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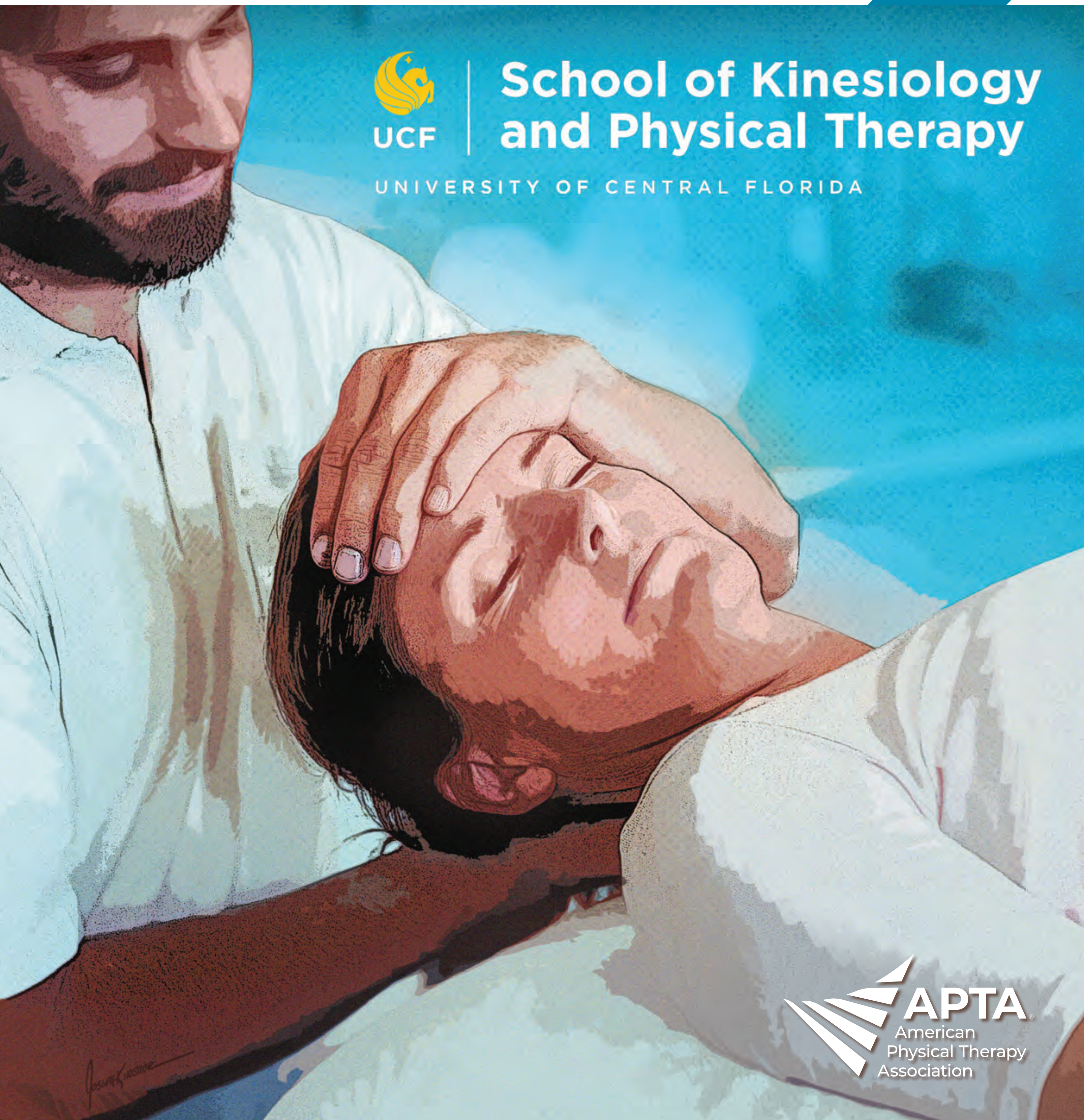
ORTHOPAEDIC PHYSICAL THERAPY PRACTICE

The publication of the Academy of Orthopaedic Physical Therapy, APTA



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The publication of the Academy of Orthopaedic Physical Therapy, APTA

In this issue

Regular features

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To serve as an advocate and resource for the practice of Orthopaedic Physical Therapy by fostering quality patient/client care and promoting professional growth.

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President's Corner

"Resilience or Languishing"

Joseph M. Donnelly, PT, DHSc, FAPTA

I want to thank the AOPT BOD and staff for their resilience, hard work, and continued dedication to the membership and profession during the COVID-19 pandemic. There have been many challenges that we faced head on and at the same time discovered many opportunities to improve efficiencies and member engagement.

The AOPT is committed to Practice, Research, Education, and Advocacy for continued growth and progress for both orthopaedic physical therapy practice and the profession. The AOPT leadership continues to move the new Strategic Framework forward. This brings all the special interest groups and committees in alignment with the organization's strategic framework to develop an effective and cohesive leadership team.

The one thing the COVID-19 pandemic taught us is to be flexible, adaptable, and that change would be constant as we navigated the unknown. As a result of uncertainty and the unknown, "I have felt tired, very tired, and at times confused and lost." As I searched for words or a word to describe these feelings of Blah through a University meeting, I learned that languishing may be the new word of choice to describe these feelings. Languishing has a couple definitions, the first being to become weak, feeble, or enervated and the second one is to be or live in a state of depression or decreasing vitality. So perhaps spending that last 14-16 months during the Pandemic in variable forms of self -isolation or living in a bubble with a few people, and a constantly changing work environment, perhaps languishing is a good word to use. At the end of the day what is missing is our human interaction, human touch, the feeling of joy when you see your family and friends because the digital screen is not a substitute for what we as humans and physical therapists prefer. I am optimistic that we have turned the corner and we will establish what our new normal is over the next couple of years; I do know for me it is going to be a lot of hugs, joy, and smiles.

Here is an inspirational quote from Rosabeth Moss Kanter that I find quite compelling:

> "Everything looks like a failure in the middle. There are numerous roadblocks, obstacles, and surprises on the journey to change, and each one tempts us to give up. Give up prematurely, and the change effort is automatically a failure. Find a way around the obstacles, perhaps by making some tweaks in the plan, and keep going. Persistence and perseverance are essential to successful innovation and change."

I believe the COVID-19 pandemic has presented many opportunities for change regarding practice, education, research, and advocacy for our profession. Will we capitalize on the opportunities or will we dig our heels in and go back to how it was or use to be? I say we seize these opportunities to doing things differently as we move toward our vision of "Transforming Society by Optimizing Movement to Improve the Human Experience." Motion is the lotion to getting our patients/clients back in action after 14-16 months of static prolonged postures and declining activity levels. We need to seize this moment and be the practitioner of choice for movement impairments caused by the COVID-19 pandemic.

The AOPT's Pain SIG in collaboration with other Section/Academies, APTA, and ACAPT will be releasing the long-awaited Pain Education Manual for DPT educators this summer. This has been a monumental task led by Mark Shepard and the Pain SIG. It is modeled after the Manipulation Educational Manual to guide DPT educators regarding curricular content specific to pain science education in DPT programs. I want to personally thank the work group for staying focused during the pandemic to produce this much needed document. A job well done and on behalf of the AOPT leadership team, thank you!

Additionally, I want to take this opportunity to thank Tara Jo Manal for her service to the AOPT over the past 2.5 years as a Director. Tara Jo has accepted the Senior Vice President of Scientific Affairs at APTA effective July 1, 2021. We wish Tara Jo the best of luck in her new position. During the May AOPT BOD meeting, the Board appointed Annette Karim to serve as interim Director effective June 1, 2021 – February 2022 to complete Tara Jo's term.

In closing and as we prepare for the

Value and Payment	***• Enhance payment for services by demonstrating the value of physical therapy***
Positioning and Public Awareness	***• Position members as experts in managing movement and functional performance impairments***
Diversity, Equity, and Inclusion	***• Increase the diversity of members and leaders and engage in efforts to make AOPT a more inclusive organization***
Evidence to Best Practice	***• Promote the development and implementation of evidence to best practice***

House of Delegates (HOD), I would like to take an opportunity to share some thoughts from my esteemed colleague and AOPT Past President, Steve McDavitt regarding scope of practice safety and efficacy.

"I support the Special Committee review and decision on the PTA not voting in HOD and why this is an important issue that needs to be discussed. We all appreciate the HOD is where Physical Therapist practice pertaining to standards, ethics, positions, and policies are deliberated and determined. I do not understand the rationale being brought forward supporting PTA voting in the HOD. The special committee to the bylaws (SCB) position clearly stated well-founded rationale opposing changes in the ability of PTA Caucus delegates to vote on motions coming before the house in their "Special Committee to Review Bylaws and Prepare Amendments" report. What is the issue? I agree with the opponents that we are better together, but I disagree on their opposition because, we are not the same. Inclusivity doesn't mean everyone has the same rights and privileges as members of the APTA. We need to accept our differences and work together as we pledged coming into the field of physical therapy fully knowing our differences and our accountabilities. Also, on the opposing side to support voting in the HOD by policies on component level voting in comparison, is invalid Yes, regulation can be determined at the component level however, standards of practice, scope of practice, code of ethics, and how regulation is seen and considered by the oversight of the representative professional association (APTA), is controlled by the house of delegates.

This debate on voting should first reconcile who has the scope of practice (physical therapist) and in that appreciation, who therefore should oversee and prescribe the standards within scope of practice across standards for practice, code of ethics and standards of ethical conduct. Certainly, that would be the physical therapist. It appears to me that in my leadership experience over the course of greater than two decades, some in our profession continue to demonstrate institutional amnesia about the historical purpose of the development and implementation of the physical therapist assistant and drift into their own self-biased validation and interpretation, leading to promoting advancement of PTA scope of work and governance creep. Why do we have such a severe problem accepting that there are differences in purpose, and practice rights and privileges of the physical therapist assistant and the physical therapist? This necessary line drawn between purpose and responsibilities as well as practice rights and privileges are not about disenfranchising, being mean or indifferent, or not appreciating value for either PTs or PTAs. It is reality based on the physical therapist having the scope of practice and therefore the necessary oversight on standards for practice and code of ethics etc.

If we are the same, then one of two things must occur.

1. PTAs should now be considered as having a scope of practice and have all rights and responsibilities as the PT. If that is the case, then we are saying that an associate degree is all that is needed to meet and derive practice standards. Since all practice vignettes for scope of practice, ethics, APTA policies and positions, and payment coding have been based on physical therapist practice skills and responsibilities across the DPT physical therapist management model including clinical reasoning, then what we must now change includes our APTA positions and policies, public awareness campaigns, regulations within practice acts, remove the DPT, and to prevent being disingenuous or worse fraudulent, adapt payment codes accordingly to significantly reduced reimbursement. There go the phases of our evolution backwards from today's practitioner of accountability (current), back to autonomy (2013-2020), back to allied professionals (1940/50-2000), and land back to reconstructive aides (1913-1940).

Or

2. PTs continue to practice owning the scope of practice within physical therapy and appreciating and integrating physical therapist assistant under the supervision and responsibility of the physical therapist and the standards they uphold in scope of practice and ethics etc.

This is the profession of physical therapy but within that it is where the physical therapist has the scope of practice framed within their oversight and determination for standards within the practice, code of ethics and ethical conduct. The physical therapist assistant has no scope of practice, only a scope of work and must abide by the collaboration and oversight of the physical therapist who defines and oversees standards of practice, practice code of ethics and ethical conduct. This decision on voting in the HOD is not a personal one but rather a professional one. This is not about being unfair or apathetic for the PTA. This is about the ownership and the delivery of standards for the principles of practice, scope of practice and oversight that must be governed by the practitioner having that scope of practice.

Not supporting PTA voting in the HOD is not indicating that physical therapist assistants are not valuable in their point of view within physical therapist practice. Nor does it mean they do not have a voice. Frankly, many organizations have voting and nonvoting members providing insight and deliberations within their boards I have been on boards within AOPT and APTA leadership without voting privileges, and from deliberations and presentation of positions, I have had more than enough opportunities to speak where it made a significant influence and impact on the vote during the debates.

The investigation, logic, and validity of the investigation by the special committee is clear and concise on the voting issue yet we continue to have these empathetic debates not only about voting but about practice. Physical therapist practice is founded not just on psychomotor skills but on a complex oversight involving clinical reasoning as defined by the practice algorithm (Physical Therapist Management Model-*Guide to Physical Therapist Practice*) of examination, evaluation, diagnosis, prognosis, determining the plan of care including intervention, and measuring results and outcomes. We have worked for decades to get away from being known as a practice of interventions.

The PT:PTA team works well within the physical therapist management model. However, let us not forget that the scope of practice is the responsibility of the physical therapist not the physical therapist assistant. As team members within the practice of physical therapy, physical therapist assistants should have input and feedback about the standards of practice, code of ethics, and standards of ethical conduct. PTAs need to realize that not having ownership on the scope of practice within physical therapy, their role and responsibility should

(Continued on page 129)

Editor's Note

How many patients do you see in a day? In a week? What does your employer expect of you for productivity? Are you a clinic owner who is trying to keep a business viable in this reimbursement climate? In this editorial, I would like to highlight two House of Delegates motions that are coming forward for consideration in September 2021. The House of Delegates is the governing body of our profession that meets annually to address issues and make changes that affect our professional practice. Both proposed motions are meant to address productivity. At the time of this writing, Ohio's Megan Donaldson, PT, PhD, is proposing the following motion:

> *The APTA shall explore and develop realistic productivity guidelines that incorporate direct, indirect, and non-patient care activities to promote a clinician's ethical behavior and wellbeing.*

The second motion addressing productivity is from Arizona's Jim Roush, PT, PhD, and at the time of this writing states:

> *The American Physical Therapy Association recognizes that unreasonable productivity standards in physical therapy can contribute to lapses in ethical behavior, increase clinician burnout, and prohibit provision of high-quality care. The APTA supports productivity standards only when they are realistic (performance standards are balanced with quality patient outcomes), respect clinical judgment, and prioritize patient and clinician well-being.*

The language in both of these motions may change or be edited multiple times before September's House of Delegates but this is the current proposed wording.

Clinic owners are challenged to provide optimal care in a diminishing reimbursement environment. They face the challenge of offering competitive salaries and have high overhead costs to maintain their business.

I hear stories from former students who are practicing in outpatient clinics across the country. They say they are being asked to treat large volumes of patients day in and day out OR have 15 minutes for treatment and being double- or triple-booked OR have less than 30 minutes for an evaluation and no time for documentation. It is a common theme among new professionals practicing orthopedics. Recently, I talked to a new graduate who decided to leave orthopedic outpatient practice in favor of acute care. He was being asked to see too many patients and after a 10- or 12-hour day, he spent his evenings writing notes at home. He was hopeful that perhaps other clinics would have more realistic productivity standards, but he was mistaken. He heard from potential employers who expected him to see ~35-45 patients per day. This is beyond what a reasonable practicing physical therapist should be asked to do.

The Academy of Orthopaedics is sending two delegates this year to vote at the House of Delegates, Chief Delegate James Spencer, and Delegate Gretchen Self. This is the first year that Academies and Sections have been able to vote, so this year is much different than any previous year. Previously, Academies and Sections were only able to discuss, co-sponsor, or refute a motion. James Spencer is the Practice Chair, and he will be overseeing this process. The Academy thanks James for his work to benefit our members and stay abreast of all of the discussions on these motions.

In this editorial, I hoped to make you aware of these two motions. If you have interest in these motions, whether to agree or disagree with these potential changes, please consider emailing James at jspencer@orthopt.org to provide input as an Academy of Orthopaedics member and consider going to the APTA Hub website and view the Motion and Report discussions to review the forum on this topic. http://communities.apta.org/p/co/ly/gid=16

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

PRESIDENT'S CORNER

(Continued from page 128)

not be having an oversight vote on physical therapist practice standards, ethics, or other influential components of governance. This is not an issue of disenfranchising physical therapist assistants. Voting on physical therapy practice standards, including code of ethics, influences physical therapist scope of practice and therefore until there is such a time that there is a change in this PT:PTA relationship within physical therapy, PTAs should not be voting on such.

We need to stop this "us vs them" mentality. It is eroding our energy to do our good work as a team. PTs and PTAs are the field of physical therapy. We are better together but we are not the same. We should accept and respect our differences and work together as we pledged coming into the field of physical therapy fully knowing our differences in accountabilities."

It is July and the slate of candidates has been presented to you for the August elections for AOPT BOD and Nominating Committee. This is your opportunity to engage in the selection of your AOPT BOD and Nominating Committee. Remember that SIG leadership elections occur in November.

I hope everyone is enjoying their summer and reuniting with family and friends. Take a moment to experience the joy and have a great summer.

Best Regards,
Joe Donnelly

Immediate Changes in Cervical Range of Motion and Myofascial Sensitivity After Standardized Manual Stretches: A Randomized Controlled Trial

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ABSTRACT

Background and Purpose: Adequate cervical range of motion (ROM) is necessary to perform functional activities of daily living, and pathologies such as migraines, tension headaches, and neck pain have been associated with a decrease in ROM. While interventions often address ROM deficits, the magnitude of change for common interventions such as passive manual stretches is not clear. Therefore, the purpose of this study was to evaluate the influence of myofascial stretches on cervical ROM and myofascial sensitivity. **Methods:** Sixty participants (mean age 25.1±3.7; 32 female/28 male) with no history of neck pain were randomized into one of two groups: stretching group (n = 30) or control group (n = 30). The stretching group received a standardized manual stretching protocol. The control group did not receive any intervention. **Findings:** Group by time interactions were found to be significant for left side bend (p=0.001) 95% CI (-3.0,3.2); right side bend (p=0.025) 95% CI (5.0,1.8) and left rotation (p=0.003) 95% CI (-7.4,2.2). **Clinical Relevance:** Manual stretching to specific muscles seem to improve cervical ROM. Clinicians may consider this intervention as an internal part of a treatment session; particularly when the patient would be better served with an increase in ROM. **Conclusion:** After a single session of the manual stretching procedure, participants immediately demonstrated increased cervical ROM. Future research will need to evaluate the long-term effects.

Key Words: algometry, pain perception, pressure pain threshold

INTRODUCTION

Individuals require a sufficient amount of cervical range of motion (ROM) to perform functional activities of daily living.[1] Many factors contribute to decreased cervical ROM, including but limited to degenerative changes and osteophyte formation along the C-spine, soft tissue injuries, pain as well as muscular tightness along the neck and upper trunk.[2,3] Pathologies linked to limitations in cervical ROM include migraines,[4] tension headaches,[5] and neck pain,[6] which can result in disability and functional impairments. Common interventions used to increase cervical ROM may play a significant role in managing these conditions.

The cervical spine requires activation of various muscles in addition to proper biomechanical function to allow for movement to occur in all planes. Tightness of structures within the cervical spine such as ligaments, muscles, and intervertebral disc pathologies may contribute to decreased cervical ROM.[6] Furthermore, increased myofascial sensitivity has been shown to be a contributing factor to decreased ROM.[7,8] Myofascial sensitivity may be influenced by trauma, overuse, or mechanical overload/stress, leading to shortening, loss of oxygen supply, and loss of nutrient supply on local tissues.[5]

One of the interventions that has demonstrated effectiveness with regards to decreasing myofascial sensitivity is stretching.[7,9] Stretching is a general term used to describe any therapeutic maneuver designed to increase the extensibility of soft tissues, thereby improving ROM by increasing the length of structures that have become adaptively shortened, losing extensibility over time.[10,11] Improvements in ROM are a result of biomechanical and neural changes in both the contractile and non-contractile elements of the muscle-tendon unit.[12] These changes are thought to be the result of increased muscle extensibility and decreased muscle stiffness.[13] Many forms of stretching are effective, however, the traditional and most commonly used is static stretching.[14] Evidence suggests that static stretching is most effective at increasing ROM, with the greatest change occurring between 15 and 30 seconds,[15,16] however, no further increase was noted after 4 sets.[17]

The positive effects of stretching have been widely cited throughout the literature, and include increased ROM, as well as decreased sensitivity to pain and pressure.[7,18,19] Tunwattanapong et al[20] reported that a regular stretching exercise program performed for 4 weeks decreased neck and shoulder pain in addition to demonstrating improved neck function in office workers with chronic moderate to severe pain. Oliveira-Campelo et al[7] found that a passive stretching technique applied to the upper trapezius muscle had significant immediate improvements in lateral flexion ROM by 24% and an increase in pressure pain threshold (PPT) by 31.6%. Hanney et al[18] investigated the immediate effects of manual stretching and cervicothoracic junction manipulation on cervical ROM along with upper thoracic PPT. The authors' results demonstrated significant differences in cervical ROM, however, further research is needed to determine changes in PPT of the upper trapezius.

Although authors have examined the effects of soft tissue massage,[21] neck exercises,[22-24] stretching,[18,25] and joint mobilization/manipulation,[26-28] on myofascial sensitivity and ROM, there is limited evidence that has examined isolated standardized stretching programs targeting multiple muscles surrounding the cervical spine.

Despite the current evidence on stretching and its correlation to myofascial sensitivity and cervical ROM, no recent studies have evaluated the immediate effects of a standardized manual stretching procedure for specific muscles surrounding the cervical spine. Currently, it is unclear whether performing manual stretching to the upper trapezius and levator scapulae musculature will produce an immediate significant change in cervical ROM and pressure sensitivity when compared to a control group. Therefore, the purpose of this study was to investigate the immediate effects of a standardized stretching procedure of the upper trapezius and levator scapulae muscles on cervical ROM and PPT in an asymptomatic population.

METHODS

Participants

Participants aged 18-60 years old were recruited for this investigation through word of mouth and posted flyers around the University of Central Florida (UCF) campus. Students, faculty, and staff members interested in participating were screened for eligibility. The screening process involved an investigator measuring cervical flexion with a CROM device that has demonstrated an intraclass correlation coefficient (ICC) of 0.89 and a standard error of measure of 2.8°.[29]

Prior to the screening process, potential participants were required to fill out a health form questionnaire to clear for contraindications and precautions to stretching and cervical movements (eg, recent neck trauma or surgery). Inclusion criteria included participants between the ages of 18 and 60 with active cervical flexion < 45˚ (determined via the screening process). A limitation in cervical flexion ROM was included as an inclusion criteria to optimize the potential a stretching protocol would alter ROM. Exclusion criteria included minors, prisoners, participants with cognitive impairments (determined by ability to complete health form questionnaire), and participants with recent neck surgeries or pre-existing neck injuries. An a priori power analysis was performed based on a margin of error of 5% and confidence level of 95% that 60 participants were needed for a power of 0.80. The procedure was approved by the UCF Institutional Review Board.

Procedure

The study was a single-blinded randomized controlled trial. A single room was divided in half and had a door for each side of the divided room for participants to enter and exit. The primary outcomes, cervical ROM and PPT, were assessed on one side of the room, and the interventions were performed on the other side. Investigator 1 explained the study protocol and obtained informed consent. Investigator 2, who was the designated data collector and blinded to the study groups, recorded the baseline measurements.

Cervical range of motion

An investigator blinded to the assessment began by explaining what the assessment device was going to be used for, what was to be expected, and instructions regarding the starting body position and desired motion to be measured using verbal and tactile cues as needed. Tactile cues included taps on the shoulder to indicate the side being measured. Cervical ROM including flexion, extension, side bending left, side bending right, rotation left, and rotation right was measured using a CROM device (**Figure 1**). The participants were positioned in a seated upright position and for each direction of cervical motion, one of the following instructions were given, "Tuck your chin, then bring your chin to your chest," "tuck your chin, then look up towards the ceiling, tilting your head back as far as you can," "bring your ear to your shoulder," and "turn your head and look over your shoulder." The participants were also given instructions to move into each desired direction as far as possible. Each direction was performed and measured twice, and the average of the measurements was recorded. The CROMTM device is a reliable tool for cervical ROM measurements, with an ICC ranging from 0.89 and 0.98.[29]

Figure 1. Cervical Range of Motion Device

Figure 2. Upper Trapezius Pressure Pain Threshold Assessment

Pressure pain threshold

The blinded investigator began by explaining what the assessment device was going to be used for, what was to be expected, and instructions regarding starting body position and a signal from the participant telling the investigator when to stop. The PPT was recorded using a Wagner FDX-25 hand-held digital pressure algometer (Wagner Instruments, Greenwich, CT). The investigator performed each assessment uniformly by applying force at the same rate of 5 Pa/second. The first measurement of PPT was applied to the upper trapezius muscle. The participants were in a seated position and a mark was applied to the midpoint between C7 and the acromion along the upper trapezius muscle belly to standardize the measurement (**Figure 2**). The participants were provided the following instructions, "I'm going to begin applying pressure to your muscle. I want you to tell me the moment the sensation changes from comfortable pressure to slight discomfort." Slow pressure was applied until the participants said "now." Once the participants signaled a stopping point, the investigator read and recorded the pressure directly from the algometer device. The second measurement of pain pressure was applied to the levator scapulae muscle. The participants were positioned in prone and a mark was applied 2 cm above the lower insertion located in the upper medial border of the scapulae to standardize the measurement (**Figure 3**). The participants were provided the same instructions as mentioned above for the upper trapezius muscle. The interrater reliability for the Wagner FDX-25 hand held digital pressure algometer has been reported to be excellent (ICC = 0.79-0.90).[30]

Randomization

Once the baseline data were recorded on the participant's data collection form, investigator 1 randomized the participants into one of two groups: stretching group, or a control group that received no treatment interventions. Constrained randomization was completed by having the participants draw either a letter A or B from an opaque jar. Letter A was designated controlled group, and letter B was the treatment group. After being placed into either the control or treatment group, participants then entered the intervention side of the room, where investigator 3 awaited to either implement the treatment protocol or perform no treatment.

Intervention group

If the participants drew the letter B, investigator 3 implemented the stretching protocol. If the participants felt more than slight pain with manual stretching, the investigator stopped the stretch and the participants were withdrawn from the study.

Stretching upper trapezius

The participants were positioned supine on the treatment table. The investigator was positioned at the head of the treatment table. With one hand, the investigator passively moved the participant's head into lateral flexion away and rotation toward the depressed shoulder, and then into flexion until a muscle barrier was felt. To standardize the amount of force applied to all the participants, the investigator used the MicroFET Digital Handheld Dynamometer (Hoggan Scientific, Salt Lake City, UT) to depress the shoulder by providing 100 N of force to the acromion (**Figure 4**). The stretch was held for 30 seconds and performed twice for the right upper trapezius and twice for the left upper trapezius.

Stretching levator scapulae

Following the upper trapezius stretch, the investigator repeated the same procedure to stretch the right and left levator scapulae muscles. To do so, the investigator passively moved the participant's head into lateral flexion away and rotation away from the depressed shoulder, and then into flexion until a muscle barrier was felt. Once again, the investigator used the MicroFET Handheld Dynamometer to depress the shoulder by providing 100 N of force to the acromion (**Figure 5**). The stretch was held for 30 seconds and performed twice for the right levator scapulae and twice for the left levator scapulae. After the stretches, participants returned to the assessment side of the room, where investigator 2 collected and recorded post-test measurements.

Control group

If the participants drew letter 'A', they were placed in the control group and did not receive any intervention. Participants in this group waited in the intervention side of the room for 5 minutes in a seated position. Participants then returned to the assessment side of the room, where investigator 2 collected and recorded post-test measurements. See **Figure 6**.

Statistical analysis

All data were analyzed using SPSS (IBM version 25; Armonk, NY). Within group differences from baseline to post-intervention were evaluated via a dependent t-test, between group differences were evaluated via independent t-test and 95% confidence intervals, and lastly, group-by-time interactions were evaluated by a repeated measure analysis of variance (ANOVA). A p-value of < 0.05 was considered statistically significant.

