engineers was introduced to establish a baseline of understanding of our profession. A working relationship, by demonstrating value in team-based activities was developed, using tangible human-centered problems that required interdisciplinary teams to provide solutions.

METHODS

Phase I

Interdisciplinary experiences between biomedical engineering and physical therapy students and faculty were built into an existing engineering course, Capstone Design. The course is a requirement for undergraduate students in their final year of the Biomedical Engineering Department. On two separate occasions, faculty and students from the physical therapy program participated in the engineering class sessions. Initially, physical therapy students and faculty participated in a roundtable discussion about the profession of physical therapy, the scope of practice, and physical therapists' educational training. Engineering students were encouraged to ask questions about clinical experience and the role of equipment in typical patient encounters. The roundtable session concluded with a discussion, guided by the engineering faculty, regarding device design and usability from the perspective of a physical therapist.

The physical therapy students and the faculty returned two weeks later to the Capstone Design class for the second interdisciplinary activity. Before this class period, small groups of biomedical engineering students were charged with the task of designing a simple physical ankle model, incorporating objects readily available in the home. Physical therapy faculty and students used the class period to circulate through the groups to provide feedback on each of the engineering groups' models. They provided feedback on the accuracy of the anatomic and kinesiologic properties of each ankle model. In turn, the engineering student groups communicated the limitations of materials available to produce a more accurate model. The engineering students discussed the design decisions that were made based on ranking the importance of specific ankle anatomical or kinesiologic properties while practicing communication skills necessary to work with future clients.

Both physical therapy and engineering students completed surveys on their participation in the various collaborative opportunities, lessons learned on communication, integration of suggestions into design, provision of constructive feedback, and experience with interdisciplinary collaboration. The survey was disseminated after the culmination of the class.

Phase II

The intent of Phase II was to build upon student feedback that tangible examples of design issues were helpful when collaborating with other disciplines. It was decided to continue to use the Capstone Design course in the Biomedical Engineering curriculum to achieve this while opening the opportunity to the mechanical engineering Capstone Design class as well. During this phase, faculty from the physical therapy program were invited to pitch a problem statement. The engineering students then created a product that would solve the problem statement given by the physical therapist. Four different projects from the physical therapy faculty were pitched and selected, each involving different areas of physical therapy practice ranging from orthopaedics, pediatrics, neurologic, and pain science (Figure 1).

The orthopaedic physical therapy practice problem statement was: "Accelerometery has the potential to detect those at risk for overuse running injuries such as shin splints. Feedback regarding an individual's tibial acceleration may even be a treatment to reduce the risk of shin splints. Currently, published literature and the only commercially available device measures only one leg at a time, limiting the capacity to assess what might be happening on the contralateral limb." The problem statement was available to both Biomedical Engineering and Mechanical Engineering student Senior Design courses.

Engineering students rated all submitted projects from high to low (1 to 5, respectively). Students were placed into groups based on which projects they ranked the highest. Once placed in design teams, the contact information of the faculty member that proposed the design problem statement was given to the group. Each design team scheduled monthly meetings with the faculty and any physical therapy students that are working as research assistants with the faculty. Meetings facilitated discussions regarding the clinical applicability of potential design ideas and iterations. Design teams were also encouraged to use electronic communication as needed.

FINDINGS

Phase I

Student representative quotes from engineering and physical therapy students are provided in Table 1. General themes that emerged from student feedback were: Benefits of Collaboration, Refining Communication, and Learning and Growing. When breaking down feedback related to subcomponents of Phase I, students overwhelmingly reported that large group discussions on the knowledge base and education of a physical therapist were helpful. These interactions allowed the engineering students to conceptualize clinical needs and feedback from their physical therapist partner. The engineering students felt that roundtable discussions helped generate additional human factors that might affect the design process. Small group discussions and repeated interactions between physical therapy and engineering students encouraged meta-cognition. Finally, project-based interactions provided real scenarios in which many of the previously mentioned benefits occurred.

Phase II

Biomedical engineering students chose the pediatric, neurologic, and pain-science projects. A mechanical engineering student group selected the orthopaedic project. Each of the 4 design groups consisted of 4 to 5 final year engineering students. Each group similarly scheduled regular meetings with the physical therapy faculty and students that proposed the problem statement. The mechanical engineering group is discussed as the exemplar. Key aspects of the students' design process discussed during meetings are summarized in Table 2.

The first interdisciplinary meeting between engineering and physical therapy members was to discuss the overall problem, prevalence, and impact. This open dialogue facilitated a robust discussion regarding the potential application of the device that would serve to solve the problem statement. The team identified that tibial stress fractures are among the top 5 most common running injuries with as high as a 10.6% recurrence rate.[10,11] Once a tibial stress fracture occurs, an individual will feel pain during weight-

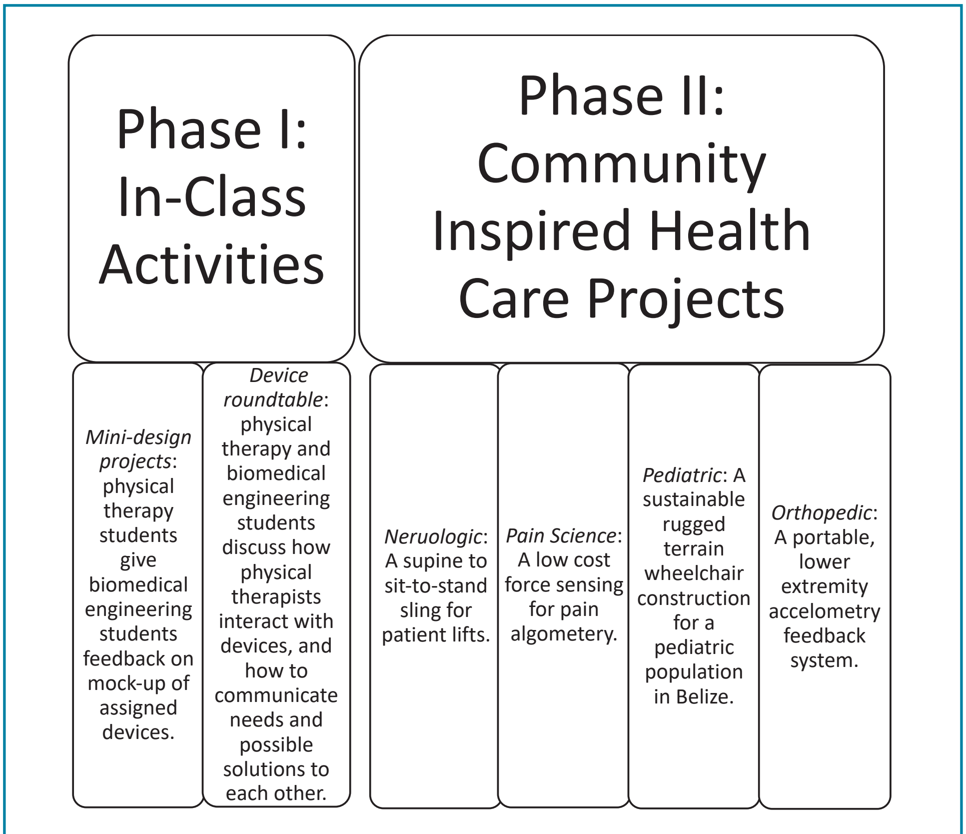

Figure 1. Description of physical therapist and faculty with engineering students and faculty in two integrative phases.

bearing activities that is relieved with rest. The rehabilitation period following a stress fracture ranges about 4 to 12 weeks.[12] During these weeks, runners are more vulnerable to creating habits of physical inactivity. Continued physical inactivity is a known risk factor for cardiovascular disease, depression, certain cancers, and high blood pressure.[13] Prevention of tibial stress fractures can help prevent athletes from slipping into a cycle of physical inactivity.

The expanded problem statement then led to the framework of a solution to the problem, incorporating principles relevant to both engineers and physical therapists. Previous research demonstrated excellent reliability and validity using wearable devices to measure tibial acceleration unilaterally.[14] Tibial acceleration data can estimate forces placed on the tibia, and in turn, monitor the risk of tibial stress fractures. The exact link between tibial acceleration and bone strain has not yet been figured out completely through research but is currently used as a proxy measurement by clinicians and researchers. Tibial acceleration is affected by similar factors that would effect bone strain, such as running technique, velocity, surface, and lower extremity stiffness.[15] A study by Milner et al[16] revealed that runners with a history of tibial stress fractures had significantly higher tibial accelerations than participants without them. Due to the current research findings, tibial acceleration can be used to monitor potential injury risk.

Even in healthy populations, asymmetries exist between lower extremities.[17] The existing literature has conflicting results regarding the significance of limb asymmetries. Potentially, asymmetries can impact lower extremity stiffness and loading rates, which relates to the risk of injuries. Furthermore, there is mixed evidence surrounding the effects of fatigue on symmetry between limbs.[17-20] The inclusion of both lower limbs while measuring tibial acceleration can potentially increase the ability to detect the risk of tibial stress fractures. The design team then made the decision that a critical feature of the new system would be to have the capacity to measure tibial acceleration of both lower extremities simultaneously.

At this stage of the design process, many different ideas started to emerge, as this device could not only be used as an assessment device for clinical analysis, but also as feedback to the user for both assessment and training purposes. The duality of purpose spurred a meaningful interdisciplinary conversation regarding the graphical user interface. Design parameters were prioritized to provide essential information for real-time feedback while other information was processed offline. Robust discussions for prioritization occurred through analysis of both motor control principles, as well as possibilities and limitations of the system components. The team continued to build off previous literature finding that runners using real-time audio feedback from a tibial accelerometer were able to significantly reduce their positive peak tibial accelerations in as little as 5 minutes. Moreover, 10 minutes of biofeedback allowed runners to maintain their gait adaptations even without the real-time feedback temporarily.[21] Likewise, runners using visual feedback were able to reduce positive peak tibial acceleration, vertical impact peak, vertical instantaneous loading rate, and vertical average loading rate. Users reported that the modifications to running gait felt natural after just a few sessions and their changes were maintained for at least one month after cessation of biofeedback.[22]

Concurrently, the team chose the accelerometer that would minimize size and mass while collecting and communicating the signal to a central processing device at sufficient speeds to maintain a meaningful signal. With each progressive decision-making step, a needs and brainstorming session occurred, followed by an assessment of device components that would improve the device. Needs ranged from the type of signal that was desired, the type of data processing that would be necessary, file storage size, method of user interaction desired, preventing reproducing an already existing system, and potential add-on uses for the system in the future to apply readily integrated new questions and needs that arise. At the final stage, the engineering team wrote an app in Java for an Android smartphone communicated with two accelerometers embedded onto a chip with Bluetooth technology. The accelerometers were individually housed in a sealed enclosure consisting of a 3-D printed flexible material in serial with a strap that was secured to the individual's distal shank. The process was iterative and an example of interdisciplinary knowledge culminating in a new device to answer a pressing clinical need. Studies will follow that investigate simultaneous lower limb kinetics to establish a symmetry index of acceleration, detect deviations, and serve as an intervention tool.

Table 1. Phase I Student Responses. Representative quotes from student feedback following phase I activities.

Categories	Representative Quotes
Benefits of Collaboration	"The experiences definitely showed the value of having multiple groups from different backgrounds collaborating to solve a common problem." (SEng) "Insightful time to integrate our professions." (SPT)
Refining Communication	"I was able to practice providing feedback to group members constructively and listening to the concerns of people with different perspectives/list of concerns." (SPT) "I think capstone in general was good for me to break this old teaching [of not questioning] and, while treating people with respect you can still elaborate on ideas." (SEng)
Learning and Growing	"It was helpful to think through all the aspects a physical therapist would be concerned with and then prioritize those ideas with what the engineers are concerned with. By comparing the two perspectives it helped me solidify my own clinical thinking for physical therapy." (SPT) "Working with individuals in the physical therapy profession really taught us to put our primary focus on [user needs] and not get so lost in the design that the needs of the users are not met." (SEng)
Community Engagement	"It opened my eyes to this idea of real world problem solving and that we have so much to learn from each-others disciplines and interests." (SEng)
Abbreviations: SPT, student physical therapist; SEng, engineering student	

Table 2. Phase II Design Components. Examples of design component matched to necessary specifications and considerations for the device. Collaborations between engineering and physical therapy students and faculty drove decisions for final design components.

Design Concept	Decisions Regarding Design Specifications
System	Processor capacity necessary to collect and process data
	Sensor specifications necessary to capture and transmit wanted data
Graphical User Interface	Necessary information to be input by the user
	Essential, desirable, and nice-to-have real-time feedback to the user
	Essential, desirable, and nice-to-have delayed feedback to the user
Sensor Selection	Data streaming and storing capabilities
	Sensor size and weight
Sensor-User Interface	Sensor location
	Protection of the device in all situations of device use
	Comfort of the material and fit of interface

CLINICAL RELEVANCE

A single-site, stepwise progression in an academic setting to introduce the value of physical therapy to engineers as part of an interdisciplinary team, facilitated an understanding of the physical therapy program through roundtable discussions and a "mini-design" project. The value of the interdisciplinary partnerships increased through contributions by physical therapy faculty and students in Capstone Design projects with undergraduate final year mechanical and biomedical engineering students.

Productive collaborations between physical therapists and engineers in the literature do exist and have the opportunity to make important changes in patients' lives. For those with neurologic conditions, inertial sensing systems are being developed to monitor movement in the community.[23] Computerized methods to measure limb volume are validated for those with lymphedema due to breast cancer,[24] increasing the ease of diagnosis and monitoring the effects of treatment. Environments used in pediatric and early intervention are being enriched using robotic interactions,[25] and virtual reality environments are being used to measure and decrease fall risk in elderly patients.[26] Recent orthopaedic examples include using exercise equipment embedded with sensors to monitor home programs following joint replacement,[27] sensors that communicate with a mobile phone to measure knee movement remotely,[28] and using depth-sensing cameras to assess gait.[29] The unique needs of the orthopaedic patient population should continue to be addressed through developments in technology and design. The orthopaedic physical therapist should continue to be a part of the team that develops technology to assist in accurate diagnosis, treatment, and ongoing reassessment of their patients.

When surveyed, clinicians have identified barriers to using technology in the clinic. Barriers include a lack of time when technology takes longer than traditional methods, additive cost of devices and software, lack of standardization of measurements and methods, and poor interpretability or understanding of the results.[30] Clinicians do agree that wearable monitoring technology could enhance physical therapy assessments. Still, they feel that a single device or measuring a separate function does not meet the diverse scope of patient needs and treatments.[31] When explicitly discussing technology-driven feedback to patients undergoing orthopaedic rehabilitation, clinicians perceive the significant value to the patient but identify the technical challenges of tailoring rehabilitation to the individual.[32] Although optimism exists towards the potential of technology to improve rehabilitation, physical therapists need to directly engage with those that are developing the technologies to improve the ability to apply technologies to patients.

This study has demonstrated a successful iterative approach to engage physical therapy and engineering faculty and students in the academic setting actively. Establishing an understanding of each other's professions is an essential component of interdisciplinary work.[5,9] This was accomplished through round table discussions and a limited scope group project. Surveying students in both fields supported positive interactions and experiences. After evidence of successfully completing the first phase, a second phase of proven strategy in interdisciplinary work resulted in problem-based learning in small groups.[33] During the problem-based interactions, physical therapy proposed a clinical problem for engineering senior design students. Physical therapy faculty and students served as consultants for the project design during monthly meetings. This structure facilitated engineering students and faculty to work together to optimize the design of clinician-supported and patient-friendly technology. Further, the request to expand problem-based learning to more than one engineering discipline (biomedical and mechanical), is further evidence of the success of this iterative approach.

Future directions for these programs will include establishing a mechanism in which to allow physical therapy students to earn course credits for collaborative work with engineering design teams. Although few universities have been able to achieve this, it will enable physical therapy students, not only engineering students, to reward the invested time through course credits instead of being volunteer-based for the student physical therapists. Continued future directions would also involve a post-design year for each technology developed. Depending on the intent of the technology, this post-design year would assess the clinical or research application and encourage quality improvement and redevelopment processes critical to ensuring the optimal usability for patients and clinicians.

CONCLUSIONS

This is an academic example of a stepwise approach to engage engineers by first establishing a baseline understanding of each other's professions and then engaging in meaningful problem-based cases. Physical therapists must continue to strive to engage with engineers as part of the interdisciplinary team in developing clinically useful technologies that are accurate, purposeful, and easy to use.

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Continuous Quality Improvement to Eventuate Learning Health Care Systems in Physical Therapy Practice

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ABSTRACT

Background and Purpose: Achieving the Quadruple Aim in health care, necessitates the integration of evidence-based practice and practice-based evidence for quality improvement (QI) and learning. Physical therapists require guidance on approaches to QI that integrate knowledge generated from research and generated in clinical practice. The purpose of this paper is to review a method by which practicing physical therapists can leverage data from their own practices as a basis for QI and learning. **Methods:** The conceptualization of a learning health system (LHS) in relation to QI in health care was reviewed to describe the Institute for Healthcare Improvement model for QI and case operationalizing the model for physical therapists. **Clinical Relevance:** Practicing physical therapists review how to apply a framework for QI based upon relevant practice-based evidence. **Conclusion:** Operationalizing continuous cycles of QI within the physical therapy practice will improve the quality of patient care and patient outcomes and will facilitate the Institute of Medicine's vision of LHS in rehabilitation.

Key Words: learning health systems, physical therapy, quality improvement methods

INTRODUCTION

Achieving the Quadruple Aim in health care requires a commitment to evidence-based practice (EBP) that focuses on improving the quality and safety of patient care, while reducing costs and engaging clinicians for increased job satisfaction.[1] Adoption of evidence into clinical practice involves a complex set of phenomena including the exponential growth in available research, access to evidence in a format that is readily usable by clinicians, and clinician knowledge, skills, and confidence in EBP.[2] Reviewing the increasing volume of research can compete with existing demands of clinical practice. Further, evaluating the readiness of evidence for implementation can be challenged by a lack of familiarity with the myriad of study designs and interpretation of study results. Even a basic understanding of the efficacy and effectiveness of findings may not provide guidance on the applicability of those findings in relation to specific patients. These barriers have led to increased efforts to develop and disseminate clinical practice guidelines (CPGs) and evidence summaries as guidance for clinicians. Emphasis has also been placed on developing and teaching EBP competencies within specific health professions.[1] Likewise, the profession is beginning to see improvements in the quality of care based upon these initiatives.[3] Yet, guidance is required on how practicing clinicians can adopt systematic approaches to quality improvement that integrate knowledge generated from research with clinical expertise and knowledge generated in clinical practice.

Recent conceptualizations of quality improvement in health care have focused on aligning the latest research with knowledge from clinical practice and patient outcomes.[4] Adoption of electronic medical records in health care makes it possible to analyze significant amounts of clinical data at a rate and volume not previously envisioned. Likewise, health care systems and individual practices have the capacity to generate evidence about their own functioning that can prove essential for learning, quality improvement, and professional development. This capacity offers the potential for practice-based evidence to compliment EBP, creating a system in which both internal knowledge and external knowledge guide patient-centered care. For example, practice-based evidence can prove particularly valuable when patients have many co-morbidities that make application of CPGs and evidence summaries difficult. To realize such a system, practicing clinicians require additional guidance on how to generate knowledge from their own clinics and patient populations for continuous learning and for quality improvement.

The purpose of this paper is to provide the practicing physical therapists a method to leverage data from their own practices as a basis for quality improvement and professional development. Operationalizing systems for learning from practice-based evidence within an individual practice or larger health care institution can provide a basis for continuous quality improvement and methods for efficient incorporation of research evidence to support the Quadruple Aim.

LEARNING HEALTH SYSTEMS

In 2007, the Institute of Medicine[5] conceptualized the idea of a learning health system (LHS) that is capable of continuously, routinely, and efficiently studying and improving itself through the collection of clinically relevant data. According to Friedman and colleagues,[6] a LHS has 5 observable components: (1) patients' characteristics and experiences are available as data, (2) knowledge derived from this data is available to support health-related decisions, (3) improvement is continuous through ongoing study related to specific goals, (4) infrastructure enables this to happen routinely, and (5) stakeholders within the system view these activities as part of their culture.

Within the LHS, there is bi-directional knowledge generation and dissemination, where the system scans the external environment for knowledge from research that can be used to improve outcomes, safety, and quality of care. It also generates internal knowledge about its own functioning through outcomes-based decision-making that informs changes to processes and practices. The knowledge gained from internal assessment of care can then be disseminated to the broader external health care system. Hence, knowledge generation and dissemination flow from the research environment to the clinical environment to the research environment, forming a continuous communication network while breaking down the artificial barriers between clinical care and research.

The development of a LHS in rehabilitation has been explored. Jette,[7] in his 2012

Mary McMillan lecture, suggests physical therapists must incorporate 3 critical skills noted by Atul Gawande[8]: (1) they must be interested in data and its relation to performance; (2) use the data to solve problems, especially related to patient-centered care; and (3) know how to "scale up." Scaling up allows one to use data to assess the organization's ability to collaborate, disseminate new knowledge, and reduce failures by assuring processes are followed that have been shown to be effective. Applying these 3 skills would allow physical therapists to establish the foundation of a learning system vital to continuous quality improvement.

QUALITY IMPROVEMENT

Over the past few decades, health care systems worldwide have been under scrutiny because of issues regarding quality and errors. In the United States, two landmark reports from the Institute of Medicine (IOM) identified the impact of medical errors and threats to safety on patients, families, health care, and the nation. In 1999, *To Err is Human*,[9] shed light on the frequency of safety problems and medical errors in the United States health care system. This report identified the physical, psychological, and economic toll of medical errors. After this report was released, the public and government officials demanded more information on not only the problems with safety and errors but also on potential solutions. In *Crossing the Quality Chasm*,[10] the IOM provided an update on problems associated with quality and medical errors and offered recommendations for fundamental changes to the United States health care system. Among the suggestions was the need for clarity on what performance expectations lead to a safe and error-free health care system. This suggestion initiated the push to have system-wide quality and safety performance measures. As a result, the United States sought a new organizational framework for its health care system that included a patient-centered care model, the use of evidence-based practice interventions, reliance on outcomes based performance measures, and a comprehensive plan to prepare the workforce to better serve patients in a world of expanding knowledge and rapid change.

Over the nearly two decades since these reports, the recommendations proposed by the IOM have not been fully realized. According to a 2017 study, approximately 15% of all hospital expenditures and activities are related to medical errors and safety issues.[11] Some economists estimate that the United States spends a trillion dollars annually on direct and indirect costs associated with medical errors and quality problems.[12] Fortunately, recent evidence suggests that the decades-long emphasis on quality improvement in health care is having some positive effects. For example, Peterson-Kaiser Health System Trackers[13] indicate that common hospital acquired conditions, like adverse drug events and falls significantly decreased between 2014 and 2017 attribute the decrease, in part, to the effective implementation of practices to improve patient safety and quality of care.