Figure 3. Levator Scapulae Pressure Pain Threshold Assessment

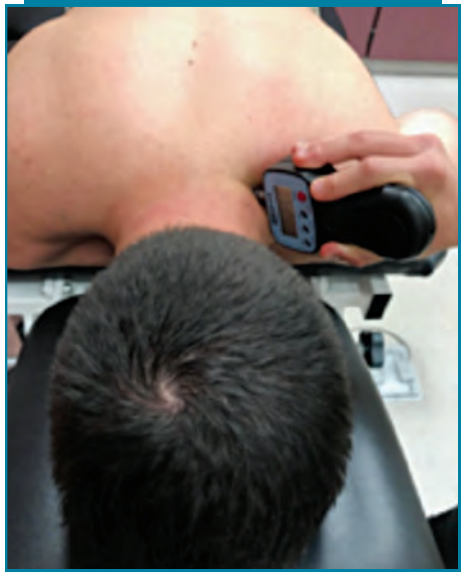
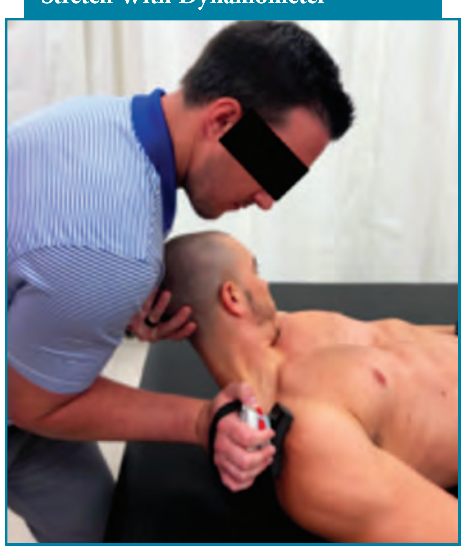


Figure 4. Manual Upper Trapezius Stretch With Dynamometer

Figure 5. Manual Levator Scapulae Stretch With Dynamometer



RESULTS

A total of 60 participants were recruited (32 female, 28 male) with a mean age of 25.1 (±3.7) years. These participants met the inclusion criteria and provided informed consent for participation in the study. Participants were randomized into a manual stretching group or a control group. There were no statistically significant differences with baseline demographics for age, height, and weight. Initial PPT and ROM values also did not demonstrate statistically significant baseline differences (**Table 1**).

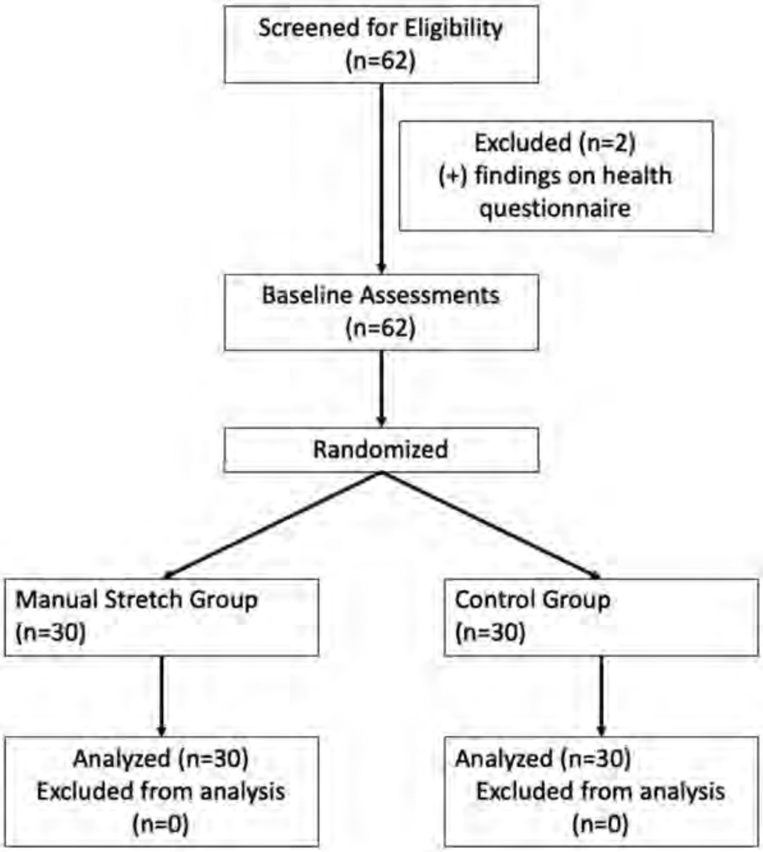
Within group differences were significant from baseline to post-intervention in the manual stretching group for ROM with left and right cervical side-bending (p = 0.001) and left cervical rotation (p = 0.004), and left upper trapezius PPT (p = 0.033) (**Table 2**). A repeated measures ANOVA showed a significant group by time interaction for left cervical side bending (p = 0.001), right cervical side bending (p = 0.025), and left cervical rotation (p = 0.003) **(Table 2)**.

DISCUSSION

The purpose of this study was to investigate the immediate effects of a standardized stretching procedure of the upper trapezius and levator scapulae muscles on cervical ROM and PPT. The participants who received a passive, manual stretch demonstrated increased left and right lateral flexion ROM, left rotation ROM, and left upper trapezius PPT. Previous studies have found similar results,[7,18] however, this is the first study that investigated the immediate effects of an isolated stretching procedure involving upper trapezius and levator scapulae.

Although stretching to increase soft tissue extensibility is not a novel intervention, there is debate as to whether muscle can be lengthened after a single treatment.[31] Numerous studies have attributed an increase in tissue extensibility to biomechanical and neural changes in both contractile and non-contractile elements of the muscle-tendon unit.[12] This concept may also contribute to the improvements found in PPT. Hutton[32] described 4 mechanisms in which an individual can develop a ROM limitation (neurogenic, myogenic, joint, and connective tissue). It was postulated that stretching attempts to modify the first 2 mechanisms as they deal with the voluntary/reflex control and passive/active properties of the muscle,

Figure 6. Research Flow Diagram



respectively.[32] Another study analyzed the response between stretching programs of different durations and found no differences in muscle length or stiffness, but attributed the increased ROM to increased stretch tolerance.[33] These results indicate that there is not necessarily a change in tissue length, but rather a change in myofascial sensitivity. Thus, similar to the studies mentioned above, the results of the current study indicate that the improvements found in both ROM and PPT may have stemmed more from altering the acute stretch perception rather than a true change in muscle length.

The results of this study showed significant differences in cervical ROM within the stretching group compared to the control group. This may in part be explained by using the principle of creep, which occurs when a load is applied over time, the tissue lengthens, and the muscle assumes a new length.[34] The major factors in determining the extent of creep are the duration of the stretch and the amount of force applied. The time component was manipulated by carefully selecting the duration the stretch was maintained and the number of repetitions performed. The stretching group received 2 repetitions of 30-second stretches. Authors have suggested 30-second holds were just as effective as stretches held for 1 minute, but both were superior to stretches held only 15 seconds.[15] Authors also suggest that there is little to no benefit with greater than 2 repetitions of stretches.[17] The force component was manipulated with a combination of depressing the scapula with 100 N of force and stretching the muscle until a tissue barrier was felt. This standardized technique allowed for greater consistency across trials.

Although this study was performed within an asymptomatic population, it provides a foundation for future studies involving a symptomatic population. Neck pain commonly prompts an individual to seek medical attention and can result in functional limitations and decreased quality of life. Pain reflects actual or potential tissue damage.[35] In regards to this study, nociceptors convert mechanical stimuli from the pressure algometer to nociceptive signals. These signals travel to the dorsal horn of the spinal cord, to the thalamus, and terminate in the somatosensory cortex. Participants in this study were asked to report when the pressure sensation transitioned into "slight discomfort." This suggests a limited significance for PPT, where only the left upper trapezius showed a statistically significant increase in PPT for the experimental group (p = 0.033). This may be due to myofascial sensitivity as a phenomenon that can be influenced by many factors. There is a large biopsychosocial model of pain that takes into consideration physical factors, personal factors, and environmental factors that all interact together and play a role in pain perception.[36]

The immediate improvement in active ROM of the cervical spine should prompt clinicians to consider the most effective way to sequence a treatment session. If participants can achieve an immediate increase in cervical ROM and decreased myofascial sensitivity following a stretch, this may allow for strengthening exercises to be performed throughout a greater ROM with increased tolerance.

Table 1. Baseline Demographics of Participants (n=60)

	Stretch group	Control group	Overall	p-value
Sex	18 female/12 male	14 female/16 male	32 female/28 male	0.48
Age mean (SD)	24.5 years (± 2.6)	25.7 years (± 4.5)	25.1 years (± 3.7)	0.22
Height mean (SD)	67.1 in (± 3.4)	67.0 in (± 4.5)	67 in (± 4.0)	0.92
Weight mean (SD)	149.7 lbs (± 23.7)	159.1 lbs (± 39.2)	154.4 lbs (± 32.7)	0.27
Abbreviations: in, inches; lbs, pounds; SD, standard deviation				

Table 2. Group Comparisons of Cervical ROM and PPT Pre- and Postintervention

	Control (N = 30)			Experimental (N = 30)		
	Pre	Post	p-value	Pre	Post	p-value
Flexion (°)	34.00 (±10.84)	32.87 (±10.46)	0.37	40.07 (±9.69)	41.67 (±10.98)	0.28
Extension (°)	26.60 (±15.83)	26.43 (13.72)	0.89	33.13 (±16.87)	36.53 (±17.89)	0.08
LSB (°)	42.13 (±6.37)	43.07 (±6.05)	0.21	40.40 (±6.26)	43 (±5.91)	0.00*
RSB (°)	42.80 (±6.09)	42.47 (±6.96)	0.64	41.07 (±6.12)	44.07 (±6.36)	0.00*
Lrot (°)	67.77 (±12.52)	70.47 (±11.25)	0.13	69.47 (±5.30)	73.07 (±6.82)	0.00*
Rrot (°)	71.07 (±11.71)	73.53 (±8.58)	0.19	73.07 (±5.84)	72.40 (±12.40)	0.74
L UT PPT (kpa)	324.67 (±124.34)	301.17 (±120)	0.05	303.60 (±114.50)	325.10 (±151.64)	0.03*
R UT PPT(kpa)	334.03 (±143.35)	334.10 (±139.41)	0.99	321.47 (±151.64)	329.60 (±124.29)	0.56
L LS PPT(kpa)	293.50 (±124.55)	300.27 (±133.70)	0.45	294.93 (±201.01)	284.23 (±102.24)	0.80
R LS PPT(kpa)	319.17 (±170.29)	331.50 (±159.85)	0.39	294.17 (±181.47)	313.47 (±136.05)	0.30

Abbreviations: kpa: Kilo Pascal; L LS, left levator stretch; Lrot, left rotation; LSB, left side bend; L UT, left upper trapezius; N, sample size; PPT, pressure pain threshold; R LS, right levator stretch; Rrot, right rotation; RSB, right side bend; R UT, right upper trapezius

* $p < 0.05$

Limitations

There were several limitations in this study, including lack of long-term follow-up and a population consisting of asymptomatic, healthy, young adults. This study only investigated the immediate effects of stretching on ROM and PPT, leaving results of long-term effects questionable. Longer term studies would be able to elaborate on any lasting effects after a single-treatment session and its potential use for clinical application. This study was conducted on an asymptomatic population; therefore, these results do not apply to the clinic. Using healthy participants allows establishment of a baseline, as well as recognize the effects of interventions in participants who are pain-free and without functional limitations. Future research is needed to evaluate the effects in symptomatic population.

Despite the best effort to standardize the manual stretching procedure, some inherent variabilities could not be controlled. The upper trapezius and levator scapulae muscles assist with movement in 3 planes of motion. The degree of flexion, lateral flexion, and rotation may have been slightly different for each participant during the various stretches targeting a specific muscle. An investigator stretched each participant to a tissue barrier to verify that the muscle has reached the limit of available motion. Variability in cervical ROM measurement results may be attributed to the young and healthy status of the study population, who did not present with substantial limitations in cervical ROM.

Another reason that may have contributed to the variability in the results may be due to inconsistent delivery rates with the pressure algometer when measuring PPTs. This could have subsequently influenced the perception of muscle sensitivity. Although the evaluator attempted to deliver pressure at a rate of 5 Pa/second, it is difficult to maintain the exact rate throughout all trials. Patient perception must also be considered as a limiting factor for finding significance with PPT measurements. Despite that all participants were instructed to notify the investigator when slight discomfort was felt, each participant may have different perceptions and interpretation of the definition. Lastly, the predetermined location of the PPT testing was located directly in the middle of the upper trapezius muscle of every participant to allow for more uniform testing. As previously mentioned, trigger points were not assessed before the intervention; thus, it is possible that the point of testing potentially overlapped with an existing trigger point altering one's muscle sensitivity and ultimately delineating a true understanding of the relationship between the PPT and the treatment.

CONCLUSION

This study demonstrates the immediate effects of a standardized stretching procedure on the upper trapezius and levator scapulae muscles with regard to improved cervical ROM and PPT. Results from this study can be used as a foundation for further research and consideration for clinical application. Future studies involving a symptomatic population are necessary to evaluate the immediate effects of a standardized stretching program in those with myofascial neck pain. In addition, longer duration studies would be able to elaborate on any lasting effects after a single-treatment session.

Between Groups at Baseline	Between Groups Difference	Time-by group interaction
p-value	Mean (95% CI)	p-value
0.260	-8.8 (-14.3,-3.3)	0.81
0.127	-10.1 (-18.3,-1.9)	0.15
0.292	0.1 (-3.0,3.2)	0.00*
0.276	-1.6 (-5.0,1.8)	0.03*
0.496	-2.6 (-7.4,2.2)	0.00*
0.406	1.1 (-4.4,6.6)	0.51
0.498	-23.9 (-87.4, 39.6)	0.90
0.743	4.5 (-63.8, 72.8)	0.70
0.974	16.0 (-45.5, 77.5)	0.93
0.584	18.0 (-58.7, 94.8)	0.17

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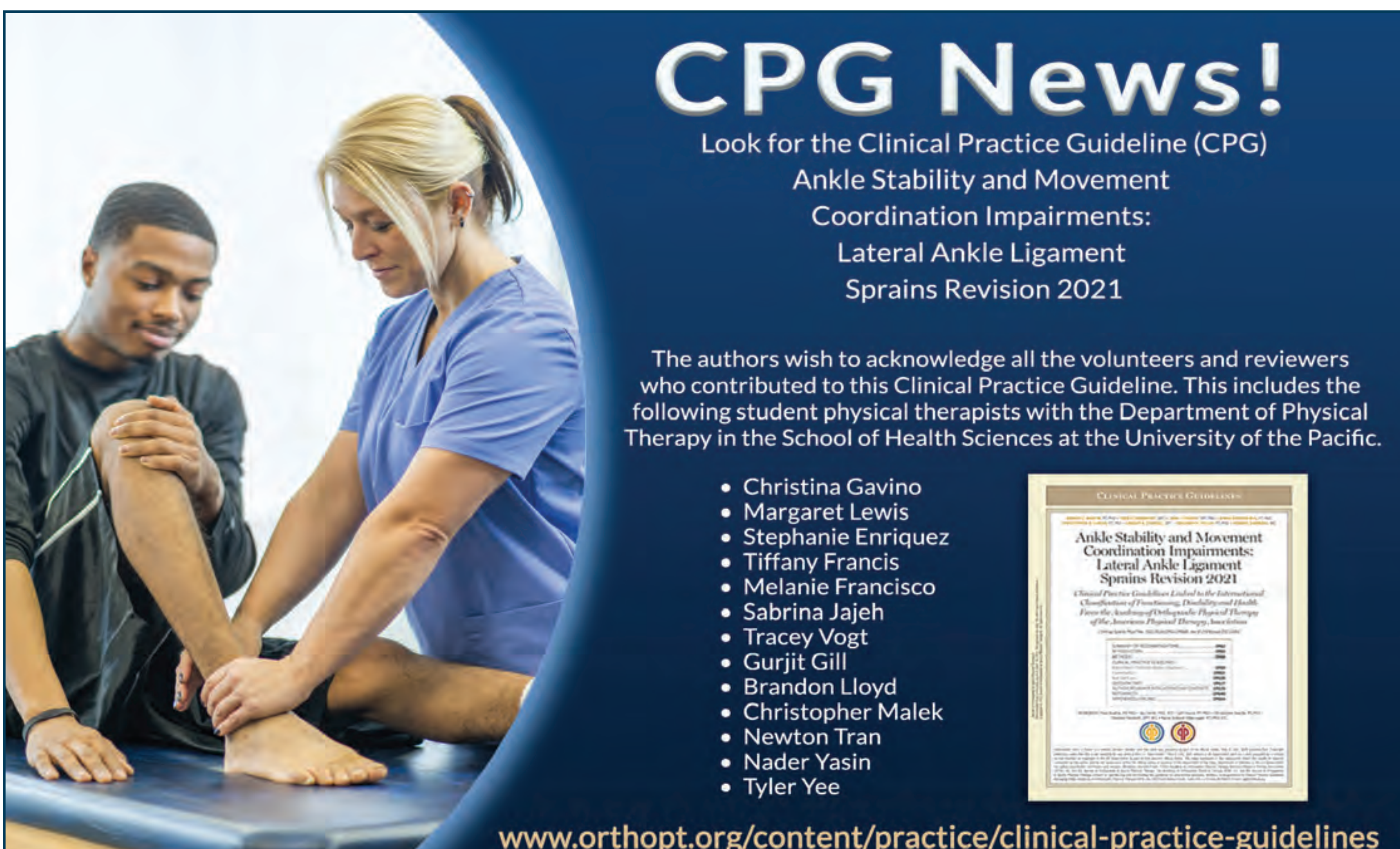

The Effect of Kinesio Tape on Lower Extremity Kinematics and Muscle Activation During a Unilateral Squat

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ABSTRACT

Background/Purpose: Application of Kinesio Tape (KT) may increase muscular activity and reduce dynamic knee valgus during a unilateral squat. This cohort study investigated the effects of femoral spiral taping on muscle activation and knee kinematics during a unilateral squat. **Methods:** Fourteen participants (mean age 25.3 ± 2.6 years) performed unilateral squats with and without application of KT. Muscle activation was recorded, and knee angle was categorized as valgus, varus, or neutral. **Findings:** Analysis of surface electromyographic (sEMG) data demonstrated no significant difference between conditions in general muscle activation ($F = 1.194$, $p = 0.29$, $\eta 2 = 0.084$). Comparison of knee alignment between conditions showed no significant interaction between tape application and knee angle classification ($p = 0.32$). **Clinical Relevance:** Despite anecdotal evidence in KT for muscle activation, these results do not justify its use during a unilateral squat. **Conclusions:** Kinesio Tape does not increase muscle activation or decrease knee valgus angle during a unilateral squat.

Key Words: dynamic knee valgus, intervention, muscular facilitation

INTRODUCTION

Kinesio Tape (KT) is a thin elastic tape designed to mimic the properties of human skin.[1] The use of KT has recently increased in both professional and recreational athletes. A variety of proposed benefits of KT that could translate to improved sport performance and safety, including facilitating or inhibiting muscle activation and increasing joint stability. It has been hypothesized that a facilitatory KT application can increase activity in target muscles and reduce undesirable kinematics that could be useful in injury prevention. However, evidence for the efficacy of KT for these purposes and the mechanisms by which it could achieve is lacking.

Based on the existing literature, the ability of KT to facilitate a muscle is largely a result of changes to cutaneous nerve stimulation. However, due to gaps in the literature, it is sometimes necessary to extrapolate the mechanism for the proposed effects from research void of tape application. One study investigating the effects of an external stimulus on muscle activity demonstrated a correlation between increased afferent peripheral nerve stimulation and increased excitability of the motor cortex.[2] Another study suggested that KT could increase muscle activity by providing cutaneous stimulation that could partially overcome attenuation of afferent feedback to gamma motor neurons in muscle spindles.[3] Attenuation of afferent feedback is hypothesized to commonly occur following joint injury and disease. The decreased afferent input to muscles has also been associated with decreased maximal voluntary muscle activity. Furthermore, cutaneous stimulation has been shown to reduce motor neuron threshold, allowing for more efficient recruitment of motor units.[4] Finally, afferent cutaneous stimulation via stretch of the skin from KT has been shown to increase both motor unit firing rate and muscle activity.[5]

There is conflicting evidence regarding the ability of KT to facilitate a target muscle. A study comparing hip muscle activation via electromyography (EMG) found no significant difference between facilitatory, inhibitory, or sham or no taping.[6] However, another study examining peak torque of the knee extensors during facilitatory, inhibitory, or sham taping did identify a significant difference based on the taping technique used.[7] Taping the knee extensors for facilitation showed a significant increase in peak torque compared to taping for inhibition, while no significant difference in muscle activation was found between any of the taping conditions.[7]

Despite these inconsistencies in the evidence, KT is commonly applied to assist in injury prevention or recovery. In theory, a facilitatory application to antagonist muscles could increase activity in muscles that oppose an undesirable joint motion such as excessive knee valgus. This is a common and troublesome kinematic change that has been linked to anterior cruciate ligament (ACL) tears. Knee valgus angles serve as the primary predictor of ACL injury.[8] While muscle activity throughout the entire lower extremity influences kinematics of the knee, hip strength has been demonstrated to be especially influential.[9] Gluteus medius strengthening is often emphasized in rehabilitation programs[10] and has been associated with positive outcomes for knee dysfunction.[7,11] Increased hip abductor and external rotator strength is beneficial in preventing injuries and in reducing knee pain[10,12] and adverse knee kinematics,[11] whereas weakness has been linked to increased knee valgus, undesirable changes in sport performance[13] and heightened injury risk for athletes.[14]

With this correlation in mind, this study aimed to investigate whether the KT applied in a spiral pattern across the posterior hip and the medial knee would decrease knee valgus by facilitating the hip abductors and external rotators that eccentrically control this motion. The study could also determine the utility of KT as a supplemental treatment tool to prevent ACL tears through the described mechanism. It was hypothesized that a facilitatory femoral spiral taping application would increase muscle activation in key hip muscles (vastus lateralis, biceps femoris, gluteus medius, gluteus maximus), and decrease dynamic knee valgus during a unilateral squat. This study attempted to expand on prior research by Song et al which found no significant effect of tape on females with patellofemoral pain when compared to a healthy control group. The study also measured changes to muscle activation in additional lower extremity musculature.[15]

METHODS

Participants

This study was approved by the Institutional Review Board at the University of Central Florida. Fourteen participants (9 female, 5 male) were recruited via email and word of mouth from the University of Central Florida and the surrounding community. Participants aged 18-50 years of age were eligible for participation and were screened for physical activity participation via Physical Activity Readiness Questionnaire (PAR-Q). Any positive response on the PAR-Q excluded the participant from participation. Additional exclusion criteria included (1) previous surgical history of the test leg within the past 12 months; (2) body mass index (BMI) score of >30; and (3) knee ligament instability as defined by positive anterior drawer, posterior drawer, valgus stress test, or varus stress test. After screening for exclusion criteria, all participants signed an approved Institutional Review Board consent form after being allowed the opportunity to ask any additional questions. A comprehensive demographic form was administered to collect anthropometric data, extremity dominance, level of activity, and significant medical history within the past year. To ensure adequate physical ability to participate in the study, participants must have demonstrated the ability to perform a barefoot, unilateral squat using their dominant leg to at least 45° of knee flexion, measured with a hand-held goniometer (**Table 1**).

Surface Electromyography

Surface electromyography (sEMG) was used to assess muscle activation of the involved lower extremity, given its widespread use in assessment and non-invasive accuracy of neuromuscular activity.[16] Wireless bipolar (inter-electrode distance = 10 mm) surface EMG sensors (bandwidth = 20-450 Hz; Trigno EMG, Delsys, Inc., Natick, MA) were placed over the gluteus maximus, gluteus medius, vastus lateralis, and biceps femoris muscles using guidelines described by the SENIAM project (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles).[17] After marking the appropriate sensor location, the participants' skin was prepared to facilitate good electrode-skin contact needed to obtain quality signal readings. This was performed by shaving the target area with a single-use disposable razor to remove any hair, followed by blotting with adhesive tape, and wiping with alcohol swab to remove excess debris. The area was dried before electrode placement, and this procedure was repeated for each of the target muscles. The SENIAM reports that this method of skin preparation allows for fewer and smaller electrical interference (artifacts), less imbalance between electrodes, and decreased noise for improved signal quality.[17]

Surface Electromyography Amplitude Normalization

While there are several methods to normalize EMG values, a literature review in the Journal of Electromyography and Kinesiology recommends using maximal voluntary isometric contraction at one chosen angle to normalize EMG as opposed to multiple angle isometrics at specified angles throughout the test conditions or dynamic maximal EMG, as these processes are more time consuming and have no evidence to support their superiority.[18] Three maximal isometric barbell back squats were performed to obtain a normalized EMG measurement as a percentage of maximum voluntary contraction in the 4 muscle groups. Each repetition was performed with a 10-second isometric hold, along with a 2-minute rest break in between trials to allow for muscle recovery, and to avoid the influence of neuromuscular fatigue on performance. The barbell was maximally weighted and secured to avoid movement of equipment during the trial. Participants were positioned under the barbell with height adjusted to allow for at least 45° of knee flexion, as measured by a hand-held goniometer. A single piece of tape was used as a visual indicator to mark foot placement to maintain consistency throughout repetitions. All trials were performed barefoot, using dominant lower extremity as the stance leg (**Figure 1**). For each muscle, the sEMG amplitude (root-mean-squared) values obtained from the entire duration of the maximal contractions were averaged and used for subsequent normalization.

Kinesio Tape application

The KT was applied to the dominant lower extremity. Participants were random-

Table 1. Participant Demographics for the Current Study

Participant	Age	Height (cm)	Weight (kg)	BMI	Sex
001	24	170.18	63.5	21.9	F
002	24	177.8	77.11	24.4	M
003	25	170.18	74.84	25.8	M
004	26	160.02	56.7	22.1	F
005	25	165.1	71.67	26.3	M
006	28	162.56	68.04	25.7	F
007	31	152.40	53.98	23.2	F
008	24	175.26	79.38	25.8	M
009	24	172.72	61.24	20.5	F
010	29	165.10	58.97	21.6	M
011	22	167.64	68.04	24.2	F
012	26	160.02	49.9	19.5	F
013	22	172.72	65.77	22.0	F
014	24	162.56	56.25	21.3	F
Mean	**25.29 (±2.55) yrs**	**166.73 (±6.95) cm**	**64.67 (±9.03) kg**	**23.16 (±2.21)**	

Abbreviation: BMI, body mass index

ized to receive taping either before the first set of unilateral squats or after. The participant's leg was first cleaned with alcohol and placed in slight knee flexion, hip flexion, and hip external rotation. One strip of 2-inch KT was anchored at the posterior superior iliac spine and applied proximal-distally in a spiral pattern across the gluteal muscle group, medially down the anterior thigh, and anchored at the medial knee. The active portion of the tape was stretched to 75% of its maximal tension, while no tension was put at the anchor points. Following application, the tape was rubbed vigorously to activate the adhesive properties of the tape.

Procedure

The effectiveness of KT was assessed through frontal plane knee kinematic and muscle activation changes during performance of a unilateral squat within participants. A unilateral squat was chosen as it is one of the most commonly used assessments of leg muscle strength, endurance,[19-22] and lower extremity stability.[19,23,24] It is a reasonable tool for screening for dynamic valgus collapse,[19] and is recognized as an inexpensive and easy to perform test, with meaningful implications due to its neuromuscular and motor similarities to many other functional athletic movements.[25-27] Unilateral squat performance was assessed through goniometric angle measurement to ensure knee flexion angle, sEMG to track muscle activation, and two-dimensional (2D) video analysis of point markers to measure medial collapse. After electrode placement and maximal EMG activation were measured, point markers were placed at the center of the anterior superior iliac spine, patella, and ankle mortise on the side of the dominant lower extremity, as defined by the side with which the participants would kick a ball (**Figure 2**).

Each participant performed 2 sets of 3 unilateral squats, one set with KT applied and the other without. The order of taping was randomized with half of the participants performing the first repetitions of unilateral squats before the application of KT and the other half performing the first repetitions with KT already applied. After completing the first measured trial, participants then changed to the opposite condition and had KT applied or removed as needed before performing their second set of unilateral squats. During each squat, the amplitude of the sEMG signal (root-mean-squared) for each muscle was quantified throughout the entire range of motion. These values were then normalized to those obtained during the maximal isometric squats.