Quality improvement has its roots in the automobile, manufacturing, and aviation industries.[14] In these industries methods such as total quality management and LEAN Six Sigma are used to improve quality and efficiency and eliminate waste. Similar goals of improving quality, efficiency, and cost are now being applied to health care. The Institute for Healthcare Improvement (IHI) has been a leader in incorporating the principles of quality improvement into health care and, to that end, adopted the Quadruple Aim, which relates health care system quality to improvements in population health, patient experience, costs of care, and health care team well-being.[15]

Quality Improvement in Physical Therapy: A Systems Approach

Physical therapists often think about quality care and safety in relation to their patients. Commonly asked questions include, "Am I doing the right things for my patients? Are the activities and exercises I am providing safe for my patient to do?" Usually, physical therapists think in terms of their relationship with the patient as primarily responsible for safe and effective rehabilitation. However, unpacking this relationship, additional factors may affect the safety and outcome of treatment. On the patient side the motivation to improve or the fear associated with the pain they are experiencing are important factors that may affect the outcome of care. The patient may be under stress that keeps them from complying with the treatment plan. On the physical therapists' side, experiences with similar patients, the amount of time available with each patient, and the exhaustion felt toward the end of the day may affect the overall success of the intervention and perhaps influence safety.

If a systems approach to rehabilitation is adopted, clinicians might also recognize that the surgery the patient had prior to coming to the physical therapist, the stresses of payment and insurance coverage limitations, the patient's home or work environments, and the quality and structure of the clinic and hospital all play a role in the ultimate success of rehabilitation. As we begin to investigate the efficacy and effectiveness of rehabilitation care, clinicians need to recognize that there are many stakeholders within this picture. As health care workers start to look at continuous quality improvement, therapists may find themselves in discussions with stakeholders who are not traditionally thought of as important to physical therapy care. For example, natural collaborators for quality patient-centered care might include occupational therapists and speech language therapists; moreover, strategies to improve care may go beyond the walls of rehabilitation.

In taking a systems approach to quality improvement in physical therapy, clinicians come to recognize that quality improvement within the system of care requires that all members of the health system commit to continuous learning with a goal toward process and outcome improvement. To achieve the Quadruple Aim, health professionals must evaluate evidence from research (external evidence) and evidence related to their own performance (internal evidence) to plan and implement changes that will improve patient outcomes, patient safety, and the quality of care. Advances such as access to electronic health records of all providers seeing a patient and professional and interprofessional registries can provide access to data on a much larger scale than previously possible. However, challenges remain regarding how to harness the data and interpret it in relation to quality improvement goals.

The Institute of Healthcare Improvement Model of Improvement

To systematically approach quality improvement initiatives within the clinical setting the integration of a guiding framework is essential. A physical therapy team working on a quality improvement project (QIP) might want to adopt one of the most highly regarded frameworks—the IHI Model of Improvement that includes a Plan-Do-Study-Act, or PDSA, cycle (Figure 1). The PDSA cycle is the most commonly used tool in quality improvement programs within health care.[16]

The QIP team would first want to answer the 3 questions that initiate the IHI's Model of Improvement. First, they determine, "What are we trying to accomplish?" Here, they consider the aim of the quality improvement efforts. The aim or purpose statement

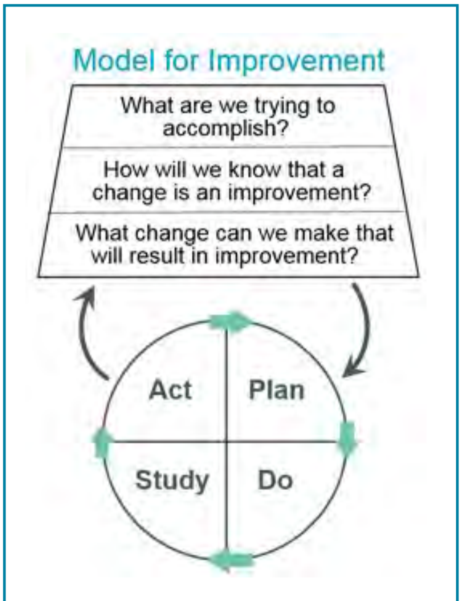

Figure 1. The Institute of Healthcare Improvement Model for Improvement. Reprinted with permission from Langley GJ, Provost LP. *The Improvement Guide: A Practical Approach to Enhancing Organizational Performance*. 2nd ed. Copyright 2009, Wiley Books.

should be bold, realistic, clear, concise, measurable, and meaningful. The QIP team is encouraged to describe the specific level of improvement, who the quality improvement program will affect, and the timeframe.

Next, the QIP team will determine, "How will we know that a change is an improvement?" To answer this question, the QIP team will develop a measure or measures to assess the change. In some cases, this could be an outcome measure or measures that demonstrate the impact of the intervention on the patient, his or her health, or well-being. An outcome measure is considered the gold standard in quality measurement. For example, the QIP team may choose to measure if the average Oswestry score for patients with low back pain is above the minimal clinically important difference over 6 months.

The QIP team may select a process measure to see if positive change or an improvement occurs. A process measure looks at the steps in the process that could lead to improvement. An example of a process measure is determining the percentage of patients with low back pain who completed the Oswestry Disability Index over a 6-month period. For process measures, the primary interest is measuring if the process was performed, not its outcome. The final measure type is referred to as a balancing measure. Balancing measures look at unanticipated consequences of change. For example, if a quality improvement program aims to improve lower extremity strength for all patients with anterior cruciate ligament impairment and the clinician changes all patients' exercise programs to an accelerated, high velocity exercise program, one might expect greater stress to the lumbar spine. So, a balancing measure may include using a validated low back pain measure to ensure the program is not having an unanticipated negative effect on another bodily area.

The last question to consider in the IHI Model of Improvement is, "What changes can we make that we believe will result in improvement?" Ideas for change should be based on the experiences of working within the system. Therapists may look at workflow changes, changes in the work environment, changes in care plans for certain populations, or the use of newer evidence-based practices.

After answering the 3 initiating questions, the QIP team would progress through the 4 stages of the PDSA cycle. The first stage of the PDSA cycle requires that the QIP team plan the strategy they will use to test their improvement solution. During the plan stage, the QIP team should state the question they want to answer and make a prediction about what they think will happen. Consider the overall aim of the quality improvement project and what is expected to happen with this specific solution. This stage also requires the QIP team to consider the 4 Ws: "Who is responsible for the plan?, What will they do to implement the solution?, When will they start and complete the testing for this solution?, and Where will they start the solution (for example, in one clinic or department or throughout the system)." Also, the QIP team should consider what data need to be collected to assess if the changes have been successful.

After completing the Plan stage, the QIP team moves on to the Do stage. During this stage, the QIP team implements the plan as outlined in the first stage and collects appropriate data to later determine the level of success. The team should document unanticipated challenges encountered during the plan because documentation will be helpful in determining the needs for a subsequent PDSA cycle.

After implementing the planned changes and collecting the requisite data, the QIP team will move into the Study stage. In this stage, the collected data is analyzed to evaluate the level of success and identify challenges. A comparison to the initial predictions and prior performance of the selected measures will help determine the level of success. Ideally, QIP team will discuss the results prior to entering the final stage of the cycle.

In the final, or Act stage, the QIP team reviews the outcomes from the Study stage to make decisions on subsequent actions. Subsequent actions might include (1) making the strategy that was tested in the PDSA cycle standard practice if the results showed success, (2) amending the original plan and re-testing if there was success but was below expectations, or (3) abandoning the plan and starting a different plan if no positive change was demonstrated. If the decision is to amend the original plan or start a new plan, the QIP team moves through a new PDSA cycle.

QIP CASE EXAMPLE

The following case example will be used to further illustrate the utility of the PDSA cycle in the guidance of a quality improvement project within an LHS.

An outpatient clinic, which is part of a statewide organization, provides physical and occupational therapy services to their local community. In an effort to improve quality of care, the therapy team desires to increase their effective use of functional outcome measures to drive evidence-based best practice. To aid in this effort, the clinic establishes a local QIP team and begins with the IHI model to determine their objective. The first step is to review the clinic's Electronic Medical Record. The QIP team finds that the outcomes of upper extremity issues are problematic in their clinic, so they request a more detailed analysis comparing their clinic's results to the organization's data (Table 1). The QIP team notes some concerning issues especially regarding the average treatment duration and sessions for upper extremity conditions and the lackluster Quick DASH results. Using the IHI Model for Improvement, the QIP team develops objectives to the quality improvement program (Table 2).

During the Plan stage of the PDSA cycle, the QIP team decides to focus on the use of the Quick-DASH, as this tool is currently used by both occupational and physical therapists and the initial results demonstrated problems with its implementation. Upon further study of the comparison data, the QIP team decides that a major issue is the low percentage of patients with upper extremity problems who were provided the Quick DASH (28% vs 65%). In addition, the QIP team survey the clinicians and find

Table 1. Electronic Health Record Data Comparing the Clinic to the Organization Data

Organization Profile for Shoulder/Elbow/Wrist Pain	Case Clinic	Case Organization
# of patients: n	105	2,843
Age: mean (SD)	49 (16)	45 (14)
Gender: %	62 (female) 38 (male)	57 (female) 43 (male)
Average # treatment sessions	14.4	8.8
Average treatment duration in weeks	8.6	5.2
% patients provided with QuickDASH in initial evaluation	28	65
Average pre-treatment QuickDASH score	59.4	48.6
Average post-treatment QuickDASH score	44.6	27.4
Average change score	14.8	21.2
% of patients with QuickDASH change score ≥16 points (MCID)	45	70
% of patients with no/mild disability post-treatment	54	75

that most clinicians did not understand the purpose of the QuickDASH and did not use the findings in treatment planning.

To reach the objective of increasing the usage of the QuickDASH and improve the clinic's care for patients with upper extremity problems, the QIP team designs the following plan:

1. Improve front office processes that assures patients are receiving the QuickDASH.
2. Motivate patients to complete the QuickDASH by having clinician's review the results with the patients.
3. Develop an education program for clinicians to review the QuickDASH purpose and its importance to care planning.

In addition, the team decides on the following measures to assess after 3 months:

(1) % of patients receiving the QuickDASH in the initial evaluation.
(2) % of patients completing the QuickDASH in the initial evaluation.
(3) Average pre-treatment QuickDASH score.
(4) Average post-treatment QuickDASH score.
(5) Average change score of QuickDASH from pre- to post-treatment.

During the Do stage of the PDSA cycle, the QIP team implements the training process to front office staff and clinicians through a series of in-services and individual meetings. The QIP team finds that although there was initial resistance to the new procedures, most clinicians and staff find the training helpful.

Table 2. The Clinic's Quality Improvements Objectives Using the IHI Model

What are we trying to accomplish?	Improve health related outcome measures pertaining to upper extremity functioning and occupational performance.
How will we know that change is an improvement?	Improved scores of quality indicators focusing on increased use of the QuickDASH and enhanced health outcomes.
What change can we make that will result in improvement?	Targeted education of all team members to enhance knowledge of utility and benefit of functional outcome measures.

In the third stage, or Study stage, the QIP team will meet to analyze, interpret, and discuss the collected data to establish the success of the plan. Table 3 shows the results of the measures after 3 months. The QIP team determines that the educational intervention was successful in improving the dissemination of the QuickDASH as a greater percentage of eligible patients were receiving the QuickDASH that has now surpassed the organization's rate; however, they are disappointed in the average and change scores. This is especially important because the QuickDASH change score did not surpass the minimal clinically important difference (MCID) of 16 points.

In the Act stage, the QIP team determines the QuickDASH training will become a standard operating procedure in their clinic. Since the pre-post intervention QuickDASH scores did not reach the MCID, the team discusses that a new PDSA be initiated and include a training program reviewing available CPGs on upper extremity injuries (UEI). They establish a new group to explore the literature on UEI CPGs and discuss ways to implement a new training program for the clinicians.

As our case demonstrates, QIP teams repeatedly develop PDSA cycles to test new ideas or make modifications to existing ideas, moving from one cycle to the next. Aligning to the LHS concept, the QIP team recognizes that there will always be room for improvement based on new knowledge from the external environment (from research or policy) and knowledge from internal data analysis. Ivers et al[16] and Wells et al[17] suggests that engagement in quality improvement leads to better patient outcomes and the development of a culture of improvement.

Table 3. Quality Indicators 3 Months After Quality Improvement Plan

Quality Indicators (after 3 months)	Case Clinic	Case Organization
% of patients receiving the QuickDash in the initial evaluation	87%	72%
% of patients completing the QuickDash in the initial evaluation	79%	61%
Average pre-treatment QuickDASH score	56.9%	49.3%
Average post-treatment QuickDASH score	42.4%	28.9%
Average change score	14.5	20.4

CONCLUSION

Current health care systems are focusing on establishing a culture of quality incorporating learning from external (research) and internal (clinical EHR data) sources while providing the infrastructure that allows for continuous assessment of new clinically generated data. For this phenomenon to be effective in rehabilitation, physical therapists need to establish processes to integrate external evidence in the clinic and develop the infrastructure to assess and learn from their internal evidence or clinically generated data. In this paper, the authors provide a method and case example guided by the IHI Model of Improvement, to establish a continuous quality improvement program based on clinically generated data from an EHR for physical therapists.

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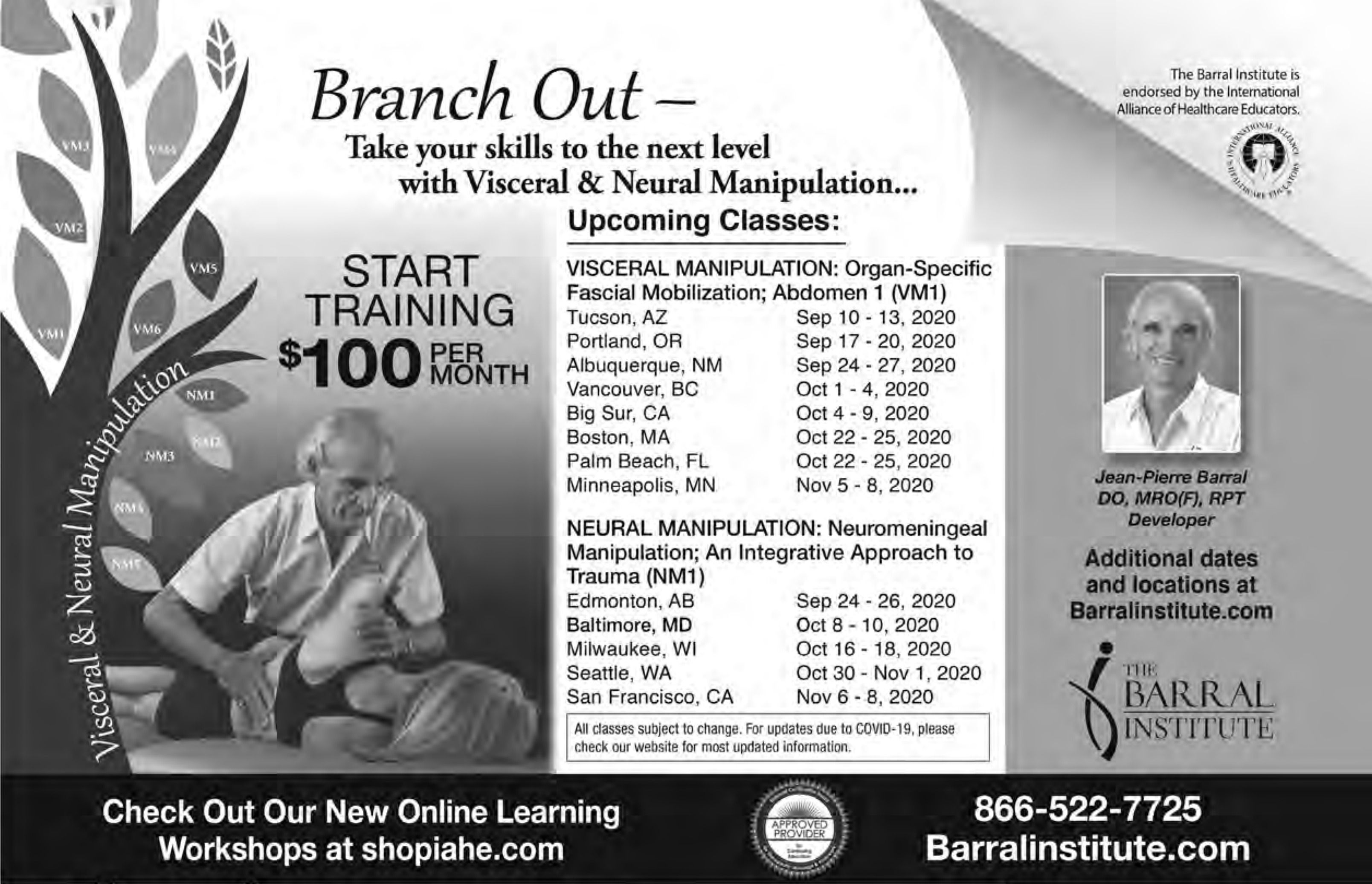
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Chronic Sacroiliac Joint and Pelvic Girdle Pain and Dysfunction Successfully Managed with a Multimodal and Multidisciplinary Approach: A Case Series

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ABSTRACT

Background and Purpose: Sacroiliac joint (SIJ) or pelvic girdle pain (PGP) account for 20-40% of all low back pain cases in the United States. Diagnosis and management of these disorders can be challenging due to limited and conflicting evidence in the literature and the varying patient presentation. The purpose of this case series is to describe the outcome observed in 3 patients presenting with pain in the SIJ region treated with an interdisciplinary and multimodal treatment approach. **Methods:** Three patients presented with chronic PGP and dysfunction who had failed previous conservative management. Each was treated with a series of prolotherapy, joint manipulations, pelvic belting, and stabilization exercises. **Findings:** All 3 patients reported being pain-free at 6 months as well as at 24-month follow-up. **Clinical Relevance/Conclusion:** This case series demonstrates the importance of a collaborative model of care for managing persons with chronic PGP and dysfunction who have failed conservative management.

Key Words: manipulation, pelvic belting, prolotherapy, therapeutic exercise

BACKGROUND AND PURPOSE

The worldwide prevalence of persistent low back pain (LBP) ranges from 10-45%.[1-4] The prevalence of LBP within the United States is 20-30%.[5] Of those cases, 20-40% are associated with sacroiliac joint (SIJ) or pelvic girdle pain (PGP). Many factors are associated with pain and dysfunction of the SIJ and pelvic girdle (PG) including trauma, congenital hypermobility, arthritis (degenerative, systemic, infectious), pregnancy, and idiopathic causes.[6,7] Considering the high cost to society and the potential for long term disability, providing effective and efficient interventions for LBP and PGP are a common goal for clinicians.

According to the European guideline on PGP, impairments of the SIJ are not limited to intraarticular pain and often include impairments of the surrounding muscles or connective tissues, as well as, aberrant and asymmetrical movement patterns within the region of the lumbo-pelvic-hip complex.[7] These impairments have a negative impact on the PG's role in support and load transfer between the lower extremities and trunk. This variability in observed impairments increases the challenge of SIJ diagnosis and management.

According to a 2010 systematic review, clinicians are unable to reliably consider the pain referral pattern or history of specific pain provoking activities when considering a diagnostic classification.[8] Additionally, there is conflicting evidence supporting the diagnostic utility of many clinical and imaging examinations.[9-11] These combined factors make diagnosis challenging.

Management of SIJ and PG dysfunction varies and includes providing pelvic stability via a pelvic belt, manipulation, exercise, surgical fusion, intra-articular injections, acupuncture, prolotherapy, plasma rich platelet injections, neuroaugmentation, and radiofrequency ablation.[12-14] The purpose of this case series is to describe the outcome observed in 3 patients presenting with pain in the SIJ region treated with an interdisciplinary and multimodal treatment approach.

CASE DESCRIPTION

Case 1

A 43-year-old male with a chronic history of insidious right posterior pelvic pain. He was a competitive football player and wrestler in college and continued to remain active including running, cycling, and weightlifting daily. His previous treatment included chiropractic and physical therapy that emphasized spinal and pelvic manipulations as well as flexibility and stabilization exercises. He reported that the interventions were helpful but did not eliminate the need for continued care.

Case 2

A 30-year-old nulliparous female with a chronic history of right posterior pelvic pain following an injury as a college athlete participating in crew. She reported slipping in a boat and falling onto her sacrum. Her previous conservative management included physical therapy that emphasized pelvic manipulations, use of a pelvic belt, and stabilization exercises. She reported that interventions were helpful but had not allowed her to return to full activity and function without pain.

Case 3

A 32-year-old nulliparous female with a chronic history of insidious right > left posterior pelvic pain and a history of Ehlers-Danlos Syndrome (EDS). The patient's previous conservative management included pelvic manipulations, use of a pelvic belt, and stabilization exercises. She reported that the interventions were helpful but did not eliminate the need for continued care and considering her diagnosis of EDS she desired a more sustainable solution.

Examination

After obtaining consent, all patients underwent a clinical examination that included assessment of posture, a screen of the lumbar, thoracic, hip regions, repeated movements, and provocation and mobility testing of the pelvic girdle. Remarkable findings are reported in Table 1.

Clinical Impression

A combination of tests and measures were used to classify the patients with impaired joint mobility, motor function, and muscle performance of the pelvic girdle. Observation was used to assess for aberrant lumbopelvic motion patterns. The observed inability of the patient to dissociate femoral movement from lumbo-pelvic movement further supported a classification of impaired

Table 1. Remarkable Clinical Examination Findings of the Three Patients

Test and Measure	Initial Evaluation	6 months	2 years
Case 1			
Numeric Pain Rating Scale Score	4/10	0/10	0/10
Forward flexion test right	Positive	Negative	Not Tested
Seated flexion test right	Positive	Negative	Not Tested
Active straight leg raise test right	Positive	Negative	Not Tested
Sacroiliac joint distraction test	Positive for posterior pelvic pain on right	Negative	Not Tested
Sacroiliac joint compression test right	Negative	Negative	Not Tested
Sacroiliac joint thigh thrust test right	Positive	Negative	Not Tested
Lumbo-pelvic movement control screening	Inability to dissociate movement of the femur from the lumbo-pelvic girdle in multiple planes	Able to dissociate movement of the femur from the lumbo-pelvic girdle in multiple planes	Not Tested
Palpation	Pain in the region of the right posterior superior iliac spine and along the long dorsal sacroiliac ligament	Unremarkable	
Global Rating of Change Score			+7
Case 2			
Numeric Pain Rating Scale Score	4/10	0/10	0/10
Forward flexion test right	Positive	Negative	Not Tested
Seated flexion test right	Positive	Negative	Not Tested
Active straight leg raise test right	Positive	Negative	Not Tested
Sacroiliac joint distraction test	Positive posterior pelvic pain on right	Negative	Not Tested
Sacroiliac joint compression test right	Positive	Negative	Not Tested
Sacroiliac joint thigh thrust test right	Positive	Negative	Not Tested
Lumbo-pelvic movement control screening	Inability to dissociate movement of the femur from the lumbo-pelvic girdle in multiple planes	Able to dissociate movement of the femur from the lumbo-pelvic girdle in multiple planes	Not Tested
Palpation	Pain in the region of the right posterior superior iliac spine and along the long dorsal sacroiliac ligament	Unremarkable	
Global Rating of Change Score			+7
Case 3			
Numeric Pain Rating Scale Score	6/10	0/10	0/10
Forward flexion test right	Positive	Negative	Not Tested
Seated flexion test right	Positive	Negative	Not Tested
Active straight leg raise test right	Positive	Negative	Not Tested
Sacroiliac joint distraction test	Positive posterior pelvic pain bilateral	Negative	Not Tested
Sacroiliac joint compression test right	Negative	Negative	Not Tested
Sacroiliac joint thigh thrust test right	Positive	Negative	Not Tested
Lumbo-pelvic movement control screening	Inability to dissociate movement of the femur from the lumbo-pelvic girdle in multiple planes	Able to dissociate movement of the femur from the lumbo-pelvic girdle in multipl planes	Not Tested
Palpation	Pain in the region of the right > left posterior superior iliac spine and along the long dorsal sacroiliac ligament, bilaterally	Unremarkable	
Global Rating of Change Score			+6

motor function and muscle performance of the pelvic girdle. Although mobility tests of the pelvic girdle generally have poor diagnostic utility, the investigators used the standing (Sp: 87) and seated forward flexion test (Sn: 3, Sp: 90) to confirm a remarkable mobility deficit on the right side in each patient case.[18]

The distraction and thigh thrust test reproduced remarkable posterior pelvic pain on the right in all patients and bilaterally in Case 3. The distraction test has moderate specificity (Sn 60, Sp 81) and the thigh thrust test has moderate sensitivity (Sn 88, Sp 69) aiding the clinician to rule in the sacroiliac joint as the primary pain generator.[15] Finally, the active straight leg raise test was observed to be remarkable with testing on the right side in all 3 patients. The active straight leg raise (ASLR) test should be included in the clinical examination of a patient with PGP as it has moderate specificity (Sp 0.94, Sn 0.87) and aids the clinician in screening for impaired ability to stabilize the pelvic girdle.[16,17] Based on these findings (see Table 1), the 3 patients were diagnosed with sacroiliac joint dysfunction and pelvic ring instability.

Intervention

Each patient was treated by the primary author using a right sacroiliac joint nutation manipulation (Figure 1), muscle energy technique for pubic symphysis (Figure 2), and application of a pelvic ring belt positioned below the level of the anterior superior iliac spine. A nutation manipulation was based on the remarkable observed forward flexion test on the right, which also correlated with the patient's primary symptomatic side. Upon reassessment within 2 weeks, it was noted that the patients were unable to maintain a normal pelvic alignment when retesting with the forward flexion test. Since each patient did not have success with their prior conservative management, it was suggested that the patients consider prolotherapy to assist with the goal of pelvic girdle stabilization.

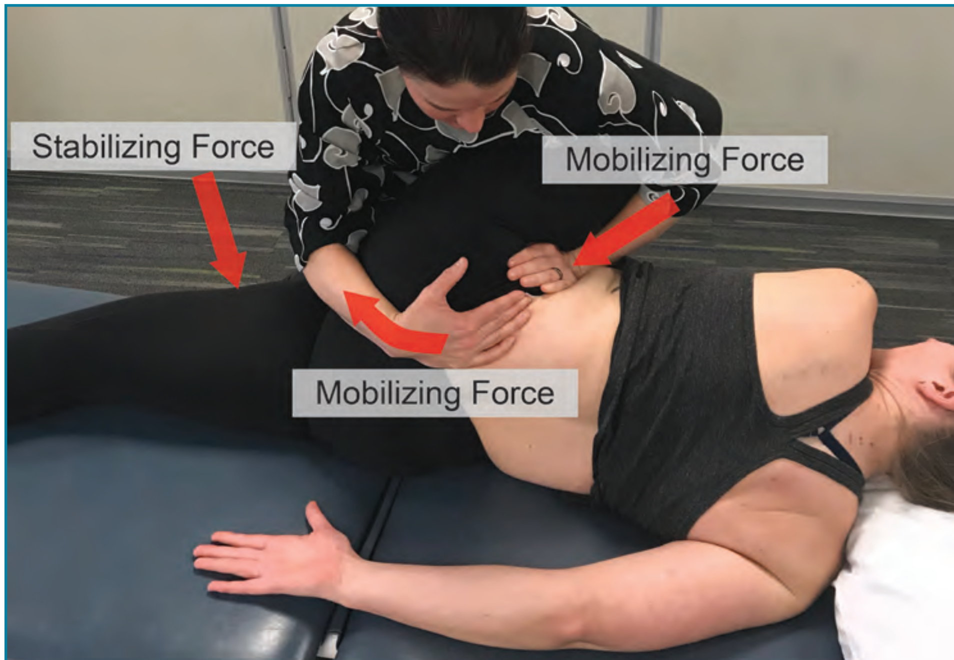

Figure 1. Sacroiliac joint nutation manipulation positioning for the left sacroiliac joint.

Figure 2. Muscle energy technique for pubic symphysis. A, Resisted hip abduction isometric. B, Resisted hip adduction isometric.

Prolotherapy is an injection-using a sclerosing agent at the ligament-bone interface to induce an inflammatory response and the deposition of collagen fibers in weak connective tissue. Our injection mixture contains 10 mL of Dextrose 50% (D50), 5 mL of 0.5% bupivacaine, and 5 mL of 1% lidocaine. The final concentration of dextrose is 25%. Secondary to the ring-like nature of the pelvis the target is the bilateral sacroiliac joints for extra-articular injection along both sides of the joint with 5 mL of the aforementioned mixture (Figure 3A). The iliolumbar ligament at the distal end of the transverse process of L5 bilaterally was targeted with 2.5 mL of the injection mixture (Figure 3B). Finally, the pubic symphysis was injected with 2 mL of the D50 mixture (Figure 3C). These injections were performed by the physician under fluoroscopic guidance, the injectate is delivered via a 25-gauge, 3.5" spinal needle following skin preparation with chlorhexidine and skin anesthesia with 1% lidocaine. The injections are performed 3 times, with 2 weeks between each set of injections. The physical therapist meets the patient at each visit and alignment of the pelvic girdle is assessed. If needed, a pelvic manipulation is performed to promote proper alignment prior and post each set of injections.

Physical therapy focused on progression of a home based lumbo-pelvic stabilization program that first addressed activation of the core including the transverse abdominus, multifidus, and pelvic floor muscles. Once the patient was able to perform and hold a coactivation of these muscles he or she worked on the ability to dissociate femoral movements from lumbo-pelvic movements in multiple planes and at varying speeds.

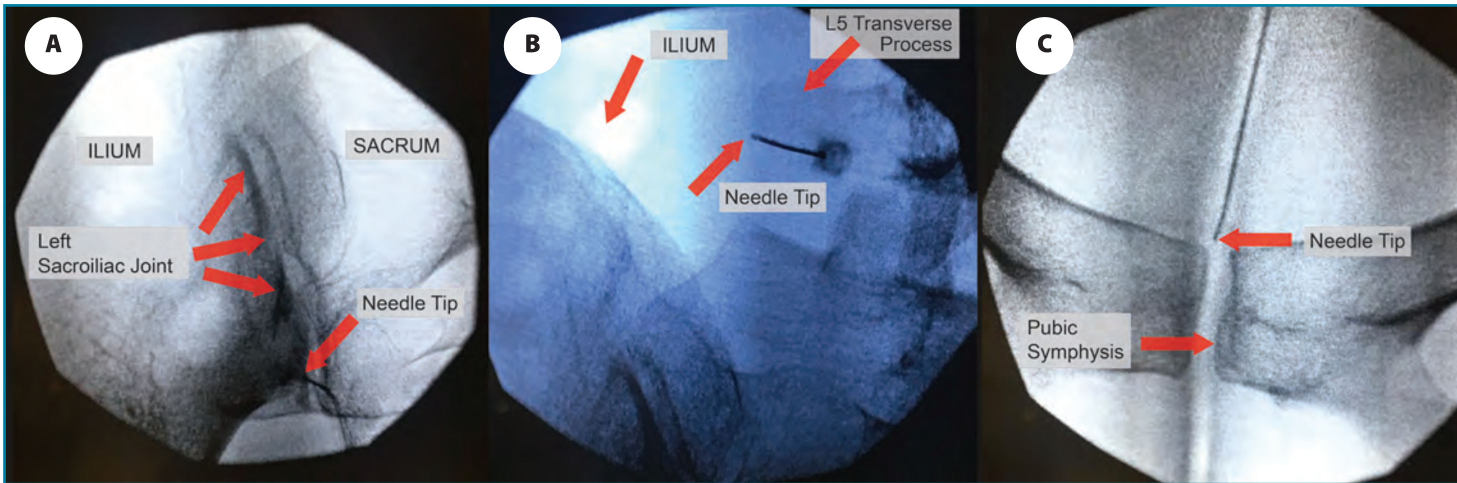

Figure 3. Fluoroscopic images of prolotherapy injection. A, Left sacroiliac joint. B, L5 transverse process. C, Pubic symphysis.

The program was then progressed to include a combination of static and dynamic movement progressions. The specific exercises were adapted based on the individual needs of each patient. A sample of various stabilization exercises are listed in Table 2. Each patient was seen at the initial phase of the exercise progressions and then two weeks later to review or modify their program; the stabilization program lasted 6 months. The use of a pelvic belt was continued up to 3 months followed by wear only at night for an additional month.

OUTCOMES

All 3 patients reported being pain-free at 6 months and all examination findings were observed as unremarkable. At 2-year follow-up, all patients reported a remarkable response to the intervention as recorded on the Global Rating of Change scale (GRoC).[19] See Table 1 for results.

DISCUSSION

This case series describes the successful management of persistent posterior pelvic girdle pain using a collaborative model. A combination of prolotherapy, pelvic girdle manipulation, use of a pelvic belt, and lumbo-pelvic stabilization exercises allowed all 3 patients to report their symptoms as "a great deal" to "very great deal better" at 24 months follow-up. Additionally, it is well known that SIJ and PGP is more prevalent in women and more specifically in pregnant and postpartum women.[7] This case series included the successful management of one male and two nulliparous females. On another note it is also well known that persons with EDS have persistent issues associated with joint hypermobility.[20] In this case series, the authors were able to report the successful management of a young woman with persistent PGP who also had EDS.

The pelvic girdle is able to resist shear forces across the pelvis using a combination of both form and force closure; however, an imbalance can result in pain and dysfunction. The treatment protocol for these 3 patients was designed to improve pelvic girdle stability by promoting force closure to treat persistent pelvic girdle dysfunction. Use of a sacroiliac compression belt is a common intervention in the conservative management of SIJ dysfunction. In a hypermobile SIJ, the body's anatomical form and force closure mechanisms can be impaired, resulting in lumbo-pelvic pain and instability. In patients with increased SIJ laxity, compression belts are intended to provide an external stabilizing force similar to the internal support normally provided by the transverse abdominis, multifidus, internal oblique, and pelvic floor muscles.[21,22] The use of a compression belt around the pelvis may help "improve proprioception and balance and to increase force closure in the sacroiliac joint", particularly in peripartum females.[21] An author recommends the belt be worn just inferior to the anterior superior iliac spines, rather than around the pubic symphysis, for maximum stability.[21] Often, a sacroiliac belt is used in combination with other interventions such as stabilization exercises, rather than a standalone modality. Our group used belts to assist with stabilization of the pelvis throughout the prolotherapy injection period and up to 16 weeks post prolotherapy. This timeframe respects purported tissue healing time lines and scar tissue maturation.[23]

Multiple researchers have reported that joint manipulation produces significant positive outcomes in persons suffering from SIJ dysfunction;[24,25] however, few provide reasoning for the specific manipulation selected.[26-29] Contrary to past research, the authors used the clinical examination to dictate the selected technique. Additionally, therapeutic stabilization exercises have been found to be efficacious for persons with LBP as well as PGP.[24,25] It is suggested that muscles need at least 6 weeks to exhibit neuromuscular adaptation;[30] therefore, it was the goal of the authors to provide an exercise progression respecting this timeline for each phase of rehabilitation.

There have been conflicting results when comparing exercise alone with exercise and joint manipulation combined.[25] However, Nejati et al[24] performed a randomized controlled trial examining the difference between joint manipulation, joint manipulation with stabilization exercises, and stabilization exercises alone. A single session of joint manipulation was found to improve reported function and pain at 6 weeks as compared to daily stabilization exercises and daily stabilization exercises combined with a single session joint manipulation. However, exercise and exercise with manipulation were superior to manipulation alone at 12 weeks. All groups exhibited statistically significant changes in pain and reported function at 12 weeks follow-up, with no treatment superior to the other. Despite reported positive outcomes, on average, interventions did not result in resolution of pain or reported dysfunction. Additionally, the reported outcomes were observed to trend back toward base-line measures at 12-week follow-up, which may suggest the need for additional interventions and/or self-care strategies to maintain the positive outcomes. The authors have observed simi-

Table 2. Sample Stabilization Exercise Protocol

Exercise Intervention	Parameters
Phase I: Protective phase 1-2 months	**Phase I: Protective phase 1-2 months**
1. Transverse abdominus, levator ani, and multifidus	6–60 second hold 10 repetitions, daily
1a. Prone hip Active ROM IR/ER with knee bent to 90° (progression)	30-60 repetitions, daily
1a. Supine hip Active ROM IR/ER in hooklying (progression)	30-60 repetitions, daily
2. Isometric: Hip abduction, belt around knees	6–60 second hold, 5–10 repetitions, 3 times per week
2a. Isometric: Bridge, hip abduction belt around knees, and latissimus dorsi (progression)	6–60 second hold, 5–10 repetitions, 3 times per week
3. Isometric: Hip adduction	6–60 second hold, 5–10 repetitions, 3 times per week
3a. Isometric: Bridge, hip adduction with yoga block, and latissimus dorsi (progression)	6–60 second hold, 5–10 repetitions, 3 times per week
Phase II: Controlled motion phase 3-4 months	**Phase II: Controlled motion phase 3-4 months**
4. Isometric: Wall bridge, hip abduction, and latissimus dorsi	6–60 second hold, 5–10 repetitions, 3 times per week
4a. Isometric: Single leg wall bridge, hip abduction, and latissimus dorsi (progression)	6–60 second hold, 5 repetitions each side, 3 times per week
5. Isometric: Wall bridge, hip adduction, and latissimus dorsi	6–60 second hold, 5–10 repetitions, 3 times per week
5a. Isometric: Single leg wall bridge, hip adduction, and latissimus dorsi (progression)	6–60 second hold, 5 repetitions each side, 3 times per week
6. Quadruped fire hydrant	6–60 second hold, 5 repetitions each side, 3 times per week
6a. Alternating arm-leg raise (progression)	6–60 second hold, 5 repetitions each side, 3 times per week (no > 2.5 minutes each leg)
7. Front plank on knees and elbows	6–60 second hold, 5–10 repetitions, daily
7a. Front plank on toes and elbows (progression)	6–60 second hold, 5–10 repetitions, daily
8. Side plank on knees and elbow	6–60 second hold, 5–10 repetitions each side, 3 times per week (no > 2.5 minutes each side)
9. Isometric: Wall sit, hip abduction with belt, and latissimus dorsi	6–60 second hold, 5–10 repetitions, 3 times per week
9a. Isometric: Wall sit, hip abduction with belt, and latissimus pull downs with TheraBand (progression)	20 pull downs, 5 repetitions, 3 times per week
10. Isometric: Wall sit, hip adduction with yoga block, and latissimus dorsi	6–60 second hold, 5–10 repetitions, 3 times per week
10a. Isometric: Wall sit, hip adduction with yoga block, and latissimus dorsi pull downs with TheraBand (progression)	20 pull downs, 5 repetitions, 3 times per week
11. Isometric: Standing hip abduction	6–60 second hold, 5–10 repetitions each side, 3 times per week (no > 2.5 minutes each side)
Phase III: Return to function phase 5-6 months	**Phase III: Return to function phase 5-6 months**
12. Heel strike to foot flat with latissimus dorsi activation with TheraBand resistance	5x20 repetitions, each side, performed 3 times per week
12a. Heel strike hop with latissimus dorsi activation with TheraBand resistance (progression)	3x20 repetitions, each side, performed 3 times per week
13. Front plank on toes alternating leg lifts add ankle weights as tolerated	6–60 second hold, 5–10 repetitions each side, daily (no > 2.5 minutes per leg); add ankle weight as tolerated
14. Side plank on ankles with hip abduction leg lift	6–60 second hold, 5–10 repetitions each side, daily (no > 2.5 minutes each side); add ankle weight as tolerated

Abbreviations: ROM, range of motion; IR, internal rotation; ER, external rotation

lar findings and have adopted a multi-modal approach including prolotherapy when conservative management of exercise and manipulation do not resolve impaired joint mobility, motor function, and muscle performance of the pelvic girdle.

When conservative management is not successful, surgical intervention may be warranted. Fusion stabilization procedures may be performed unilaterally or bilaterally, depending on patient presentation, with the intent to reduce range of motion in the SIJ in order to improve overall pelvic stability.[31] However, current evidence is limited regarding the efficacy of surgical fusion for the management of SIJ syndrome. Authors suggest that "results are variable, with good to poor outcomes reported."[32] One recent randomized controlled trial by Dengler et al[33] reported that patients who underwent SIJ arthrodesis demonstrated significant improvements of 50% reduction in LBP and dysfunction compared to those who received conservative treatment.[13,34] According to a collaborative model of PGP representing the collective views of a group of experts, "SIJ surgery" was suggested as the third most effective intervention to impact a patient's quality of life and pain; however it was considered less effective in improving a patient's level of disability.[32] Despite these results, it should be noted most available literature reports on small sample sizes and patients with multi-year persistent SIJ pain, thus limiting the generalization of results.

The authors of the current case report recommend the use of prolotherapy as a less invasive means to improve pelvic girdle stability without the increased risks associated with surgery. Prolotherapy has the potential to preserve pelvic ring function in women of child bearing years. Prolotherapy is not currently recommended as an intervention by the European Guideline on PGP secondary to the limited supportive research. Yelland et al[35] failed to show a significant difference between groups treated with either a series of 6 prolotherapy injections and exercise or normal activity or a control injection of lidocaine and exercise or normal activity. However, the exercises Yelland et al[35] suggested were not specific to muscle groups purported to support force closure and were not progressive to challenge return to function demands. Additionally, the protocol used for the 3 patients in this case series not only used a series of 3 injections every 2 weeks but also included manipulation of the pelvic girdle, as needed, prior to the procedure and application of pelvic girdle compression belt to assist with immobilization during collagen maturation.

This is a retrospective, single-center, single-physical therapist, and single-physician case series. Secondary to the limited number of cases the ability to generalize these findings to persons with PGP are limited. Therefore, it would be beneficial to further explore these issues using more robust approaches such as within a randomized controlled approach. Although the passage of time could account for the observed success and high patient satisfaction rating, this is probably unlikely considering the persistent nature of symptoms and previous management in these patients without resolution prior to being treated by the authors of this case series. This case series highlights the importance of a collaborative model of care for managing persons with persistent PGP and dysfunction who have failed conservative management.

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Congratulations 2020 Awardees

The American Physical Therapy Association (APTA) has announced the 2020 Honors and Awards program recipients. The following members of the Academy of Orthopaedic Physical Therapy have been selected by APTA's Board of Directors to receive the following awards:

Catherine Worthingham Fellows of APTA
Jennifer Stevens-Lapsley, PT, PhD, FAPTA
Kenneth Harwood, PT, PhD, FAPTA
Joseph M. Donnelly, PT, DHS, FAPTA
Board-Certified Orthopaedic Clinical Specialist
Sandra L. Kaplan, PT, PhD, FAPTA
Leland E. Dibble, PT, ATC, PhD, FAPTA
Stephen J. Hunter, PT, DPT, FAPTA
Board-Certified Orthopaedic Clinical Specialist
Robin L. Marcus, PT, PhD, FAPTA
Board-Certified Orthopaedic Clinical Specialist
Paul A. Rockar, Jr, PT, DPT, MS, FAPTA

26th John J.P. Maley Lecture Award
Timothy W. Flynn, PT, PhD, FAPTA
Board-Certified Orthopaedic Clinical Specialist

Lucy Blair Service Award
Douglas M. White, PT, DPT
Board-Certified Orthopaedic Clinical Specialist
Lucinda Pfalzer, PT, PhD, FAPTA
Elmer Platz, PT
Alan V. Meade, PT, BSPT, DScPT
Paul A. Rockar, Jr, PT, DPT, MS, FAPTA
Danny D. Smith, PT, DPT
Board-Certified Orthopaedic &
Sports Clinical Specialist

Marilyn Moffat Leadership Award
Paul A. Rockar, Jr, PT, DPT, MS, FAPTA

Henry O and Florence P Kendall Practice Award
Michael J. Moore, PT

Outstanding PTA Award
Natalie Noland, PTA, BS

Humanitarian Award
Michael Geelhoed, PT, DPT
Board-Certified Orthopaedic Clinical Specialist

Societal Impact Award
James R. Giebfried, PT, DPT, MA, MBA

Marian Williams Award for Research in Physical Therapy
Christopher M. Powers, PT, PhD, FAPTA

Mary McMillan Scholarship Award
Brittanie Brantley, PTA

Eugene Michels New Investigator Award
Daniel White, PT

Dorothy Baethke-Eleanor Carlin Award for Excellence in Academic Teaching
Mark Bishop, PT, PhD, FAPTA

Outstanding PT Resident Award
Lindsay White Walston, PT, DPT
Board-Certified Neurologic and Orthopaedic Clinical Specialist

Dorothy Briggs Memorial Scientific Inquiry Award
Richard S. Severin, PT, DPT
Board-Certified Cardiovascular and Pulmonary Clinical Specialist
Adam Wielechowski, PT, DPT
Board-Certified Orthopaedic Clinical Specialist

Chattanooga Research Award
Linda J. Resnik, PT, PhD, FAPTA

We applaud these individuals for their outstanding accomplishments!

President's Message

Rick Wickstrom, PT, DPT, CPE

I am pleased to announce that OHSIG leaders have established a new mission, vision, and strategic initiatives to align with the AOPT Strategic Plan and initiative priorities that were finalized at CSM 2020. OHSIG members may access this document from our website at https://www.orthopt.org/content/special-interest-groups/occupational-health.

This is a good time to reflect about how our actions moving forward each day position us for future success in our area of expertise. I would like to call out several examples of professionalism and actions within our OHSIG and throughout our professional association that have encouraged or inspired me during this uncertain time:

- Our Work Rehab CPG Subcommittee led by Lorena Payne and Dee Daley has completed a quality review of 291 additional articles for the Work Rehabilitation CPG and have submitted this evidence-based practice manuscript for review.
- Our Communications Committee led by Cory Blickenstaff and Peter McMenamin is forging ahead with an update of our Current Concepts document on the Role of the PT in Occupational Health. This outward facing document will communicate our qualifications and expertise to outside stakeholders.
- We are recruiting members to a new Membership Subcommittee that is charged with our strategic initiative of establishing key contact OHSIG member experts in all states to enhance payment and service opportunities in occupational health. If you have a passion for payment policy advocacy in occupational health in your state, please let us know about your interest in getting involved.
- OHSIG leaders submitted a proposal to AOPT to establish an educational program and certificate in occupational health as our centerpiece initiative to support OHSIG's vision is to lead the world in optimizing movement, musculoskeletal health, and work participation from hire to retire.