Figure 1. An Example of the Unilateral Maximal Isometric Squat Procedure Used to Normalize the sEMG Amplitude Values Obtained During the Subsequent Kinesio Tape and Control Conditions (sEMG sensors not shown)

Participants were video recorded briefly with a single stationary camera positioned 55 inches in front of them during performance of the unilateral squats. The 2D video analysis of point markers is an accurate way to determine dynamic knee valgus,[28] and thus, was used to determine frontal plane kinematics of the lower extremity following test completion. Video analysis was performed via 3 researchers who classified dynamic knee angles as either valgus, varus, or neutral based on clinical judgement.

Statistical Analyses

Mean differences in normalized sEMG amplitude were evaluated using a 2-way repeated measure (invention [control, KT] × muscle [vastus lateralis, biceps femoris, gluteus medius, gluteus maximus]) analysis of variance (ANOVA). Bonferroni post hoc comparison was used as appropriate to identify specific sources of variance. The partial eta squared statistic was used to report the effect size for each factor assessed. Changes to knee angle classification between the conditions were assessed using a Wilcoxon signed-rank test. An alpha level of 0.05 was set for statistical analysis to identify significance. Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS V.22).

Figure 2. An Example of a Participant Performing A Unilateral Squat

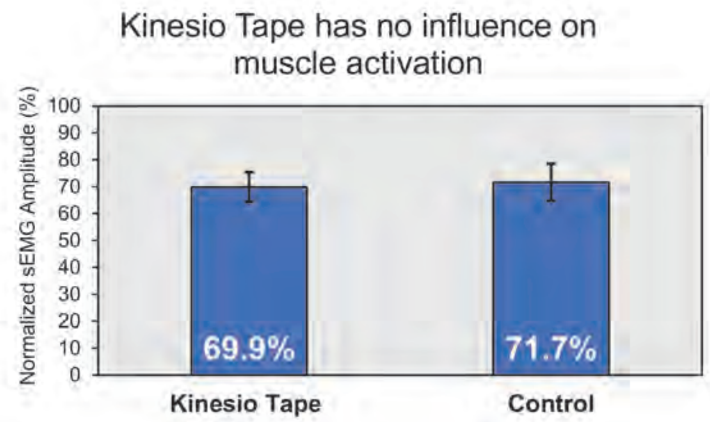
In this image, Kinesio Tape was applied in a spiral pattern to the right hip and thigh.

RESULTS

Surface Electromyography Amplitude

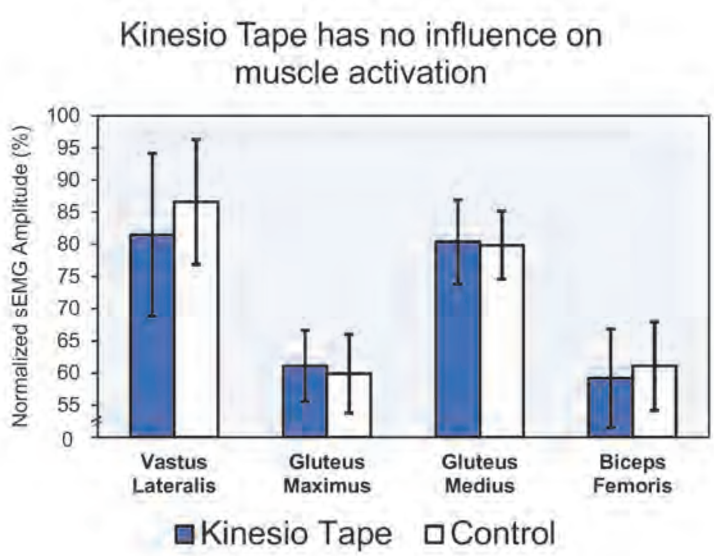
Analysis of the normalized sEMG amplitude data via a 2-way repeated measures ANOVA demonstrated no significant difference in general muscle activation during the unilateral squat protocol with KT applied compared to the control (F = 1.194, p = 0.29, $\eta 2$ = 0.084) (**Figure 3**). Furthermore, no difference in muscle activation was found in any of the 4 individual muscles when comparing conditions (F = 0.617, p = 0.48, $\eta 2$ = 0.045) (**Figure 4**). A significant difference in muscle activation, independent of condition, was found (F = 5.887, p = 0.01, $\eta 2$ = 0.312) between the following muscle groups: biceps femoris and gluteus medius (p = 0.018), as well as gluteus medius compared to gluteus maximus ($p < 0.001$).

Figure 3. Mean Normalized sEMG Amplitude Values Collapsed Across the 4 Muscles During the Control and Kinesio Tape Conditions



The bar graphs display mean ± standard error of the mean. The data label inside each bar corresponds to the mean value.

Figure 4. Mean Normalized sEMG Amplitude Values for Each of the 4 Muscles During the Kinesio Tape and Control Conditions



The bar graphs display mean ± standard error of the mean. The results indicated that there were significant differences among the 4 muscles, but not between conditions.

Knee Angle Classification

Comparison of dynamic knee valgus alignment between control and KT conditions via a Wilcoxon signed-rank test showed no significant interaction between tape application and knee angle classification ($p = 0.32$). All participants but one maintained the same knee alignment classification between test conditions. One participant demonstrated a shift from neutral positioning to knee valgus following tape application.

DISCUSSION

The results of this study suggest that the spiral application of KT to posterolateral hip musculature has no significant effect on muscle activation or knee angle classification during a unilateral squat. When analyzing changes to these factors during performance of the test procedure, results were compared between trials with the tape applied and without. This demonstrated that there was no significant difference in activation for individual muscles or in the average of all 4. A significant difference in activation levels between the 4 muscles was identified; however, this was not impacted by the addition or removal of the tape. This finding simply underscores an expected finding in any dynamic activity: that each muscle functions independently. Tape application also did not impact the classification of frontal plane knee angle as neutral, valgus, or varus. Thirteen participants maintained the same classification between test conditions, while one displayed a shift from neutral positioning to knee valgus following tape application.

These findings do not support the initial hypothesis that femoral spiral KT application to the lower extremity could increase muscle activation or decrease knee valgus angle during a unilateral squat. Instead, this study supports previous research concluding that KT does not affect EMG output. For example, when investigating the effects facilitatory and inhibitory taping against a control on wrist extensor activation, no significant difference was found between applications.[29] Another study demonstrated no significant difference in muscle activation of the biceps femoris, vastus lateralis, and vastus medialis during barbell back squats when comparing facilitatory, inhibitory, and sham taping against a control.[6] Furthermore, these findings are consistent with previous research examining the effects of femoral rotational taping on muscle activation, which showed no change in EMG output between rectus femoris, gluteus medius, and gluteus maximus between tape, sham, and no tape conditions.[15] While these studies examined different taping techniques, target muscles, and dynamic activities, they all investigated the degree to which KT could potentially change muscle function.

The findings of this research have implications for sports injury prevention and rehabilitation as decreasing dynamic knee valgus angle may reduce the risk of ACL injury. This link is supported by previous research that has identified increased knee valgus angle as the primary predictor of ACL injury.[8] Since the results of this study suggest that KT does not effectively decrease knee valgus angle during a unilateral squat, its ability to decrease risk of ACL injury by reducing this risk factor is not supported. Additionally, KT application was not effective at increasing activation of key posterolateral hip muscles that eccentrically control dynamic knee valgus during a unilateral squat. Hence, KT may not be an effective training tool to influence muscle activation nor dynamic knee valgus to reduce the risk of ACL tears during activities that involve a unilateral squat or similar motion.

While KT application did not produce significant increases in muscle activation, it is possible that KT could create benefits in sports performance through means other than muscle facilitation or inhibition. A systematic review showed significant improvements in athletic performance after taping, regardless of changes to muscle activation.[30] This suggests other possible mechanisms through which KT may improve performance despite insignificant changes in muscle function. It is unclear if improvements to sport performance, in this case, would also translate to decreased risk for lower extremity injuries such as ACL tears.

Due to the wide range of applications and purposes for KT use, it is important not to generalize these findings to KT entirely. Different muscle applications, taping techniques, test activities, and methods of capturing data could all elicit different outcomes. Future research is warranted to further investigate the mechanism by which KT may affect athletic performance.

Limitations

Several limitations were identified throughout completion of this study. First, the sample size was limited to only 14 healthy participants, mainly based on participant availability via convenience sampling. Additionally, none of the participants reported any previous lower extremity injury or surgical history within the past 12 months. This could limit the external validity of our study as it cannot be assumed that KT will produce a similar effect in injured individuals. It can be speculated that muscular characteristics including baseline strength, neuromuscular activity, and muscular recruitment patterns can be impaired in non-healthy adults, who could potentially benefit from an external stimulus.

Tape application was also an inherent limitation of the intervention, as the predetermined degree of stretch was required to be estimated by the researcher and could not be feasibly performed in an identical manner for each tape application. Similarly, angle of application and subsequently the coverage over key muscle bellies are likely to have varied between participants. Furthermore, individual body morphology could have impacted the effectiveness of the tape. Quantity and distribution of adipose tissue to the lower extremity would have altered the depth between skin and muscle that the tape would be required to exert an effect across. To control for variability in tape technique, one researcher was designated to perform all KT application for the duration of the study.

Finally, the researchers were restricted by financial considerations and available funding for research technologies that may have limited the ability to detect nuanced effects of the KT. For example, rather than measuring knee valgus angle through a highly accurate mechanism such as electrogoniometry, frontal plane knee angle was broadly categorized as neutral, varus, or valgus. Some participants exhibited small, beneficial changes in knee angle that were not able to be captured in this study. This same limitation also affected the ability to ensure consistency in squat depth. Relatedly, the lack of instrumentation may have influenced the accuracy of squat depth to exactly 45° of knee flexion, where participants may squat beyond this angle, which could have impacted muscle output.

CONCLUSION

These findings do not support the use of a femoral spiral KT application to the posterolateral lower extremity hip muscles to increase muscle activation or decrease knee valgus angle during a unilateral squat. Because hip abductor and external rotator strengthening is commonly used in rehabilitation settings to reduce or prevent dynamic valgus collapse of the knee, it would be beneficial to identify a method of facilitation to these muscles. However, these results do not justify adjunctive use of femoral rotational taping to facilitate increased muscle activation during functional exercises such as a unilateral squat. Continued research on the efficacy of additional taping strategies and femoral spiral taping on other dynamic activities is warranted.

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The Closed Chain Effects of Static Ankle Bracing on Squatting Mechanics

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ABSTRACT

Background and Purpose: Ankle sprains are the most common musculoskeletal injury and individuals may choose to wear an ankle brace. The purpose of this study was to investigate the relationship between wearing an ankle brace and movement compensations during an overhead squat. **Methods:** Thirty asymptomatic participants performed 3 squats: one squat without ankle braces, one squat with a single ankle braced, and one squat with bilateral bracing. Squats were recorded and visually analyzed using the Hudl application. **Findings:** A repeated measures ANOVA test identified a statistically significant ($p < .001$) difference in knee flexion under both single bracing (mean, 120.57°) and bilateral bracing conditions (119.30°) as compared to the unbraced condition (mean, 124.6°). **Clinical Relevance:** Although ankle bracing was shown to reduce knee flexion during a squat, further research would be necessary to determine if this would influence performance or conditioning variables. **Conclusion:** This investigation adds to the current knowledge about the effects of ankle bracing on closed chain movement.

Key Words: injury prevention, lower extremity, movement patterns

INTRODUCTION

Ankle sprains are the most common musculoskeletal injury that affects both recreational and competitive athletes with an estimated yearly societal cost of $6.2 billion in the United States.[1-4] Authors suggest that ankle injuries are the primary reason for games missed due to injury in the athletic population, and athletes experiencing one ankle sprain are more likely to sustain recurrent ankle sprains, often leading to chronic ankle instability.[2,5,6] The most common type of ankle injury is the inversion (lateral) ankle sprain, which occurs when the ankle is subjected to an applied inversion force while the foot is in a plantar flexed position.[7-10] The majority of ankle sprains occur when an athlete is performing a weight-bearing closed chain movement in which the peroneal muscles must act eccentrically to control an inversion force.[9] As an attempt to reduce the risk of this common injury, many athletes may choose to, or be required to, wear an external ankle support during practice or competition, especially in populations that have experienced a prior ankle sprain.[10-12] Three-year recurrence of an ankle sprain has been reported to be as high as 34%.[1] Yet, there is no current consensus regarding the safety and effectiveness of ankle bracing as a prophylactic agent.

A review of the literature showed that semi-rigid (hinged) braces and soft (lace-up and/or Velcro) braces were two of the most commonly studied categories of ankle braces.[7,9,13] As ankle inversion is the primary component of lateral sprains, braces from both categories are designed to limit this frontal plane movement.[13-18] Additionally, numerous studies have shown that soft braces offer significantly less sagittal plane motion than hinged braces.[13-16] Soft braces, specifically lace-up braces, have been shown to restrict ankle dorsiflexion during jumping and landing tasks.[7,14,16] This may be due to their design, in which the laces are tightened directly over the talocrural joint, potentially interfering with the normal joint arthrokinematics required for dorsiflexion.

Due to the interaction between anatomic structures of the kinetic chain, there is likely a relationship between reduced ankle dorsiflexion and knee kinematics during dynamic tasks. A study by Klem et al[5] found that lace-up ankle braces increased knee internal rotation and abduction angles at the knee, as well as compressive and shear forces at the knee during the deceleration phase of cutting maneuvers. Additionally, DiStefano et al[15] reported increases in knee flexion when landing while wearing a lace-up brace. Authors have shown that decreases in ankle dorsiflexion range of motion may decrease an individual's dynamic balance and may increase the risk of developing an injury in the lower extremity.[8,19] Yet, another study indicated the use of prophylactic bracing to increase an athlete's balance.[17] A loss of proprioception after sustaining an ankle sprain may also contribute to future reinjury and prophylactic bracing may assist in providing the additional proprioceptive input.[3,17,20] These deviations in the lower extremity kinematics could be a cause for concern as they may predispose an athlete to injury.[21]

While several studies have investigated the effects of ankle stabilization on plyometric tasks such as landing and cutting maneuvers, there have been no studies that investigate the effects on lower extremity kinematics during closed chain movements while using an ankle brace. Dill et al[22] demonstrated that an innate structural restriction in dorsiflexion during the weight-bearing lunge test is correlated with compensatory movement at the knee joint during an overhead squat. It is likely that an artificial restriction in dorsiflexion, such as that imposed by a lace-up ankle brace, would produce similar effects as those observed by Dill et al.[22] To evaluate this assumption, the current study investigates the relationship between wearing a lace-up ankle brace and potential movement compensations during the overhead squat. Based on current literature regarding restricted dorsiflexion and its impact on movement, one would expect that wearing a lace-up ankle brace during an overhead squat will lead to compensatory strategies at the knees, hips, and shoulders.

METHODS

Participants

This study protocol was approved by the Institutional Review Board at the University of Central Florida (UCF). Participants were recruited on a volunteer basis from the UCF campus and facilities and all participants signed an informed consent before participation.

Inclusion criteria included healthy individuals between the ages of 18 and 65 who could read, write, and understand the English language. Exclusion criteria included any inability to provide informed consent, any history of back, hip, knee, or ankle pathology in the past year, and a "yes" answer on the PAR-Q+. The PAR-Q+ was used to determine if participants were safe to participate in exercise at the time of the study.

Protocol

Participants were tested once between January and February 2019. Upon arrival, all participants reviewed the research protocol and completed the informed consent approved by the institutional review board. Participants completed a one-minute warm-up of step-ups on an 8-inch step at a self-selected comfortable pace. Following the warm-up, a Craig test was performed to assess the presence of femoral anteversion or retroversion. This was followed by an assessment of baseline dorsiflexion using a weight-bearing lunge and a digital goniometer. Weight-bearing lunge dorsiflexion measurements were found in research to be more sensitive in identifying individuals with high-risk movement patterns than a passive non-weight-bearing assessment, and is more reflective of the amount of motion an athlete will have during sport-specific closed chain activities.[19,22,23]

Squatting was performed under 3 conditions: one squat without ankle braces, one squat with the right ankle braced, and one squat with bilateral ankle bracing. The order in which each participant performed the squats was determined by group selection. Each participant randomly selected a group letter (A, B, or C) that was written on a piece of paper and placed in a bucket. There were 10 of each letter for an even distribution among groups. The assessor was blinded to the meaning of each group letter.

Single ankle bracing was done only on the right ankle to allow consistency in camera placement and based on the assumption that most individuals are right foot dominant. Foot dominance was determined during intake to assess whether foot dominance was a factor in influencing mechanics during the single ankle brace squat. Dominance was determined by asking the participant which foot they prefer to kick a ball with (28 were right foot dominant, 2 left). A lace up ankle brace (Shock Doctor, Fountain Valley, CA) was used with all participants. Appropriate sizing was determined using the ankle circumference guidelines recommended by the company. Participants wore comfortable shorts or fitted leggings and shirts as well as their athletic shoes. Self-selected athletic shoes were used rather than providing control shoes as the focus was on the ankle brace influence on squatting mechanics, regardless of the type of shoe worn. The influence of the type of shoe was controlled by ensuring each participant wore the same shoes throughout each squat condition. Verbal instructions were given before each trial: *"Stand with your feet shoulder-width apart in a comfortable position. Place your arms overhead. Next, squat down as low as you can go in a slow and controlled fashion and then stand up."* Each squat was recorded on an iPad and phone using the motion analysis application Hudl technique. To blind the assessor to the order that participants were tested, the researcher was responsible for analyzing the data and was not present in the room during data collection. The assessor was further blinded to the testing condition by having the participants don tall black socks on both feet to conceal the presence or absence of an ankle brace.

Demographic data, femoral anteversion/retroversion measures, and weight-bearing lunge data were recorded. The motion analysis application Hudl technique was used to video record the squats for visual analysis to evaluate angles of multiple joints. An iPad and phone were placed at a predetermined and premeasured height and distance from the squat location that allowed the entirety of the participant to be viewed and recorded throughout each squat. One device was placed in the sagittal plane viewing the right side of each participant and one was placed in the frontal plane to view the front of each participant. Each squat trial was recorded and saved for assessment.

Statistical Analysis

An assessor blinded to the condition order for each participant reviewed the recorded squat trials within the Hudl technique application on an iPad (9.7-inch; 1024x768, 132 ppi). The assessor slowed the video to one-eighth speed to visualize the lowest point of each squat. At the lowest point for each squat, the assessor paused the video and used the angle analysis tool to measure the acute angle for the shoulder, hip, knee, and ankle within the sagittal plane (**Figure 1**). Since only acute angles could be measured using the angle tool in Hudl technique, joint angles that were > 90° were determined by using acute angle measurement for the joint and then subtracting that measurement from 180 to capture the final joint measurement. For example, if the acute angle of the knee was measured at 50° then the final joint measurement was calculated to be 130° of knee flexion (180-50). This assessment technique was repeated 3 times for each of the joints during each of the squat trials. The 3-measurement average was then recorded for each joint angle and the data were transferred to a second researcher for data analysis.

Figure 1. Knee Flexion Measurement Using Hudl Technique

To decode the data received from the blinded assessor, the second researcher reorganized each participant's measurements according to the condition order each participant was assigned. After which, the second researcher was able to categorize all data points by the dependent variable represented (knee flexion no brace, knee flexion single brace, knee flexion bilateral braces, etc.). Variables were analyzed by SPSS (Version 24; IBM Inc.). Comparison of sagittal plane joint angles between each bracing condition (no brace, single brace, bilateral braces) were evaluated using a 3-way repeated measures ANOVA for each joint (shoulder, hip, knee, and ankle). Significance was set at $p < 0.05$, with a *post hoc* analysis using a Bonferroni correction.

RESULTS

Ultimately, 30 participants between the ages of 22 and 34 agreed to participate in this study (17 female, 13 male). A statistically significant reduction in dorsiflexion between the braced and unbraced conditions with an average reduction in dorsiflexion of 1.34° ($p = .049$) and a moderate effect size (partial eta squared .099) was observed. There was no difference in average dorsiflexion angle between the single brace and bilateral brace conditions (**Figure 2**). A statistically significant change in knee flexion angle between the 3 bracing conditions ($p < .001$) with a large effect size (partial eta squared .256) was observed. On average there was a 4.03° reduction in knee flexion during the single brace condition compared with no bracing (p =.004), as well as a 5.03° reduction in knee flexion during the bilateral brace condition when compared with no bracing (p =.001) (**Figure 3**). There was a small reduction in hip flexion angle (p = .312) between the bracing conditions, however, this change was not significant. No changes were observed in shoulder flexion angle between bracing conditions (p = .974). **Table 1** lists the average joint angles for all participants during each bracing condition.

DISCUSSION

The authors sought to investigate the relationship between prophylactically wearing an ankle brace and the effects on biomechanics during an overhead squat. Authors have reported that athletes will use prophylactic ankle bracing and/or taping to prevent further ankle injury.[12,14,16] Authors have found changes in knee biomechanics during sporting activities when prophylactic ankle taping was used to reduce the risk of ankle sprains.[11] These authors have determined that there may be a difference in knee joint loading that may serve as protection to the knee joint with specific landing tasks during the use of ankle taping.[11] Others have suggested that an alteration to knee biomechanics from external ankle stabilization may ultimately predispose an athlete to an increased risk of knee injury secondary to changes in forces at the knee.[7,13-16] To our knowledge, no studies have investigated the effects of prophylactic ankle bracing on closed chain biomechanics.

In this study, significant decreases in ankle dorsiflexion and knee flexion angles were found during squats when the participants were wearing one or more prophylactic ankle braces. Greater decreases in knee flexion were found during overhead squats when the participants were wearing bilateral ankle braces as compared to the changes found while wearing a single brace. These findings indicate that prophylactic ankle bracing has a significant impact on lower extremity kinematics during squatting. These changes may predispose athletes to injuries due to changes in force dispersion through the lower extremity joints as squatting mechanics are changed.[24-26]

This study was limited by sample homogeneity as all were asymptomatic and encompassed a relatively narrow age range (ages 22-34). The sample was of convenience and obtained from current students at UCF. The small sample size with an N of 30 increases the likelihood of a type II error. There was a statistically significant change in hip flexion angle that was not able to be determined with this sample size. Previous authors reported restricted dorsiflexion can predispose an athlete to further injuries of the lower extremity during activity.[19] The current study extrapolated from this finding and hypothesized that prophylactic ankle braces would significantly impact biomechanics during the overhead squat. As expected, biomechanics were significantly affected while wearing an ankle brace in the form of reduced knee flexion. Based on the hypothesis, the authors of the current study theorize that the change in knee flexion angle between bracing conditions may be linked to the artificially restricted dorsiflexion that was observed.

One of the most impactful limitations of the current study is the lack of research regarding the Hudl technique. Although our

Figure 2. Dorsiflexion During Overhead Squat

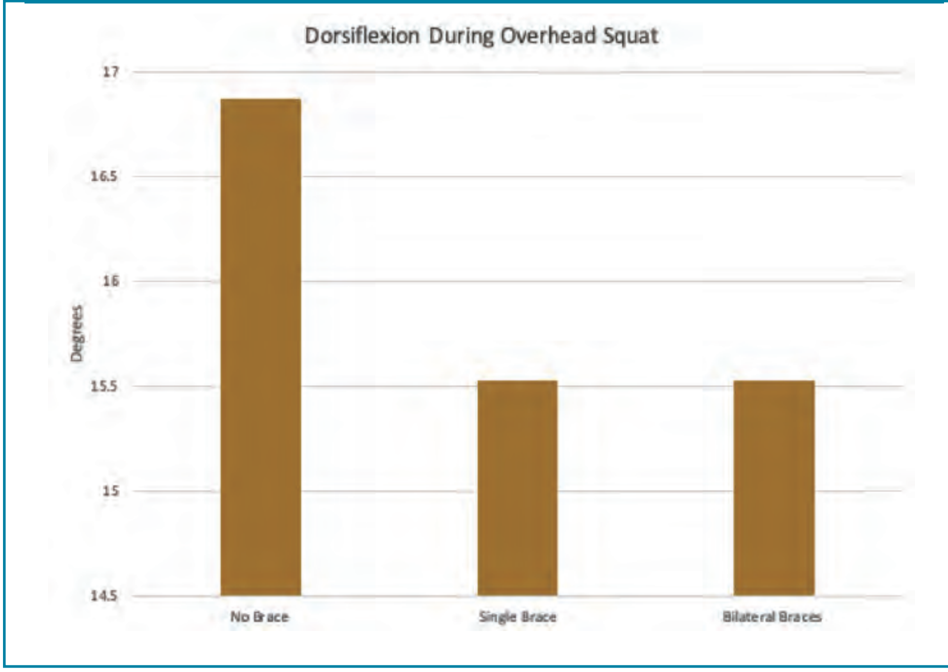

Figure 3. Knee Flexion During Overhead Squat

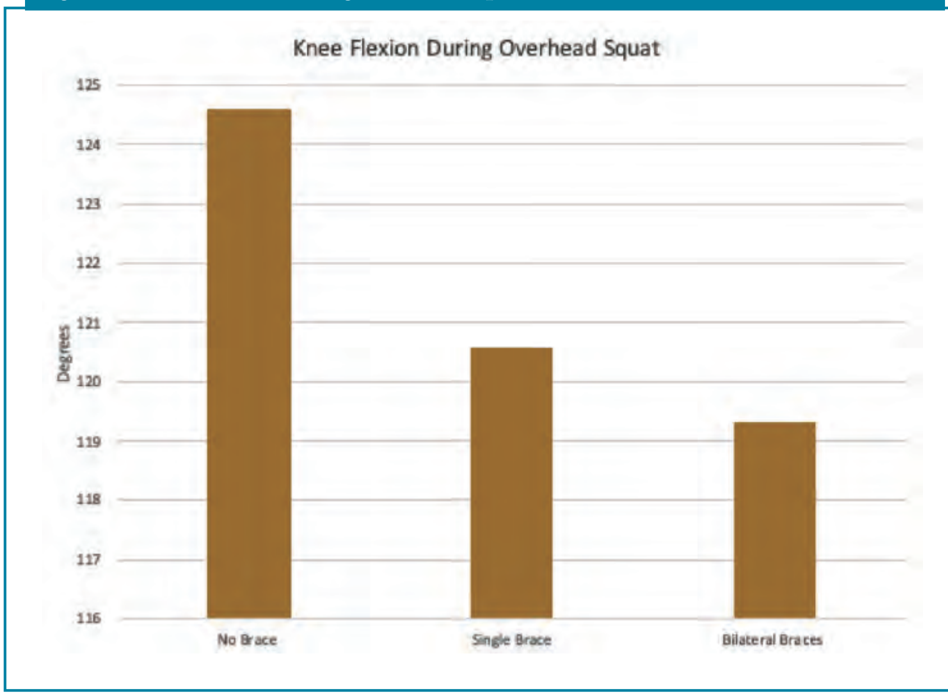

Table 1. Comparison of Means Between Bracing Conditions for All Joints Measured of All Participants (n=30)

Joint motion	No brace	Single brace	Bilateral bracing	Significance	Effect (partial eta squared)
Ankle dorsiflexion	16.87	15.53	15.53	*p* = .049*	*.099*
Knee flexion	124.60	120.57	119.30	*p* = .000*	*.256*
Hip flexion	138.57	137.17	136.67	*p* = .312	*.039*
Shoulder flexion	152.77	152.53	152.70	*p* = .974	*.001*
*$p > 0.05$					

research found statistically significant reductions in knee flexion angles during functional squats in which one or more ankle braces were donned, there is no research to our knowledge that has investigated the reliability and validity of the Hudl technique application. As such, it is unknown if the measured decrease in knee joint angles is due to meaningful change that could not be better explained by inconsistencies in intrarater measurements.

A further limitation of the research was the lack of an assessment of the squatting motions via a frontal plane view. The authors of this article intended to assess for changes in knee varus and valgus motions, ankle inversion and eversion compensations, and deviations of the trunk and lower extremities from midline in the frontal plane. These additional data points would have allowed better capture of compensatory movement during an overhead squat where the participant was wearing 1 or 2 ankle braces. For this study, each squat was recorded from both the frontal and sagittal planes. However, only the tripod used to record sagittal plane movement was equipped with bubble levels to ensure that the recording device was appropriately aligned for each squat trial. Following data collection, it was determined during analysis of the recordings that the frontal plane recording device was not leveled appropriately on the tripod stand. As such, the assessor was unable to appropriately orient horizontal lines and accurately determine deviations in kinematics using the skewed videos.