Finally, I would like to acknowledge Steve Allison for his assistance with educational and strategic planning in his new role as our OHSIG VP/Education Chair. Steve also took the lead in writing the article for this issue of *OPTP* about the *Role of the Physical Therapist to Promote Fitness-For-Duty of Commercial Drivers.* Steve was the first physical therapist in Louisiana to become a Certified Medical Examiner in 2015, which was before Louisiana upgraded its scope of practice for direct access. His example inspired me to pursue this certification myself during the downtime created by the COVID-19 pandemic. Steve mentored me on a successful petition request to get a letter from the PT Section of the Ohio OTPTAT Board to clarify that DOT Physicals are within the scope of practice of physical therapists. Steve and I both hope that our article and advocacy success in Louisiana and Ohio will prompt physical therapists in other states to pursue this examiner certification in occupational primary care!

The Role of the Physical Therapist to Promote Fitness-For-Duty of Commercial Drivers

Steve Allison, PT, DPT, OCS, CME | *Rick Wickstrom, PT, DPT, CPE*

INTRODUCTION

Obesity is a major concern in Workers Compensation insurance. A retrospective cohort study by Ostbye et al[1] found a strong linear relationship between body mass index (BMI) and the rate of Workers' Compensation claims, lost workdays, medical costs and indemnity costs. This study[1] found that injury rates were 2 times higher, lost workdays were 13 times higher, medical claims costs were 7 times higher, and indemnity claims costs were 11 times higher for the heaviest employees as compared to those employees falling within the recommended weight guidelines.

Obesity is an even bigger concern for commercial drivers when compared to other occupations. The prevalence of obesity is over 69% of commercial truck drivers, compared to 31% of working adults in the United States.[2] Most drivers reported low physical activity, poor dietary habits, and sleep deficits that contribute to obesity.[3-4] Obstructive sleep apnea is associated with obesity and poses a serious public health concern in drivers because of its association with a higher risk of motor vehicle crashes.[5] Long haul truck drivers have additional lifestyle challenges because they may be away from home for days or weeks at a time. A recent study of 2014-2018 Workers' Compensation lost-time claims by the state of Massachusetts ranked Transportation & Warehousing (2-digit NAICS 48) as the highest priority industry sector for prevention.[6]

Traditional workplace wellness programs often emphasize cardiovascular risks but ignore musculoskeletal risks that are more relevant to prevent or manage workers' compensation claims. Song et al[7] demonstrated that clinical biometrics such as blood lipid and productivity outcomes do not significantly improve in response to traditional workplace wellness programs. This approach fails to consider the unusual work lifestyle of truck drivers and musculoskeletal risk factors that contribute to higher injury or disability risks for these drivers compared to more physically demanding occupational groups. Fatiguing job demands, low social support, and not allowing workers to participate in activities during work hours are key factors that reduce worker participation in wellness programs.[8] With these considerations in mind, the purpose of this article is to inform physical therapists about how to become certified to conduct Department of Transportation (DOT) physical examinations and apply expertise in diagnosis of musculoskeletal movement disorders to promote safety and wellness of drivers from hire to retire.

FEDERAL MOTOR CARRIER SAFETY ADMINISTRATION

The Federal Motor Carrier Safety Administration (FMCSA) is the lead federal government agency responsible for regulating and providing safety oversight of commercial motor vehicles. The mission of FMCSA is to reduce crashes, injuries, and fatalities involving large trucks and buses.[9] The Medical Program Division of the FMCSA promotes the safety of American's roadways through the promulgation and implementation of medical regulations, guidelines, and polices that ensure vehicle drivers engaged in interstate commerce are physically qualified to perform their jobs as commercial truck and bus drivers.[10]

PHYSICAL DEMANDS OF COMMERCIAL DRIVING

The physical demands of commercial truck driving requires that drivers be able to have sufficient balance, flexibility, range of motion, and strength to be able to safely perform essential job functions including but not limited to climbing into and out of 18-wheel trucks and trailers; coupling and uncoupling trailers; load, secure, and unload cargo; and to perform pre-trip and post-trip inspections. In addition, CMV drivers need to have adequate vision and hearing to safely operate these large vehicles over the road.[11]

COMMERCIAL TRUCK & BUS CRASH STATISTICS

Information from the National Transportation Safety Bureau crash statistics has indicated that inadequacy in the medical certification process for CMV drivers with serious disqualifying medical conditions has directly contributed to fatal and injury crashes.[12] According to the most recent full calendar year statistics from the FMCSA in 2018:

- 4,979 large trucks and buses were involved in fatal crashes.
- 96,944 large trucks and buses were involved in injury crashes.[13]

Analysis of 2004-2011 data from the National Health Interview Survey found the highest prevalence of obesity in the transportation and material moving industry sector, especially motor vehicle operators, irrespective of gender and race/ethnicity.[14] A survey by Yeary et al[15] of transit school bus drivers found that resources for healthy eating and physical activity were limited in the garage work locations, which may account for why most bus drivers were obese and unable to meet physical activity or dietary recommendations. The rate of injury for cases that involved days away from work, job transfer or restrictions is 2.7 per 100 workers in the Truck Transportation Industry (NAICS 484)[16] and 2.5 per 100 workers in the Transit and Ground Passenger Transportation Industry (North American Industry Classification System [NAICS] 485).[17] Transit and intercity bus drivers have two times the rate of injury for musculoskeletal disorders when compared to light truck and delivery drivers that have much more physical duties.[18]

NATIONAL REGISTRY OF CERTIFIED MEDICAL EXAMINERS

The National Registry of Certified Medical Examiners (National Registry) is a Federal program that establishes training and certification requirements for health care professionals that perform physical qualification examinations for commercial truck and bus drivers, commonly referred to as DOT medical examinations. The National Registry was created to ensure that medical examiners have sufficient understanding about how FMCSA medical regulations and related guidance apply to CMV drivers, to enhance CMV driver health, and to reduce CMV driver-related highway crashes. Upon completion of required training, the health care professional may print their certificate qualifying them to sit for the National Registry of Certified Medical Examiners (NRCME) examination and if successful become a Certified DOT Medical Examiner.

DOT MEDICAL EXAMINATIONS

As of May 21, 2014, only certified Medical examiners listed on the National Registry are allowed to perform CMV driver physical examinations, to determine a driver's fitness-for-duty using the Medical Examination Report Form (Form MCSA-5875).[19] Medical examiners are required to review the driver's reported health history, and discuss any medical issues or the use of any medications that could be disqualifying or impair the driver's ability to safely operate a large truck or bus. Medical examiners should obtain additional tests or consultations from other medical professionals, as necessary, to adequately assess the medical fitness of a driver.

BASIC TESTS

Medical examiners are also required to review basic test results and perform a physical examination to determine a CMV driver's fitness-for-duty. Basic test results include:

- Height
- Weight
- Pulse rate
- Pulse rhythm
- Blood pressure
- Urinalysis (specific gravity, protein, blood, and sugar) done by urine dipstick
- Vision screening tests
  - Visual acuity done by Snellen chart or comparable test
  - Horizontal field of vision test
  - Color vision test (red, green, and amber)
  - Referral for testing by optometrist or ophthalmologist if necessary
- Hearing screening tests
  - Forced whisper test
  - Referral for audiometric testing when necessary

Trained assistive personnel may perform the basic tests listed above and record test results. However, medical examiners are required to review and attest to the validity of all documented test results. When blood pressure, pulse rate, or both are significant factors in a medical examiner's decision not to certify a driver, it is recommended that medical examiners obtain their own measurements. Abnormal urine dipstick readings may also indicate the need for referral to another medical provider for additional testing to adequately assess a driver's medical fitness-for-duty.

PHYSICAL EXAMINATION

The medical examiner is required to perform the physical examination and document any abnormal findings, even if not disqualifying. The medical examiner should indicate whether the abnormality affects a driver's ability to safely operate a CMV, and if additional medical evaluation is needed to adequately determine medical fitness for duty. The DOT physical examination consists of a basic screening of the following body systems for any abnormalities:

- General
  - Posture, tremors, affect, demeanor, fragile, obese, and signs of alcohol or drug abuse
- Skin
  - Discoloration, burns, wounds, and scars
- Eyes
  - Pupillary equality, reaction to light and accommodation, ocular motility, ocular muscle imbalance, extraocular movement, nystagmus, and exophthalmos
- Ears
  - Scarring of tympanic membrane, occlusion of external canal, and perforated eardrums

- Mouth/Throat
  - Sores or discoloration
- Cardiovascular
  - Arrythmia, murmur, extra sounds, enlargement, pacemaker, implantable cardioverter defibrillator, pitting edema in lower extremities, or other signs of cardiac disease
- Lungs/Chest
  - Abnormal chest wall expansion, respiratory rate, breath sounds including wheezes or alveolar rales, cyanosis, clubbing of fingers, or other signs of pulmonary disease
- Abdomen
  - Enlarged liver and spleen, masses, bruits, hiatal and umbilical hernia, significant abdominal wall muscle weakness, tenderness, and bowel sounds
- Genito-urinary System including Hernias
  - Inguinal hernias resulting in driver discomfort and results from urine dipstick results for signs of underlying medical problems
- Back/Spine
  - Deformities, limitations of motion, muscle spasm at rest or with range of motion testing, and tenderness
- Extremities/Joints
  - Loss, impairment or deformity of arm, hand, finger, leg, foot or toe; sufficient grasp and prehension in the upper limbs to maintain steering wheel grip; sufficient mobility and strength in the lower limbs to operate pedals properly; sufficient mobility and strength in upper and lower limbs for climbing; signs of progressive musculoskeletal conditions such as muscle atrophy, weakness, or hypotonia; clubbing or edema in the extremities that may indicate the presence of an underlying heart, lung, or vascular condition
- Neurological System including Reflexes
  - Impaired coordination, speech pattern, deep tendon reflexes, Babinski' reflex, and sensory impairment
- Gait
  - Ataxia, balance, and limp
- Vascular System
  - Abnormal pulse and amplitude, carotid or arterial bruits, varicose veins, and other signs of arterial or venous insufficiency

MEDICAL CERTIFICATION OF CMV DRIVER

The CMV drivers must obtain an updated DOT medical examination at least every two years to ensure they remain medically fit-for-duty. Certain medical conditions and/or findings may warrant periodic medical monitoring with medical certifications issued for shorter time periods, and other medical conditions and/or findings are automatically disqualifying.

Determining medical fitness-for-duty is ultimately the responsibility of the certified medical examiner. While other medical specialists' opinions about a driver's ability to safely operate a commercial vehicle, the final determination rests with the certified medical examiner to protect public safety.

PHYSICAL THERAPIST EDUCATION

The practice of physical therapy continues to evolve in response to societal needs, regulations, and as evidenced-based clinical practice guidelines become available. Currently, all 256 accredited physical therapy programs in the United States confer a Doctor of Physical Therapy (DPT) degree. To practice as a physical therapist in the United States, individuals must graduate from a Commission Accreditation of Physical Therapy Education accredited DPT program and pass a national licensure examination.

The required curriculum in all accredited DPT programs includes content and learning experiences in the biological, physical, behavioral, and movements sciences necessary for entry level practice. Topics covered include anatomy, physiology, genetics, exercise science, biomechanics, kinesiology, neuroscience, pathology, pharmacology, diagnostic imaging, histology, nutrition, and psychosocial aspects of health and disability.

The DPT curriculums also include content and learning experiences about the cardiovascular, endocrine, metabolic, gastrointestinal, genital and reproductive, hematologic, hepatic and biliary, immune, integumentary, lymphatic, musculoskeletal, nervous, respiratory, renal and urologic systems, and medical and surgical conditions across the lifespan commonly seen in physical therapy practice.[20]

PHYSICAL THERAPIST SCOPE OF PRACTICE

Physical therapists are qualified by professional training and national licensure to establish a diagnosis based on an individual's history, systems review, and tests and measures from a physical examination and any other relevant diagnostic testing.[21] Physical therapists practicing in private or hospital-based outpatient clinics routinely perform hundreds to thousands of physical examinations every year. Physical therapists are uniquely qualified to evaluate the effects various medical conditions have on an individual's ability to function. It is not uncommon during physical examinations for physical therapists to uncover medical conditions that have not been diagnosed by a medical doctor. In these instances, physical therapists refer the patient back to their treating doctor or their primary care physician for further medical evaluation.

Physical therapists specializing in occupational health routinely perform physical examinations as part of a pre-employment/post-offer and fitness-for-duty functional testing protocol for employers representing a wide range of industries. It is common to find significant musculoskeletal impairments during physical examinations of "apparently healthy" individuals who have no reported history of problems. Musculoskeletal impairments commonly encountered during physical examinations include rotator cuff tears, joint and spine stiffness with loss of motion, joint instability, scoliosis, and hiatal hernias. However, other medical conditions such as Parkinson's disease, progressive idiopathic polyneuropathy, impending hip fractures associated with avascular necrosis, diabetes, high blood pressure, vision deficits, and hearing loss have all been discovered during physical examinations performed by physical therapists.

NATIONAL REGISTRY REQUIREMENTS

To become a certified DOT medical examiner and be listed on the National Registry, health care professionals must complete training and testing on the FMCSA physical qualifications standards and guidelines. As of May 21, 2014, all medical certificates issued to interstate truck and bus drivers must come from medical examiners listed on the National Registry. To become a certified medical examiner, a health care professional must meet the following requirements:

- Be licensed, certified, or registered to perform medical ex-

aminations in accordance with applicable State laws and regulations.
- Complete a training program in FMCSA's physical qualification standards and guidelines conducted by a private-sector training provider accredited by a nationally recognized medical profession accrediting organization that provides continuing education credits.
- Pass the FMCSA medical examiner certification test administered by an FMCSA-authorized private-sector testing organization.[22]

Currently, five (5) Physical Therapy State Licensure Boards (TX, AR, LA, ND, and OH) in the United States have determined that it is within the scope of physical therapists to perform physical examinations as required by the U.S. Department of Transportation, Federal Motor Carrier Safety Administration.

INTEGRATING WELLNESS FOR TRUCK DRIVERS

In the past few decades, workplace wellness programs have grown in popularity to promote healthy lifestyle behaviors and improve the management of chronic diseases such as diabetes, heart disease, chronic lung disorders, depression, and cancer. Among different types of wellness programs and strategies (eg, health coaching, health education/literacy, lifestyle management), 80% of programs offer health screenings such as health risk assessment surveys and biometric screenings with feedback to reduce personal health risks or better manage chronic disease.[23] In a robust review of 51 studies of workplace wellness published between 1984 and 2012, Baxter et al[24] reported a negative return on investment when they only considered randomized control trials and excluded early return to work and workplace injury prevention studies. Wipfli et al[25] conducted a cluster-randomized trial of a weight loss intervention for truck drivers that included a web-based computer and smart phone-accessible format and group weight loss competition that included self-monitoring of body weight and behavior, computer-based training, and motivational interviewing by health coaches. They found that program completers demonstrated greater weight loss than those who did not. Web-based self-monitoring of body weight and health behaviors was found to be particularly impactful for this mobile population.

There are several major concerns about how workplace wellness programs are currently implemented. First, traditional programs often emphasize cardiovascular risks, but ignore musculoskeletal fitness risks that are more relevant to workplace injury prevention, disability management, and lifestyle functioning of workers. Musculoskeletal disorders are the most common medical conditions in adults under 65, resulting in an estimated annual cost of $980 billion for medical treatment and lost wages in the United States.[26] Second, significant financial and administrative costs are required to implement health risk screening and follow-up program interventions. As a result, smaller employers are more likely to limit the scope of biometric screening to review tobacco use, calculate BMI (weight in kilograms divided by the square of height in meters), and check for abnormal blood pressure.[27] Blood work (eg, blood cholesterol, blood glucose) and aerobic fitness tests are often excluded due to financial or scheduling constraints. Third, feedback in the form of educational messages is often missing or inadequate to promote behavioral change. For example, workers may receive generic recommendations to increase their physical activity when obesity is present; however, no objective biometrics of physical fitness are routinely included in most programs to support accountable care and promote suitable physical activity of workers from hire to retire.

RECOMMENDATIONS TO IMPROVE DRIVER FITNESS-FOR-DUTY

Since employers often pay the cost for the DOT physical examination, they often select the site where the driver receives the examination. This examination is mandated to occur at least every two years; therefore, this creates potential for the same examiner to monitor the movement performance of drivers from hire to retire. If a movement screen is integrated with the DOT physical examination process, then pre-injury baseline information collected would support follow-up health coaching to reduce the personal and economic cost of musculoskeletal disorders. The DOT examination process allows flexibility to collect objective metrics that relate to musculoskeletal fitness.

Establishing a baseline of objective measures to quantify functional movement performance to supplement the DOT Physical Examination. This will benefit the design of wellness and health care programs in the following ways:

- Objective measures create accountability to motivate lifestyle behavioral changes to promote healthy physical activity.
- Establishing some normative data on these tests for long haul and passenger transport drivers will support interpretation of driver results to motivate fitness accountability.
- Establishing a pre-injury baseline of functional performance facilitates the setting of realistic functional recovery goals.

Linking the DOT Medical Examination with objective movement biometrics and health coaching would encourage drivers to engage in suitable physical activities and dietary management practices that would be realistic for their challenging work-life schedules.

CONCLUSION

The extensive training physical therapists receive in screening for disease and evaluation of the neuromusculoskeletal system provide the firm foundation for performing very thorough commercial driver fitness-for-duty physical examinations. Most items required during a DOT physical examination are second nature and routine for many physical therapists. However, there are a few items listed for the DOT physical examination that will require some refresher training during post-professional continuing education.

The authors strongly encourage more physical therapists to use their expertise and specialized knowledge in functional screening to become certified DOT medical examiners. Before proceeding with FMCSA-mandated training, you should make sure that FMCSA has received a clarification letter from your state licensing board that the DOT physical examination is within your scope of practice. This scope of practice issue has already been established as a precedent in Arkansas, Louisiana, North Dakota, Ohio, and Texas. We hope that you consider the Occupational Health Special Interest Group (OHSIG) as a primary resource to excel in services such as DOT Examinations that promote a healthy and safe work force. The OHSIG facilitates professional development, shares current information, identifies opportunities for collaboration among related organizations, and supports physical therapy professionals in occupational health practice and research initiatives.

(Continued on page 166)

OCCUPATIONAL HEALTH

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President's Message

Laurel Daniels Abbruzzese, PT, EdD

Greetings PASIG members! As physical therapists dedicated to serving the performing arts community, we are all familiar with the phrase, "The show must go on!" It is a saying used to encourage people to keep doing what they are doing even if they are experiencing difficulties and things are not going as planned. For many performing artists, "the show" met its match in the form of COVID-19.

On March 12th, Broadway went dark in New York City, and in an effort to protect public health, traveling off-Broadway shows, music concerts, gigs, and festivals have been cancelled all across the country. Major ballet companies have cancelled their spring seasons.

Collegiate dancers are finishing out their semesters taking class in their homes, using chairs and bed rails as ballet barres. Summer dance intensives are being cancelled or offered virtually. "Drawn to Life" by Cirque du Soleil® & Disney, which has been preparing all year, was forced into quarantine 4 days before its scheduled opening this past March. It was heartbreaking for all of their performers and the health care team that had to be let go without a return-to-work date.

It is the first week of May as I write this letter and the future remains uncertain. Social distancing is still a priority and reopen dates for most across the country have yet to be announced. For some of our performing arts therapists affiliated with larger teach-

(Continued on page 175)

Hello AOPT Foot and Ankle SIG members!

We write this newsletter in the midst of widespread stay-at-home orders across the country. Social-distancing, home-schooling, synchronous and asynchronous learning, telehealth, and personal protective equipment have all become a norm in our vocabulary, and lives. In this time of constant shuffling and re-shuffling of plans and priorities, it is a bit difficult to write about the FASIG initiatives for the year. But, in the midst of change there is also excitement. It is nice to have the time to move some of our planned tasks ahead and exciting to see how the "new-normal" may expand how we do things in the future. Highlights for a few of the FASIG initiatives are included below. The FASIG would also like to recognize the wonderful contribution of Dr. Kimberly Veirs, MPT, PhD, ATC, who submitted the manuscript titled, *Multi-Segment Assessment of Ankle and Foot Kinematics during Relevé Barefoot Demi-Pointe and En Pointe* for this edition of *OP*. This study provides a wonderful example of shared interest between the FASIG and the Performing Arts SIG and an opportunity to promote a greater understanding of multi-segment foot motion in dancers—a group with truly amazing feet!

- The American Orthopaedic Foot and Ankle Society (AOFAS) Annual Meeting is planned for September 9-12 at the San Antonio Convention Center. This is an example of plans that remain in flux. The FASIG continues to work with the AOFAS planning committee to develop high-level foot and ankle programming. This remains an exciting opportunity because this year the content may be delivered

(Continued on page 179)

Multi-Segment Assessment of Ankle and Foot Kinematics during *Relevé* Barefoot and *En Pointe*

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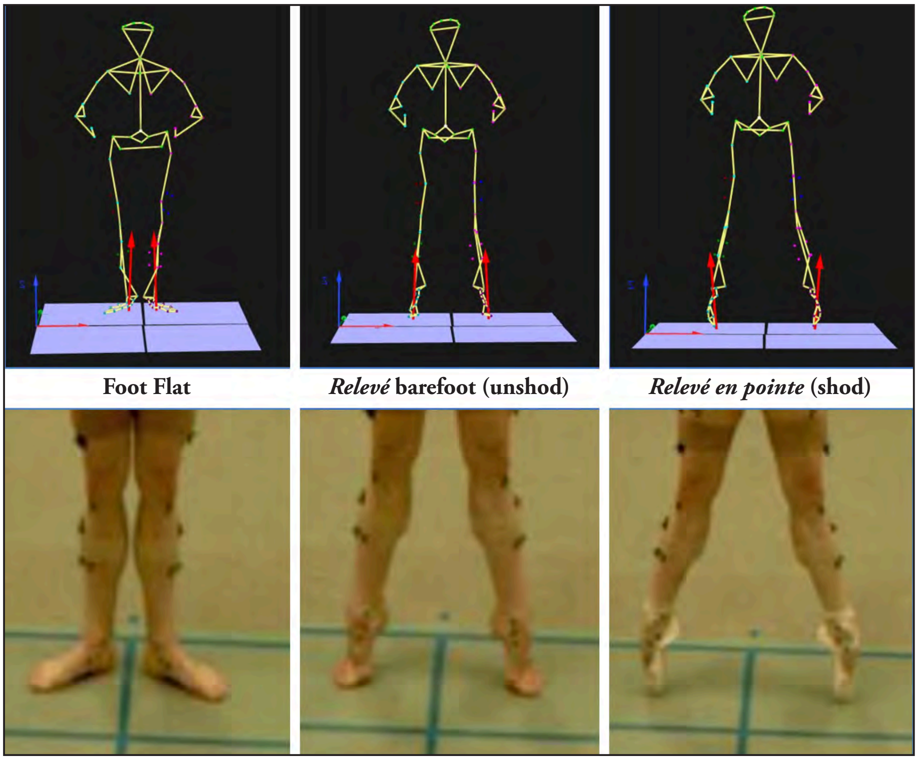
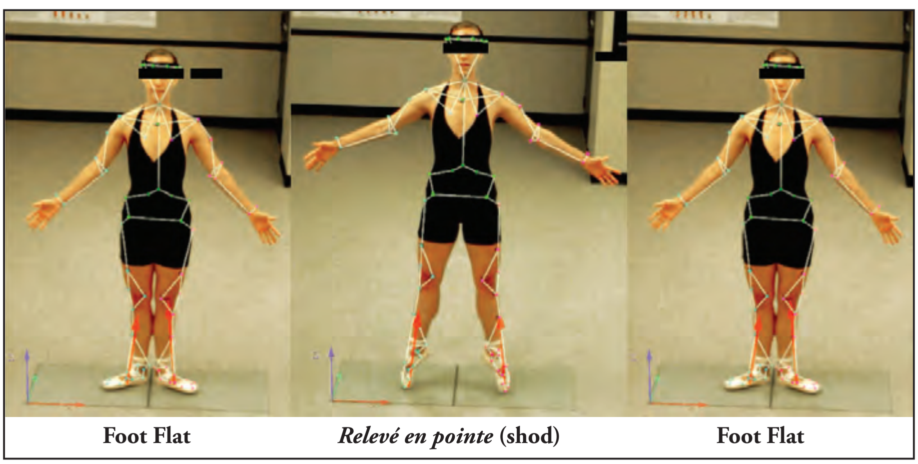
As many as 95% of dancers sustain at least one injury each year throughout their career.[1] Epidemiologists link dance-related injury rates to multiple factors, such as level of training, demographics (eg, age and gender), poor muscle strength and motor control, flexibility (insufficient or excessive), faulty alignment, and joint range of motion (ROM) (eg, hypermobility).[1,2] Although the definitive risk factors linked to the high prevalence of injury are largely unknown, there is extensive evidence that overuse, linked to repetitive movement, causes the preponderance of injuries among ballet dancers.[2] Fundamental ballet dance repertoire requires the performer to repetitively move through and balance in extreme ranges of motion of the foot and ankle complex, possibly contributing to the high rates of injuries among dancers.[3] Unique to ballet art form, dancers must balance and perform while in *relevé* barefoot (Picture 1; standing unshod on the balls of the feet [the metatarsal heads]; also called "demi-pointe") and *en pointe* (Picture 1; standing on the toes in pointe shoes [shod] with maximum plantar flexion (PF) of the ankle joint in pointe shoes). One way to assume *relevé* is to rise onto demi-pointe or *en pointe* by plantar flexing the foot (lifting the heel then the midfoot) with the knees and hips extended and the trunk held upright. This movement is commonly called *elevé* (Picture 2).[4]

Dancing barefoot and *en pointe* places different stresses and strains on the dancers' body and requires distinctive technical demands in part because the pointe shoe functions to provide stiffness for support and stability.[3,5,6] Pointe shoes are fabricated of a toe box (layers of burlap, cardboard, and/or paper glued together to form the standing platform and the vamp), shank (the cardboard and/or leather insole of the shoe), and satin covering.[6] When *en pointe*, the dancer stands on the toe box platform and must have support from the shank for safety.[6] The dancers' fully plantar flexed or "pointed" foot is proposed to come from the combined movement of the ankle (talocrural) joint and the 4 segments of the foot-complex: the hindfoot, midfoot, forefoot, and first meta-



Picture 1. First position images from Qualisys™ (Red arrows are ground reaction force arrows from AMTI force plates).



Picture 2. *Elevé* event (foot flat to foot flat events).

tarsal phalangeal (MTP) joint or hallux.[3] This combined movement allows for tri-planar ROM (supination and pronation) with 3 degrees of freedom: PF/dorsiflexion (DF), adduction/abduction, and inversion/eversion.[3] Radiographic studies measuring dancers at end-range of DF and PF found that, on average, the talocrural joint provides 70% of the ROM while the combined movement of the foot-complex joints account for the remaining 30%.[7] Precisely which joints and to what degree each of the foot-complex segments move to attain the remaining 30% of these movements have not been described.[4] Only recently have technological advances provided the tools necessary to evaluate the foot-complex *in vivo* during movement.

Three-dimensional (3D) motion capture systems are valid and reliable tools that have the capacity to record *in vivo* kinematics of the ankle and foot in all three planes of movement (sagittal, frontal, and transverse) during gait and other dynamic movements using reflective tracking markers.[8,9] Much like sports medicine, dance medicine researchers are using whole-body 3D motion capture technology as an initial assessment tool to describe biomechanics unique to the dance population and ascertain risk for injury.[4] Yet, there is a dearth of literature describing the *in vivo* kinetics and kinematics of the foot-complex during fundamental dance-specific movements, limiting the clinician's ability to adequately evaluate dancers' technique.

The foot and ankle are assessed during whole-body motion capture to varying degrees of specificity based on the number and placement of reflective tracking markers.[9] The number and placement of tracking markers on anatomical landmarks create a biomechanical model used for analyzing *in vivo* kinematics.[10] The 3D single-segment foot models combine the foot-ankle complex into one rigid body whereas 3D multi-segment foot models (3DMFM) allow for evaluation of the foot segments separate from the ankle joint.[9,10] Thus, a comprehensive evaluation of the dancers' foot-complex separate from the ankle joint requires evaluation of dance-specific movement using a 3DMFM.[8]

Carter et al[11-13] were the first to analyze dance-specific movement using a 3DMFM by modifying 6 components of the Rizzoli foot model (RFM) on barefoot dancers. Carter et al[11] specifically tested reliability of their proposed 3DMFM specific for dance movement using intraclass correlation coefficients (ICC). Investigators reported high intra- and inter-assessor reliability for first MTP sagittal plane joint movement (ICC ≥ 0.75) and poor to excellent inter-assessor reliability (0.5 > ICC ≥ 0.75) for 3 of the 5 inter-segmental angles during the point-flex-point trials, including the midfoot segments. These results provide evidence that using a multi-segment foot model has the potential to be a valuable tool to evaluate total, segmental, and inter-segmental ROM of the foot and ankle during dance-specific movement.[11] A thorough literature review through 2018 garnered no evidence of a study that applied a 3DMFM to dancers in pointe shoes or a study that directly compared *in vivo* biomechanics of dancers performing movement barefoot (BF) and *en pointe*,[4] whereby necessitating a pilot study to explore the capability of a biomechanical foot model to describe foot movement in these two conditions.

The primary purposes of this manuscript are to advance the physical therapists' understanding of the unique demands placed on the foot-complex when balancing in *relevé* and describe the biomechanical differences between the barefoot and *en pointe* conditions. Evidence presented is based on results from a larger cross-sectional pilot study and aim to augment the dance-specific functional evaluation of the ankle and foot-complex. The pilot study was conducted to describe and compare the kinematics at 18 joint angles (Table 1) for healthy, elite ballet dancer's foot and ankle in two conditions, BF and *en pointe*, during *relevé* in first position using a modified RFM.[14,15] Investigators chose the RFM over other multi-segment foot models described in the literature because it has been validated for use with several different patient populations[9,16-19] and is one of the few 3DMFM's consistently described as highly reliable[11,18,20] and repeatable[16,21] on the BF. Additionally, the RFM demonstrated repeatability thresholds that are consistent with BF findings when applied to a shoe during gait.[22] Because dance-specific movement requires extreme ROM to perform correctly[3,7,11,23] (eg, ankle PF and hallux extension in BF *relevé*), the RFM required modifications to design the BF and shod dance-specific models. These modifications also aimed to increase the accuracy of marker placement on the shoe.[24] The pilot study model included 5 segments, the ankle, hindfoot/calcaneus, midfoot, forefoot/metatarsals, and the hallux, which enabled analysis of the total, segmental, and intersegmental kinematics of the foot-ankle complex during dance-specific movement (see Table 1).

MATERIALS AND METHODS

Instrumentation and Biomechanical Model

A 12-camera Qualisys™ Motion Analysis System housed in the Center for Human Performance (CHPM) laboratory at the University of Oklahoma Health Sciences Center (OUHSC), College of Allied Health recorded 3D kinematic and kinetic data on 11 elite ballet dancers. The cameras, mounted in a fixed configuration, tracked reflective surface markers that were attached to anatomical landmarks using double-sided tape. A digitized procedure captured the 3D coordinates of each marker subsequently used as the basis for calculating segmental joint angles[25] during dance-specific movement. The AMTI Force plates (AMTI, Watertown, MA) simultaneously recorded ground reaction forces and center of pressure location data at 2,400 Hz.

Seventy-six reflective skin-mounted anatomical markers and two sets of cluster tracking markers affixed in the same stepwise fashion using double-sided tape enabled whole-body recording of *in vivo* motion-related data.[4] Forty of the reflexive markers were secured to the trunk and pelvis (sternum, R/L acromions, C7, R/L infrascapular angles, L3, R/L posterior superior iliac spines, R/L iliac crests, R/L anterior superior iliac spines [ASIS], and the apex of the sacrum), the upper extremities (R/L humeri, R/L medial and lateral epicondyles, R/L olecranons, R/L radii, and R/L ulnas), and the lower extremities (R/L greater trochanters, R/L thigh at

Table 1. Range of Motion Angle Differences (BF-Shod) at the Peak *Relevé* Event of the *Elevé*

Angle	HL Estimates	95% CIs	p-values	Greater angle	Med BF	Med Shod	Med Diff
Ankle DF-PF	-5.9839	-12.7280, 2.5090	0.123	Shod	161.3	167.8	-6.5
Hallux Ext	-14.311	-25.4691, -3.6271	**0.0147***	Shod	120.7	134.6	-13.9
S2F	-6.0194	-11.3217, 2.3147	0.123	Shod	11.3	18.0	-6.8
S2V	6.9953	3.1586, 13.0299	**0.0005***	BF	19.6	13.1	6.6
MLA	8.9625	1.1523, 15.9241	**0.0115***	BF	99.9	90.9	9.1
Sha-Cal	-4.0922	-12.3305, 2.9732	0.2475	Shod	30.8	34.4	-3.6
Cal-Met X	-5.199	-22.6924, 10.8574	0.393	Shod	-5.7	2.2	-7.9
Cal-Met Y	-4.1718	-14.9302, 6.6361	0.4813	Shod	-6.9	-4.2	-2.6
Cal-Met Z	50.1423	36.8909, 62.0782	**<0.0001***	BF	-51.3	-93.7	42.3
Cal-Mid X	-4.0232	-13.2716, 6.0938	0.6305	Shod	-7.8	-5.1	-2.7
Cal-Mid Y	-0.3038	-5.9829, 5.4265	0.9705	Shod	-4.5	-4.8	0.33
Cal-Mid Z	21.4409	2.3898, 35.9351	**0.0355***	BF	7.5	-17.5	24.9
Met-Hal X	7.5787	-2.2257, 19.1839	0.123	BF	3.6	-2.9	6.5
Met-Hal Y	7.6086	-5.5495, 19.3123	0.315	BF	9.0	6.1	2.9
Met-Hal Z	-0.0927	-17.2969, 18.7823	0.9999	Shod	63.9	70.1	-6.1
Mid-Met X	2.5646	-12.0872, 22.5716	0.6842	BF	-5.2	-11.5	6.3
Mid-Met Y	5.4723	-10.4833, 24.9344	0.4813	BF	-7.9	-9.5	1.6
Mid-Met Z	25.181	8.9921, 52.0841	**0.0002***	BF	-52.7	-71.2	18.5

Negative (-) values = Shod greater than BF
Positive (+) values = BF greater than Shod

* $p < 0.05$

Hodges-Lehmann (HL) Estimates (degrees), exact Wilcoxon signed-rank p-values; Median joint angle (BF, shod, and angle difference)

the midpoint between the ASIS and superior apex of the patella, R/L lateral and medial condyles, R/L tibial tubercles, R/L fibular heads, and R/L shank at the midpoint between the tibial tubercle and ankle joint). Eight markers equally spaced on a headband, spanning from just proximal to the right mastoid process to the left mastoid process, defined the head segment. Two sets of cluster tracking markers with 4 reflective markers on each were placed on the midpoint of each thigh and shank.

The first author used a stepwise fashion to secure 14 reflective markers to each foot and ankle for all participants. The anatomical tracking markers, labeled with acronyms as per the modified RFM (Figures 1A and 1B), include the medial and lateral malleoli (MM, LM), proximal calcaneal ridge (FCP), distal calcaneus over the attachment of the Achilles tendon (FCD), sustentaculum tali (ST) of the calcaneus, apex of the peroneal tubercle, medial apex of the navicular tuberosity (TN), tuberosity of the 5th metatarsal (MT) (VMB), lateral aspect of the head of the 5th MT (VMH), medial aspect of the base and head of the 1st MT (FMB, FMH), base and head of the 2nd MT (SMB, SMH) and the distal hallux on the center of the toenail (HD). A second trained investigator confirmed all marker placements for accuracy.

Experimental Procedure

Data collection took an average of two hours per participant (n = 11; median age: 21 y, median height: 1.68 m, median weight: 55.11 kg). The OUHSC Institutional Review Board provided approval for this study before recruitment and protocol commencement and all participants were formally consented for human subject protection. All participants met the study's inclusion criteria (female ballet dancer, currently dances *en pointe* at the elite level (18 - 40 y), no current injuries preventing them from assuming the *en pointe* position, no chronic injury or past surgical history to the forefoot resulting in fusion of the first MTP joint, able to raise *en pointe* without handheld assistance or the use of a secure platform, such as a ballet *barré*, and English speaking). An "elite ballet dancer" was operationally defined as either a pre-professional ballet dancer (dancers either at the university level or pre-professional dance school with the intention of becoming a professional ballet dancer) or a professional ballet dancer (dancers currently under contract or employed with a professional ballet company) who currently train *en pointe*.

Participants completed an intake sheet including demographics (sex, age, current employment/school, pointe shoe type, age started dancing, and number of years *en pointe*) and medical information (current health status, medications, and past medical history including dance-related and non-dance-related injuries, and surgeries). Baseline measurements included height (m), weight (kg), baseline heart rate (bpm), baseline blood pressure, generalized or specific pain level on the Wong-Baker FACES® Pain Rating Scale,[26] and a posture screen. The first author, a licensed physical therapist, conducted foot and ankle evaluations (goniometric ROM, joint mobility, and manual muscle testing) and inspected the pointe shoes to ensure the shank and box were "broken in" but not "broken" or unstable as described in a previous study investigating pointe shoe deterioration.[5] Documentation of the shoe included the brand, wear patterns, and stability of the shoes' vamp, box, platform, and shank.

Data collection

Participants wore a sleeveless leotard during data collection. Standardization of attire intended to limit clothing artifact to reduce tracking errors of the markers and improve the accuracy of measures.[8] A standardized protocol for data collection included performing the standard Qualisys™ motion capture system calibration and 10 minutes of ballet-specific warm-up. The BF trials preceded shod trials for all participants to allow investigators to locate anatomical landmarks on the BF to mirror the application of markers on the pointe shoe. Dancers performed 10 to 15 repetitions of *elevé* (see Picture 2) in an open first position (small separation between the heels; Picture 1)[11] at the dancers' self-selected pace and their natural degree of turnout (lower extremity external rotation). The open first position ensured that the two calcaneal markers did not touch during data collection.[11] The stepwise protocol was repeated for the shod trials.

Data processing

Before data processing, every digitized raw data point for each marker was labeled as per the dance-specific biomechanical model created for this pilot study using the Qualisys™ software. The "peak *relevé*" and "foot flat" events were marked for each trial (see Picture 1). The "peak *relevé*" event was defined as the point in time when the dancer was balanced or paused in the *relevé* position with maximum ankle PF and bodyweight most centered between the two legs. The ground reaction force arrows derived from the AMTI force plates (see Picture 1) and the sinusoidal *in vivo* waveform graphs were used to determine the point in time when the dancer was balanced and weight most symmetrically distributed between the lower extremities. The "foot-flat" angle event was the point in time when the dancer assumes the most symmetrical weight bearing between the two legs with knees extended, ankles dorsiflexed, and the feet flat on the floor in first position. The precise requisite for marking these *in vivo* events occurred when the force arrows demonstrated the most symmetry between the lower extremities before changing position during the "*elevé* event." The "*elevé* event" was defined as the movement between 2 foot-flat events (see Picture 2). Raw data marked with the events were transferred from Qualisys™ into Visual 3D (V3D) for filtering and processing.

Data were analyzed on 10 of the 11 participants. Researchers excluded Dancer 1 data after technological upgrades to the motion capture system in the CHPM rendered the technical reference frames of her data inconsistent with the other 10 participants' data. As *relevé* in first position is a symmetrical movement[27] and a previous study reported high correlation (ICC = 0.99) in ankle movement patterns between the two extremities during *relevé en pointe*,[28] data analysis was performed on one foot-ankle complex per participant (n_{Right} = 5; n_{Left} = 5). The foot and ankle with "full fill" of marker tracking during 5 consecutive movement trials was chosen as the criteria for determining which LE to use for analyses. "Full fill" indicates that at least part of the tracking marker is visible during the entire movement trial 100% of the time[29] to ensure robust data collection. Data were processed in V3D using a low-pass Butterworth filter and a standard cutoff frequency of 6 Hz and normalized for each participant using body weight (kg) and height (m).[10] *Post hoc* analysis found no significant difference between the right and left extremities for all variables tested in the pilot study.[4]

Data analysis

The absolute mean difference angle of the 5 consecutive first position *elevé* events for each of the 10 participants determined the absolute value for the total amount of ROM for the group (|Total

ROM $_{individual}$|= |peak *relevé* angle $_{individual}$ – foot flat angle $_{individual}$|) for the 18 variables tested. Movement between segments included 4 tri-planar intersegmental articulations (calcaneus-metatarsal [cal-met], calcaneus-midfoot [cal-mid], metatarsal-hallux [met-hal], midfoot-metatarsal [mid-met]), as defined by the modified RFM (Figure 1C).[15] Note, that when interpreting the intersegmental movement, the reference or non-moving segment is listed first and the moving segment is listed second (eg, for the cal-mid interseg-ment, the midfoot segment is moving relative to the calcaneus segment).[14] The other 6 joint angles analyzed were measured in one plane each: 3 in the sagittal plane (medial longitudinal arch [MLA], ankle, and hallux), one in the frontal plane of the hindfoot (shank-calcaneus [sha-cal]), and two in the transverse plane of the forefoot (the angle between the second and first metatarsals [S2F] and second and fifth metatarsals [S2V]) (see Table 1). The MLA, shank-calcaneus, S2F, and S2V joint angles were derived as per the RFM with modifications as described by Veirs et al.[4] The ankle and hallux joint angles assessed in the pilot study 3DMFM aimed to replicate how ROM is typically measured by clinicians. The ankle angle was measured using the fibular head (FH), LM, and 5th metatarsal head (VMH) tracking markers. The hallux angle was measured using the head of the first MTP (proximal), the base of the first MTP (center), and the distal hallux (distal) tracking markers.[4]

Statistical analysis

Data did not follow a normal distribution; therefore, non-parametric Wilcoxon signed-rank test and Hodges-Lehmann (HL) estimates with 95% confidence intervals (CIs) were used. Range of motion values and differences between measures of central tendencies (median) for the two conditions were reported for the peak angle (see Table 1). The null hypothesis for the peak ROM data were not different between condition (BF and shod) for each of the 18 variables tested at an alpha level of 0.05.

Figure 1. 3D Multi-Segment Foot Model (Modified Rizzoli Foot Model [RFM])[4] Placement of anatomical target markers.* A, barefoot. B, Pointe shoe. C, Foot model segments.

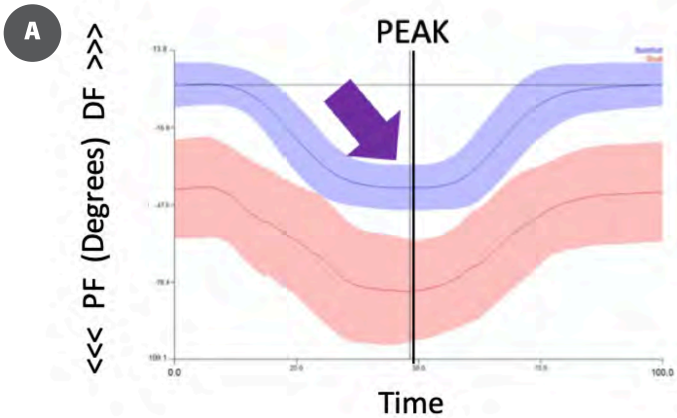
*** Fibular Head (FH) marker: Not pictured (used when calculating kinematics of the ankle joint segment).**

Results

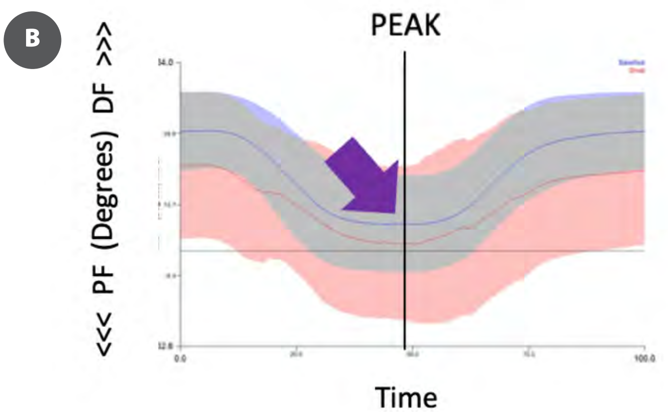
No differences were found between 12 of the 18 variables tested for ROM at the peak angle of the *relevé* in first position and resulted in failure to reject the null hypothesis for those variables (Table 1). Results describe significantly greater ROM at 5 variables in the BF condition and 1 variable in the shod condition. In BF, greater movement resulted between 3 foot-complex segments in the sag-ittal plane: the calcaneus-metatarsal (Figure 2A; HL 50.14°, 95% CI: (36.89°, 62.08°), p<01), the calcaneus-midfoot (Figure 2B; HL 21.44°, 95% CI: (2.39°, 35.94°), p=0.03), and the midfoot-metatarsal (Figure 2C: HL 25.18°, 95% CI: (8.99°, 52.08°), p<0.01). When BF, more movement occurred in the arch of the foot as greater excursion was observed at the MLA (Figure 2D; HL 8.96°, 95% CI: (1.15°, 15.92°), p<0.01), and S2V (Figure 2E; HL 6.99°, 95% CI: (3.16°, 13.03°), p<0.01) angles. The sagittal plane peak angle of the hallux was the only segment with significantly greater ROM in the shod condition (Figure 2F; HL 14.31°, 95% CI: (3.63°, 25.47°), p = 0.01).