Further research has the potential to expand on these findings that knee angles were significantly affected by the presence of an ankle brace during squatting. To further expand on these findings, follow-up research should investigate the effects of ankle bracing on weight distribution, squat depth, varus/valgus and inversion/eversion moments, pelvic tilting, and/or lumbar lordosis during squatting. It is meaningful to investigate other biomechanics of the trunk and lower extremities to better determine where sources of compensation may occur during functional activities that are performed while wearing a prophylactic ankle brace. Furthermore, the changes observed in knee flexion angle may have also been impacted by subjective experiences of differences in squatting while wearing unilateral or bilateral ankle braces versus no bracing. The small sample size, lack of established psychometric properties of the Hudl technique, and lack of frontal plane assessment may have limited the study in capturing the movement restrictions imposed by the brace.

This study found significant changes in knee joint angles when a participant performed a squat while wearing a prophylactic ankle brace. Thus, it could be theorized that such kinematic changes could potentially pose an increased risk for injury. Further research is needed using additional techniques such as EMG to determine if the compensatory changes lead to true changes in muscle firing rates or fiber recruitment, fatigue, or force differentials that explain potential overuse injuries. A cohort study design to follow athletic populations over a significant time and participation in sport to determine outcomes associated with wearing prophylactic ankle braces could also be used.

Ankle taping is another common prophylactic intervention used in athletic populations.[10] Hall et al[10] investigated the effects of prophylactic ankle taping versus bracing on inversion range of motion, time to maximum inversion, inversion velocity, and perceived ankle stability. Hall et al[10] determined that the bracing condition revealed more restriction and at a decreased rate when compared to taping. This study was unable to determine if a similar reduction of knee flexion range of motion occurred. Future studies may use a clinical population with recurrent ankle sprains or knee pain to determine if compensatory motions arise from wearing a prophylactic ankle brace or taping during functional movements. If these compensations do occur, it would be important to determine if the compensatory deviation in motion exacerbates injury-related pain or increases repeat injury to the same joint or new injury in a different joint.

While the reduction in dorsiflexion range of motion was only an average difference of 1.34° between groups, it is important to note that the clinical significance of this decrease may be of a greater magnitude. Additionally, this relatively small change may have contributed to the greater change observed up the kinetic chain. In the present study, the knee joint assumed the greatest loss in range of motion, and the hip joint, further up the chain, did not compensate as greatly. This also highlights the need for better understanding regarding the influence of single joint restriction on the entirety of the kinetic chain. Future research should investigate the extent to which alterations in joint mechanics can be fully compensated by the closest proximal joint before traveling further up the chain. Additionally, differences in joint structure and function may cause some joints, such as the hip, to respond differently to distal joint restrictions than other joints, such as the knee. However, additional research is needed to investigate this theory.

CONCLUSION

The current study suggests wearing a lace-up ankle brace significantly reduces ankle dorsiflexion and knee flexion angles during a bodyweight overhead squat. Although this study is unable to determine if these changes influence the risk of injury in otherwise healthy adult populations, it should encourage clinicians to reflect on their recommendations to patients and/or clients. Clinicians who recommend prophylactic ankle bracing may consider the risk of changing biomechanics during functional movements while using a prophylactic ankle brace. However, without further research, this is a clinical reasoning decision that each healthcare professional must make.

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The Effect of Mobilization With Movement and Passive Stretching on Hip Range of Motion: A Randomized Controlled Trial

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ABSTRACT

Background and Purpose: A decrease in hip range of motion (ROM) is a risk factor for multiple orthopedic conditions; however, little evidence exists to determine the most effective treatment. The purpose of this study was to determine if hip mobilization with movement (MWM) is superior to passive stretching for increasing hip ROM. **Methods:** Fifty-eight participants with impaired hip ROM were randomized to a control group or received a single bout of either a hip MWM or hip passive stretch (HPS). Measurements for hip ROM were taken immediately before and after the intervention. **Findings:** No significant differences were noted between groups at baseline ($p > 0.05$). Group-by-time analysis revealed a significant difference between the control and treatment groups; however, no significant difference was noted between the hip MWM and hip stretch groups ($p < 0.01$). **Conclusion:** Improvements in ROM were achieved in both stretching and MWM groups indicating comparable efficacy. **Clinical Relevance:** Hip MWM and stretching have comparable treatment effects on ROM. Clinicians may consider patient comfort when choosing the most appropriate approach to treating limitations in hip ROM.

Key Words: flexibility, groin injury, internal rotation, femoral-acetabular joint

INTRODUCTION

The hip joint is characterized by inherent boney stability and serves an important role in linking the trunk and lower limbs. As such, range of motion (ROM) impairments of the hip may impact an individual's ability to perform functional activities and have direct implications on athletic activities. Furthermore, ROM impairments may impact the biomechanical properties of the hip and predispose the hip and neighboring joints to injury. Authors suggest associations between hip ROM deficits and pathology including chronic low back pain,[1-5] hip osteoarthritis (OA),[6,7] athletic chronic groin injury,[8] and sports hernia.[9] More specifically, a Clinical Practice Guideline for hip OA suggests that limited hip flexion and internal rotation (IR) are part of the criteria that may be used to identify patients with hip OA.[7] Groin pain is a concern for many athletes, especially those in rugby, football, soccer, ice hockey, or other sport requiring vigorous repetitive adductor use.[9-11] Authors suggest that groin pain and the overarching sports hernia have multiple etiologies, but significant increased risk factors include participation in higher level of sport, low-training levels compared to sport demand, previous groin injury, reduced hip IR ROM of the symptomatic hip by 3.7° compared to same-sport athletes without groin pain, and decreased hip adductor strength.[10,11]

These deficits in ROM may be related to various physiological factors, including restriction in soft-tissue extensibility, an inability of musculotendinous units to expand to a lengthened position, an arthrokinematic block through bony prominences, or inflammation related swelling of the joint or joint capsule.[12-14] In clinical outpatient settings, stretching and mobilization with movement (MWM) are two frequently used techniques to improve an individual's available ROM. The same two are also the most studied techniques to improve hip ROM.[7,15-20] Passive static stretching is theorized to provide improved flexibility to a muscle through lessened excitability of the muscle spindle, and increased inhibition via autogenic biochemical changes as opposed to mechanical lengthening or increased extensibility of the muscle fiber.[21,22] However, MWM has been studied sparingly in the area of the hip, but its mechanism of action to improve ROM while reducing painful movement includes theories such as stretch of the joint capsule with subsequent improvement in neuromuscular control, and central mechanisms decreasing nociceptive stimuli and fear avoidance to engage in further ROM.[23-25] Stretching and MWM techniques have demonstrated effectiveness[15,16] within the literature. However, it is not clear if one is superior to the other for immediate improvement in hip ROM within the same study population.

To our knowledge, there are only 2 studies that evaluated hip MWM to elucidate effects on hip pain, ROM, and physical performance.[15,16] Neither study included a comparison of stretching and MWM. Therefore, the purpose of this study was to determine the pre- and post-intervention differences in hip ROM when an IR MWM or IR passive stretch (IRPS) was applied to an asymptomatic population with limited hip IR.

METHODS

Study Design

A single-blinded randomized controlled trial was used to compare 2 different techniques used in clinical practice to improve hip ROM--passive hip stretching and hip MWM. A control group was also included that required participants to sit on a table for 5 minutes with no treatment. Pretest measurements for all hip passive ROM motions including flexion, IR, external rotation (ER), and extension were performed on qualifying subjects. Following measurements, groups were determined via randomization, and interventions were subsequently performed based on group allocation. Posttest measurements of hip passive ROM immediately followed the intervention to acutely determine changes in hip ROM.

Subjects

A convenience sample of individuals from the University of Central Florida (UCF) and the surrounding central Florida area was recruited for this investigation. The inclusion criteria consisted of individuals between the ages of 18 and 65 years old with hip passive IR of 25° or less on at least one side. Exclusion criteria consisted of individuals that had undergone surgery on their hip within the last 12 months, and the participant's report of hip pain within the last 12 months. All participants that met the inclusion criteria and agreed to participate in the study were provided with and gave informed consent.

The protocol for this study was approved by the Institutional Review Board at UCF.

Procedure

The study was a single-blinded randomized controlled trial. Investigator 1 provided a brief description of the study, explained the study protocol, and obtained informed consent. Investigator 2 performed the screening and measurements, while Investigator 3 performed the interventions. Investigators 1 and 3 were blinded to the participant group assignment. After the screening was completed, Investigator 2 left the room while Investigator 1 and 3 entered the room. Investigator 3 performed the intervention, while Investigator 1 monitored time and provided supervision to ensure that treatment fidelity was maintained.

Hip Range of Motion

After screening to rule out participants with exclusion criteria and providing consent to participate, participants subsequently received pretest measurements of hip IR, ER, flexion, and extension. The participant's hip IR passive ROM was measured bilaterally in sitting. Sitting hip IR was preferred over prone measurement due to evidence suggesting that despite pelvic stabilization, hip IR in prone leads to increased IR values when compared to the same leg measured in sitting.[13,26,27] Measurements of ER were performed in sitting while flexion was performed in supine. Lastly, extension was performed in prone. All passive ROM were assessed with the measurement technique detailed by Norkin and White.[13] Measurements of hip IR using a goniometer have demonstrated good to excellent reliability, with intraclass correlation coefficient (ICC) values reported as 0.75 to 0.91[28] and 0.80.[29] Aalto et al[30] reported ICC values between 0.813 and 0.982 for hip flexion, and between 0.918 and 0.961 for hip extension.[31]

Randomization

After pretest measurements, participants were randomized into an intervention group by selecting between opaque cards. Each card represented a single intervention assigned to the number on the underside of the card. The number assignment did not change for the entirety of the study, and the number was not shared with the participants to protect the randomization process. Investigator 3 was the only investigator not blind to which number corresponded to which treatment as they were the investigator performing the intervention. Finally, all participants were instructed to not disclose or discuss their intervention with another investigator or potential participant.

Intervention

The technique for the MWM was chosen based on literature from Mulligan and Beselga et al.[15,23] This technique required the participant to be supine, with investigator 3 on the side of the leg to be mobilized. The participant's hip was flexed to 90°, and a mobilization belt was placed around the proximal femur, with the padded portion of the mobilization belt as close to the hip joint as comfortably possible. Once the belt was placed, the participant was allowed to adjust the belt as needed to ensure comfort. The rest of the belt was placed around the hips of investigator and served to create an inferolateral distraction force at the participant's hip that demonstrated the ROM deficit. Additionally, the femur was adducted slightly across the body once the hip was in 90° of flexion. The participant's knee was allowed to stay fully flexed during the MWM to better control the passive IR moment provided by the investigator. Once the distraction force was applied at the hip, the investigator took the participant's hip into full IR while maintaining the distraction (**Figure 1**). This technique was adapted and slightly altered from that described by Beselga et al[15] due to the difference in sample size and lack of pathology or symptoms in all included participants.[23] While maintaining the distraction force, the investigator mobilized the participant's hip into end range IR with overpressure for 10 repetitions, then allowed for 30 seconds of rest. This was repeated for 3 sets, for 30 total repetitions. The participant was instructed to relax their leg and allow for the investigator to move the leg without resistance during the MWM.

The internal rotation passive stretch intervention was provided in the same position described for the MWM but without the use of a mobilization belt or distraction force. The hip was flexed to 90°, the knee was allowed to flex passively to reduce pressure across the knee joint, and the investigator used the same hand placements to apply and sustain a hip IR stretch for 30 seconds (**Figure 2**). The participant rested for 10 seconds after each 30-second period. Three repetitions were completed for a total of 90 seconds of stretch time.[32]

Figure 1. Internal Rotation Mobilization with Movement Used in the Study (N=58)

Figure 2. Internal Rotation Passive Stretch Used in the Study (N=58)

Statistical Analysis

All data were analyzed using SPSS (IBM version 25; Armonk, NY). Baseline statistical differences between-groups were analyzed with an independent t-test. Within-group differences of pre- and posttest measurements were assessed with a dependent t-test. Lastly, group-by-time interactions were evaluated with a repeated measure analysis of variance (ANOVA). All analyses were completed with a 95% confidence interval and a p-value of < 0.05 considered statistically significant.

RESULTS

Demographics of included participants are described in **Table 1**. The sample

Table 1. Baseline Characteristics of Study Participants (N=58)

	Overall (N=58)	MWM group (n=19)	Stretch Group (n=17)	Control Group (n=22)	p-value
Gender, % female	19%	26.3%	17.6	13.6	0.58
Age in years, mean ± SD	25.4 (6.2)	24.1 (5.1)	25.7 (6.1)	26.4 (7.2)	0.49
Height, (cm) mean ± SD	175.7 (10.3	173.1 (11.9)	177.1 (10.6)	176.8 (8.4)	0.43
Body mass (kg), mean ± SD	80.0 (16.4)	79.4 (17.8)	79.7 (18.3)	80.8 (14.4)	0.96
BMI	25.8 (4.1)	26.3 (4.6)	25.3 (4.9)	25.7 (2.9)	0.75

Abbreviations: BMI, body mass index; cm, centimeters; kg, kilograms; MWM, mobilization with movement; SD, standard deviation

included 58 individuals randomized into either MWM (n=19), IRPS (n=17), or control (n=22). **Figure 3** provides a flow diagram of the process to compile our randomized participants for final analysis. At baseline, independent *t* – tests suggest no significant differences between groups for any pre-intervention ROM measurement (**Table 1**). Group-by-time interactions were determined with repeated-measures ANOVA that revealed a significant relationship (p = 0.001) for immediate ROM changes in the hip treatment groups (MWM and IRPS) for IR, ER, flexion, and extension compared to the control group. However, no significant differences were noted between the treatment groups (MWM vs IRPS). Within-group changes assessed with a dependent sample *t* – test revealed significant changes in both MWM and IRPS groups in IR ($p < 0.001$) (**Table 2**).

DISCUSSION

This is the first randomized controlled trial to use a 3-armed, single-blinded design to assess for immediate change in passive hip ROM between IR stretching and MWM. The purpose of this study was to evaluate differences in hip ROM when an IR MWM or IR passive stretch was applied to a population with restricted hip ROM. Our results suggest both interventions are more effective than no treatment; however, there was not a significant difference between the MWM and stretch groups. Prior research on MWM suggests that there is validity in applying an MWM over a sham IR MWM[15] or caudal MWM to improve hip IR.[16] Beselga et al[15] reported a significant change from baseline to end of treatment of 25.1 ± 7.2° to 29.4 ± 7.4° IR, respectively, with a 95% confidence interval (5.8, 2.9) for within-group changes. Hip IR minimum detectable changes have been reported from various sources with goniometery.[15,27] Walsh et al[18] suggested no significant differences in hip ROM with self-performed hip flexion MWM, but clinician-applied caudal hip flexion MWM appeared to increase immediately available standing, functional IR ($p = 0.01$). Differentiating the current study from the past two studies is the increased mean age of participants with the MWM group at 78.3 ± 6.1 and the sham group at 77.5 ± 6.9, each in years.[17] Secondly, the participants in the study by Beselga et al[15] had a clinical diagnosis of OA and chronic hip pain which differs greatly from our criteria that eliminated participants that had hip pain within the past 12 months. Other limitations of comparing the Beselga et al[15] and Walsh et al[16] studies to this investigation include the lack of information of measurement position[15] and use of a bubble inclinometer for IR measurement.[18] As discussed earlier, the position chosen to measure IR will significantly affect the reading favoring larger readings in prone due to the increased compensatory movement of the pelvis and lumbar spine.[26,31,32]

The theories explaining MWM's effectiveness is still debated in the literature. The positional fault theory originally proposed by the pioneer of the MWM, Brian Mulligan,[23] is an unlikely consideration to explain changes in hip ROM due to the congruency of the femoral head in the acetabulum and lack of substantive evidence recording changes in bone position before and after MWM intervention.[15,23,25,33] Other theories have suggested central nervous system processing changes to include hypoalgesia and indirect endogenous pain inhibition may also provide painful joints additional stimulus to

Figure 3. Consort Diagram of Participants Throughout the Study

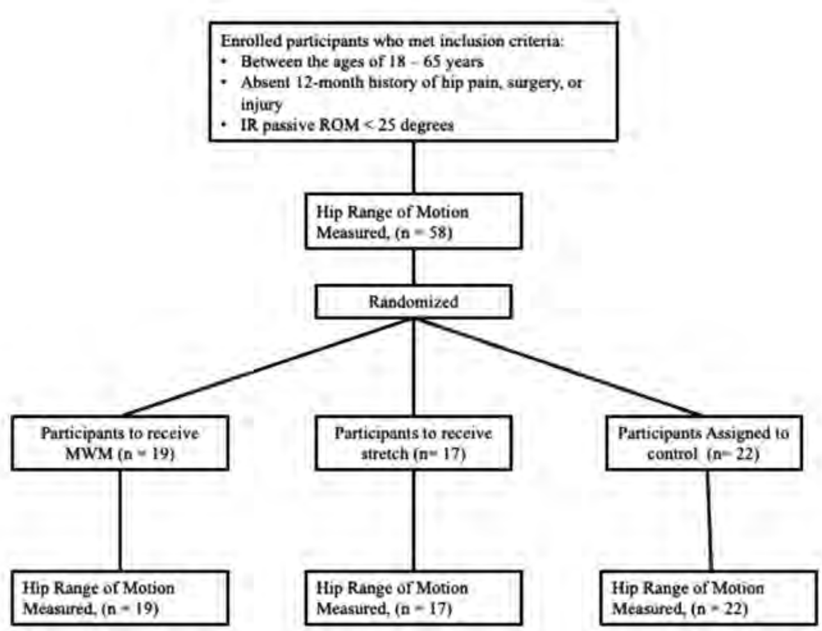

Table 2. Group Comparison Before and After Intervention

	Hip Stretch (n=17)				Hip MWM (n=19)				Control (n=22)				Between Groups at Baseline	Time by Group Interaction
	Pre mean (SD)	Post mean (SD)	p-value	Mean diff (95% CI)	Pre mean (SD)	Post mean (SD)	p-value	Mean diff (95% CI)	Pre mean (SD)	Post mean (SD)	p-value	Mean diff (95% CI)	p-value	p-value
Hip IR	22.4 (±2.1)	25.4 (±3.5)	*p*<0.01	-3.0 (-4.3 to -1.7)	22.8 (±1.9)	26.5 (±3.9)	*p*<0.01	-3.7 (-5.2 to -2.1)	22.2 (±1.8)	22.5 (±2.9)	*p*<0.44	-0.3 (-0.9 to 0.5)	*p*=0.65	p=0.01
Hip ER	30.6 (±1.6)	34.7 (±4.1)	*p*<0.01	5.4 (3.2 to 7.6)	30.3 (±1.7)	37.2 (±6.4)	*p*<0.11	1.9 (-0.4 to 4.2)	31.2 (±1.1)	32.4 (±2.6)	*p*<0.92	-0.1 (-0.9 to 0.8)	*p*=0.12	p=0.01
Hip Flexion	122.2 (±2.1)	131.4 (±2.1)	*p*<0.90	-0.2 (-3.1 to 2.7)	122.1 (±2.8)	131.4 (±2.6)	*p*<0.01	2.8 (1.4 to 4.1)	120.6 (±3.1)	122.3 (±2.1)	*p*<0.34	0.3 (-0.4 to 1.0)	*p*=0.79	p=0.01
Hip Extension	7.6 (±1.1)	14.9 (±2.5)	*p*<0.01	-6.9 (-10.8 to -3.0)	8.1 (±1.1)	19.5 (±4.7)	*p*<0.01	-7.2 (-8.6 to -5.7)	7.5 (±1.2)	7.4 (±1.2)	*p*<0.45	0.1 (-0.2 to 0.5)	*p*=2.34	p=0.01

Abbreviations: CI, confidence intervals; ER, external rotation; diff, difference; IR, internal rotation; MWM, mobilization with movement; SD standard deviation

assist in gating pain to reduce painful end feels, reduce fear avoidance, and allow for increased ROM.[24,25,33-35] However, because this research was performed on individuals who were not experiencing pain, the authors acknowledge these pain inhibiting mechanisms are unlikely to explain the significant changes in hip ROM observed. Authors have suggested neurophysiological changes to decrease contractility of antagonist muscle groups in asymptomatic shoulders and therefore may be a component of interest in this study population.[25,36] However, further research needs to be performed before conclusions should be drawn regarding the neurophysiologic or biomechanical mechanism of MWM.

The implications to improve global ROM and prevent injury or risk for chronic pain are evident. Research from Birrel et al[6] comparing hip IR measurements of individuals with varying degrees of hip OA found severe radiographic OA to be associated with IR of less than 28°. In young rugby athletes, decreased ER and IR range of hip motion was predictive of the development of chronic groin injury over the course of a season of play.[8] Interestingly, all the athletes demonstrated a significant lack in IR in both dominant and non-dominant lower extremities, but only the combination of decreased IR and ER proved to precede groin injury.[8] Furthermore, there are immediate improvements in ROM and reduced pain evident in athletes after receiving hip mobilization interventions.[37,38] Mau and Baker[39] reported a case study of a female collegiate basketball player with an acute lateral ankle sprain who received MWM after 10 days of minimal results from conventional strengthening, balance, and mobility exercises. After the MWM and taping were included in the care plan, they reported their patient no longer experienced pain as reported at baseline. This study evaluates a sample population that may benefit from this technique (ie, individuals with limited ROM).

CONCLUSION

Deficits in hip ROM can lead to difficulties with functional mobility, ambulation, and performing activities of daily living. Hip IR MWM and a passive IR stretch demonstrates the ability to significantly improve available hip ROM. These two interventions may be useful in clinical practice as well as prior to athletic performance to immediately improve hip ROM. Further areas of study surrounding this topic should include testing long-term effects, serial interventions, and the influence of MWM versus stretching of athletes in and out of competition season.

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The Effects of Pain Neuroscience Education on Pain in a Healthy Population

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ABSTRACT

Background and Purpose: Pain neuroscience education (PNE) can improve pain understanding in people with pain. This study investigated a single session of PNE on pain knowledge, fear-avoidance beliefs, and pressure pain threshold in a healthy population. **Methods:** Twenty-five healthy participants (mean age 23.5 ± 3.3 years) were randomized into a PNE group or a control group. Outcomes included pressure pain threshold using a pressure algometer, fear-avoidance beliefs (Fear-Avoidance Beliefs Questionnaire [FABQ]), and pain knowledge (Revised Neurophysiology of Pain Questionnaire [RNPQ]). **Findings:** The PNE group demonstrated a significant increase in quadriceps pressure pain threshold ($p=0.050$, $\eta2=0.163$) and a significant improvement in pain knowledge ($p=0.004$, $\eta2=0.324$). A nonsignificant decrease in fear-avoidance beliefs was seen in the PNE group with a moderate to large effect size ($p=0.081$, $\eta2=0.132$). **Clinical Relevance:** Improving pain understanding in healthy individuals may lower the risk of experiencing chronic pain. **Conclusion:** Pain neuroscience education can improve understanding of pain in healthy individuals.

Key Words: acute pain, pain science, pressure algometry, pressure pain threshold

INTRODUCTION

The understanding and treatment of acute and chronic pain have evolved rapidly in the past decade. It has shifted away from a biomedical paradigm that emphasizes tissue abnormality and pathology as a chief determinant of pain, to a new understanding that the pain experience is complex and multifactorial. This evolved understanding incorporates not only biological tissues but also considers the psychological and social aspects that affect the perception of pain in the brain. This perceptual component of pain has recently come to the forefront of literature regarding patients in chronic pain and the overall pain experience.[1-3]

In patients with chronic pain, there is often an absence of biological tissue pathology despite the presence of continued symptoms. A large body of literature[1-3] supports the effect of psychological factors on perceived pain in these patients. Through examination of the hypothalamic-pituitary axis during periods of stress, compounded with symptom clusters, it has been demonstrated that the stress response in the brain can amplify or even manifest symptoms in patients suffering from chronic pain, despite the absence of acute tissue damage.[4] This psychological component of pain has been shown to not only influence the perception of pain in these patients but also serves as a viable strategy for treatment as pain neuroscience education (PNE). This treatment approach aims to alter a patient's beliefs about their pain experience.[5-7] While the use of PNE in patients suffering from persistent pain across a multitude of diagnoses is well documented in the literature,[1,2,8,9] a gap exists for the utility of PNE in patients experiencing acute bouts of pain, both from diagnosable pathologies and idiopathic causes.

This gap in pain research, largely due to the lack of funding, is becoming a growing problem for the American health care system. Currently, chronic pain accounts for an estimated total annual cost of $560-635 billion, with $261-300 billion coming from health care costs and $299-335 billion coming from the lost productivity of workers who are experiencing chronic pain.[10] The literature does not account for the fact that most patients with chronic pain began with an acute bout of diagnosable or idiopathic pain, which for one reason or another did not properly resolve and developed into a persistent pain experience. This cycle leads to a considerable financial burden on both the health care system and the general economy.

Aside from treating patients with acute pain prior to it becoming chronic, there are options in managing chronic pain that may reduce the health care burden while simultaneously improving patient outcomes. Currently, research shows that over one-third of patients with chronic pain receive analgesic drugs or injections as a first option to manage chronic pain.[11] While this treatment may address the symptoms involved in the chronic pain experience, it does little to manage the underlying cause or improve long-term outcomes, ultimately resulting in frequent usage of the health care system and the concomitant necessity for high-cost pharmaceuticals. A possible option to subvert the extensive cost of pharmaceutical intervention is the introduction of education-based therapy for patients experiencing chronic pain. A meta-analysis by Losina et al that investigated pain management in osteoarthritis found that only 11% of studies examined the effects of behavioral interventions with a comparative 69% investigating pharmaceutical interventions.[12] In efforts to address this deficit and reduce the financial burden of individuals suffering from chronic pain, PNE may be an effective intervention for administration to healthy individuals during an episode of acute pain. Hence, the purpose of this study was to examine the effects of a PNE session on pain tolerance, pain knowledge, and beliefs about pain in healthy individuals. It was hypothesized that various positive effects on pain tolerance level, pain knowledge, and beliefs about pain would occur after a brief session of PNE.

METHODS

Study Design

All procedures were approved by the University of Central Florida Institutional Review Board. Individuals were initially screened for eligibility via a phone screening, and those deemed eligible were scheduled for the first of 2 sessions. During session 1, participants completed baseline questionnaires (further described in "questionnaires" subsection), underwent pressure pain threshold (PPT) testing, and were randomized by the same researcher (JM) into either a PNE group or a control group. The PNE group participated in a 10- to 15-minute educational session about pain at the end of session 1. Session 2 took place one week after session 1. Participants were encouraged to schedule the 1-week follow-up at the same time as session 1 to control for confounding variables. Participants in the PNE group could ask any questions regarding the education they received during session 1. Both groups completed pain knowledge/belief questionnaires and PPT was assessed. All procedures in each session were performed in the same two classroom locations at the University of Central Florida.

Participants

Participants were recruited from the community through flyers and word of mouth. Participants were excluded if they were under 18 years of age, previously received PNE at any point, recorded a score greater than 2/10 on the Numeric Pain Rating Scale, or if they described their health status as "fair" or "poor." Participants were deemed healthy and eligible for the study when self-reporting general health status as "good" or "excellent." Forty-three individuals were screened with 18 being deemed ineligible due to exclusion criteria. Twenty-five healthy individuals qualified for and participated in the study (**Figure 1**). All participants were made aware of the study procedures and signed written consent forms prior to participation.

Questionnaires

Screening questionnaire: A custom questionnaire was created and administered over the phone to assess eligibility for the study. The questionnaire screened for the following eligibility criteria: age, health status (poor, fair, good, excellent), pain level, and exposure to PNE.

General questionnaire: A custom questionnaire was created and administered during session 1 to collect the following: sex, ethnicity, prior pain experience, weekly physical activity, and sleep parameters.