DISCUSSION

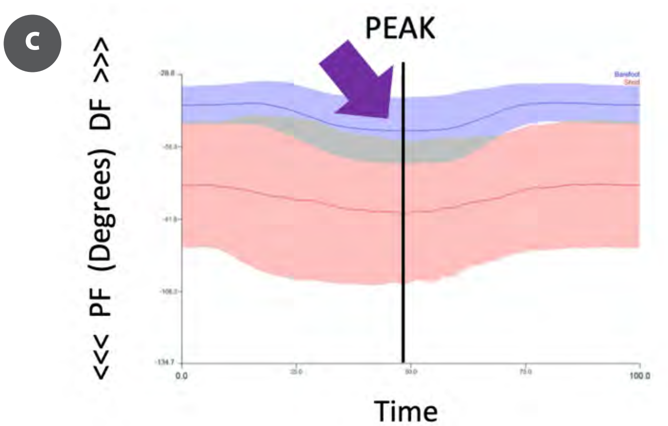
Results from the current study suggest there is greater sagittal movement between 3 segments of the foot-complex (the hindfoot [calcaneus], midfoot, and forefoot [meta-tarsals]) and the MLA (arch height[15]), and greater rotational movement in the foot (S2V: second MT relative to the fifth MT) when the dancer is balancing in *relevé* BF



A, Calcaneus-Metatarsal (sagittal plane angle forefoot movement relative to the hindfoot) Greater ROM BF than shod (DF+/PF -)



B, Calcaneus-Midfoot (sagittal plane angle midfoot movement relative to the hindfoot) Greater ROM BF than shod (DF +/PF -)

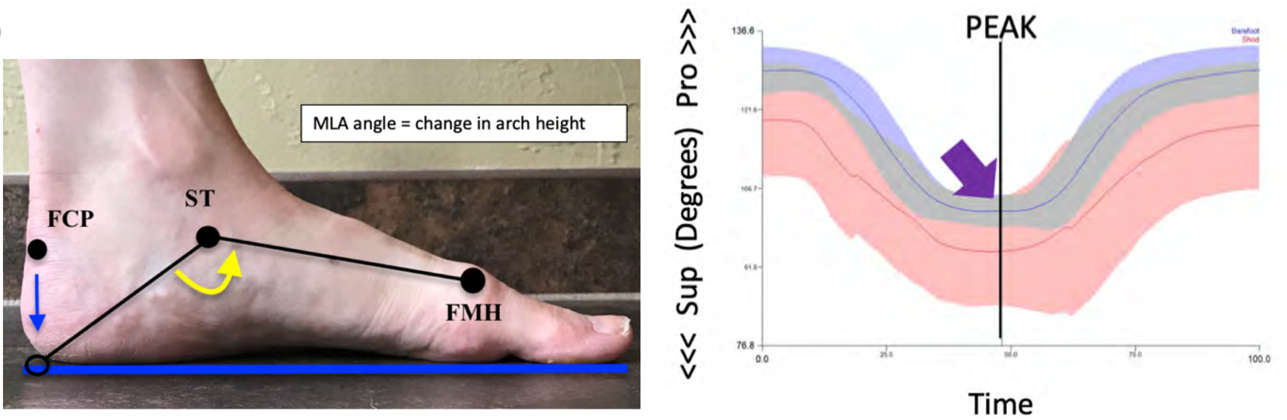


C, Midfoot-Metatarsal (sagittal plane angle forefoot movement relative to the midfoot) Greater ROM BF than shod (DF +/PF -)

Figure 2. ***In vivo*** **waveform graphs during first position *elevé* for the 6 variables with significant ROM differences at the peak *relevé* event.**
Kinematic waveform graphs of the 6 variables (A) calcaneus-metatarsal, (B) calcaneus-midfoot, (C) midfoot-metatarsal, (D) MLA, (E) S2V, and (F) the hallux angle of the right foot and ankle (n = 5) during first position *elevé* from foot flat to foot flat: BF compared to shod conditions (group mean ± SD between foot flat and foot flat events). The black vertical line at approximately the 50% timeframe is the *relevé* event (mean ± SD). The darker colored red and blue lines are the means for each condition. The red shaded areas are the SD's for the shod condition. The blue shaded areas are the SD's for the BF condition. The gray areas are where the two conditions overlap. Positive HL estimates indicate BF angles were greater. Negative HL estimates indicate shod angles were greater. Note: 3D motion capture systems measure movement relative to the plantar surface/ the floor (eg, PF angle values are negative and DF values are positive) with the exception of the MLA. *Refer to Figure 1 for description of hindfoot, midfoot, and forefoot segments and marker placement.*

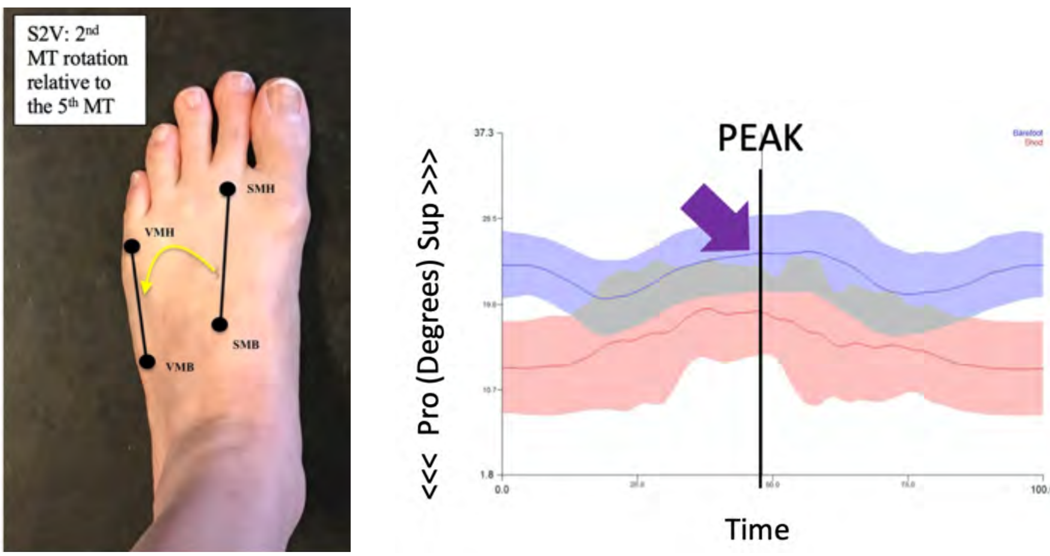
(Figure 2 continued on page 173)

D



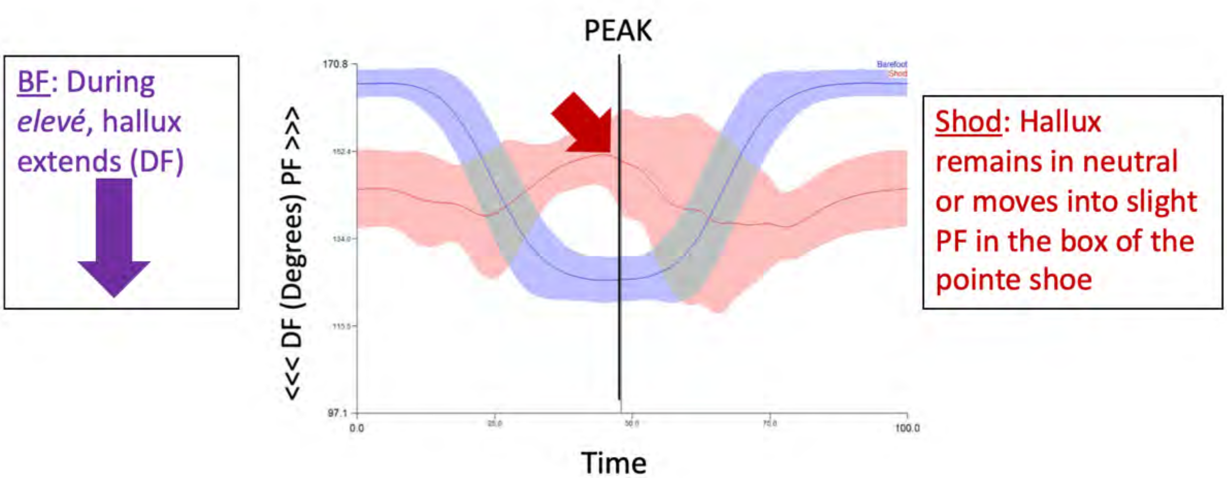
D, Medial Longitudinal Arch (MLA) angles Greater ROM BF than shod (Angle calculated relative to the arch of the foot; Pronation > Supination)

E



E, S2V rotational angle Greater ROM BF than shod (Angle calculated relative to the plantar surface of the foot; Supination > Pronation)

F



F, Hallux angle (Greater ROM angle shod than BF)
The V3D software calculates the hallux angle relative to the plantar surface.

than *en pointe*. These differences align with the evidence that the forefoot and midfoot are blocked by the pointe shoe[6] when shod but during barefoot movement, the foot is free to move in its full tri-planar ROM to its peak *relevé* position. A significant greater angle difference was found in the shod condition at the hallux segment. These results specifically demonstrate how the hallux segment must move a greater distance from its resting position on the floor in foot flat to get into *relevé en pointe* than BF.

The extrinsic stability to stand *en pointe* on the platform of the pointe shoe comes, in part, from the stiff toe box that bundles the toes together to absorb forces during axial loading[6] and the shank of the shoe. As the pointe shoe restricts the forefoot and toes[6] and the toes maintain a relatively neutral alignment,[3,7] the results of the current study support that the sagittal motion necessary to balance *en pointe* must come entirely from foot segments proximal to the forefoot. When shod, there was significantly less ROM of the S2V angle (rotational movement of the second MT relative to the fifth MT) and MLA as compared to BF. These results suggest that the shank of the pointe shoe limits rotational and sagittal movement of the midfoot and forefoot, respectively.

Previous authors indicate that the dancer's base of support is less stable when the lower extremities are turned-out than parallel because the longitudinal axis of the foot changes from the anterior-posterior plane to the medio-lateral plane.[30] However, classical ballet technique dictates the lower extremities to be maintained in a turned out position, ideally defined as a combination of 180° between the two legs.[13,31,32] The demand for the "ideal" or "perfect turnout"[33] among ballet dancers lends to "forced turnout" when dancers force their hips, knees, or feet and ankles beyond their physiological limits.[13,34] Resultant compensatory strategies include destabilization of the MLA into pronation, abduction of the forefoot, and external rotation at the knees[12,13,34] placing undue stress and strain on soft tissues, predisposing dancers to injury.[31] The authors of the current study suggest that clinicians should evaluate the dancer turned-out in the first position both barefooted and in pointe shoes. Measuring the change in arch height, pronation, and foot abduction could potentially determine if there are differences in compensatory strategies between the two conditions when balancing in *relevé*.

Dancers perform *elevé en pointe* either by springing up or rolling through demi-pointe to get onto the box of the pointe shoe. Either way, the dancer must press the hallux and forefoot into the ground against the hard shank of the pointe shoe to get from foot flat to *en pointe*. While balancing in barefoot *relevé*, the MTP joints, especially the first MTP joint, must have sufficient flexibility and mobility for balance. In addition to the differences in the hallux angle, the difference in body weight placement in BF and shod was observed at the peak of the *relevé* using the direction of the force arrows in Qualisys™ (Pictures 1 and 2). These observations align with imagery studies using magnetic resonance imaging[3] and radiography[7] of dancers *en pointe* that illustrate how the anterior surface of the talus becomes the primary weight-bearing site in the ankle. Clinicians could use this evidence when evaluating dancers as they balance in *relevé* barefoot and shod to visualize where they balance their weight and how they shift their weight to balance in *relevé*. This recommendation is analogous to using an imaginary plumb line when evaluating posture.

Although peak ankle PF ROM angles were not significantly different between conditions (p=0.123) in the pilot study, clinicians should be aware that ballet dancers' functional PF ROM needs measurably exceeded normative values of the general population (0-50°).[3,7] Results from this study (med_{BF} = 161.3°, med_{shod} = 176.8°) are consistent with other studies describing that the greatest amount of dancers' PF movement occurs at the talocrural joint when both weight-bearing *en pointe*[3] and plantar flexing or "pointing" the foot in non-weight bearing.[7] Based on observation of the position of the talocrural joint relative to the foot-complex weight-bearing point of this sample of elite dancers during the peak ROM event (see Pictures 1 and 2), the talocrural joint should generally align over the weight-bearing surface of the foot: the first MTP joint when BF and the distal hallux point (box of the pointe shoe) when *en pointe*. If the talocrural joint is not in these alignments, the clinician should conduct joint-specific mobility and ROM testing to determine how the dancer could achieve better alignment when in *relevé*. Based on the current study, a biomechanical dance-specific evaluation of the foot and ankle should include (1) static posture evaluations in the turned-out position in foot flat and *relevé* (barefoot and *en pointe*); (2) functional evaluation of dynamic dance-specific movement, including the *elevé* movement and static *relevé*, BF, and shod *en pointe*; and (3) functional ROM and mobility testing of the ankle and foot-complex.

CONCLUSION

The current study was the first to describe and compare *in vivo*, tri-planar movement of the foot-ankle complex with dancers BF and *en pointe* using a 3DMFM. Results support the contention that dancing BF involves different biomechanics than dancing *en pointe*. Ballet dancers must repeatedly balance in *relevé*, which places atypical stresses and strains on the joints and soft tissues of the foot and ankle.[3] The repetitive forces placed on the foot and ankle during dance-specific movement possibly contributes to injuries unique to the dance population, including stress fractures at the second and third metatarsals, flexor hallucis longus tendinopathies, and sprains/strains at the tarsometatarsal (Lisfranc) joint complex.[1,2]

The current study advances the physical therapists' understanding of the unique demands placed on the foot-complex when balancing in *relevé* and describe the biomechanical differences between the barefoot and *en pointe* conditions. Evidence presented are based on results from a larger cross-sectional pilot study and aim to augment the dance-specific functional evaluation of the ankle and foot-complex. The information provided is not intended to be an all-inclusive discussion of how to conduct a full and comprehensive dance-specific evaluation, considering other factors were not discussed or explored in the pilot study (eg, strength, proprioception, endurance). In short, investigators intend that the newfound knowledge from the pilot study will contribute to the clinicians' understanding of the biomechanics of the foot-complex during dance-specific movement that are unique and specific to the art form.

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PERFORMING ARTS SIG

(Continued from page 167)

ing hospitals, physical therapists have been redeployed to help with COVID-19 efforts, working on acute care units and in the intensive care units. Others have closed their clinics for in-person visits and are developing their telehealth practices. This has been a challenging landscape to navigate with policies restricting the number of visits and delivery of services across state lines. Technology can be a great resource, but it has its limits. Certain tests and measures cannot be administered virtually and manual therapy techniques are on hold, but the critical role of movement analysis is highlighted in these virtual environments. One of our PASIG members shared that the increased use of telehealth during the COVID-19 crisis has actually led to improved interprofessional communication. She shared that for two particular cases (a mid foot stress fracture and an anterior cruciate ligament reconstruction) she has been having telehealth interprofessional meetings with the physicians, dietitians, and psychologists with and without the patients to ensure that they are getting proper care. Thanks to telehealth, they are having more team meetings rather than multiple one-on one conversations. This encouraging anecdote leaves me hopeful that we could come out of this crisis stronger, with new creative and efficient ways to meet the health needs of our artists.

Many of you are likely feeling the financial impact of the pandemic. You have been providing pro-bono services and wellness programming to your artists, while at the same time struggling to stay afloat. Hopefully some of you were able to take advantage of the digital performances offered on the web by companies like New York City Ballet (https://www.nycballet.com), Alvin Ailey (https://www.alvinailey.org), Ballet Hispanico (https://www.ballethispanico.org/bunidos/watch-party), and The Metropolitan Opera (https://metoperafree.brightcove.services/?videoId=6152402347001). Our very own Academy of Orthopaedics is also offering the archived Independent Study Course (ISC) "Physical Therapy for the Performing Artist" at a reduced rate of $10. [A bargain not to be missed!]. This course is available at: https://www.orthopt.org/content/education/independent-study-courses/browse-archived-courses/physical-therapy-for-the-performing-artist. Now is a great time to explore affordable on-line professional development offerings and virtual classes.

Even with all of the changes associated with the pandemic, the business of the PASIG moves on. In our case, the show does go on. I want to welcome the newest member of the PASIG leadership team, Tiffani Marulli, the Performing Arts Fellowship Director at The Ohio State University. She will take on the role of PASIG Fellowship Advisory Board Chair. She will work with the directors at Harkness Center for Dance Injuries at NYU Langone, Johns Hopkins Medicine, and Columbia University Irving Medical Center / West Side Dance PT to support our new Performing Arts Fellowship Programs.

Under the leadership of our new Research Chair, Mark Romanick, we continue to send out citation blasts to our PASIG list serve. In March we had, "Respiratory Issues in Wind Instrumentalists" (Mark Romanick, PT, PhD, ATC), in April, "Returning to Dance After ACL Reconstruction" (Kynaston Schultz, SPT), in May, "Biomechanics, Motor Control, and Injury in Percussionists" (Stephen Cabebe, SPT), and in June, "Resistance Training for Female Ballet Dancers" (Danielle Farzanegan, PT, DPT, Sports PT Resident). The research team is also working on ways to make some of our archived blasts more accessible and to recruit new contributors for *OPTP.*

Rosie Canizares has been working with presenters and has secured two performing arts education session proposals for CSM 2021 (Emergency Medical Response for the Performer and Management of the Adolescent and Pre-professional Dancer) and two pre-conference courses focused on aerial artists and upper extremity ultrasound. We will be reinvigorating the ISC Taskforce, under Rosie's leadership, in order to develop new interactive learning modules focused on physical therapy for performing artists.

Our Membership Chair, Jessica Waters, is working on a member survey that will help to identify programming interests and research needs. We currently have a gap between our 699 members registered through AOPT and our 220 Facebook members. The link to our PASIG Facebook Page is: https://www.facebook.com/groups/PT4PERFORMERS/. It is a closed group and sometimes takes a while to cross-reference membership lists, but we encourage you to join. It is a great way to have quick access to the performing arts physical therapist community.

Lastly, I would like to spotlight one of our PASIG student members, Isabella Scangamore, a member of our PASIG Communications/PR Committee. As you will hear from Isabella, it is never too soon to get involved in APTA activities, and the PASIG is a very accessible first step.

As a student member, you should also know that you are eligible for the PASIG research scholarship if you have had an abstract accepted for CSM!

STUDENT SPOTLIGHT:

I am Isabella Scangamor, a third-year DPT student from Thomas Jefferson University in Philadelphia. I completed my undergraduate education at Muhlenberg College in Allentown, PA, where I was a dance major. I have consistently been passionate about working with dancers since it is very close to my heart, and such a fascinating population with unique demands on the body and mind, melding sport and artistry. I started looking for opportunities to get involved in performing arts physical therapy as soon as I started graduate school. I joined the PASIG the fall of my first year in physical therapy school after we had an in-class discussion about Sections and SIGs through the APTA, which spurred some self-research. I thought that this group would be a perfect way to get involved in performing arts physical therapy, see what it was all about, and start connecting with practicing clinicians and researchers already in the field.

It is so easy to get involved in the PASIG as a student! I am on the PR Committee, and other students have written citation blasts, case studies for *OPTP,* served on various committees, presented research, and created educational resources (like the figure skating glossary). It is a brilliant opportunity to start networking with like-minded people who are passionate about the same things as you, including dance, music, gymnastics, circus arts, theatre, and figure skating. The commitment to the PASIG is flexible, with opportunities to learn how to contribute to the field and build your resume. I found it exciting, especially at CSM since I had the privilege to attend this past February, to be in a room and "nerd-out" about all things performing arts-related, future research, new treatment methodology, and advancements in education. As the only person interested in performing arts physical therapy in my cohort, this was heaven. Every time I get a notification from our Facebook group, I get excited to see what is happening at the moment. If you are considering joining the PASIG, especially as a student, I highly recommend taking the leap.

President's Message

Nancy Robnett Durban, PT, MS, DPT

The Pain Special Interest Group is continuing its efforts in developing the Pain Specialization and Residency/Fellowship, the DPT Education Manual and Resource Guide for Standards on Pain Education, and Clinical Practice Guidelines for Education as an Intervention for individuals with musculoskeletal pain. We will continue to offer our members Pain Pearls and Pain SIG Research: Abstracts, Articles, and Reviews emails in the future. Lastly, the Pain SIG strategic plan is currently under revision and when complete will be on our website. Please watch your inbox for education opportunities coming your way.

Thank you to all physical therapist front line providers. The adjective used to describe this present time in our lives is "unprecedented." Synonymously, unparalleled, extraordinary, record, first-time, unique, exceptional, unmatched, unrivaled could be used as a substitute. The way in which we respond to this time requires physical therapists to practice in innovative, unique, nontraditional, path breaking, pioneering, pivoting, or trailblazing ways. Our Digital physical therapy practice is evolving at rapid speed in response to COVID-19. The following is a point of view article aiming to review current evidence of digital physical therapy practice for patients with pain now and in the future and to reflect on the pain of it all. A special thank you to Alan Chong W Lee, PT, DPT, PhD, Board-Certified Clinical Specialist in Geriatric Physical Therapy for his insight and knowledge as a digital physical therapy practice subject matter expert.

DIGITAL PHYSICAL THERAPY…THE PAIN OF IT ALL

Nancy Robnett Durban, PT, MS, DPT

Prior to COVID-19, telemedicine had mostly been used in emergency and natural disaster situations and during infectious disease outbreaks such as Severe Acute Respiratory Syndrome (SARS) pandemic in 2003.[1] The ability to use a secure telecommunication system between a health care provider and a patient remotely is known as telehealth while telemedicine and telerehabilitation are terms to define medical and rehabilitation professions using telehealth services. Prior to COVID-19, I taught the topic of physical therapy delivered by telehealth in a module entitled, "The Future of Physical Therapy Pain Management." Well, the future is now. This pandemic has transformed health care delivery with digital practice and telehealth. The aims of this point of view article are to examine the evidence of digital physical therapy practice with patients/clients in the literature and its application to patients/clients with pain now and in the future.

Recently, the World Confederation of Physical Therapy and the International Network of Physical Therapy Regulatory Authorities combined their efforts to develop a Digital Physical Therapy Taskforce.[2] The aim of the Digital Taskforce was to propose an international definition and purpose for digital physical therapy practice. Digital practice is defined as, "a term used to describe health care services, support, and information provided remotely via digital communication and devices."[2] The purpose of digital physical therapy is defined as a means, "to facilitate effective delivery of physical therapy services by improving access to care and information and managing health care resources."[2]

It is safe to say the practice of digital physical therapy has "zoomed" in light of COVID-19. As discussed in Lee et al's point of view article, "it is clear that digital practice is a transformation in physical therapist practice, in which communication-based services (e-visits, virtual check-ins) beyond telehealth, telerehabilitation, and telemedicine are added to increase remote access to care while preserving scarce resources, including personal protective equipment"[3] and reducing cross contamination caused by close contact of in-person visits. Offering unique or innovative physical therapy solutions to patients' needs is not out of the norm during in-person physical therapist practice. We do this every day. What is out of the norm is trying to administer physical therapy without the hands-on touch so necessary to our delivery of service. Using the means of digital physical therapy practice to "touch" our patients during this time is necessary. Clearly, there are limitations associated without being able to touch a patient during a physical examination, but there are opportunities to perfect our listening and history taking skills.[4] These touch points will require both hands-on and virtual check-ins to complement the best care now and post COVID-19 in the digital age.

In the literature, there is supporting evidence to move forward in digital practice and telehealth for patients with knee osteoarthritis (OA).[5-7] These studies investigated digital practice intervention for patients with mild knee OA. In two separate studies, Hinman et al[5] investigated exercise management for patients with OA via skype. The Skype business and health care program include a secured encrypted platform for telehealth use. Additionally, Lawford et al[6] examined the perception of people with OA who received exercise support via the telephone services by physical therapists. Recently, the Center for Medicare and Medicaid Services (CMS) in the United States added telephone service codes during this public health emergency (PHE) period. The results of the investigations had similar outcomes. The study participants liked the convenience, time efficiency, not having to travel or wait in the waiting room with this digital form of care delivery models. They also liked having the one-to-one undivided attention of the physical therapist. However, participants in both studies indicated they would have liked an in-person visit initially to develop a patient-provider relationship. As for the physical therapists who participated in the studies, they reported that the flexibility of the treatment allowed the participant to cancel and reschedule, which was disruptive to their workflow. Additionally, the participating physical therapists reported some discomfort they experienced with having to rely on the participant reported information rather than hands-on evaluation and assessment. Investigators in the Lawford et al's study[7] noted the physical therapists realized that telephone based physical therapy intervention exceeded their expectations and that the initial need for visual interactions was less of a problem than initially thought to be. Their experience led to a new interest in this delivery of service. The telephone interactions provided the physical therapists the opportunity to focus on effective conversation that allowed the patients to be more open than they experienced in the clinic. Physical therapists stated that the advantages were that the

PAIN MANAGEMENT

phone intervention was convenient for patients, helped improve exercise adherence, and led to improvements in confidence, reduction of pain, and increased function. At the conclusion of the theses studies, participants reported satisfaction of results such as having reduction of pain, improvement of function, and self-confidence. Both investigators concluded that digital physical therapist exercise management of patients with OA has the potential as a treatment option either as a sole treatment model or in combination with in person physical therapy practice. Lawford et al[7] additionally concluded that telephone intervention should not be a substitute for the in-person physical therapy care. Telephone support has also been determined to help self-management of patients with low back pain,[8] neck pain,[9] and patients with fibromyalgia.[10]

In addition to digital physical therapy studies of patients with OA, Schulz-Heik et al[11] investigated the response of Veterans who participated in an in-person and telehealth clinical yoga program. Their results indicate no significant difference in satisfaction or overall improvement of Veterans who participated in yoga-based intervention via telehealth or in-person. More than 80% of participants who endorsed a problem with pain, energy level, depression, or anxiety reported improvement in these symptoms in a group-based exercise program via telehealth. This result may seem irrelevant but it is not. What is important is the fact that the Veterans in this clinical yoga program reported similar high levels of satisfaction and improvement in multiple problem areas supporting the use of yoga via telehealth. However, other novel telehealth for complex treatments such as mirror therapy for the treatment of patients with phantom limb pain has been initiated and may require further research investigation.[12]

In terms of reliability and validity of telehealth assessments, Truter et al[13] investigated the validity associated with the measure of spinal posture, active movements of the lumbar spine, and the passive straight leg raise (SLR) test remotely. In-person measurements by a physical therapist's assessments were compared with telehealth assessment of spinal posture, active movements of the lumbar spine, and the SLR test. Pain, disability, and clinical measurements were also assessed and compared. High levels of agreement were found with detecting pain with specific lumbar movements, eliciting symptoms, and sensitizing the SLR test between digital and in person assessment. However, only moderate agreement occurred with identifying the worst lumbar spine movement direction, SLR range of motion, and active lumbar spine range of motion and poor agreement occurred with postural analysis and identifying reasons for limitations to lumbar movements. The study concluded that there are some valid assessments of patients with back pain that can be done via telehealth such as detecting pain with specific lumbar movements, eliciting symptoms, and sensitizing the SLR test. The validity and reliability associated with the internet-based physiotherapy assessment for musculoskeletal disorders has also been investigated by Mani et al.[14] Their results indicated that the digital physical therapy assessment of pain, swelling, range of motion, muscle strength, balance, gait and functional assessment demonstrated good concurrent validity. Additionally, Mani et al's14 results indicate low to moderate concurrent validity of lumbar spine posture, special orthopaedic tests, neurodynamic tests, and scar assessments. Mani et al concluded that internet-based telehealth physical therapy assessment is "technically feasible with overall good concurrent validity and excellent reliability, except for lumbar spine posture, orthopaedic special tests, neurodynamic tests, and scar assessment."[14]

A systematic review of the evidence on the effectiveness of exercise-based telemedicine in chronic pain has been conducted by Adamse et al.[15] There were 16 studies included in their meta-analyses. This investigation concluded that exercise-based telemedicine interventions do not seem to have added value to usual care. As substitution of usual care, telemedicine might be applicable but due to limited quality of the evidence, further exploration is needed for the rapidly developing field of telemedicine.[15] Therefore, exercise-based telemedicine interventions appear to be somewhat effective in reducing pain and improving physical activity and activities of daily living for chronic pain patients, when compared to no intervention when medically deemed necessary.

When there is no ability or it is not safe to practice in-person delivery of care, it is important to focus on the delivery of digital physical therapy for the treatment of patients in pain is effective and the improvement of function. There are limitations to this practice such as to provide acceptance and willingness to learning new valid and reliable delivery of care they may have not been taught in their academic training. Hence, the need for continuing education is critical. Due to COVID-19, further evidence and practice guidelines will be necessary since physical therapists can furnish telehealth and communication-based services (telephone, e-visits, virtual check-ins) by CMS during this PHE. For example, future practice and research must include both in-person care and digital practice in patients with pain to determine the best dosage and practice. Furthermore, future payment, regulation, and interstate practice must be addressed in order to safeguard patient privacy, provider malpractice, and reduce unwarranted services and potential abuse and fraud in digital practice.

In light of COVID-19, we are providing individualized personal digital physical therapy care, becoming digital savvy, and perfecting listening and digital skills. We have to. This will provide new opportunities for the physical therapy profession to deliver valid and reliable high-quality care so that patients/clients and providers will all benefit in the future and solidify the evidence. We are increasing accessibility. We are reducing barriers of time and space. We are providing individualized personal digital physical therapy care. We are keeping safe. But the pain of it all is not just about addressing the pain of our patients. The pain of it all expands to include the physical and emotional pain some physical therapists are experiencing delivering digital practice. Prolonged sitting, headsets, breathing through masks for hours, face shields, or goggles, work station ergonomics, and stress to name a few. There is a great expanse of professional and personal stress such as accommodating to necessary rapid change, not abandoning our patients, keeping ourselves and family members safe physically and financially. There is also a significant grief of loss…loss of loved ones, patients, celebrations of any kind (life, death, adoptions, weddings, birthdays, graduations, vacations, hugs...). In this ever rapidly changing time, we need to take a moment to take care of ourselves so we can take care of others. We know what to do. We are physical therapists. Check the ergonomics of your desk. Yes, sit with both feet on the floor. Practice what we are preaching to our patients. Take breaks, walk, run, or bike. Just move. Do something every day that brings you joy. Be mindful. Eat nutritionally. Drink your water. Get good sleep and take deep breaths.

In conclusion, we are physical therapists. We have been charged to transform society. Now we are transforming our practice. This transformation has to continue. It needs to become part of the now normal service delivery model of physical therapy as advocated by the American Physical Therapy Association's House of Delegates.[16] The digital practice of physical therapy has and will continue to enhance our delivery of care. Ensuring digital physical therapy practice is embedded in our routine delivery of care will keep us digitally ready for the future. So, are you ready to embrace digital practice and telehealth—Pain of it all?

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FOOT & ANKLE SIG

(Continued from page 167)

partially, or fully, online. Our hope is this may allow an expanded opportunity to share that programming with the FASIG community. So, stay-tuned because at the time this edition of *OP* reaches you there will likely be more plans in place for this "virtual" conference. www.aofas.org/annual-meeting

- We previously reported on the progress of the foot and ankle fellowship initiative. As an update, our Declaration of Intent Letter was accepted by the American Board of Physical Therapy Residency and Fellowship Education (ABPTRFE) in February 2020. We have now submitted a *Practice Analysis Survey* that will form the backbone of the document to develop the specialty practice. Please stay tuned for updates on this initiative as the FASIG and the AOPT are eager to move this process ahead. Again, many thanks to our Practice Analysis Coordinators, Project consultant, and the entire taskforce working on this.
- The FASIG Practice Committee together with guidance from the AOPT Public Relations Committee is working on creating infographics to share information about common foot and ankle pathologies. These will be shared across the AOPT. Versions may also be developed to inform patients about common conditions and what to expect when seeking treatment. A special thanks to the FASIG Practice Chair, Megan Peach, DPT, OCS, CSCS, who is coordinating this effort.

We wish everyone in the FASIG, and the whole AOPT, health and well-being as the world adjusts in the wake of the COVID-19 pandemic. We are certainly all impacted as educators, health care providers, parents, community members, citizens, and partners in the process to get through this uncertain time. We will see how the summer and fall progress to allow us to return to many of our prior activities—but likely with a new wealth of online experiences.

The FASIG Leadership

https://www.orthopt.org/content/special-interest-groups/foot-ankle

Imaging and Clinical Practice Guidelines

One initiative of the SIG that will be reflected in upcoming products from the AOPT is the appropriate inclusion of imaging in future Clinical Practice Guidelines (CPGs). Imaging SIG representatives have met with the CPG editors and have jointly established a process by which imaging content, where indicated, is part of the initial CPG formulation at the start of the process and the portion of the draft CPG that addresses imaging will also be reviewed prior to publication. This is a noteworthy advancement to address greater consistency of imaging as part of clinical reasoning toward patient management being part of the acknowledged standard of care. Jim Dauber, who is the Imaging SIG Liaison for the AOPT Practice Committee, is coordinating small teams of individuals with expertise in the practice areas covered by the CPGs.

Nominations and Elections 2020

This summer, the Imaging SIG Nominating Committee will be seeking interest from those considering a nomination for the office of SIG Vice President. The election will be conducted in November with the term of office beginning immediately after CSM 2021 and lasting 3 years. If you are interested, please make yourself known to the Nominating Committee Chair, Mohini Rawat, at mohinirawat@gmail.com.

A position on the Nominating Committee will also be selected this year. Each year, one person is elected to the Nominating Committee for a 3-year term with the final year of that term being Chair of the committee. Involvement with the Nominating Committee is a great way to establish your presence within the SIG and prepare for future leadership roles. If you are interested, please let Mohini know.

The Office of SIG Vice President

Long-time SIG contributor, Jim Elliott had completed one term as SIG Vice President and 2 of the 3 years of his second term before recently stepping down. Jim, previously at Northwestern University and now at University of Sydney (Australia), simply had too many roles and too many tasks to manage the SIG Vice President role in the manner he preferred. If you have an opportunity to express your appreciation to Jim for his many years of service to the SIG, please do so. Fortunately, a very capable successor has stepped in to fill that position for the remaining one year of that 3-year term. Marie Corkery, PT, DPT, MHS, FAAOMPT, was appointed to assume the role as SIG Vice President immediately after CSM in Denver. She and Jim jointly contributed to the SIG submissions for CSM 2021 in Orlando.

Special Article on Ultrasound

Did you catch the special article on ultrasound in physical therapist practice in the April issue of *OPTP*? If not, please go back and take note of the contents of that article. The many uses of how diagnostic ultrasound informing clinical decision-making and enhance patient management along with its capabilities in research are covered. This is done through the perspectives of several practitioners and educators across the country. If you have an interest in possibly pursuing ultrasound as part of your clinical practice, that article is a must read.

Imaging Referral Privileges…So Far

At present, we have 7 jurisdictions in the United States where physical therapist practice includes referral for imaging. Either by specific legislative action or by interpretation of existing regulatory language, referral for imaging by physical therapists has been established in Wisconsin, Utah, Colorado, Maryland, the District of Columbia, New Jersey, and Pennsylvania.

At least 2 states are attempting to pass specific legislative initiatives this year. Results and details will be coming in future issues of this newsletter.

Remember the Imaging SIG Scholarship for CSM

Do you or one of your colleagues have research completed or near completion that will be presented at CSM 2021 in Orlando? Remember that each year the Imaging SIG selects a scholarship recipient from the applicants among those with accepted presentations at CSM. If you or your colleague's work has been accepted, information to apply for the scholarship is available on the Imaging SIG pages at the AOPT website. Please investigate at: https://www.orthopt.org/content/special-interest-groups/imaging/imaging-sig-scholarship.

Strategic Plan

By the time this issue of *OPTP* is published, the Imaging SIG will have updated its strategic plan and established continuing direction for its immediate future. As you may recall, the AOPT leadership met in October 2019 in La Crosse, WI, to update the Academy's strategic plan. Subsequently, all the SIGs under the purview of the AOPT also updated their strategic plans. Strategic plan information is available on the Imaging SIG's web pages at https://www.orthopt.org/content/special-interest-groups/imaging.

ORF-SIG Dashboard:

Total Members: *343 (+29)*
- Facebook Group: 110 (+2)

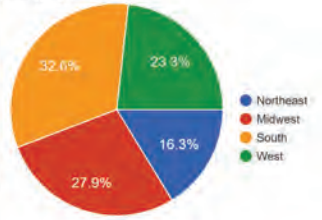
ABPTRFE ACCREDITED PROGRAMS:
- Residencies:
  - Orthopaedic: 107 (-2)
- Fellowships:
  - Hand: 0 (-2)
  - Movement: 2
  - OMPT: 27 (-8)
  - Performing Arts: 1
  - Spine: 3
  - Upper Extremity: 3

ACOMPTE ACCREDITED PROGRAMS
- OMPT: 26

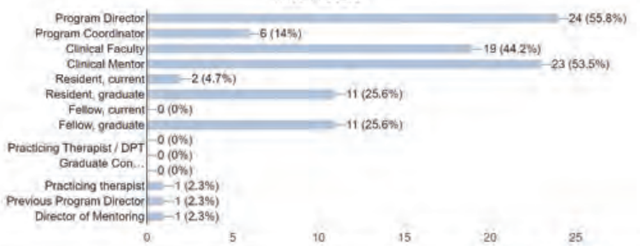
(+/- in members/programs since last quarter)

Current Member Make-up:

Demographic Regions:



Who We Are



Please Scan the QR Code and complete the survey if you haven't already:

ORF-SIG Members,

It is hard to believe that just a few months ago several of us were all together at the 2020 Combined Sections' Meeting. Since then we have seen a significant change of events with the coronavirus (COVID-19) pandemic turning to the center of all our lives. Our thoughts and prayers go out to all individuals who have become ill, and/or lost family and friends due to the pandemic. Additionally, we know the pandemic has extended beyond our hospital walls greatly affecting the community as many private practices as well as outpatient clinics have temporarily closed to prevent the significant spread of the virus. We want to thank all those who have been in the front lines of health care directly fighting the virus as well as the other members of society assisting with the development of personal protective equipment and creating resources for businesses to sustain the long term impacts we may undergo.

The impact of COVID-19 has affected us all, including our physical therapy residency and fellowship programs. In doing so this has created significant challenges for all members involved in residency and fellowship education. To assist programs, faculty, and participants through these challenging times the Orthopaedic Residency and Fellowship Special Interest Group (ORF-SIG) has collaborated in creating a resource for programs to continue providing options for post professional education. This resource will continue to be updated as new information is provided. Please subscribe to the ORF-SIG APTA Communities Hub to collaborate and discuss your program challenges and triumphs.

http://communities.apta.org/p/fo/st/thread=15235

The ORF-SIG would also like to thank the members of COVID-19 Subcommittee for their time and effort putting this document together.

- **Subcommittee Members:** Kirk Bentzen, Kathleen Geist, Steven Kareha, Molly Malloy, Carrie Schwoerer

Stay Healthy,
Matt Haberl
ORF-SIG President

Accreditation Guidelines

1. **American Board of Physical Therapy Residency and Fellowship Education (ABPTRFE) Accreditation Guidelines**
   a. Guidance provided by the ABPTRFE if a program is affected by COVID-19.
      i. ABPTRFE provided temporary guidance that will remain in effect for all programs until informed that guidance is no longer in effect.
      ii. ABPTRFE recommended that all programmatic changes are reviewed by the institution's legal counsel.
      iii. ABPTRFE recommended the use of online, remote or virtual technologies for delivery of educational hours even if these methods were not previously utilized by the program. Programs will not need to submit a substantive change form for the use of distance education during the pandemic.
   b. ABPTRFE specific program requirement waivers for programs affected by COVID-19:
      i. **Practice Setting:** Programs may waive the minimum hours within a required practice setting.
      ii. **Practice Hours:** Programs may waive up to 50% (750 residency, 425 fellowship) of the total practice hours provided the participant has met the program outcomes.
      iii. **Mentoring Hours:** Programs may waive up to 50 hours of the 150 hours of 1:1 mentoring. A minimum of 65 hours of mentoring must be in person (1:1) for residency programs and 50 hours must be in person (1:1) for fellowship programs.
      iv. **Faculty Evaluations:** ABPTRFE is suspending the requirement for faculty evaluations including the annual mentor observation evaluation.
      v. **Other program outcomes** not specifically addressed by one of the above waivers should be met for program completion.
   c. Complete ABPTRFE statement may be found here:
      i. https://apta.informz.net/APTA/data/images/ABPTRFE/ABPTRFEGuidanceOnCOVID-19.pdf
2. **Accreditation Council on Orthopaedic Physical Therapy Education (ACOMPTE) for accredited Orthopaedic Manual Physical Therapy Fellowship Programs.**
   a. **Guidance provided by ACOMPTE if a program is affected by COVID-19:**
      i. ACOMPTE provided temporary guidance that will

remain in effect for all programs until informed that guidance is no longer in effect.

ii. ACOMPTE recommended that all programmatic changes are reviewed by the institution's legal counsel.

b. ACOMPTE specific program delivery changes for programs affected by COVID-19:

i. For fellows-in-training (FiT) on track to graduate spring or summer 2020 and are unable to extend the length of their time in the program, ACOMPTE supports program modification using virtual technology to ensure the total 150 hours of 1:1 mentorship hours with a Fellow of AAOMPT are completed with a reduction in non-Fellow AAOMPT mentorship hours provided the FiT has met the program outcomes.

ii. Potential options to consider include, but are not limited to:
1. Delaying or extending normal program completion time frames
2. Delayed graduation
3. Putting the program "on hold" for a period of time
4. Delaying future cohorts of learners
5. Options at this time not evident, but those that may be identified by PDs, and presented to ACOMPTE at a later time in defense of actions taken.

iii. **Time Extension:** Programs may offer a specific time extension.

iv. **Educational Hours:** Programs may use online, remote, or virtual technologies for delivery of educational hours, even if those methods were not previously used by the program.

v. **Required Practice Setting:** Programs may waive the minimum hours within a required practice setting.

vi. **Curriculum Changes:** Programs may develop alternative assessments.

vii. **Practice Hours:** Programs may temporarily waive up to 50% of the total practice hours, provided the participant has met the program outcomes, AND at least 500 total hours of fellowship training is completed by each individual FiT.

viii. **Mentoring Hours:** The PD has the discretion to allow that some portion of these mentoring hours may occur in-person or using synchronous or asynchronous methodologies. The clinical supervision standards remain in effect.

ix. **Faculty Evaluations:** ACOMPTE is temporarily suspending the requirement for faculty evaluations, including the annual mentor observation evaluation.

<u>Ensuring participant completion</u>

1. Change in educational delivery options:

Each program must make their own decisions regarding the best actions to take to ensure continued education for its participants, while following national, state, and local regulations/ recommendations. The COVID-19 pandemic may lead to a delay in the normal program completion time for participants. Decisions to participate in practice sites, extend time to graduation, and/or delaying the start of the program's start date may pose ethical and legal consequences; therefore, programs are encouraged to have program changes be reviewed by legal counsel representing their institution/program.

a. **Educational Hours and Didactic Content:**

i. Educational requirements for residency and fellowship programs remain unchanged; however, programs may alter the methodology in which the didactic content and educational hours are delivered. The utilization of online, remote, or virtual technologies can be implemented for delivery of educational hours, even if those methods were not previously used or reported in the accreditation documentation.

ii. The American Council of Academic Physical Therapy (ACAPT) provides a variety of resources to assist faculty in the transition to an online learning format.
1. https://www.acapt.org/covid19-response

b. **Timing of delivery:**

i. Programs may alter the curricular sequence by providing an increase in didactic content during this period of limited patient and provider contact reserving more in-person learning opportunities at a later date.

c. **Skills Check Offs:**

i. Skills check offs and manual labs fall under "Educational Hours" which the ABPTRFE guidance states that the program can modify the format to an online or virtual learning mode to assess skills during this time. Labs can be completed virtually provided the learning will be consistent as well as the ability of the program to assess resident achievement of the outcomes.

ii. In the absence of virtual labs, programs have tasked participants with identifying psychometric properties of a test/measure/hands on skill as well as patient and provider positioning to successfully complete the skill.

2. Utilization of telemedicine/education

a. **Patient Care hours:**

i. When possible, programs should still attempt to meet minimum practice hour requirements within required practice settings outlined within the DRP/ DFP for the program's area of practice.

ii. **Telemedicine:** Hours completed via Telemedicine with a typical patient population for the residency will be allowed to count as patient care hours.

b. **Mentorship hours:**

When possible, programs should still attempt to meet minimum mentorship hour requirements. Given limited patient interaction and institutional restrictions on number of individuals within a clinic the following exceptions have been applied:

i. **150 Total Hours Requirement:**
1. **ABPTRFE Total Hours minimal requirement** reduced to **100 hours:**
a. **65 hours: 1:1 Mentorship**
i. **ABPTRFE:** No change in the way these hours are obtained has changed. Qualifi-

cations for 1:1 mentorship still requires the mentor and participant fully present during patient care mentoring.

b. 35 Hours: Non 1:1 Mentorship

i. **ABPTRFE:** Mentoring hours are allowed to be completed virtually through video conferencing, online or via phone discussion.

2. **ACOMPTE:** ACOMPTE supports program modification using virtual technology to ensure the total 150 hours of 1:1 mentorship hours with a Fellow of AAOMPT are completed with a reduction in non-Fellow AAOMPT mentorship hours provided the FiT has met the program outcomes.

   a. Program directors may use discretion allowing some portion of these mentoring hours may occur in-person or using synchronous or asynchronous methodologies. The clinical supervision standards remain in effect: 75 hours of technology based distant synchronous and asynchronous mentoring and 75 hours of direct mentoring (1:1) with a FAAOMPT. It is preferable that the important 75/75 hours 1:1 direct Mentorship with a FAAOMPT Fellowship training be direct and in person if possible.

c. **Live Exams:**

   i. Programs are allowed to use alternatives for live patient exams such as videotaping or via telemedicine. A new evaluation can be completed and the program director/mentor can watch the recorded video or watch live via zoom to use as a live patient examination for the assessment of residents. The program coordinator is required to fill out the same grading form. The alternative methods must demonstrate that the program is still able to assess resident progress and that they are meeting program goals/outcomes.

d. **Telemedicine Resources:**

   i. Telemedicine guidelines and state practice acts are continually changing where we encourage practitioners to routinely refer back to resources for updates.