Assessment of pain knowledge and beliefs about pain: This assessment used a combination of questionnaires including the Fear-Avoidance Beliefs Questionnaire (FABQ) and the Revised Neurophysiology of Pain Questionnaire (RNPQ) to assess pain knowledge and beliefs, using a numeric rating scale and true or false questions related to the pain assessment, knowledge, and beliefs of the participants.

Experimental Pain Outcome

Pressure algometry has been proven to be an effective way to determine an individual's PPT[13,14] and has demonstrated high levels of intrarater reliability on various anatomical landmarks in individuals with and without pain.[14-16] A handheld digital algometer (PAIN TESTTM FPX, Wagner Instruments, Greenwich, CT) with a linear response force between 0 and 100 pounds of force (lbf) and a 1cm^2 round rubber covered tip was used to determine PPT at the anatomical sites used by Cruz-Almedia et al.[17] This included the upper trapezius, quadricep, and extensor carpi radialis on the dominant side of the participant after a trial on the webbing of the dorsum of the hand between the second and third digits. The average of 3 trials at each location was used for data collection, with rest periods between trials dictated by the participant. Pressure pain threshold force with the pressure algometer was applied at a rate of 1 pound of pressure per second. The following instruction was given to the participant: "I'm going to apply pressure to your muscle. I want you to tell me the moment the sensation changes from comfortable pressure to slightly unpleasant pain." Slow pressure was applied until the participant said "now." The researcher conducting the PPT assessment was blinded to groups of the participants. The location of the pressure was determined via the methods described as follows:

Upper trapezius procedure: The participant was in a seated position and a downward force was applied approximately to the midpoint between the seventh cervical vertebrae (C7) and the acromion along the upper trapezius muscle.

Quadriceps procedure: The participant was in a seated position with their feet on the floor and knees bent at 90°. A downward force was applied approximately halfway between the hip crease and the superior portion of the patella.

Extensor carpi radialis (ECR) procedure: The participant was in a seated position with their arm resting on a table with the elbow bent at 90°. The examiner palpated the belly of the ECR, and a downward force was applied.

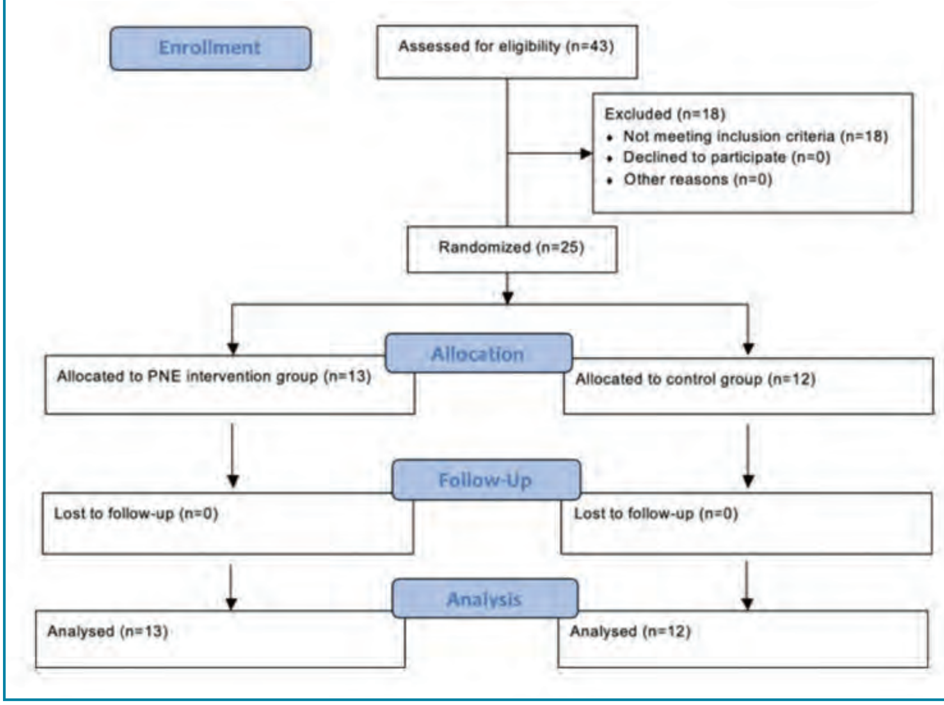
Administration of PNE

Each participant in the intervention group went through a 10- to 15-minute educational intervention delivered by the same researcher using material in the book, *Why Do I Hurt?* by Louw.[18] Main themes of this book have previously been used and its efficacy has been well-documented in numerous studies.[2,8,9,19,20] The main themes of the book include the role of everyone's 'alarm system,' tissue healing, central sensitization, and strategies for bringing nerve sensitivity back down to normal. Various images, metaphors, and examples were used to improve the understanding of the information. The format was conversational, and the participants were encouraged to ask questions throughout. The presentation did not specifically target any content requested in the questionnaires.

Statistical Analyses

To determine the overall effect of the PNE session, 5 separate one-way analyses of covariance (ANCOVAs) were used to examine the adjusted posttest quadriceps PPT, upper trapezius PPT, extensor carpi radialis PPT,

Figure 1. Flow Diagram of Study Progress in the Consolidated Standards of Reporting Trials (CONSORT)



FABQ, and RNPQ data.[21,22] The grouping was the independent variable and included 2 levels, intervention and control. The pretest and posttest values were used as the covariate and dependent variable, respectively. Prior to performing each ANCOVA, the homogeneity of slopes assumption was assessed via performing a regression analysis[21] Bonferroni-corrected post hoc pairwise comparisons were then used to examine the between-group differences. An alpha level of 0.05 was used to determine statistical significance. The ANCOVA's partial eta squared (η2) statistic was calculated and values of 0.01, 0.06, and 0.14 corresponded to small, moderate, and large differences, respectively.[23] Separate bivariate correlations were completed to assess relationships between age, exercise, sleep, and baseline PPT measures. Statistical Package for the Social Sciences (SPSS) software (version 25.0, SPSS Inc., Chicago, IL) was used for all statistical analyses.

RESULTS

Participants (N=25) were randomized into intervention (n=13) and control (n=12) groups. Characteristics of the groups were similar and displayed in **Table 1**.

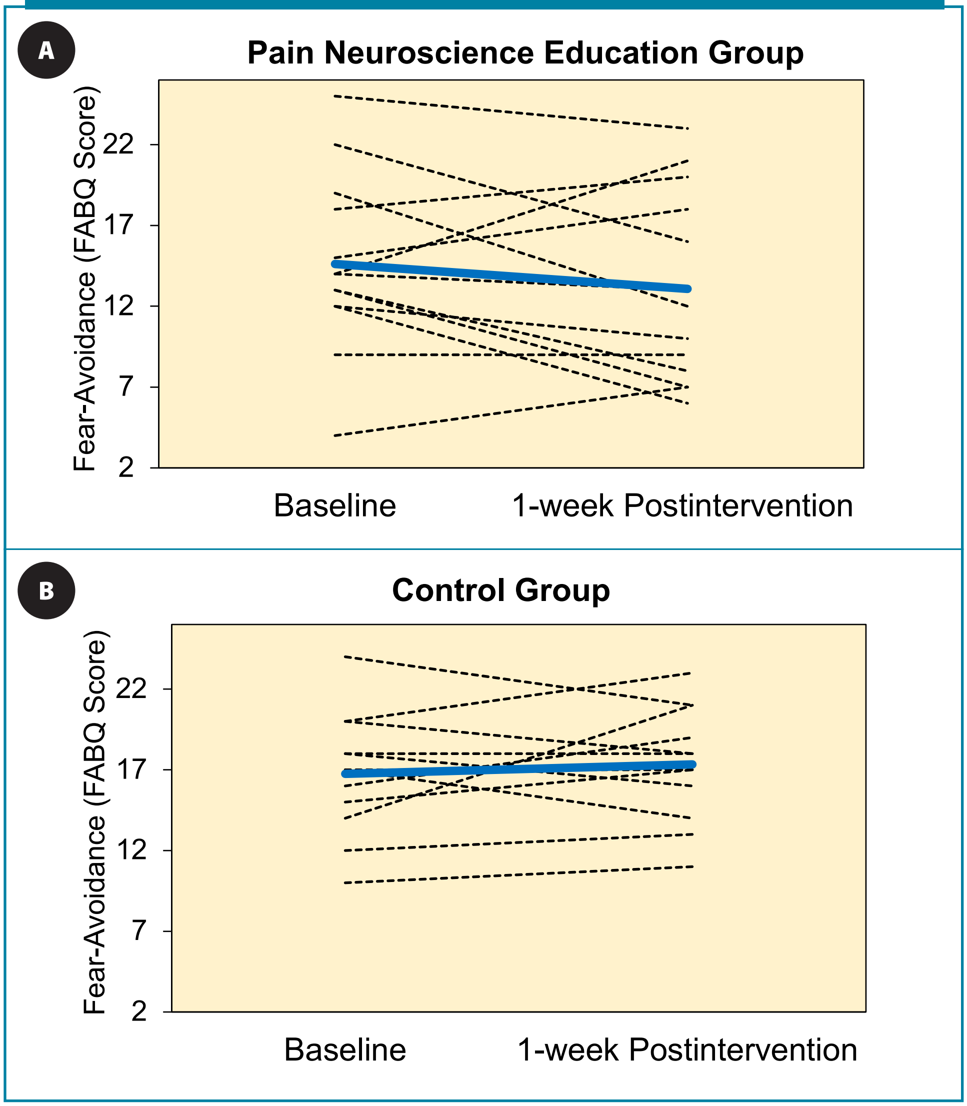
Table 1. Participant Characteristics of the Current Study (N=25)

	Intervention (n=13)	Control (n=12)
Age (years)	22.54	24.58
Female (%)	9 (69.2%)	8 (66.6%)
White, non-Hispanic	12 (92.3%)	9 (75%)
Exercise (minutes/week)	168.08	186.66
Sleep (hours/night)	6.69	6.66

Fear-Avoidance Beliefs

Concerning changes in FABQ scores, the ANCOVA revealed that, although there was a difference in scores between groups, the difference was not statistically significant ($p=0.081$); however, a moderate to large effect size was noted ($\eta2=0.132$). The FABQ was scored out of 96 points, with a higher score being associated with more fear-avoidance behaviors exhibited. The difference in mean postintervention scores was 13.08 points out of 96 for the intervention group and 17.33 points for the control group, with a lower score representing decreased fear-avoidance beliefs with activity (**Figure 2**). **Figure 2** displays individual participant changes on the FABQ from baseline to 1-week postintervention. As dictated by the blue line, a decrease in mean score on the FABQ and overall fear-avoidance beliefs from baseline to post-intervention is seen in the PNE group (**Figure 2A**), but not in the control group (**Figure 2B**).

Figure 2. Individual Participant Changes on the FABQ from Baseline to 1-week Postintervention



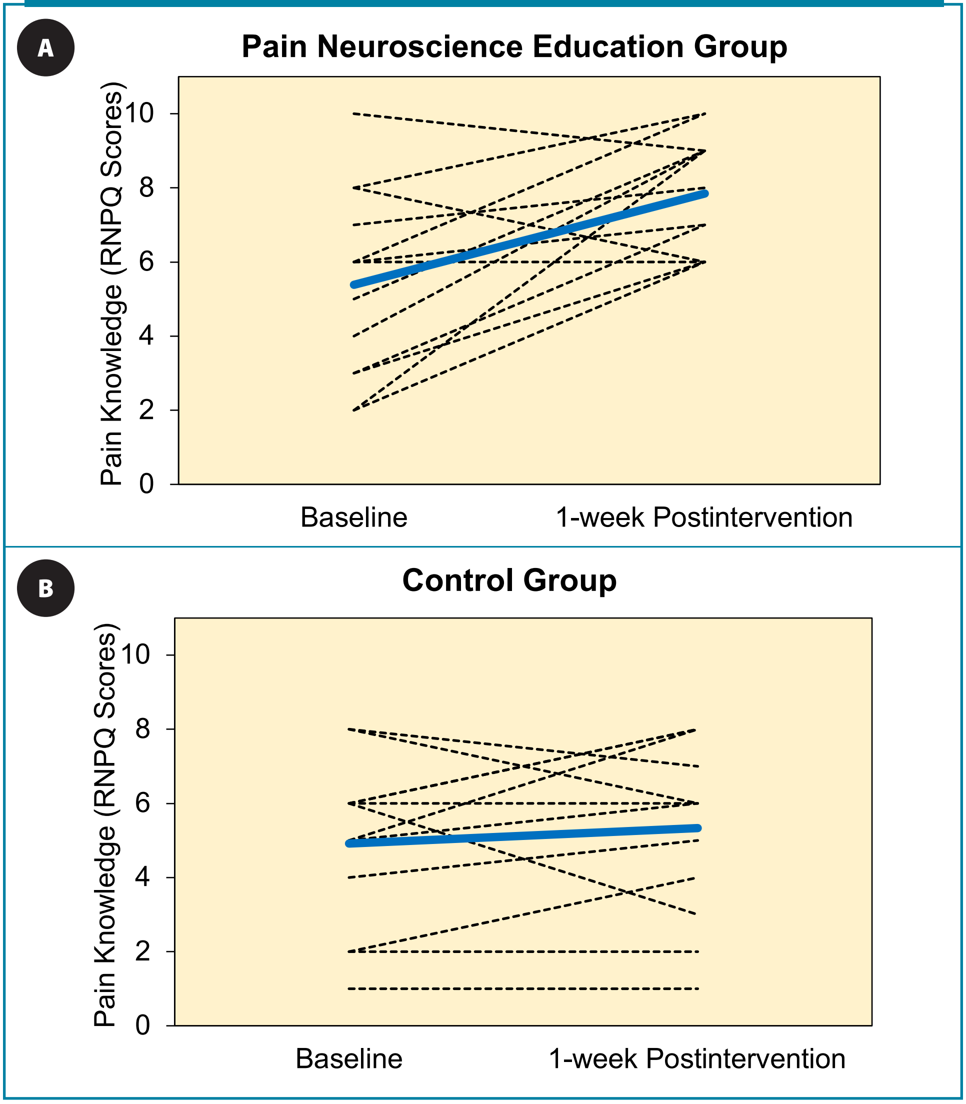
Pain Knowledge

The ANCOVA for the RNPQ scores showed a significant difference in scores between the control group and intervention group ($p=0.004$) and a large effect size ($\eta2=0.324$). After adjusting for other variables, participants in the intervention group answered 7.752 questions correctly (out of 13 questions), while the control group answered 5.435 questions correctly after the intervention (**Figure 3**). **Figure 3** displays individual participant changes on the RNPQ from baseline to 1-week postintervention. As dictated by the blue line, a decrease in mean score on the RNPQ and overall pain knowledge from baseline to postintervention is seen in the PNE group (**Figure 3A**), but not in the control group (**Figure 3B**).

Pressure Pain Threshold

The ANCOVAs for the 3 different muscles tested during PPT revealed that the quadriceps testing site had the most meaningful difference between the groups with a large effect size ($p=0.050$, $\eta2=0.163$). Force (14.04

Figure 3. Individual Participant Changes on the RNPQ from Baseline to 1-week Postintervention



pounds) was needed to evoke discomfort in the intervention group, while only 10.78 pounds of force was needed for the control group (**Figure 4**). There were no significant differences between the groups for the upper trapezius (p=0.121, η2=0.106) or the extensor carpi radialis PPT scores (p=0.358, η2=0.039). **Figure 4** displays individual participant changes in PPTs for the quadriceps muscle group from baseline to 1-week postintervention. As dictated by the blue line, an increase in mean PPT and overall pain tolerance from baseline to postintervention is seen in the PNE group (**Figure 4A**), but not in the control group (**Figure 4B**).

Other Associations

Bivariate correlations were examined to determine any existing relationships among the data collected from the baseline questionnaires and PPT results. These variables included PPT average scores for each muscle group, the FABQ and RNPQ scores, age of the participants, their average weekly minutes of exercise, average hours of sleep per night, average minutes it takes to fall asleep, and the change scores for the FABQ, RNPQ, and PPT testing. Upon analysis, no significant relationships were found among any of the variables in question.

DISCUSSION

It has previously been demonstrated that the application of PNE may decrease pain levels in individuals with chronic pain,[8,24-27] however, few studies have investigated its usage on individuals without pain.[5] The shortest duration of documented PNE sessions in current literature is 30 minutes,[8,28-30] thus, this study is one of the first to find positive effects from a shorter, 10- to 15-minute, educational session. The current study reflects the potential use of a shorter session of PNE for individuals without pain.

It was hypothesized that various positive effects, including improved pain tolerance levels as well as pain knowledge and beliefs, would occur after administration of PNE in the healthy population. The results support that pain knowledge, PPT levels, and fear-avoidance beliefs were improved in a group that received a single 10- to 15-minute PNE session, compared to a control group.

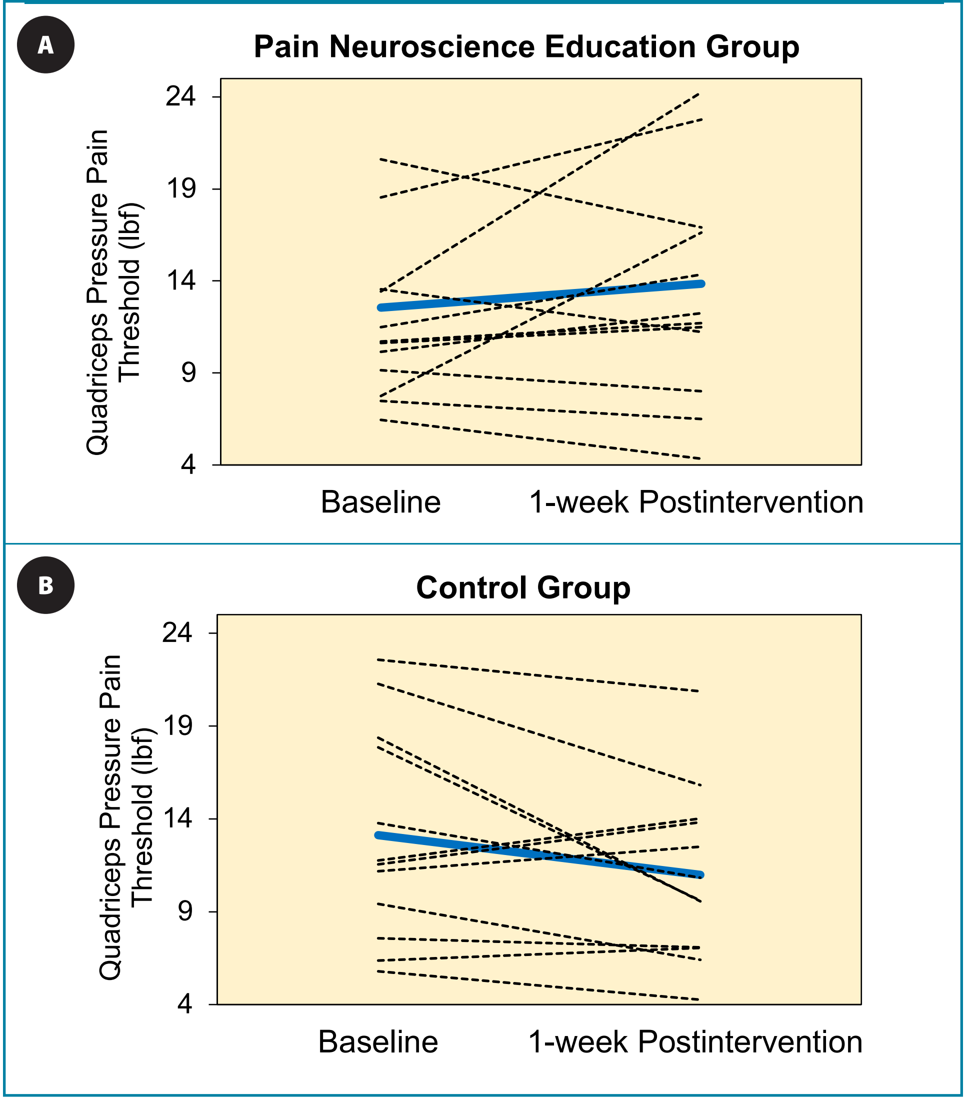
A finding from this study that is consistent with current literature[3,20,31,32] is the increase in pain knowledge after receiving a PNE session. The RNPQ was used to assess the level of pain knowledge. At baseline, the intervention group recorded an average score of 5.38 correct responses and the control group recorded an average score of 4.92 correct responses out of 13 questions. After administration of PNE, the intervention group's average score was 7.85 correct responses (2.47-point increase), while the control group's average score was 5.33 correct responses (0.41-point increase). This reinforces the belief that a short educational PNE session is powerful enough to make a statistically significant difference in an individual's knowledge of pain.

While there was not a statistically significant difference in the FABQ scores of participants in the PNE group when compared to the control group, a large effect size was observed from 10 to 15 minutes of PNE. This large effect size suggests that there may be merit to providing certain patients with short bouts of PNE to achieve a large effect on fear-avoidance beliefs.

Also, of important note, the quadriceps muscle group showed a statistically significant improvement in PPT in the PNE group when compared to the control group. This improvement is not only statistically significant, but it also demonstrated a large effect size. However, this muscle group was the only one to demonstrate a statistically significant change in PPT following PNE. Whether this was truly due to a change in pain perception or random chance should be further evaluated in future studies.

This study had a few inherent limitations that must be mentioned. To begin with, the sample size was relatively small (N=25) and for that reason, sampling not only has a greater chance of being affected by a potential outlier but also makes it difficult to generalize the results to the general healthy, young adult population at large. Additionally, there was low heterogeneity within the sample; most participants were selected from the first-year

Figure 4. Individual Participant Changes in Pressure Pain Thresholds for the Quadriceps Muscle Group from Baseline to 1-week PostIntervention



cohort at the University of Central Florida's Doctor of Physical Therapy program and, thus, more likely share many common traits. If a greater number of participants were used from the general population outside of health-related fields, the results may have been different. Furthermore, there was difficulty in standardizing the rate of application of the pressure algometer during testing. This limitation was reduced by having just one researcher apply all the algometer pressure measures after completing numerous practice repetitions at 1 pound of force per second.

In summary, the results of this study demonstrate that a single 10- to 15-minute bout of PNE can lead to improvements in pain knowledge and PPT, with potential improvements in fear-avoidance beliefs. These improvements may be useful in decreasing the number of patients that transition from acute to chronic pain, thus decreasing the future financial burden of individuals at risk of acquiring chronic pain. Future directions should be aimed to examine long-term results of this short educational intervention, as this study focused on short-term results of 1 week. Furthermore, analyzing the effects of multiple educational sessions may be warranted since that may have an increased effect on overall learning and retention. Other forms of acute pain stimuli should also be incorporated into future acute pain studies to determine potential differences in effects.

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Return to Golf Following Rotator Cuff Repair: Trends of Physical Therapist Practice

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ABSTRACT

Background & Purpose: Rotator cuff tears in adult golfers are common and often lead to subsequent repair. Literature is lacking in thorough guidance on return to golf. The purpose of this study is to investigate practice patterns of physical therapists who prescribe return-to-golf activities and progression for their patient's post rotator cuff repair. **Methods:** Surveys were sent to over 1000 physical therapists regarding their practice patterns for return to golf in a clinical vignette for a status post repair of a medium sized full thickness supraspinatus tear. **Findings**: The average return to putting was 9.2 weeks and use of a driver with a full-swing was 23.8 weeks. There was a significant relationship in respondent patterns for progression from putting through the use of a driver. However, those physical therapists who use a protocol were significantly more conservative than those who use clinical judgment. **Clinical Relevance:** This study provides practice patterns that could assist in decision-making of physical therapists who treat golfers. **Conclusion:** Physical therapists are relatively consistent with their prescription of return-to-golf activities and progression through all club use. However, more research is needed to provide evidence-based guidance for return to golf post rotator cuff repair.

Key Words: golf swing, return to sport, supraspinatus repair

INTRODUCTION

The sport of golf is currently played by more than 60 million people across two-thirds of the countries of the world.[1] Golf is associated with improved physical and mental health in participants[2] as well as improved aerobic physical activity, dynamic balance, and strength.[3,4] Although the sport of golf offers health benefits, it does come with some level of risk for injury.[5-7]

Due to the complex and repetitive nature of the golf swing, the shoulder joint is a common location for injury.[7-10] The golf swing requires a large degree of musculoskeletal activity to the shoulder complex. Strain to the rotator cuff during the golf swing is evident throughout the phases of the swing to promote dynamic glenohumeral stability and transition from acceleration to deceleration at various points during the phases in the swing. In addition, peaks in internal rotation produce potential points of impingement and micro-strains to the rotator cuff musculature, especially at the end of the backswing, its transition to the acceleration phase during the downswing, and throughout follow-through.[11,12]

Studies suggest that shoulder pain and pathology is relatively common in amateur golfers, with some reporting it to be present in 8-12% of all golfers[13] and even as high as 17.6%.[14] Two of the most common mechanism of injuries that amateur golfers incur are overuse injuries and poor biomechanics.[13] Although participation in golf does not directly cause rotator cuff tears, strain to the rotator cuff musculature on the lead arm is considered the most common shoulder injury.[8-10] Shoulder pain present in the lead shoulder at the top of backswing may be indicative of tightness of rotator cuff musculature, tightness of the posterior capsule, or posterior capsulitis.[9,13]

McHardy et al[6] followed 588 amateur golfers for 1 year. After the study, 78 of the golfers had reported a total of 93 injuries with 63 reporting a single injury and 15 reporting 2 injuries. The shoulder complex accounted for 11.8% of the injuries incurred during the study. Injury occurred most commonly during ball impact (23.7%), follow-through phase (21.5%), and during backswing (8.6%). Golfers who played 3 or more rounds of golf per week were more prone to injury (OR = 3.73, 95% CI 1.29-10.75). A final review of 412 patients who had suffered golf-related injury found that 85 (20.6%) had shoulder pathologies. Of these shoulder injuries, 93% were found to have rotator cuff pathology.[6]

While poor technique and biomechanics have been associated with injury, one cannot overlook the relationship of age-related changes as they relate to golf and the stresses on the shoulder. It has been estimated that as high as 54% of all adults over the age of 60 have a partial or complete rotator cuff tear and that 4-32% of the population currently has a symptomatic rotator cuff tear.[15] With more than 25% of golfers being reported to be over the age of 50, there is likely to be a population in need.[7] This is especially important due to the inherent loss of extensibility of soft tissues and biomechanical restrictions associated with age have been linked to rotator cuff pathology in golfers.[16]

Individuals over the age of 50 have a much higher rate of injury than younger golfers.[17] Authors have demonstrated that in general, younger golfers are more likely to suffer a shoulder injury due to instability or a traumatic injury; middle-aged golfers tend to be affected by subacromial impingement, rotator cuff diseases, or acromioclavicular diseases; and older golfers are more prone to rotator cuff injuries and arthrosis of the glenohumeral joint. This increased demand can ultimately lead to injury of these structures.[9,18,19]

Due to the biomechanics of the golf swing and the age of older adult golfers, the potential risk of inflammation and rupture and subsequent surgical repair of the rotator cuff signifies a need to establish return-to-golf programs post-rotator cuff repairs. The literature is relatively void of golf rehabilitation programs for patients who are status post rotator cuff repair. While most studies deal with injury prevention treatment for golfers or conservative treatment options for pain in the shoulder, very few examine the return-to-golf activities during the recovery from a rotator cuff repair.

Early studies on patient outcomes and return to sport after rotator cuff repair lack specificity in the actual return-to-sport activities. Vives et al reported on recreational golfers who, in association with a standardized rotator cuff repair protocol, returned patients to golf activities by putting and chipping at 3 months and use of a driver at 5 months.[20] Tibone et al studied 45 overhead athletes with partial or complete rotator cuff tears. While it outlined an extensive rehabilitation protocol, it did not specify golf-related activities during the recovery stage and noted that participation in sports was not allowed until 6 months postsurgery.[21] A study carried out by Liu included 10 golfers out of 44 patients that received arthroscopically-assisted rotator cuff repair.[22] The author's approach to rehabilitation was more aggressive, allowing full progression to unrestricted activity between 3 and 4 months. However, the study did not note golf progression specifically.

More recently, some guidance has been provided that seems to acknowledge the progressive stresses in club use and swing. A published review by Van der Meijden described an interval program for return to sport through initiation of putting and chipping, with progression through small, medium, and long-distance irons and woods. The authors suggest that such progression occurs after 12 to 16 weeks postoperatively.[23] In a larger scale analysis of return to sport, Antoni et al found that over 90% of recreational golfers returned to sport. However, golf was not isolated in the outcomes reporting of all recreational athletes from various sports returning at approximately 6 months postoperatively, with approximately two-thirds reporting being completely asymptomatic.[24] Alternatively, another report examining rotator cuff repairs for golfers estimated a return to sport at 4 to 5 months.[25]

Although most rotator cuff tears occur off of the golf course, the repetitive nature of the golf swing predisposes the golfer to an increased risk of rotator cuff tear. With this association and the fact that recreational golfers enjoy the health and leisure aspect of this sport, one can see the importance of establishing rehabilitation protocols that allow for return to golf as soon as possible. This leads to 2 questions. If an adult recreational golfer experiences a rotator cuff tear and requires surgical repair, (1) Are there sufficient evidenced-based guidelines for return-to-golf activities following rotator cuff repair?, and (2) what are the current practice patterns among physical therapists in returning the patient to golf activities? The goal of this cross-sectional study is to identify trends for rehabilitation and return-to-golf guidelines for patients following rotator cuff repair by surveying physical therapists.

METHODS

Study Design and Protocol

This was a survey study of practices of physical therapists and the protocol was approved by the Institutional Review Board at the University of Central Florida.

Instrumentation

The electronic survey included a case vignette that was developed by agreement of 2 board-certified clinical specialists in orthopaedic and sports physical therapy. The survey involved data collection of demographics, guidance sources on golf, and decision-making with an open response for a hypothetical patient scenario. The scenario portrayed the same standardized patient and queried the physical therapist initiation of specified golf activities at a postoperative week status. The specified golf activities included putting, chipping (shots within 20 yards of the green), pitching (shots 20–70 yards from the green), full swing of a golf club with a modified swing speed or exertion (75% effort), full swing of a golf club (5-iron to 9-iron) with full swing speed (100% effort), and full swing with a driver (100% effort). The standardized patient scenario was as follows:

Consider a 40- to 50-year-old patient who has had an arthroscopic repair of a medium sized, full thickness tear of the supraspinatus. Assuming no complications and a normal recovery, when (post-op week) would you typically allow this patient to return to___________

Sampling

A sample of convenience was used. Sampling was conducted by identifying the top 10 states with the greatest number of golf courses according to www.golfnow.com. These states included Florida, California, Michigan, Texas, New York, Ohio, Pennsylvania, Illinois, North Carolina, and Wisconsin. Once these states were identified, physical therapists practicing in these states were located using the APTA website's "find a PT" link and emails were collected. Only physical therapists who were practicing in these 10 states, who self-identified as practicing in the 'musculoskeletal' area, and who had a listed email on the APTA website were surveyed. A total of 1015 physical therapists were invited to participate. A total of 114 completed responses were returned resulting in a 11.2% response rate.

Data Analysis

All data analysis was performed using IBM's SPSS Statistics 25 software. Descriptive statistics were used to identify central tendency of respondents, while tests of association were used to examine the relationship of responses from each stage of golf activity progression. Differences in return to play patterns were also examined through analysis of variance to determine mean score differences based on respondent groups, which included groupings based on educational level, experience, board certifications, interest in golf, experience treating patient population, and resource utilization for clinical decision-making.

FINDINGS

Respondents

The physical therapy education level of respondents was closely distributed with the range being 20.2-27.2% within each category of degree level (BS, MS, DPT, transitional DPT). Only 4.4% held an academic doctorate. Approximately 45% of the respondents were practicing in the state of Florida, while the remaining were distributed between 9 other states at <10% each. Exactly 50% of the respondents had >15 years of experience, while those with 6 to 10 years and 11 to 15 years each held approximately 20% of the respondents. Two-thirds of the respondents reported significant experience treating golfers, 38% reporting being recreational golfers, with an additional 16% identifying as an avid golfer. Approximately 48% were board-certified clinical specialists in orthopaedics or sports, and 83% reported holding some level of advanced certification or training in a related area such as athletic training, Titleist Performance Institute (TPI) certification, etc. Guidance in return to golf was indicated as being in accordance with clinical judgement in 65% of the respondents whereas approximately 35% used a protocol.

Return to Golf

The overall average return to golfing with a driver was 23.8 weeks (SD 8.3) postsurgery. Putting activities were usually prescribed at 9.2 weeks (SD 3.4). Mean weeks and standard deviations are reported in **Table 1**.

The linear relationship of the mean week responses for each activity can be viewed in **Figure 1**. Pearson correlation coefficients denote the relationship of each of these activities. All variables possess a significantly positive relationship with each other ($p < .001$). The strongest relationship existed between full swings with irons and full swing with

Table 1. Respondent Return-to-Golf Activity in Postoperative Weeks

Golf activity	Postoperative week (SD)
Putting	9.2 (3.4)
Chipping	12.4 (4.0)
Pitching	15.0 (4.8)
Irons (modified)	17.9 (5.3)
Irons (full)	21.4 (7.4)
Drivers	23.8 (8.3)

drivers (R=.953), while the weakest was the association between putting and driver use (R=.465). However, the Pearson correlation also revealed that all relationships among weeks in return to activity were statistically significant.

When examining group differences based on clinician education, years of experience, advanced certifications, and gold interest, there was no statistically significant difference in weeks where return-to-golf activities were prescribed. All group patterns remained in a linear relationship and without differences between groups (**Figures 2-6**).

Clinicians were also compared with regards to use of clinical judgment versus the use of a protocol for the progression of a patient through return-to-golf events. Those respondents who use protocols progressed patients more conservatively compared to their peers who use clinical judgment. An ANOVA revealed statistically significant differences ($p < .05$) in return to putting (protocol: 10.9 weeks; judgment: 8.7 weeks), chipping (protocol: 14.2 weeks; judgment: 11.9 weeks), pitching (protocol: 17.1 weeks; judgment: 14.3 weeks) and modified iron (75%) swing (protocol: 20.4 weeks; judgment: 17.4 weeks) ($p < 0.05$). Full iron and driver swings were also more conservative per protocol recommendations compared to clinical judgment; however, a significant difference was not identified (**Figure 6**).

CLINICAL RELEVANCE

This study was conducted to attempt to identify return-to-golf protocol trends following rotator cuff tear and subsequent repair based upon current practice patterns of physical therapists. The authors of the current study found that the average return to full play for golf was approximately 24 weeks post rotator cuff repair with the initiation of putting beginning at approximately 8 weeks postoperative. It should be noted

Figure 1. Mean Responses for Return-to-Golf Activity

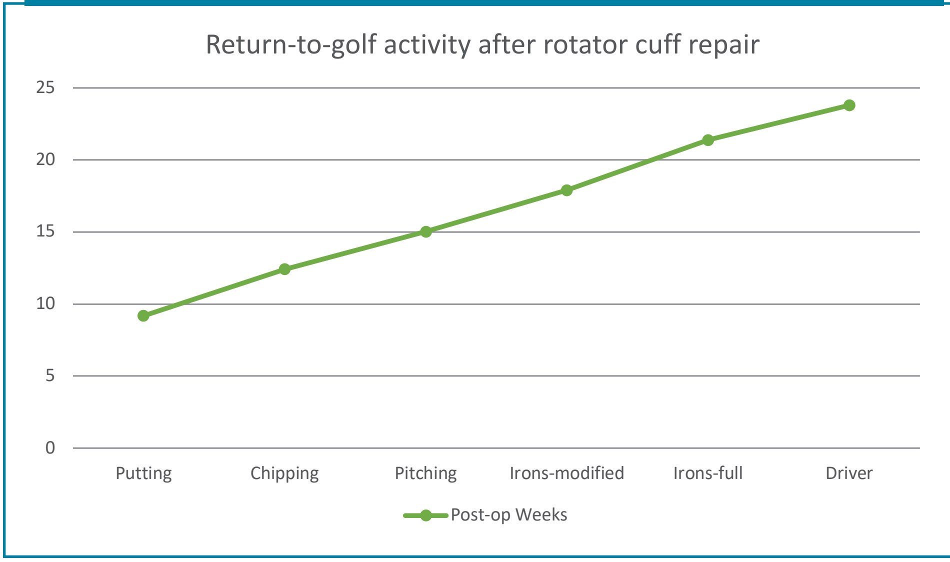


Figure 2. Mean Response Comparison Based on Education

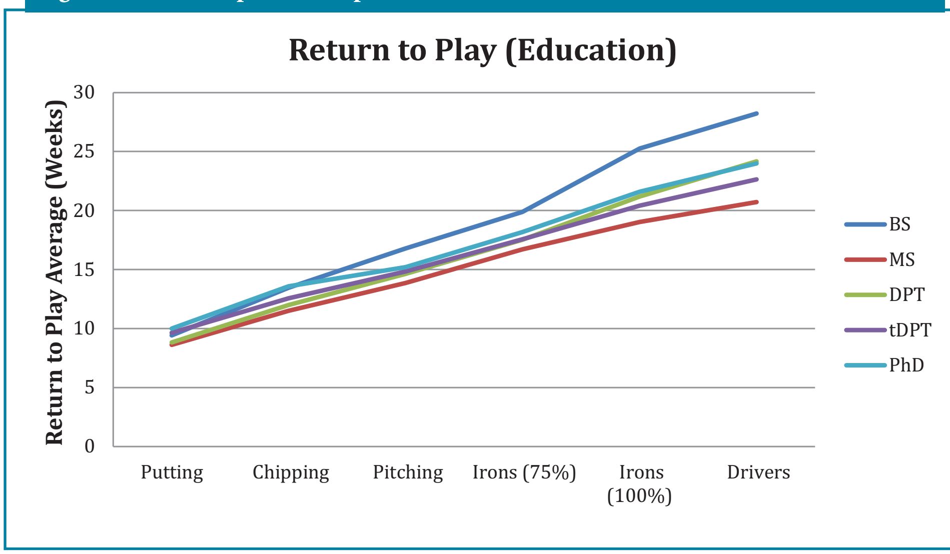


Figure 3. Mean Response Comparison Based on Experience

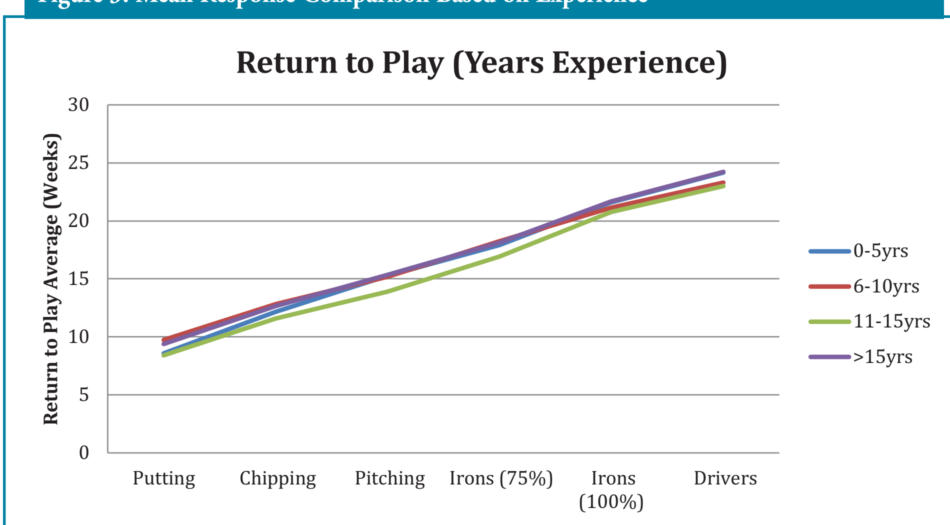


Figure 4. Mean Response Comparison Based on Board Certification

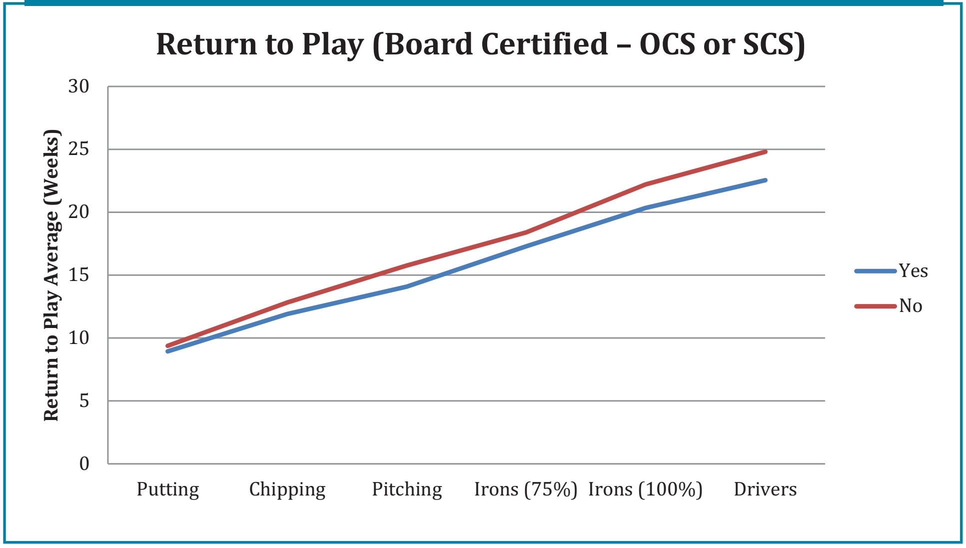


Figure 5. Mean Response Comparison Based on Golf Interest

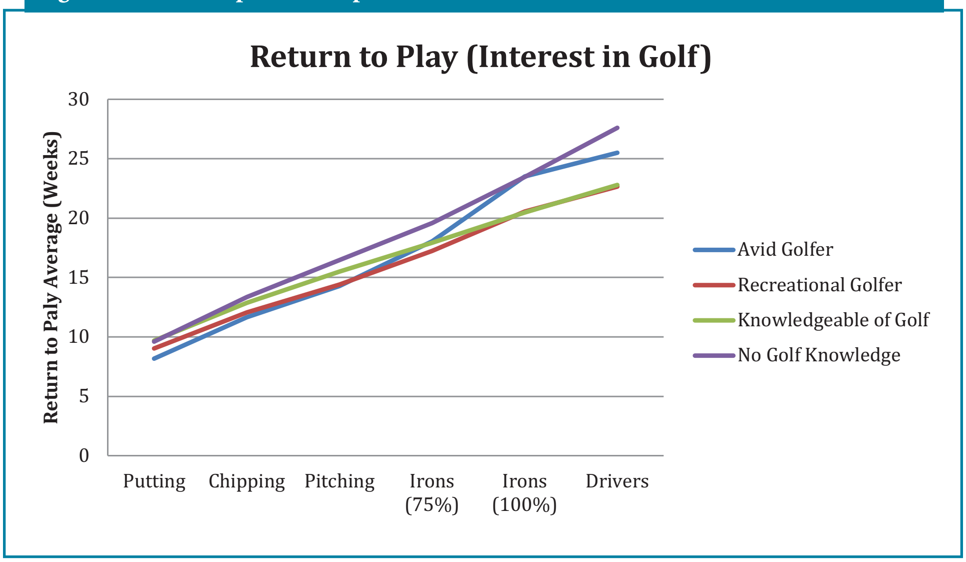
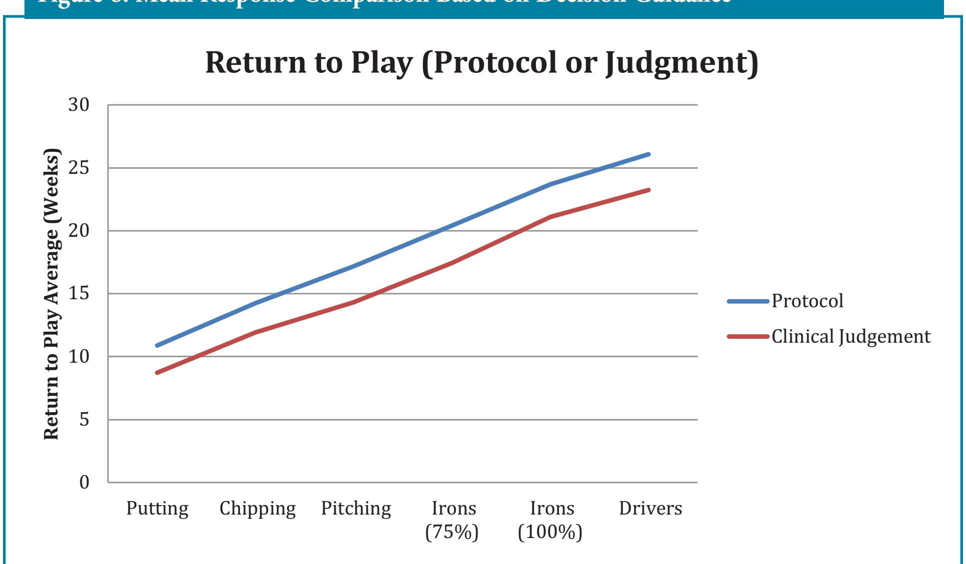


Figure 6. Mean Response Comparison Based on Decision Guidance



that these responses were purely based off of a hypothetical patient with a medium-sized supraspinatus tear that had a normal recovery and no complications or comorbidities. Thus several factors would likely influence decision-making.

Upon examination of the descriptive data, some interesting trends were observed. All groups possessed a much stronger agreement in the prescription of return to putting, which held the most agreement via lowest standard deviation in all groups of respondents. However, as the swing progressed to the increased demands of a full, unrestricted swing with an iron and then driver, the standard deviation widened. This gradual increase in the standard deviation as the swing progressed in aggressiveness as the respondent approached the full swing with irons and drivers could be an indication of the variability in recovery of patients that can occur as they respond to stresses of the golf swing in their surgical shoulder or the notion of meeting certain criteria as patients progress through rehabilitation phases (ie, range of motion, strength, pain levels). However, it should also be noted that this period of time (full swing irons to full swing drivers) possessed the strongest correlation in responses.

As evident by the significant and strong correlation coefficients, the relationship between each activity was linear. Physical therapist respondents allowed progression of each activity by a range of 2.4 to 3.2 weeks at each stage in golf swing or club use. This likely indicated that respondents felt the stresses throughout were progressive in stress. The largest gap in progression was the transition from putting to chipping (3.2 weeks) and the closest gap was full swing with irons to full swing with drivers, indicating that the stress anticipated in the shoulder at these two final stages may be similar.

The results of the current study align with existing literature. Cho and Rhee found that 97% of small tears, 87% of medium tears, and 59% of large or massive tears have reached complete healing by 26 weeks post-surgery.[26] This postoperative period coincides with physical therapists' return of full swing golf activities with irons and drivers, found in this study. Although a concept review on rotator cuff rehabilitation by van der Meijden et al does not describe early postoperative activities directly related to golf, a return-to-sport program is promoted after the 12- to 16-week time period.[23] That timeframe aligns with this study's identification of hitting golf balls with modified swings and without full exertion.

The lack of literature on rotator cuff rehabilitation and return to golf may be the reason for the differences found when examining patterns of responses between those who use protocols versus solely clinical judgment. At each point of golf activity collected, those using clinical judgment prescribed the activity between 2 and 3 weeks sooner than those who used a formal protocol. Numerous well-established resources on rotator cuff rehabilitation do not specify early activities in golf such as putting.[23,27]

Despite a lack of statistical significance, the results do show some possible degree of variation in practice patterns among outpatient physical therapists. Board-certified clinical specialists in orthopaedics or sports tended to initiate return-to-golf activities sooner than nonclinical specialists, which was more evident in the full swings with irons and drivers. This same trend was observed in data from all respondents who possessed advanced certifications versus none. The lack of widely disseminated resources or evidence-based protocols in the literature could be one of the reasons to aid physical therapists in determining the most appropriate timeframes to return to key activities of golf. Notably, the current study found that 53.5% rely solely on clinical judgment when treating these patients and 18.6% use physician guidance.

Because more than half of physical therapists surveyed rely on clinical judgment, and large standard deviation values were seen in survey responses, the need for an evidence-based tool to help bring physical therapists into more of a consensus may be justified. In addition, results of studies such as this provide some detail to practice patterns of physical therapists that relates to the timing of activity. However, this approach is not criterion-based, which has been described in the literature.[9] Interval golf programs that are criterion-based could be aligned with time-based evidence to provide best guidance in the consideration of return to golf.

CONCLUSION

Physical therapists who treat patients post rotator cuff repair demonstrate some consistency in return-to-golf activities, especially in the early stages of golf such as putting and light chipping. The progression through club use follows a linear pattern of activity as it relates to postoperative weeks, demonstrating a linear thought process in a patient's recovery. However, much more discrepancy exists as patients are progressed through more aggressive club use, and physical therapist patterns differ based on clinical judgment versus protocol use. Thus, the development of a more evidence-based and specific protocol on return to golf after rotator cuff repair may be warranted.

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President's Message

Rick Wickstrom, PT, DPT, CPE, CME

The quote below prompted me to reflect on inspirational examples from family, friends, and physical therapy colleagues who coped positively with psychological distress in the face of negative impacts from COVID-19, political unrest and other personal challenges:

You get to decide where your time goes. You can either spend it moving forward, or you can spend it putting out fires. You decide. And if you don't decide, others will decide for you."

—Tony Morgan

We are blessed to have incredible passion and talent among Occupational Health SIG volunteers. These contributions fuel our initiatives with a common vision to optimize movement, musculoskeletal health, and work participation from hire to retire:

- Our Practice Committee led by Lorena Payne (Chair) has completed OHSIG's first evidence-based Clinical Practice Guideline to improve how physical therapists manage work participation restrictions after injury or illness! Check out this publication in *JOSPT*.
- Our Research Committee led by Marc Campo (Chair) is forging ahead with our initiative to create an advanced practice educational credential to qualify and promote occupational health professionals with advanced competencies. Author teams are moving forward to developing monographs for 2 independent study courses: (1) Workplace Programs to Promote Worker Health and (2) Clinical Care of Workers with Participation Restrictions. Our Steering Committee is developing the credentialing component that includes an interactive webinar for current concepts and an Occupational Health Capstone project with a focus on one or more practice areas.
- Our Membership Committee led by Caroline Furtak (Chair) is progressing our initiative to establish OHSIG members to serve as state resource liaisons for payment policy inquiries and presentations to implement our CPG and other issues related to occupational health.
- Our Communications Committee led by Cory Blickenstaff (Chair) is working with AOPT staff on a new initiave to implement a comprehensive member profile to support networking among members. We invite OHSIG members to participate in discussions on our Occupational Health SIG Facebook Page. Let us know your needs, or simply share your story about how your practice is moving forward in the wake of COVID-19 challenges.
- Our Nominating Committee members Michelle Despres (Chair), Jeff Paddock, and David Hoyle are doing a great job of encouraging new leaders as well as assisting with some of our initiatives.

In the article that follows, OHSIG leaders partnered with Trevor A. Lentz, PT, PhD, MPH, to encourage occupational health applications for the OSPRO-YF 10-item Assessment Tool that was developed with research grant funding by the Academy of Orthopaedic Physical Therapy. Enjoy!

OSPRO-YF 10-Item Assessment Tool: A Measure of Psychosocial Risks that Influence Chronic Pain and Work Disability

Rick Wickstrom, PT, DPT, CPE, CME; Trevor Lentz, PT, PhD, MPH; Steve Allison, PT, DPT, OCS, CME

The OSPRO-YF 10-Item Assessment Tool is a concise, patient-report questionnaire that was designed to estimate multiple dimensions of psychological distress that adversely influence how people respond to musculoskeletal pain.[1] The intent behind the OSPRO Yellow Flag (OSPRO-YF) assessment tool was not to create an entirely different questionnaire, but rather to develop a more innovative and efficient method to capture information provided by a variety of existing 'legacy' psychological questionnaires such as the Pain Catastrophizing Scale (PCS) and Fear-Avoidance Beliefs Questionnaire (FABQ). OSPRO is an acronym that refers to the Optimal Screening for Prediction of Referral and Outcome cohort study that focused on creating concise and standardized tools to improve assessments by orthopaedic physical therapists. Researchers at the University of Florida developed 17-item, 10-item, and 7-item versions of this yellow flag assessment tool with grant funding from the Academy of Orthopaedic Physical Therapy.[1,2] The development process consisted of separate sequential studies conducted in 2 different cohorts: a Development cohort and Validation cohort.

The Development cohort was a cross-sectional study[2] that included 431 patients recruited from outpatient physical therapy clinics in Gainesville, FL and Jacksonville, FL. At initial evaluation, patients completed 10 full length 'legacy' questionnaires that are commonly used to assess a variety of psychological constructs. These questionnaires are grouped under the most relevant domain for pain-associated psychological distress:

- **Negative Mood Domain** measures: PHQ-9, Patient Health Questionnaire-9; STAI, State-Trait Anxiety Inventory; and STAXI, State-Trait Anger Expression Inventory.
- **Fear-Avoidance Domain** measures: TSK-11, Tampa Scale of Kinesiophobia; PCS, Pain Catastrophizing Scale; FABQ-PA, Fear-Avoidance Beliefs Questionnaire - Physical Activity subscale; FABQ-W, Fear-Avoidance Beliefs Questionnaire - Work subscale; and PASS-20, Pain Anxiety Symptoms Scale.
- **Positive Coping Domain** measures: CPAQ, Chronic Pain Acceptance Questionnaire; PSEQ, Pain Self-Efficacy Questionnaire; and SER, Self-Efficacy for Rehabilitation.

Collectively, this set of questionnaires included 132 items, and took 30-90 minutes for each participant to complete. This dataset was subjected to complex statistical processes (further detailed in the article by Lentz et al[11]) to identify smaller subsets of items that could be used to accurately estimate patient scores on the full-length questionnaires listed above. Estimating the total score for each legacy measure required the item responses in each version of the OSPRO-YF to be weighted differently. The OSPRO-YF was not designed to work like many other questionnaires where you simply add up the items to get a total score. The OSPRO-YF provides 11 total score estimates for the 10 legacy questionnaires (FABQ work and physical activity subscales are estimated separately) to evaluate aspects of negative mood, fear avoidance, and positive coping. The OSPRO-YF 10-Item form is presented in **Figure 1**.

In addition to estimating full-length questionnaire scores, the OSPRO-YF can also identify yellow flags. Yellow flags are defined (for the purposes of this tool) as questionnaire score estimates in the top quartile (for negative mood and negative pain coping characteristics) or bottom quartile (for positive coping characteristics) of all scores across participants in the OSPRO Development cohort. Just as OSPRO-YF can estimate 11 total score estimates, it can also alert providers when those score estimates are high enough (or low enough in the case of positive factors) to correspond with a yellow flag. Because score estimates are sometimes difficult to interpret clinically (ie, what score is high enough that I need to act on it?), yellow flag indicators were added to help identify which patients may be particularly at risk, and need further work-up. The 7-item version of the OSPRO-YF is a subset of the 10-item version which is itself a subset of the 17-item version. Although response burden is lower with shorter versions, there is a trade-off in accuracy for identifying yellow flags, with accuracy values of 85%, 81%, and 75% for the 17-item, 10-item, and 7-item versions, respectively. Because of complexity required for scoring, developers of the tool worked with AOPT to develop an online scoring portal for the 3 versions at: https://www.orthopt.org/yf/.

The second stage of the development process consisted of the OSPRO Validation cohort, designed to understand how the OSPRO-YF would predict important outcomes such as persistent pain, disability, quality of life, and health care use following physical therapy.[2] Recruitment for this cohort was conducted within a nationwide clinical research network of 9 sites. Participants (n=440) completed the OSPRO-YF at baseline in addition to other demographic and health–related information. The resulting studies showed the OSPRO-YF was able to predict 12-month pain intensity, region-specific disability, quality of life, and subsequent use of surgery. Studies are ongoing to better understand how performance on specific domains, like negative mood, negative coping, and positive affect can better inform prognosis and treatment selection.