      1. The APTA has compiled a variety of resources regarding Medicare/Medicaid and other third-party payers' guidelines as well as state practice acts allowing telehealth.

         a. https://www.apta.org/Telehealth/

      2. Telehealth Physical therapy provides a variety of resources including a library of actual PT/patient telehealth video sessions.

         a. https://www.apta.org/Telehealth/

<u>**Program Sustainability**</u>

1. **Applicant and Program Sharing:**

   Many institutions are currently on a hiring freeze jeopardizing whether they will be accepting participants this next year. Additionally, a delay in entry-level students graduating due to early termination of clinical rotations and/or a delay for graduated students to sit for the National Physical Therapy Exam may create a shortage in applicants. To assist with this, programs are encouraged to share any openings they have and/or available qualified applicants who they cannot retain.

   a. Residency and Fellowship- Physical Therapy Centralized Application System (RF-PT-CAS) users:

      i. If your program is in need of applicants and you have surpassed the deadline listed on RF-PTCAS, consider extending the RF-PTCAS deadline or changing the deadline to rolling admission. As soon as this is completed, applicants will again be able to see that your program is accepting applications.

   b. Non RF-PTCAS and RF-PTCAS users:

      i. The ORF-SIG has shared a survey for programs to provide to applicants not accepted into your program and are still seeking a resident/fellowship position this coming year.

      ii. If you have **additional qualified applicants** to share:

         1. Please provide the applicant access to this survey acknowledging that they are willing to share their information with other programs to contact them.

            a. Link: https://forms.gle/pUFiTnERtJphjhbo6

         2. Also, please provide these applicants with the list of Programs listed in the **In Need of Applicants tab** for the participant to reach out.

      iii. If you are in need of applicants, please add your program's name and contact information to the **In Need of Applicants tab**.

         1. Please update this list regularly. Posts will be deleted after 12 months to make sure this is kept up-to-date.

         2. Link: https://docs.google.com/spreadsheets/d/1-FjtY4YzTbbgO-9hIMXk22vcCxxQ1q6Wb6IZm5dlAkd4/edit?usp=sharing

2. **Alternative financial resources**

   a. Tuition assistance

      i. Programs may consider use of institutional foundations to provide scholarship/grants to cover tuition in part or fully.

      ii. Programs may consider deferment of tuition.

      iii. Programs may consider a payment plan for tuition over the course of the year.

   b. Unemployment Information

      i. Resident and/or faculty can be directed to: https://www.usa.gov/unemployment for further guidance related to unemployment and COVID-19 specific programs

      ii. Please visit your state's Department of Labor/Department of Workforce Development for state specific processes. An unemployment benefits finder by state is accessible at:

         1. https://www.careeronestop.org/LocalHelp/UnemploymentBenefits/Find-Unemployment-Benefits.aspx?newsearch=true

   c. Small Business Administration (SBA) Resources

      i. Coronavirus Small Business Guidance & Loan Resources are available at:

1. https://www.sba.gov/page/coronavirus-covid-19-small-business-guidance-loan-resources
   ii. Additional information related to support of business planning and counseling, can be found at (scroll toward bottom of page):
      1. https://www.sba.gov
d. Private Practice Section of the APTA (PPS) Resources:
   i. PPS has collected a variety of resources for private practices regarding how businesses can respond to the CoVid-10 pandemic including both financial and human resources related topics.
      1. https://ppsapta.org/physical-therapy-covid-19.cfm

2020 CSM ORF-SIG Residency/Fellowship Poster Winner

Consideration of Health Literacy and Acculturation in a Non-Native English-Speaking Patient: A Case Report

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ABSTRACT

Background and Purpose: Low health literacy and acculturation are risk factors for poorer health outcomes. The purpose of this case report is to describe the assessment of health literacy and acculturation in a non-English speaking patient seeking physical therapy, and how this information was used to modify the treatment approach by a physical therapist of a dissimilar cultural and language background. **Methods:** The Basic Health Literacy Screen (BHLS) and Short Acculturation Scale for Hispanics (SASH) were administered to a Hispanic non-English speaking male after total knee arthroplasty. **Findings:** The patient presented with low BHLS and SASH scores. Thus, exercise selection and dose, and language complexity for clinical and home exercise programs communication strategies, were manipulated to minimize cognitive burden and to optimize therapeutic alliance. The patient demonstrated excellent compliance and was discharged from physical therapy having met all personal and performance goals. **Clinical Relevance:** There are demographic and cultural discrepancies in the constituency of the general population compared to the physical therapy professional body in the United States. Consideration of health literacy and acculturation can help therapists to bridge this gap and build therapeutic alliance with non-English speaking patients.

Key Words: clinical reasoning, compliance, culture, therapeutic alliance

BACKGROUND

Therapeutic alliance is known to significantly affect patient outcomes;[1] however, language and cultural differences may present barriers to the development of therapeutic alliance between physical therapists and their patients. Hispanics are now the largest minority group in the United States, and approximately 40% of the Hispanics living in the United States are foreign-born.[2] However, 88.5% of physical therapists practicing in the United States identify as Caucasian, while only 2.5% are Hispanic/Latino and 1.5% are of African American descent.[3] Furthermore, in Miami-Dade County Florida, the demographic discrepancy between physical therapists and the general population might be even greater, considering 68.6% (1.89 million) of Miami-Dade residents identify as Hispanic/Latino and 52% are foreign born.[4] Therefore, physical therapists working in the Miami-Dade area, or other cities with large immigrant populations, are faced with a predicament: How do we, as a majority Caucasian and English-speaking professional body, build therapeutic alliance and optimize outcomes with non-English speaking patients?

Health literacy and acculturation are two measurable variables that are likely to impact therapeutic alliance and physical therapy outcomes with non-English speaking patients. Health literacy is defined as the ability to understand and make required health decisions to function in the health care environment.[5] It is estimated that only 12-26% of United States adults have proficient health literacy and that only 50% of the Hispanic and African American population in the United States are functionally literate.[6,7] Lower levels of health literacy are linked with poorer health outcomes, lower use of preventative services, higher rates of non-adherence with medication, higher hospitalization rates, and higher rates of chronic illness and mortality.[8,9] The U.S. Department of Health and Human Services has identified being from a racial/ethnic minority group, being a Non-native English speaker, and recent immigration to the United States as risk factors for lower health literacy.[10] Further, the U.S. Department of Health and Human Services developed a National Action Plan to Improve Health Literacy in 2010 with two main principles: (1) all people will have the right to health information that helps them make informed decisions, and (2) health services should be delivered in ways that are easy to understand and that improve health, longevity, and quality of life.[10] However, health literacy remains an often over-looked aspect of patient centered care in the U.S. health care system.[11]

Acculturation is the process of adopting behaviors, beliefs, and cultural elements of the dominant group in society. John Berry developed a model of acculturation with 4 categories: assimilation, separation, integration, and marginalization.[11] Assimilation is the adoption of the receiving culture and discarding one's heritage culture. Separation, on the other hand, is the rejection of the receiving culture and retaining of one's heritage culture. Integration is a middle ground and describes adopting the receiving culture while retaining ones heritage culture, and marginalization describes the rejection of both the receiving and heritage culture.[11] Studies have demonstrated that higher acculturation is associated with increased health-promoting behaviors (eg, preventative screens and contraceptive use) and increased physical health and emotional well-being.[12,13] A 2008 survey of Hispanic young adults in Miami, Florida found that those who identified as blended-bicultural individuals, equivalent to the integration category, reported lower social and emotional stress.[11] Thus, a patient's level of acculturation is likely to influence the patient-therapist interaction and may affect health outcomes.

A stronger alliance between therapist and patient is associated with greater patient self-efficacy, increased provider empathy, increased patient agreement with treatment recommendations, and it is a significant predictor of patient satisfaction and adherence to treatment recommendations.[9] With consideration of a foreign-born patient's level of acculturation, physical therapists can manipulate variables in the plan of care such as language use, nonverbal communication, physical contact, and educational materials to optimize therapeutic alliance and work with the patient toward mutually agreed upon goals.[9] The purpose of this case report is to describe the assessment of health literacy and acculturation in a non-English speaking patient seeking physical therapy, and how this information was used to modify the treatment approach by a physical therapist of a dissimilar cultural and language background.

CASE DESCRIPTION

The patient was a 63-year-old Cuban male with minimal English language proficiency 6 days status post left total knee arthroplasty (TKA) secondary to a varus deformity and osteoarthritis. The patient also had comorbid hypertension and type II diabetes, controlled with Lorsartan 100mg, Amlodipine 10mg, and Metformin 500mg. The patient lived with his wife, who also had minimal English language proficiency, and their 2-year-old son. The patient's goals focused on improving his tolerance for activities of daily living (ADLs) and recreational activities, with the ultimate goal of being able to play with his son on the playground.

The treating physical therapist was a Caucasian, native English-speaking female with limited Spanish language proficiency from high school and college level courses. The patient received 6 weeks of physical therapy services, during which time he was solely seen by this therapist. Translation services were used on rare instances when it was deemed that the potential for miscommunication would compromise the patient's safety. Specifically, there was an incident of increased lower extremity edema and concern for a deep vein thrombosis, and a translation service was used during this incident to mitigate the risk of miscommunication.

SELF-REPORTED OUTCOME MEASURES

The Brief Health Literacy Screen (BHLS) and Short Acculturation Scale for Hispanics (SASH) were administered to assess health literacy and acculturation, respectively.[5] The Brief Health Literacy Screen consists of 4 questions that assess how often the individual requires assistance with health care related tasks and how confident the individual is with completing forms and tasks without assistance. The sum is recorded, and the scores are categorized as limited,[4-12] marginal,[13-16] or adequate health literacy.[17-20] A score in the limited range provides insight that the patient may not be able to read most low literacy health materials. Therefore, clinicians should be aware that patients with scores of "limited" on the BHLS may need repeated oral instructions and may not be able to read a prescription label. For these patients, educational materials should be composed of illustrations or video recordings. A score of "marginal" implies that the patient may require assistance and may struggle with some educational materials, while an "adequate" score implies that the patient is able to comprehend nearly all health care related conversations, tasks, and educational materials. The BHLS has been shown to have adequate internal reliability and concurrent validity when administered by nurses in both outpatient clinic and inpatient hospital settings.[14] In this case report, a native Spanish speaker assisted the treating physical therapist with translating the BHLS into Spanish, and it was then administered to the patient at initial evaluation.

The SASH was also provided during the initial evaluation.[12] The SASH has been validated in Spanish and it assesses the patient's acculturation via 4 questions regarding what language they prefer to speak at home and in social situations. The score choices range from 1-5 and an average is taken from the patient's answers. A score lower than 2.99 is considered low acculturation.[15]

The patient scored 10 on the BHLS and 1 on the SASH indicating that the patient was limited in his health literacy and had low acculturation. Further, the patient scored a 29/80 (63.75% disability) on the Lower Extremity Functional Scale (LEFS) and 2/52 on the Pain Catastrophizing Scale (PCS) indicating high self-reported disability and low pain catastrophizing.

INTERVENTIONS

Based on his BHLS and SASH scores, care was taken to manipulate (1) the dosage of therapeutic exercise and activities and (2) the verbal and written language used when communicating with the patient (Figure 1). In response to the low health literacy score, methods were used in the prescription of exercise dosing, patient education, and home exercise programs (HEP) to minimize cognitive burden. Exercises were initially prescribed with simple and consistent instructions for sets and repetitions (eg, 3 sets of 10 repetitions for easy recall), using language that was also concise and simple. Explanations were typically only one or two sentences. These parameters were chosen with the goal of optimizing patient comfort with the rehabilitation process and optimizing early compliance (Table 1).

In response to the low acculturation score, the physical therapist provided all verbal and written communication with the patient in Spanish. Although the physical therapist had limited Spanish language proficiency, the use of translators was minimized throughout the plan of care to optimize the therapeutic alliance between the patient and therapist. The books "Spanish for the Physical Therapist: Bridging the Communication Barrier" by Asiya Nieves[6] and "Speedy Spanish for Physical Therapists" by Thomas Hart[13] were used as resources for verbal and written communication.

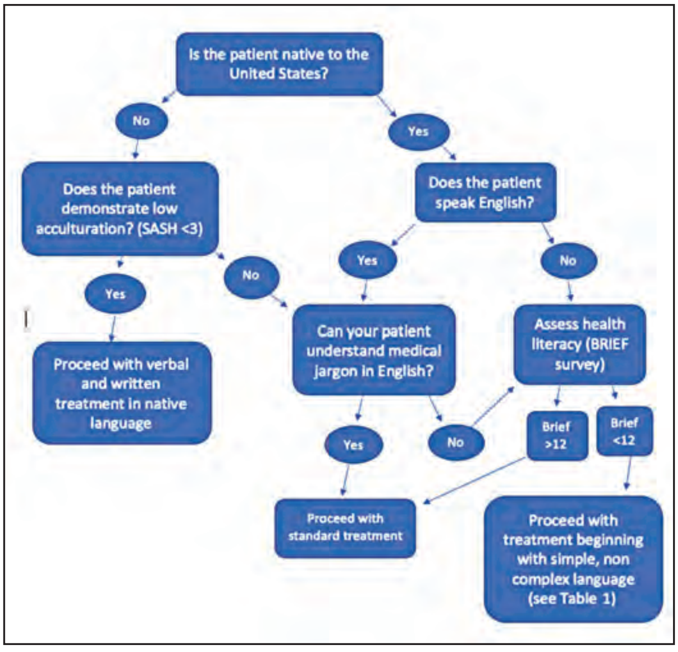

Figure 1. Decision tree for integration of acculturation and health literacy into clinical reasoning.

Table 1. Clinical Reasoning for Intervention Modification

Treatment Variable	Rationale	Intervention Modification
Language	Low acculturation	Spanish only (verbally and written)
	Low health literacy	Non-complex language Simple commands Short, concise sentences
Exercise Dosage and Parameters	Low health literacy	Simple, consistent dosages across exercises (3x10) for reduced cognitive burden Progressed exercise complexity (ie, uniplanar, BLE to multi-joint unilateral activities)
Home Exercise Program	Low health literacy	Short, concise sentences in Spanish only Ample pictures provided
Cultural Considerations	Low acculturation	Initially the wife was incorporated into therapy sessions, and slowly the patient progressed to completing entire therapy sessions without family support Discussions on his culture were integrated into the therapy sessions to gain insight to his preferences and thought process
	Low health literacy	Discussions on chronic disease management were integrated into therapy sessions to educate and encourage improved self-management

Table 2. Personal and Performance Related Measures/Goals

Objective Finding	Initial Evaluation	Progress Note	Discharge Note
Lower Extremity Functional Scale Score	29/80	58/80	68/80
Knee Flexion Active Range of Motion	46°	105°	115°
Knee Extension Active Range of Motion	Lacking 8°	Lacking 2°	0°
5x STS	22 seconds (with RW and UE support)	10 seconds (no AD or UE support)	Patient able to perform single leg STS from sitting at 90° hip and knee flexion (x30)
Single limb balance	Unable to perform; Used RW for support, difficulty weight shifting into SLS	30 second hold (goal met)	Patient able to perform SLS on airex pad with ball tosses from therapist (x30)
Straight leg raise	Unable to perform without extension lag and ~50% assistance from therapist	Independent with 5° extension lag	Independent without extension lag and 5 lb ankle weight (x30)
Gait	With RW, step to pattern	With standard cane	Daily walks with son and wife without AD
Recumbent bike	Unable to perform due to ROM limitations	Performed in clinic for 10 minutes per session	Performed in home 15-30 minutes (~3x/week)

Abbreviations: STS, sit-to-stand; RW, rolling walker; AD, assistive device; UE, upper extremity; SLS, single limb stance; ROM, range of motion

OUTCOMES

In total, the patient received 6 and a half weeks of skilled PT intervention. At the time of discharge from physical therapy, 9 weeks postoperative, he met all personal and performance related goals (Table 2). Additionally, his LEFS score improved to 68/80 (15% disability), which was a 49% improvement in self-reported disability. Other notable findings included the patient's improvements in overall physical wellness, exceptional compliance with the HEP and therapy visits, and improved understanding and self-management of his chronic conditions. The patient adopted supplementary pro-health and preventative behaviors that were not present prior to the TKA surgery. He reported performing aerobic exercise using a seated stationary bike at home for 15-30 minutes 3 times per week with a personal goal of improved physical wellness. The patient verbalized understanding of diabetic complications, and he was compliant with purchasing and using compression stockings for edema management. He also altered his workstation to allow for elevation of his lower extremities for swelling reduction.

DISCUSSION

This treatment approach, with focused consideration of health literacy and acculturation factors, likely contributed to the strong therapeutic alliance developed between therapist and patient and the excellent compliance demonstrated by the patient. Further, the strong therapeutic alliance and patient compliance may have driven the good patient outcomes observed with this patient who had multiple risk factors for poor outcomes (ie, comorbid chronic disease, low socioeconomic status, low acculturation, and low health literacy). Another unanticipated benefit of this approach was that the treating therapist self-identified personal growth with cultural competency. Thus, using health literacy and acculturation in clinical reasoning appears to have numerous benefits for patient management.

The patient went to great lengths to maintain exceptional compliance with physical therapy session attendance. Despite traveling 15 miles to the clinic for each appointment, often in heavy traffic, the patient was never late to an appointment and he only cancelled one appointment throughout his plan of care. On the one occasion of cancellation, he drove the 15 miles to the clinic just to explain to the treating therapist in person that he had a personal issue of great importance and would need to miss his appointment later that day. This event was strong evidence of the therapeutic alliance built between the therapist and patient despite their communication barriers and cultural differences.

Overcoming the communication barriers and cultural differences with the patient also led to professional and intrapersonal growth for the treating physical therapist. She reported feeling pushed to improve and refine her nonverbal communication and observational skills in order to establish patient rapport through avenues outside of explicit word choice. She also felt that the decision to minimize the use of translators allowed the patient and physical therapist to bond through their struggles to communicate. This allowed for the patient and physical therapist to directly share experiences of humor, frustration, and gratitude throughout the plan of care. Further, the growth of the physical therapist's cultural competency is of important note. Through conversations with the patient and his wife, the therapist gained knowledge of the Cuban culture and traditions. This information was used when setting goals by prioritizing aspects of the patient's beliefs and values. For example, the importance placed on family in his culture was incorporated into the physical therapy goals and plan of care by encouraging him to go on daily walks with his wife and take his son to the playground.

The primary limitation of this case study was the use of an unvalidated translation of the BHLS into Spanish. Although there are other tools for assessing health literacy, the BHLS was chosen because it is short, efficient, and direct with uncomplicated word choice. Additional research is warranted to determine if a standardized approach to modifying patient management based on health literacy and acculturation results in improved outcomes. In conclusion, this case report highlights the importance and value of integrating health literacy and acculturation factors into clinical reasoning to optimize outcomes and compliance in non-English speaking populations when there are communication and cultural barriers.

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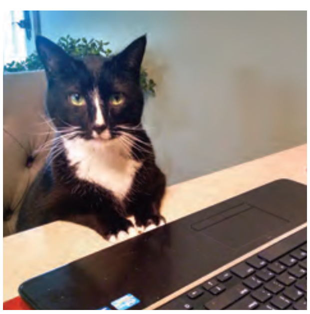
Letter From the President

Jenna Encheff, PT, PhD, CMPT, CERP

In these uncertain times, as things constantly change across the United States, and certainly within both human and animal physical therapy practices, it is important to spend our time and energy on the things we can influence and somewhat control. Like traditional human physical therapy clinics, those therapists who treat animals have had to adapt to the rapidly changing atmosphere in health care due to COVID-19. Implementing new business and practice strategies such as curb-side drop off of pets for treatment, use of telemedicine, limiting hours and number of clients in the building or barn, and social distancing in general have become new norms at this time for animal physical therapists and provides some semblance of control in these trying times. The human-animal bond is extremely important, especially in difficult times like these when people need all the support mechanisms they can get. A myriad of research studies has shown the benefits of pets on emotional, social, and mental health.[1-4] The change in our daily routines and isolation from others has put an emotional strain on many of us. However, social distancing and isolation from others has actually shined an even brighter light on the benefits of the company and interaction with our pets whether they be cats or dogs, rabbits or gerbils, horses or alpacas. Those of us who have pets do not need peer-reviewed scientific research studies to tell us the positive effects our animals have on us. Those of us who also treat animals additionally recognize the importance of helping to keep the animal healthy and sound not only for the animal's sake, but of course, for the owner's sake, as well—especially now.



My cat, Sidney, "helping" me teach an online class.

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Stepping Down

At this time, I would like to inform the APTSIG members that I have chosen to step down from my role as President of the APTSIG. I have taken on a larger role at work that does not allow me to feel as if I can give my all to the APTSIG due to time constraints. I have enjoyed my time as President and do plan to stay involved in the SIG as time allows. It is truly my wish that someday physical therapists be fully recognized as the provider of choice in rehabilitation for animals, and I am sure the APTSIG will continue to support and progress our profession in this realm.

Thank you - Jenna!

New APTSIG Officers

I would like to introduce you to the following physical therapists who were elected to positions within the APTSIG and who began their terms in February.

Vice President: Francisco Maia, PT, DPT, CCRT, is the owner of TheK9PT, a canine rehabilitation business in Chicago. He graduated with his DPT from the University of Pittsburgh in 2012 and finished his certification as a canine rehabilitation therapist through the Canine Rehabilitation Institute in 2015. He has been a member of the APTA since 2009 and member of the APTSIG since 2015. He also serves as an Assembly Representative for the Illinois Physical Therapy Association and has been working closely with them to advance legislation regarding animal rehabilitation in Illinois. Francisco will be stepping into the role of President.

Nominating Committee Members:

Nicole Windsor, PT, DPT, FAAOMPT, CERP, specializes in orthopedics and manual therapy for humans and is a Certified Equine Rehabilitation Practitioner via the University of Tennessee (2017). She attained her Master's in Physical Therapy via Wichita State University in 2004 and in 2009 attained a Fellowship in manual therapy (FAAOMPT) via The Manual Therapy Institute, while concurrently pursuing a tDPT with the University of Kansas. Most recently, she owned Cornerstone Physical Therapy, an outpatient private practice, in the Kansas City area. She was also an Assistant Professor at the University of Saint Mary in the Doctor of Physical Therapy program and is currently at the University of Kentucky working on a PhD in Rehabilitation Sciences which will assist her in returning to a role in DPT education.

Marilyn Miller, PT, PhD, GCS, is an Associate Professor in the DPT program at the California campus of University of St. Augustine. She started her career as a student in the US Army PT program; and left active duty for civilian practice working in multiple states to include New Mexico, Alabama, Arkansas, Hawaii, and now California. She earned a Master's degree in Gerontology at the University of Arkansas at Little Rock and a PhD in Higher, Professional and Adult Education at the University of Southern California. Dr. Miller has been active in multiple APTA sections, State Chapter offices & committees, as well as APTA/CAPTE positions.

Over the next few months, our new officers will continue to receive orientation to their new roles and participate in APTSIG tasks, activities, and duties. We thank them for their service!

We are actively looking for members to serve as state liaisons for the APTSIG. Each month we receive several emails asking about state specific rules and regulations related to animal physical therapy and we need members from each state who are knowledgeable in their state PT and Veterinary Practice Acts to whom we can refer these inquiries. If interested, please contact Francisco at fmaia@orthopt.org.

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