IMPLICATIONS FOR MUSCULOSKELETAL PHYSICAL THERAPY

Clinicians can use OSPRO-YF score estimates to identify which domains of pain-associated psychological distress may need to be addressed to optimize physical therapy outcomes. The OSPRO-YF may also be used to identify when psychological distress is not likely a major factor. One approach by clinicians has been to determine the total number of yellow flags (range 0-11) to get an overall sense of psychological distress, or to compare the subtotals for flags within each domain (ie, Negative Mood, Fear Avoidance, and Positive Coping) to determine which domain may need more attention. Another approach illustrated on the **Table 1** scoring example would be to calculate the percent of yellow flags for each domain, or the overall percentage of flags out of the 11 possible flags.

Importantly, authors suggest that because the OSPRO-YF is designed as a screening tool, scores should be used to inform the need for psychologically-informed interventions through interactive discussions with the patient. Information provided by this tool should not be used in isolation to determine course of treatment. A major benefit of this tool over other existing screening tools (eg, Örebro Musculoskeletal Pain Questionnaire) is that it can quickly assess a wide range of psychological factors known to influence pain and disability. A major advantage of the 1-page OSPRO-YF 10-item version (**Figure 1**) is that its items are appropriate for patients that have a broad range of musculoskeletal conditions (ie, knee, shoulder, neck, and back pain). Scoring is fairly complicated; however, the tool may be scored by programming within electronic medical records systems or by entering patient responses at https://www.orthopt.org/yf/. A data collection form for the OSPRO-YF 10-item version is presented in **Figure 1**. Numbering of items in this form identifies the subset of items from the 17-item version. This makes it more intuitive for users when entering responses for scoring at the AOPT website.

One area for future research would be to establish predictive validity cut-scores for total summary score (adding up the scores for all items) and domain sub-scores for the OSPRO-YF 10-item tool. Although total summary scores have been used in research applications,[2,3,4] summary score interpretations for clinical decision-making are not yet available. This may be worthwhile to investigate in future research, given findings by Margison and French[5] that total score for the 24-item version of the OMPQ yellow flag assessment was able to correctly predict clinical discharge status of "fit" versus "not fit" for return to work after 6 weeks of participation in work conditioning for 85% of patients, based on a cut-off total score of 147. Authors concluded that the OMPQ may be suitable for early identification of injured workers who are more likely to not improve with physical therapy and would benefit from psychosocial interventions to improve return to work success.

RELEVANCE TO OCCUPATIONAL HEALTH CLINICAL PRACTICE GUIDELINES

To date, the OSPRO-YF has been formally evaluated in general orthopedic populations with knee, shoulder, low back, and neck pain. It has not yet been rigorously evaluated in an occupational health setting, but does have great potential for helping to better inform care decisions and patient-provider interactions in this setting. Since pain-associated psychological distress negatively impacts work performance in workers with a broad range of health problems, it is helpful that OSPRO-YF items are worded in a manner that does not restrict use to patients with a specific health conditions or affected body regions. In fact, the OSPRO-YF 10-item tool may be consistently administered to patients with work performance difficulties in combination with one or more self-report measures of disability that are body-area specific.

The Occupational Health Special Interest Group in the Academy of Orthopaedic Physical Therapy has recently introduced Clinical Practice Guidelines for assisting clinicians with optimizing work participation after injury or illness.[6] There was strong evidence to support a recommendation that "Physical therapists should screen for risk factors associated with delayed return to work or work absence throughout the episode of care using patient interview and validated tools."[6]

Examples referenced in the CPG of valid/reliable self-report measures that address return to work (RTW) include the Work Ability Index (WAI), Örebro Musculoskeletal Pain Questionnaire (OMPQ), and Disabilities of the Arm, Shoulder, and Hand-Work subscale (DASH-W). The CPG identifies OSPRO-YF as an exam-

TABLE 1. Scoring Example for an Injured Worker on the OSPRO-YF 10 Item Assessment Tool

Item #	Response		Other Psychosocial Yellow Flag Assessment Tools	Score		Flags?**
			Negative Mood Domain Measures			**100%**
1	2	/3	PHQ-9 Patient Health Questionnaire-9	13.6	/27	Yes
3	2	/4	STAI State-Trait Anxiety Inventory	49.4	/80	Yes
4	2	/4	STAXI State-Trait Anger Expression Inventory	19.9	/40	Yes
			Fear Avoidance Domain Measures			**80%**
7	1	/4	TSK-11 Tampa Scale of Kinesiophobia	23.0	/44	Yes
8	2	/4	PCS Pain Catastrophizing Scale	23.3	/52	Yes
10	4	/6	FABQ-PA Fear-Avoidance Beliefs Questionnaire-Physical Activity	16.3	/24	
11	3	/6	FABQ-W Fear-Avoidance Beliefs Questionnaire-Work	20.0	/42	Yes
			PASS-20 Pain Anxiety Symptoms Scale	38.4	/100	Yes
			Positive Coping Domain Measures			**100%**
14	3	/6	CPAQ Chronic Pain Acceptance Questionnaire	53.8	/120	Yes
15	3	/6	PSEQ Pain Self-Efficacy Questionnaire	26.2	/60	Yes
17	4	/10	SER Self-Efficacy for Rehabilitation	63.1	/120	Yes
Score*	**28**	/53	**Overall Yellow Flags**	**10**	/11	**91%**

* OSPRO-YF Score is total of item response (x) scores, **except** that items 14, 15, and 17 must be reverse-scored before summing with other responses, **where** item #14 and #15 score = 6-x, and item #17 score = 10-x.
** Percent scores under Flags? next to each domain is the percent of possible "Yes" measures for each domain.

ple of another tool to identify psychosocial risk factors, with a disclaimer that the OSPRO-YF that has not been subject to research to link it with RTW.[6] The predictive ability of OMPQ has been studied by Bergström[7] and Gabel et al[8]; however, an additional benefit of the OSPRO-YF over the OMPQ is that it can quickly assess a wide range of psychological factors known to influence pain and disability. Dale et al[9] demonstrated moderate correlations between DASH-W scores with work ability, work productivity, and work severity. Armijo-Olivo et al[10] found that Item 23 on the DASH that asks about the level of work limitations for arm, shoulder, or hand problems was found to be equally predictive of the entire DASH 30-item survey for work status at 90 days. Item 11 on the OSPRO offers a similar question about work difficulty as Item 23 of the DASH and Item 2 of the DASH-W that have a more limited focus on upper extremity disorders. Since use of the DASH and DASH-W is limited to upper extremity conditions, the OSPRO-YF 10-Item tool is more applicable to a broader range of health conditions (ie, knee, shoulder, neck, and back pain) that may limit return to work. The Clinical Practice Guideline also identifies the FABQ-W (score > 27.5)[11], and TSK-11[12-13] as tools that identify RTW risk factors. The OSPRO-YF 10-Item may be used to provide accurate estimates of FABQ-W and TSK-11 scores.1 The value of the OSPRO-YF in this context is the increased efficiency and reduced response burden with estimating TSK-11 and FABQ-W scores (and others) using a tool comprised of only 10 items.

CASE ILLUSTRATION

The injured worker is a 52-year-old truck driver who operates a 24-foot box truck or a side loader truck to deliver beer and wine products on a delivery route. The heaviest case of wine weighs 50 lb and is lifted from floor level to overhead. He must also lift up to 160 lb half barrels with another worker. After injuring his shoulder at work, he continued to work for 6 months with assistance from a helper until electing to have surgery for repair of posterior labral tear, subacromial decompression, acromioclavicular joint resection/Mumford, and extensive glenohumeral joint debridement. His surgical recovery and outpatient rehabilitation was complicated by hospitalization for COVID-19. He was referred for a functional capacity evaluation (FCE) after 7 months of disability following surgery. During the FCE, he was completely cooperative and provided a consistent performance. The end range active movements of his affected shoulder were restricted and painful, with nearly normal passive range-of-movement and end feel. He demonstrated the functional ability to lift 40 lb overhead and 60 lb from a lower level at a somewhat hard level of perceived exertion. His baseline complaints of shoulder pain during sitting increased from 0/10 to 6/10 in response to performance-based functional capacity tests. His comorbidities of total knee replacement and Class III obesity (BMI 43.1, weight 305 lb) contributed to functional performance difficulties on the lower lift test and Two Square Agility Test.

The injured worker was released to RTW on modified duty with assistance from a helper in accordance with recommendations from the FCE examiner. He continued to participate in physical therapy; however, he continued to call-off work and miss physical therapy appointments with a variety of excuses. He was regularly monitored for weight checks, but was not having any success with dietary management to promote weight loss. He also reported suffering from emotional difficulties related to recent deaths in his family. His physical therapist became concerned that psychosocial factors were delaying his return to usual duties. The OSPRO-YF 10-Item Assessment Tool was administered to assess psychosocial risk factors. His scoring results in **Table 1** identified that 10 of 11 domain measures were positive for yellow flags (91%). This initial information was helpful to engage the worker in an interactive discussion that prompted his participation in cognitive behavioral therapy to reduce his psychosocial risks and motivate better compliance with home exercise and dietary management to lose weight. As this worker proceeded with interventions, the OSPRO-YF 10-Item Assessment was readministered at period intervals to monitor him for improvements with respect to yellow flags present and total scores.

CONCLUSIONS

Disability evaluation is complex and necessitates the interpretation of patient self-report measures within the context of physical performance and other risk factors, such as psychological distress, comorbidities, and heavy job demands. The Work Participation Restrictions Clinical Practice Guideline5 recommends that physical therapists use validated self-report measures in combination with physical performance tests during the initial evaluation and throughout the episode of care to measure work ability and inform treatment and prognosis for return to work. This necessitates the development of therapeutic alliances by including the worker in planning and collaborating with other health professionals to address potential barriers to work participation such as psychosocial risk factors.

Figure 1. OSPRO-YF 10-Item Assessment Tool

OSPRO-YF 10-ITEM ASSESSMENT TOOL

Instructions: Read each statement below and circle the number to the right of the statement to indicate your response.

How often are you bothered by:	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Poor appetite or overeating?	0	1	2	3

How often do you do you feel that:	**Almost never**	**Sometimes**	**Often**	**Almost always**
3. Some unimportant thoughts run through my mind and bother me	1	2	3	4
4. I am a hotheaded person	1	2	3	4

To what extent do you agree that:	**Strongly disagree**	**Somewhat disagree**	**Somewhat agree**	**Strongly agree**
7. I wouldn't have as much pain as I do if there weren't something potentially dangerous going on in my body	1	2	3	4

When you are experiencing pain, to what degree do you think or feel that:	**Not at all**	**To a slight degree**	**To a moderate degree**	**To a great degree**	**All the time**
8. I can't seem to keep the pain out of my mind.	0	1	2	3	4

To what extent do you agree that:	**Completely Disagree**						**Completely Agree**
10. I cannot do physical activities that (might) make my pain worse	0	1	2	3	4	5	6
11. My work is too heavy for me.	0	1	2	3	4	5	6

Rate the truth of each statement for you:	**Never true**						**Always true**
14. It's OK to experience pain	0	1	2	3	4	5	6
15. I lead a full life even though I have chronic pain.	0	1	2	3	4	5	6

Please rate your degree of certainty with regard to the statement below:	**I Cannot Do It**										**Certain I Can Do It**
17. I can perform my therapy no matter how I feel emotionally.	0	1	2	3	4	5	6	7	8	9	10

For more information and scoring: https://www.orthopt.org/yf/

Adapted with permission from Lentz TA, Beneciuk JM, Bialosky JE, et al. Development of a yellow flag assessment tool for orthopaedic physical therapists: results from the Optimal Screening for Prediction of Referral and Outcome (OSPRO) cohort. *J Orthop Sports Phys Ther*. 2016;46:327-343. https://doi.org/10.2519/jospt.2016.6487. ©JOSPT®, Inc.

(Continued on page 192)

President's Message

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PASIG Mission

The mission of the Performing Arts Special Interest Group (PASIG) is to be the leading physical therapy resource to the performing arts community.

PASIG Updates

- The PASIG is focused on moving our strategic initiatives forward with support from our AOPT Board champions. We want to express our gratitude and best wishes to our Board liaison, Tara Jo Manal, who will be moving on to serve as VP of Scientific Affairs at the APTA. We hate to see you go but wish you the very best Tara Jo!
- We have recorded the first 2 episodes in our Podcast Series, "PASIG Practice Pearls." Members can find links to the Podcasts on Backstage care of the Performing Artist on our web page. Thank you to Janice Ying, Marissa Schaeffer, and Rosie Canizares for your leadership on this project.
- We have updated the webpage to make the new resources created by the Outreach Committee easier to find. Thank you to Brooke Winder, Kimberly Veirs, and Tara Fredrickson for your work on this task.
- The authors of our new Circus Arts Independent Study Course are making progress and are on track for a 2022 release date. Thank you Sara Edery Altas and Katrina Lee, our ISC Chairs, and ISC authors, Emily Scherb, Matthew Greenfield, Dawn Muci, and Heather Heineman.
- Each of the 4 Performing Arts Fellowship Programs are preparing educational modules geared towards the specialized care of the performing artist. Those modules should be ready by December 2021.
- SIG Officer Nominations are open. We are seeking candidates for the open positions of PASIG Vice President/Education and Nominating Committee. Both positions will have 3-year terms beginning at CSM (2022-2025). If you have any questions, please contact our Nominating Committee Chair, Duane Scotti duane@sparkyourtraining.com
- The new PASIG apparel is a big hit (especially the ¼ zips). Consider purchasing PASIG masks and pinky balls as gifts! All proceeds support our strategic initiatives.

- We are planning to host a virtual PASIG Membership Meeting in August. Details will be sent to members via an email blast.

PASIG Performing Arts Fellowship Spotlight

The PASIG continues to support performing arts fellowship training as a means of advancing one's practice in this subspecialty area. For information about Fellowships, please contact: our Chair, Tiffani Marruli at tiffany.marulli@osumc.edu. We would also like to spotlight our PASIG members that have completed perfoming arts fellowships this past year.

Amanda Edwards, PT, DPT, OCS
Performing Arts Physical Therapy Fellow-in-Training

The Ohio State University Wexner Medical Center, Jameson Crane Sports Medicine Institute

"**The Performing Arts Physical Therapy Fellowship at Ohio State University** was a truly amazing experience, even during a pandemic! It was challenging, fun and rewarding, and helped me grow into an expert Performing Arts Medicine clinician. The program taught me how to efficiently assess and manage a performing artist from initial injury to return to sport. It was structured with didactic coursework, mentor hours, and onsite coverage, as well as other opportunities. I felt that the mentorship experience was one of the most valuable components, as my mentors were very knowledgeable, supportive, and provided ongoing feedback which helped me to develop into the clinician I am today.

"I would highly recommend the Performing Arts Physical Therapy Fellowship to anyone with a strong passion for the performing arts, wanting to better serve this population. It is an invaluable opportunity, in which you will further expand upon your own Performing Arts Medicine knowledge, experience, clinical skills, and decision-making."

For questions about the program at OHSU contact Tiffani Marruli at tiffany.marulli@osumc.edu

Monique DeLuca, PT, DPT, OCS
Fellowship-Trained Performing Arts Physical Therapist

"I chose to complete the **Johns Hopkins Performing Arts Physical Therapy Fellowship** to advance my clinical knowledge to equip me with the skills to best serve performing artists. As a former dancer and musician, I have always had a strong desire to work with performing artists and this fellowship provided me with targeted didactic and clinical experiences that allowed me to grow as a clinician and fulfill my dream of working with this unique population.

"As a former resident in orthopedic physical therapy, I have found that the structure of both residencies and fellowships allowed me to grow professionally at an accelerated rate that is unparalleled by traditional practice. The most rewarding aspects of the fellowship for me were the one-on-one mentorship provided by clinicians with expertise in this area along with my ability to network and collaborate with various performing arts specialists. At Johns

Hopkins, I have had the opportunity to collaborate with various professionals for both research and outreach initiatives with a focus on optimizing performance and reducing future injuries of performing artists.

"Since completing my fellowship January 2021, I have begun working full time with Johns Hopkins Rehabilitation network and I am currently involved in expanding the current performing arts program at a new clinic. Additionally, I hope to be involved in the fellowship program and share my experiences to help future fellows grow and develop through both mentorship and didactic work."

For questions about the program at Johns Hopkins, contact: Andrea Lasner at alasner1@jhmi.edu

Patricia Cavaleri, PT, DPT, OCS
Fellowship-Trained Performing Arts Physical Therapist

"Growing up, my life revolved around dance and music. While I always loved the arts, I wasn't sure how I wanted to turn that love into a career until high school when I was in a health and wellness class learning about muscle functions. That class started my journey to combine my interest in how the human body works with arts and movement. I completed a BS in Applied Health Sciences at the University of Wisconsin-Parkside with the plan of attending PT school. After a gap year serving in AmeriCorps, I obtained my DPT from Columbia University. While there, I took the performing arts elective and performed as part of the dance community at the school. After graduation, I worked in an outpatient private practice for a few years while working per diem backstage for Broadway and Off-Broadway productions, contributing to PASIG citation blasts, and obtained OCS certification. During 2020, I completed the **Harkness Center for Dance Injuries Performing Arts Physical Therapy Fellowship at NYU** to gain further mentorship in treating artists. Since completing the program, I feel more confident in my skills as a performing arts specialist, I've made connections with mentors that have continued to help me grow and am working to continue to help grow the knowledge of care for this wonderful population. I'd highly recommend considering a fellowship if you're interested in mentorship and to grow your clinical skills while working with performers."

For questions about the HCDI program, contact Mark Hall at Mark.Hall@nyulangone.org

The **Columbia University Irving Medical Center/West Side Dance Physical Therapy Fellowship Program** will welcome Kendall Lynch, PT, DPT, OCS, PMA-CPT, as its inaugural fellow in September 2021. For questions about the CUIMC/WSDPT program, contact Laurel Daniels Abbruzzese at la110@cumc.columbia.edu

PASIG CSM DPT Student Scholarship Winner Spotlight

After CSM 2021, PASIG Scholarship Chair, Anna Saunders, interviewed the winners about their research. Here is an excerpt from the interview with the entry level DPT PASIG scholarship winner, **Abigail Skallerud** from Wayne State University Department of Physical Therapy.

"Our research, **"Comparing Functional Lumbar Lordosis in Collegiate Dancers With and Without Low Back Pain,"** analyzed the relationships between functional lumbar lordosis, passive hip range of motion and core endurance to the incidence of low back pain in collegiate dancers. We found that increased lumbar lordosis in single leg stance movements on the right (right retiré and developpé) was correlated with increased low back pain incidence, whereas hip range of motion and core endurance measures were not related to low back pain incidence. We also found that increased supine bridge hold time was inversely related to increased lumbar lordosis in functional dance movements. What we have noticed in the research is the lack of statistical power in most of the studies due to small sample sizes (our research included) and a lack of established normative values for both range of motion and core endurance measures that encompass the athleticism and flexibility that dancers require. We suggest using our research for screening dancers for low back pain risk or injury assessment. Evaluating right retiré and developpé for increased lordosis can be used to assess injury risk or possibly understand low back pain presentation. Supine bridge hold could be used to evaluate if dancers have increased lumbar lordosis in right retiré and developpé, which in turn could potentially increase their risk of developing low back pain. One of the biggest areas for future research is to develop normative values for core endurance and range of motion specifically for dancers, as current established norms do not account for the athleticism and flexibility dancers often possess. This would help define what values are linked to increased injury risk and better guide treatment interventions. This requires increased statistical power to studies to be able to collect this information. Another area for future research is to investigate the differences in movement between one side and the other. Our study found significance with right sided movement but not with left sided movement. Exploring the reason behind this difference would be a great area for future study as well. "

Communications Committee Update - Dawn Muci

Don't miss out on PASIG news and member spotlights! Be sure to follow Twitter handle: @OrthopedicAPTA, Instagram handle: @APTA_Orthopaedic, and Facebook: @PT4Performers.

If you missed the Spotlight Series on social media, archived posts are also on the web. https://www.orthopt.org/content/special-interest-groups/performing-arts/member-spotlight

Hello AOPT and Foot and Ankle SIG members, we hope you are all having a wonderful summer!

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

Our partnership with the American Orthopaedic Foot and Ankle Society (AOFAS) continues to bring new webinars including a recent one titled, "Getting Athletes Back on their Feet" that was live this past April 2021. Our speakers Drs. Ashley Waite, Lindsay Wasserman, and Stephen Paulseth did an outstanding job discussing Achilles Tendinopathy, Running Injuries, and Forefoot Pain, respectively. Keep an eye out for future webinars via our webpage, Facebook page, or email blasts.

The FASIG submitted our pilot practice analysis to the American Board of Physical Therapy Residency and Fellowship Education (ABPTRFE) for review in April 2021. We anticipate a review in May and then the final steps to complete the process will be in sight. This has been a huge effort by many over the last 2 years. We are very excited to receive the final review and then send out the practice analysis survey at the end of 2021. Although there is just a bit more work to do, it is exciting to think about the first fellowship trained foot and ankle specialists that could be joining the community in the very near future!

The FASIG is happy to bring to our members, "Author Spotlights" showcasing exciting new research. These can be found on our website if you missed one. We hope you enjoy this medium for exploring new research and getting a *behind-the-scenes* peek with the author. The SIG plans to continue to share new research via our newsletter and additional author spotlights.

Infographics are visual images that are used to represent information or data. They can be helpful to visually summarize information and share it with others. The FASIG practice committee is working to develop infographics about common foot and ankle topics that could be used by patients and/or providers. Check out our website for a few of the developed infographics and there are more on the way!

A special thanks to Drs. Hutchins, Smith, and Cornwall for sharing their results from a recent study investigating the impact of using Leukotape to control foot posture. The FASIG is happy to share these results in this issue of *OP* for our membership.

Finally, I shared in the last newsletter that my tenure as President of the FASIG is over at the conclusion of the CSM 2022 and elections for the next leaders will occur this Fall 2021. I would welcome the opportunity to work with any interested individuals now to facilitate the transition for the next President to join the FA SIG leadership.

Put your best foot forward.

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

Control of Foot Pronation Over Time Using the Low-Dye Taping Technique and Leukotape

Naomi Hutchins, PT, DPT, ATC[1]
Craig Smith, PT, DPT[2]
Mark W. Cornwall, PT, PhD, FAPTA[3]

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[2]*The Smith Performance Center, Tucson, AZ*
[3]*Department of Physical Therapy and Athletic Training, Northern Arizona University, Flagstaff, AZ*

INTRODUCTION

Excessive foot pronation is commonly associated with overuse injuries of the lower extremity such as plantar fasciitis[1] and "Shin Splints".[2] Foot strapping is one method by which health care professionals can temporarily alter foot posture in order to reduce pain and improve function. The Low-Dye (LD) taping procedure is a common technique used to effect this change and was first documented by Ralph Dye in 1938. Since 1938, the LD taping technique has been modified in several ways making comparison between studies somewhat difficult. The common element with almost all of these modified methods is the strip of tape around the calcaneus from the first metatarsal head to the base of the fifth metatarsal.

Previous research using the LD technique with individuals demonstrating mild to moderate calcaneal eversion and a mild to moderate decrease in the height of the medial longitudinal arch on weight bearing have reported a mean change in the height of the medial longitudinal arch ranging from 3.1 mm to 7.2 mm.[3,4] In addition, research using the various modified LD taping techniques has reported a decrease in pain coincident with the reduction of calcaneal eversion and increased medial longitudinal arch height.[1,5–7]

Although the LD taping technique has shown that there is an initial significant increase in both arch height and calcaneal eversion, its effects can be lost following as little as 10 to 20 minutes of light exercise.[4,8] The decreased longevity of the tape's effect is thought to be the result of the tape stretching that reduces its initial effects. Because of this stretching, the use of a stiffer tape rather than the cloth athletic tape may increase the duration of the taping's effects. If the use of a stiffer tape with the LD taping technique could be shown to maintain the altered foot posture for several hours or days, it would be clinically important and useful. It would give clinicians a way to not only relieve acute symptoms, but it would also provide a way for the individual to remain relatively active without aggravating their symptoms. Finally, if the person's symptoms were reduced or alleviated with the tape, a more permanent solution, such as footwear or foot orthoses could be pursued with confidence. Therefore, the purpose of this study was to determine if using the LD taping procedure using as stiff tape such as Leukotape would not only immediately alter foot posture but would also maintain that change over several days. Our hypothesis was that the LD taping with Leukotape will allow the effects to last over several days.

METHODS

Participant Characteristics

The Northern Arizona University institutional review board approved the study. All of the participants provided informed written consent prior to any testing. Based on a-priori sample size estimates, a minimum of 10 participants was necessary to show statistical significance at the .01 level with a power of 0.80. Fourteen participants (7 females and 7 males) recruited from the Northern Arizona University population volunteered to participate in this study. All participants demonstrated at least 10° dorsiflexion, 20° plantarflexion, and 65° first metatarsophalangeal extension. The mean age was 25.6 years (+2.3) for the males and 24.3 years (+2.5) for the females. The mean foot posture of their right foot as measured by the Foot Posture Index (FPI) was 6.0 (+2.9) for the males and 5.1 (+2.1) for the females. Positive FPI values indicate a pronatory foot posture with values greater than 4.7 indicating significant pronation.[9] As such, all of the participants had foot postures consistent with the use of the LD taping procedure with the goal to reduce pronation.

Procedures

Each participant's dorsal arch height (DAH) and midfoot width (MFW) was measured at 50% of their total foot length using the protocol described previously in the literature.10 Following these measurements, the LD taping procedure using Leukotape was applied to both feet. Leukotape was chosen because it is fairly stiff with minimal stretch. It was felt that such qualities would therefore result in a longer lasting change in foot posture.

Using the method described by Cornwall et al,[10] the participant was positioned on a padded treatment table in the long sit position with their foot in slight plantarflexion and the calcaneus in a "neutral" position (neither inverted nor everted). Two inch wide Cover-Roll stretch tape (BSN Medical, Hamburg, Germany) was first applied beginning at the 1st metatarsophalangeal (MTP) joint, wrapping around the heel, and covering the lateral foot just distal to the base of the 5th metatarsal. A second strip running medial to lateral from the 1st MTP joint, over the plantar surface of the foot and overlapping the ends of the first strip of tape was then applied. A third strip of Cover-Roll stretch tape was placed running medial to lateral from the 1st MTP joint, over the dorsum of the foot the base of the 5th metatarsal. One and one-half inch wide Leukotape (BSN Medical, Hamburg, Germany) was then applied in the same manner over the Cover-Roll. The tape was applied to both feet to avoid any effect due to asymmetry. A single person (NH) applied the tape in the study.

Following the tape application, the DAH and MFW measurements were repeated using the same protocol as that used with the initial measurements. Participants were then instructed to run 2 (and only 2) miles each day for the next 5 days. The DAH and MDW measurements were repeated each morning at 8 a.m. and evening at 5 p.m. for the next 5 days. Participants wore the same tape throughout the entire week. The tape was not replaced, augmented, or reinforced during this time. Showering was permitted, but all were instructed to avoid soaking in a bath.

Statistical Analysis

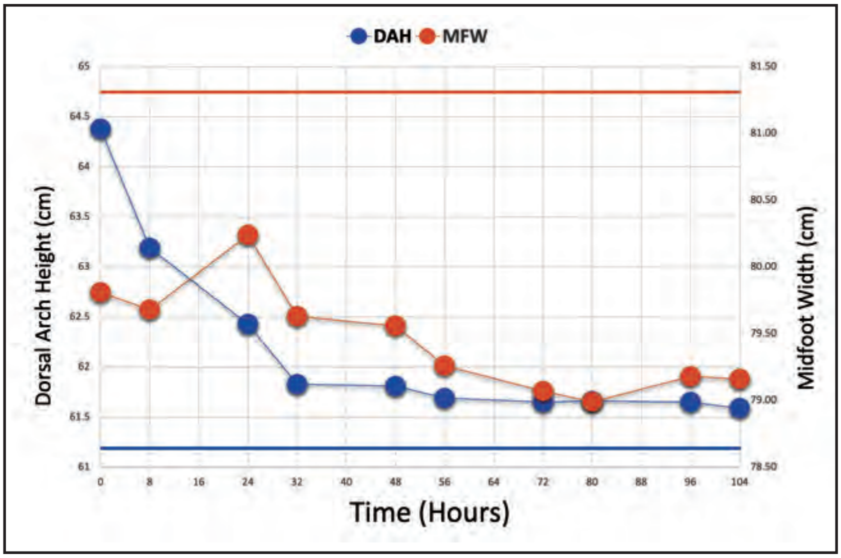
SAS statistical software, version 9.A was used for all tests of statistical significance. A repeated measures analyses of variance was used to analyze the difference between the initial pre-tape measurements and each subsequent post-tape measurement for both DAH and MFW. Post-hoc power was calculated to be 0.97, with n = 14. Because of the relatively large number of tests of significance needed for this analysis, the level of significance was set at 0.01 to reduce the possibility of committing a type 1 error.

RESULTS

No one in this study complained of discomfort or skin irritation from having the tape applied to their feet over the 5 consecutive days it was worn. The repeated measures ANOVA showed that DAH remained significantly greater compared to the pre-tape measurement ($p < 0.01$) for 32 hours, including two bouts of running 2 miles (**Figure 1**). Dorsal arch height remained elevated compared to the pre-tape measurement for the rest of the week but averaged less than 1mm and were not statistically significant from the pre-tape measurement ($p < 0.01$). See **Figure 1**.

The MFW measurements were decreased an average of 1.5 mm immediately after taping but it was not significantly significant ($p > 0.01$). The MFW values remained slightly decreased from the pre-tape measurement for the remainder of the week with the exception of 80 hours after the tape was applied. At this point, the decrease was found to be statistically significant from the pre-tape condition ($p < 0.01$). Although significant, the mean MFW at 80 hours was just 0.82 mm less than that measured before the tape was applied. See **Figure 1**.

Figure 1. Mean DAH and MFW Measurements Over 5 Days After Applying the LD Taping Technique Using Leukotape. All Participants Ran for 2 Miles Every 24 Hours.



DISCUSSION

Dorsal Arch Height

Immediately after applying the LD taping technique, DAH was significantly increased by 3.2 mm. This observed amount is between 2.2mm and 4.8mm less than previous research looking at the effect of the LD taping technique on DAH.5 The observed differences between the current study and that of previous research may be because the current study did not invert the calcaneus while the tape was applied, but rather the foot was maintained in a "neutral" position (neither inverted nor everted). The "neutral" position of the calcaneus during taping was chosen because it was found during preliminary studies, that individuals complained of discomfort and skin irritation when the stiff tape was applied to an inverted calcaneus.

The altered DAH measured in the current study remained significantly different from the pre-tape measurement until 32 hours after application. This is greater longevity than that reported by Cornwall et al using a combination of the LD and Modified Reverse-6 taping techniques.[10]

Future studies with more frequent measurements being taken would allow a more accurate estimate of when DAH is no longer statistically different from the non-tape condition. In addition, future research looking at whether placing the tape directly on the skin rather over the Cover-Roll may improve the amount of change observed as well as its durability. Not using the Cover-Roll, however, may result in skin irritation.

Midfoot Width

After applying the Leukotape, MFW was initially reduced by an average of 1.5 mm, which is again similar to that reported by Cornwall et al.[10] Although not statistically significant from the pre-tape condition, the decrease in MFW indicates that the foot was slightly less pronated while standing compared to before it was taped. Over the next 104 hours of wear, the MFW values remained fairly constant, changing less than 1.0 mm over the course of the 5 days. Comparison of MFW change and durability is limited because only one previous study investigated this variable. When compared to that one previous study, the observed initial change in MFW is 0.5 mm less than that reported by Cornwall et al.[10] The current study and that by Cornwall et al[10] used different taping methods and different types of tape, yet they both yielded similar results. Clinicians could, therefore, use either method. The method used in the current study has the advantage, however, of taking less time to apply and using less tape.

The small fluctuation in MFW measurements over the course of the 5 data collection days in the current study is most likely because of measurement error (**Figure 1**). The small temporary increase in MFW at hour 24 may be the result of increased fluid retention secondary to the participants running 2 miles shortly prior to the time the measurement was taken.

Since foot pronation is multiplanar in nature, restricted MFW may also be beneficial in alleviating symptoms for various conditions. For example, previous research has suggested a connection between MFW and patellofemoral pain syndrome.[12] Controlling MFW could therefore be useful in treating those with patellofemoral disfunction or other conditions where transverse movement of the midfoot, and thus the lower leg, is desired.

The current study is not without limitations. Although all of the participants were required to run 2 miles each day, it is not possible to extrapolate our finds to athletes or individuals that participate activities of longer duration or more medial-lateral motions. It does, however, have application to situations where pronation control is desired in a sub-acute phase of healing or when the person is beginning to return to activity and needs some pronation control.

Another limitation to the current study is that none of the participants complained of pain or discomfort. As such, it is unknown if the amount and durability of pronation control from the tape would be effective in symptom alleviation, altering muscle activation patterns, or changing poor lower extremity mechanics. There is evidence, however, suggesting that a 2.6 mm increase in DAH may be sufficient for symptom relief due to decreased tissue loading.[13,14] Further research is warranted to better answer this question.

A third limitation of this study is that DAH and MFW were not measured during walking or running. As such, although static foot posture was altered, it is unclear whether this translates to the same changes during locomotion.

CONCLUSION

Based on the results of this study, the LD taping technique using Leukotape is able to increase arch height for at least 32 hours with the individual participating in 2 bouts of moderate exercise (running 2 miles) within that time period. In addition, MFW is initially decreased and there is little or no change over 5 days of wear and daily bouts of running 2 miles.

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(Continued on page 190)

PRESIDENT'S MESSAGE…THE FUTURE OF THE PAIN SIG

Nancy Robnett Durban, PT, MS, DPT

Hello All…I hope this report finds you well and safe. I am excited to report that the Pain Education Manual is on its last revisions and will be ready for publication soon. The Pain SIG leaders are working on our new Strategic Plan and Public Relations Business Plan.

Thank You

We owe a depth of gratitude to Dana Dailey, PT, PhD, for her dedication and devotion to the Pain SIG over the years as she steps down from the role of Research Chair. Prior to Research Chair, she served as our Pain SIG President. She is an amazing professor, researcher, clinician, person, and forever friend of the Pain SIG. Thank you Dana for your service and hard work.

It is now my pleasure to introduce you to PSIG member, Bill Rubine, PT, MS. Bill received his Masters of Science in Physical Therapy from Columbia University in 2001. Since 2007, he has been the physical therapist at the Comprehensive Pain Center at Oregon Health & Science University in Portland, specializing in chronic spine pain, neuropathic pain, and functional movement disorders. Since 2009, he has been a visiting lecturer on chronic pain physical therapy at several universities in the Pacific Northwest. We are excited to announce that we will be hosting an article follow-up with Bill. This will provide members the opportunity to discuss Pain Focused Clinical Education. Thank you, Bill, for your article.

Clinical Education in a Specialized Clinical Setting: Three Recommendations

Bill Rubine, PT, MS

INTRODUCTION

A biopsychosocial approach is recommended for working with people with chronic musculoskeletal[1] and neuropathic[2] pain. For a student physical therapist to apply this approach, however, involves a combination of cognitive, affective, and psychomotor skills that can be hard to learn. Most students learn the basics as part of their regular clinical internships. But, at the academic medical center where I work, one or two students show up every year to specialize in chronic pain and pain management. Providing clear and consistent learning activities that serve the student, the patients, and the relevant institutions, can be challenging for a clinical instructor with much more training in patient care than pedagogy. This article will attempt to help meet that need by suggesting 3 sets of behavioral objectives, learning activities, and assessments that hopefully will prove useful for clinical instructors who (1) work in specialized settings with chronic pain patients, and (2) provide clinical education for student physical therapists with a special interest in chronic pain and pain management. Obviously, this cannot pretend to be the final word on the subject, but perhaps it can contribute to a discussion that would be well-placed here in the Pain SIG newsletter.

BACKGROUND

The conversation about pain, pain management, and pre-licensure physical therapy education has a long history. In 2011, the Institute of Medicine called for greater inclusion of pain and pain management in the curricula of all health care provider training programs.[3] In 2012, the International Association for the Study of Pain (IASP) published a Curriculum Outline on Pain for Physical Therapy.[4] This work was further developed and commented on by Bement et al[5] in 2014 and implemented over the following years by different physical therapy programs in individual ways. Several papers were published on the subject of teaching student physical therapists about pain in an academic setting.[6–10] These generally showed that academic preparation helped physical therapy students improve their scores on the neurophysiology of pain questionnaire,[7,9,10] and Pain Attitudes and Beliefs Scale for Physical Therapists,[10] and change their practice in simulated cases.[8] Nothing has been published, as far as I know, about incorporating an evidence-based, biopsychosocial approach to chronic pain management into clinical instruction for pre licensure physical therapists.

In 2019, a Pain Education Committee was formed with representatives from the Academy of Orthopedic Physical Therapy, the APTA (including the pain SIG), the IASP, and the American Council of Academic Physical Therapy (ACAPT) to make further recommendations for how graduate physical therapy programs could improve pain instruction in academic and clinical settings. I was a member of that committee. The manual that was produced, which should be available soon, does outline learning activities and assessments a clinical instructor, who is not necessarily a "pain specialist" can use to help a student physical therapist achieve fundamental pain-related behavioral objectives. These objectives are primarily cognitive and psychomotor and not at the highest levels of expertise. They are appropriate for a general internship with multiple priorities, but for a student with a specific interest in chronic pain, perhaps we could do more.

Two qualitative reviews[11,12] identify barriers encountered by licensed physical therapists learning to apply biopsychosocial approaches to patients in research studies and in their regular practice. The barriers reported by these therapists included (1) limited recognition of the role that psychosocial factors play in low back pain; (2) concerns that they were not sufficiently trained to address those issues, or that they are outside the physical therapy scope of practice; (3) fear that patients do not want to discuss personal issues, and prefer traditional treatment; and (5) feeling "overwhelmed" by so much information. If these experienced therapists feel overwhelmed, pre-licensure students could feel even worse. On the other hand, a student in a specialized internship can spend up to 400 hours on the subject during a typical 10-week clinical rotation, plus more time spent on documentation, case discussion, and home study. They receive one-on-one attention, work around others using the same approach, and have sufficient time available. It might be possible to help them achieve higher levels of expertise if we have concrete behavioral objectives, effective learning activities, and good assessments.

Recommendation #1

Most student physical therapists should be able to understand and recall the IASP definition of pain and many of the other pain-related terms listed in the IASP taxonomy of terms.[13] But to many of them, the words will just be abstract concepts. The definition of pain also implies certain values that might be missed: that all pain is real, and should be respected, even when it does not appear to correlate with tissue damage; that it is normal for pain to be influenced by biological, psychological, and social factors; that a person's perception of pain is a valid sensory and emotional response to an unconscious, involuntary perception of threat. The student in a specialized setting will have the opportunity to understand the terms, adopt those values, and confidently incorporate them into their practice.

The challenge is that so many of the factors that perpetuate persistent pain are "invisible"[14] to imaging or other tests, and must be inferred from patterns of signs and symptoms, movement strategies, and other clues. No clinician correctly understands every patient's situation, and not every patient gets better. In the face of such ambiguity, students need concrete behavioral objectives to pursue while they gain experience with these invisible problems, and learn to apply the values described above. This need can be met by encouraging the student to become fluent with pain-related terminology and clinical reasoning which will set them up for continued clinical development, and also demonstrates the value we place on the material.

The clinical instructor should also address the issue of independence. Many students feel they might be expected to take over the whole caseload. I give them permission to focus more on learning the concepts and less on productivity. My last student, in her first week, worked with the following group of patients: chronic whiplash with concussion x2; complex regional pain syndrome x4; chronic low back pain x2; fibromyalgia x8 (4 of whom were also diagnosed with Ehler's Danlos syndrome); chronic thoracic outlet syndrome x1; cervical radiculopathy x1; chronic neck pain x3; severe peripheral neuropathic pain x1; and chronic abdominal pain x1. These are not all entry-level patients.

Behavioral objectives:

- the student will demonstrate that they have adopted the implications of the IASP pain definition by seeking and expecting to find nociplastic, emotional, cognitive, social, or lifestyle-related factors effecting patients with persistent pain; they will look for those factors during their evaluations, and include them in their assessments.[15]
- The student will be fluent with the pain-related terminology listed in the IASP taxonomy of pain terms and use those terms in their documentation, interprofessional communication, and discussions with their clinical instructors.
- The student will project confidence and understanding when discussing these issues with patients as well, in patient-facing terms, and thereby build strong therapeutic alliance.

Learning activities:

- Ask the student to read a book such as *Explain Pain Supercharged*,[16] *Pain Neuroscience Education*,[17] or *A World of Hurt*.[18] Use the terms all the time when discussing or reasoning through patient cases. I compare the chronic pain internship to one of those 30-day intensive language schools in foreign countries. "You can't master everything in ten weeks, but you can learn the language".
- Prioritize learning over independence or productivity.

Assessment: ask the student to explain their clinical reasoning in detail in 1 or 2 patient cases. I use the radar graph described by O'Sullivan et al[15] and the ICF model[19] to help them organize their thinking.

Recommendation #2

Most pre-licensure physical therapists will be able to create pain management plans, but many of them hesitate to prioritize pain management because of a bias against passive therapy. The student in a specialized setting can learn to recognize when pain management should be a priority.

Behavioral objectives:

- The student will initiate conversations with patients about pain management, flare-ups, and flare-up plans. They will be able to use the basic techniques of motivational interviewing when indicated to help patients initiate behavior change.
- The student will independently promote healthy cardiovascular activity, address sleep issues, and teach basic stress management for each patient as indicated.
- The student will target cortical remapping with sensory discrimination training when indicated, and be able to explain this treatment in professional and patient-facing terms.

Learning activities:

- Discuss why teaching people pain management and flare-up plans is not passive therapy.[7,17,18] For people with inconsistent or widespread pain, tactile allodynia, or flare-ups lasting for days, pain management is functional activity training.
- Discuss the reasons for teaching patients about sleep, stress, pacing, and flare-ups.
- Teach the student sensory discrimination training. Discuss indications, practice testing, and training. Have them read an article on the subject[20] or a more general article on targeting cortical representations.[21]
- Discuss pain management considerations for patients with ongoing conditions that may not improve such as cancer or Ehler's Danlos Syndrome. What is the role of passive therapy in these cases? What is a pain physical therapist's role in palliative care in general?

Assessment: Review their cases. Do they include appropriate pain, fatigue, and stress management plans and a flare-up plan? Does the plan address pacing, cognition, emotion, or lifestyle? Does it include physical agents? Does the student reinforce the plan and modify it over time?

Recommendation #3

Every physical therapy student is exposed to therapeutic pain education. The student who focuses on the biopsychosocial approach can also learn when and how to reinforce pain education with exercise programs that address psycho-social factors. Theories of exercises that attempt to address cognitive factors, emotional factors, and nociplastic adaptations in people with chronic pain are described as cognitive-directed exercise,[22,23] cognitive functional therapy,[15,24] or psychologically informed physical therapy.[25] They seem to have common characteristics that student physical therapists can adopt.

Before beginning the exercises, the patient receives pain education to help them understand their pain and reduce the threat level associated with that pain. When the patient is ready, the exercises are time-contingent (not pain contingent) and goal- or task-oriented. They can begin at an easily tolerated intensity but are fairly quickly allowed to progress to a high enough intensity to engender stress or fear in the patient, as long as they perceive it to relate to their goals and seem manageable. Sometimes, if an exercise or movement seems especially threatening, the patient might be encouraged to try repeated imaginary movement as a rehearsal. During the exercises the clinician collaborates with the patient to notice any unhelpful holding patterns, to breathe, and to resolve any concerns or misconceptions that might arise.

Behavioral objectives:

- The student will use pain education to prepare patients to perform time-contingent exercise of progressively graded intensity that relates to the patient's goals and concerns.
- The student will speak with the patient about their perceptions and feelings during these exercises and collaborate with them to address any concerns.
- The student will allow the patient to work at sufficient intensity, when appropriate, to allow the patient to work through some fear, challenge their own belief, and explore new movements and behaviors.

Learning activities:

- Ask them to read articles about cognitive-directed exercise,[22,23] cognitive functional therapy,[15,24] or psychologically informed physical therapy.[25]
- Encourage them to let the therapy be sufficiently intense and goal- or task-oriented.
- Encourage the student to speak with their patients about their thoughts, feelings, concerns, and goals while they exercise.
- Suggest that the student practice imaginary movement and progressing over several days to real movements. Try Tree pose (single leg stance), Crow pose (an arm balance), or handstand. Or any movement that is safe, but difficult and a little stressful.

Assessment: Look at the student's exercise prescription. Are their exercise programs safe, but sufficiently challenging? Do the exercises relate to the patient's goals? Are the patients learning anything about their pain, their thoughts and feelings, or their movement abilities?

This essay has suggested behavioral objectives, learning activities, and assessments to be used by clinical instructors for prelicensure physical therapists who wish to focus on learning a biopsychosocial approach to chronic pain. Hopefully these tools will help clinical instructors devise learning activities that help student physical therapists internalize the meaning, and adopt the values implied by the IASP definition of pain; recognize when pain management and flare-up plans are priorities; learn about harnessing neuroplasticity to reverse nociplastic adaptations; and exercise programs that target behavior, cognition, and emotion as well as muscles and joints. This essay does not cover the bulk of pain-related material, which every graduating physical therapist needs to know, at least at some level, because it is all covered in the upcoming Pain Education Manual. There also is no discussion here of the role of physical therapy in working with patients with neuropathic pain. This is a big part of my job as a chronic pain physical therapist, which seems to be particularly hard for my students to learn, but it is beyond the scope of this project. Perhaps another member of the Pain SIG can take it up in a later issue.

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Infographic Development

Approximately the time this newsletter is published, the Imaging SIG will have two infographics available for members. One is targeted more for general public audiences while the other, being more in-depth with content, may have specific application in an advocacy role with legislators, regulators, or other stakeholders requiring more detail. These two infographics will be available on the AOPT website on the Imaging SIG pages.

This project was launched in December 2020 with volunteers Steve Kareha, Marie Corkery, YuJen Chang, and Dirk Hartog. A contest for infographic submissions was announced in January with a robust number of individuals offering their ideas. The previously mentioned work group blindly evaluated the submissions, ultimately selecting two as being most consistent with the goals of the SIG. Those authors made additional edits, acting upon the suggestions provided by the work group and those in states who had successfully passed imaging legislation. Once completed, the infographics were approved by the AOPT.

Of the two infographics selected, one was submitted by a 3rd year PT student at Elon University (NC), Shani Lewis. With the encouragement of Dr. Mary Kay Hannah, Shani created the infographic entitled, "The Image is Clear." Upon having her submission selected through a blind process from many others, Shani commented "oftentimes it is difficult to think that, as students, we can make an impactful change in our profession as a whole. Having this infographic selected is an amazing step in a positive direction that can lead to great change. For PTs to directly refer a patient for imaging represents an idea that I strongly feel that our profession needs to continue to strengthen: the concept of patient advocacy. Putting patient care first is one of the greatest things we can do to advocate for them! This will allow patient care to be expedited so we can get patients back to life faster!"

The other infographic selected was submitted by Melanie Lambert, PT, DPT, OCS, MTC, an Assistant Professor in the Doctor of Physical Therapy program at Marshall University. Melanie submitted the infographic entitled, "Advancing Best Practices: Physical Therapy & Diagnostic Imaging." Says Melanie, "when I saw the infographic contest I knew I had to take a shot. Being able to use my creative skill set to advocate for efficient patient care was an easy choice for me. For many years I viewed my creative skills as completely separate from physical therapy, it has been incredibly refreshing to see avenues where I can use them for greater benefit and to aid in pushing the profession forward. Visuals can be powerful learning tools and I was excited to see the Imaging SIG was embracing this platform. I believe many times barriers that present are due to a lack of knowledge. The more we can present information in a way that others can quickly understand and apply the more effective we will be." Further she states "I was thrilled to have my infographic selected. Thinking that something I designed might help others process and utilize information better is incredibly rewarding. I have great respect for strides that are being made in advancing physical therapy and being able to use my creative skills to serve in those efforts is a humbling opportunity. Thank you to the Imaging SIG for the opportunity."

In addition to the recognition herein, both authors received a monetary prize. If you have such creative talents or provided a submission to this contest, take note that additional infographics will be developed for additional messaging or for other target audiences. Further announcements will be forthcoming.

AIUM Webinars

The American Institute for Ultrasound in Medicine (AIUM) webinars led by physical therapists continue. On April 28, Karin Grävare Silbernagel, PT, ATC, PhD, presented a webinar entitled "Optimizing Treatment of Patellar Tendon Injuries with Ultrasound Imaging." As you may recall, Karin presented a similar webinar in December 2019 on Achilles tendon injuries. Both events were very well received.

Future webinars will include the topic of the applicability of diagnostic ultrasound in ankle sprains as presented by Col. Ted Croy, PT, PhD, OCS, and Maj. Jon Umlauf, PT, DSc, OCS. This event will be Monday, August 16 at 1:00 p.m. EDT. Additional details will be announced by e-mail to Imaging SIG members and also through AOPT social media outlets.

Additionally, during the fall, one to two webinars with AIUM will be conducted specifically on the topic of the utility of diagnostic ultrasound in physical therapist practice. At the time of submission for this newsletter, plans for this were still in the formative stages with further details to be established. Specific speakers, dates, and times will be announced.

Membership in AIUM provides access to a rich list of educational resources for diagnostic ultrasound, including previously held webinars and the content preparatory to earning the Registered in Musculoskeletal Sonography (RMSK) credential as offered by Inteleos. Access to both Inteleos and AIUM resources is available on the Imaging SIG web pages on the AOPT website. Look for "MSK Ultrasound Education and Credentialing" on the left side of the page for this information.

Federation of State Boards of Physical Therapy Webinar

On July 14 at 4:00 p.m. EDT, the Federation of State Boards of Physical Therapy will present a webinar entitled, "Imaging Referral by Physical Therapists: Progression of PT Education, Advocacy, Practice and Regulation." The presenters of this webinar are Jeanne DeKrey (President, North Dakota Board of Physical Therapy), Daniel Markels (Manager State Affairs, APTA) and Charles Hazle (President, Imaging Special Interest Group, Academy of Orthopaedic Physical Therapy). This webinar will be directed at those serving in regulatory roles across the country with a focused discussion after the initial presentation. A similar webinar may be presented by APTA for state organization leaders as the intended audience later in the year.

Learning in Small Installments

Within the next few months, the Imaging SIG will begin publishing brief informative videos as complementary segments to AOPT Clinical Practice Guidelines (CPGs). These will be concise videos of 5-8 minutes in duration covering the key elements of imaging, focusing on the diagnostic and decision-making value of imaging as related to the conditions for which CPGs are published.

The goal with these imaging vignettes is to provide a manageable, titrated learning experience for busy clinicians, who are typically unable to devote large segments of time to new learning. Additionally, once several of these segments are accumulated, a rich bank of information on imaging will be available to many types of users.

North Dakota Imaging Legislative Effort Becomes Law

On April 1, physical therapists in North Dakota were granted privileges to refer for imaging. On that date, Doug Bergum, Governor of North Dakota, signed into law SB2122, which amended the definition of physical therapy to include direct referral for radiography. The law takes effect August 1, 2021. If you attended the last web-based Imaging SIG meeting in March, APTA North Dakota President, Cindy Flom-Meland provided a description of the bill and the process through which it was developed and eventually submitted. The bill received very strong support passing through the North Dakota Senate with a 46-1 vote and then the House with a 90-2 vote.

Pictured above in the ceremonial signing of the law are (front) Senator Brad Bekkedahl, Governor Doug Burgum, Cindy Flom-Meland (President, APTA N Dakota) and (back) Chris Huravitch, Catherine Staloch, Jack McDonald (Lobbyist, APTA N Dakota), Chris Kraemer.

Presidents Webinar

On the topic of legislation and imaging referral by physical therapists, there are tentative plans for a webinar sponsored by the Imaging SIG of Presidents and or Legislative Chairpersons from states that have successfully passed referral legislation. The focus of the webinar will be on strategies and preparations for such legislative efforts, including how to counter opposing arguments and how to win advocates and alliances. With at least one state still having legislation in suspense at the time of this submission, full details remain to be clarified. Additional information will be forthcoming in the next issue of *OPTP* and through e-mail and social media.

PAIN SIG

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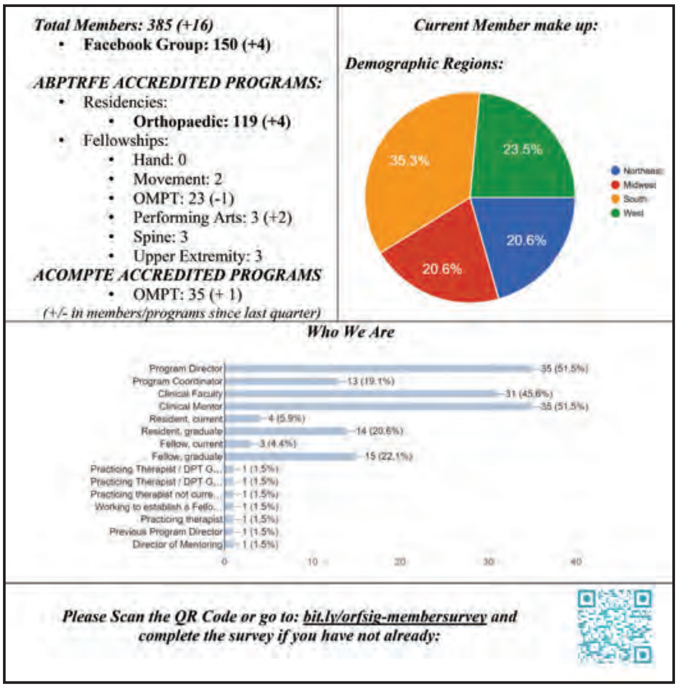
ORF-SIG Dashboard:



PRESIDENT'S MESSAGE

Spring is in the air bringing new life and rejuvenation. It is hard to believe that it has now been a year since the CoVid-19 pandemic started. While the pandemic created a significant strain on our livelihood, we are now beginning to see new growth and beginning. Often in life we find moments of struggle creating great sacrifice. It is with this sacrifice, we are challenged to grow and become stronger than where we started. Since the beginning, we have been looking for opportunity in the time of struggle. As the light starts to shine a bit brighter, we are now seeing some of these great opportunities.

Recently, Dr. Greg Hartley and colleagues published *"Residency Education: Is it Now or Never?"* in the *Physical Therapy Journal*.[1] Within this article, the authors highlighted some of the key gaps facing residency education from *Capacity* for residency program access, to *Evidence* highlighting the value of R/F education, to updating *Teaching and Learning models*, as well as the physical therapy's *Professional Progression*. While reading these it became humbling knowing that these focus areas were already known to members of the ORF-SIG. More importantly, these concerns have already been taken up by our members creating initiatives to make residency education a NOW rather than a never.

Capacity: Based on the recently published 2020 ABPTRFE Aggregate data, Orthopaedic Residency programs make up 37% of the accredited residency programs and 61% of the resident graduates[2] across the 12 different specialty areas. This most likely is due to the long history of orthopaedic residency/fellowship education within physical therapy practice. However, despite our long history and increased opportunity for access we still face great challenges for new programs to develop and for reaccreditation of more seasoned programs.

To tackle these battles, the Academy of Orthopaedic Physical Therapy and the ORF-SIG has provided grants as well as a base curriculum to assist new programs to move through accreditation. From an accreditation standpoint, we have focused on trying to highlight member concerns to our accrediting bodies by reducing some of the barriers to becoming accredited/reaccredited while still ensuring quality. Additionally, we have provided education to accredited and developing programs to ease some of the challenges provided with the accreditation process. It is our hope that these initiatives will continue to assist the growth and development of residency/fellowship education.

Evidence: Across the physical therapy residency and fellowship realm we recognize this as a priority in the future of residency and fellowship education. The ORF-SIG has been working with the Academy of Education Residency and Fellowship Special Interest Group supporting their efforts in publishing multi-specialty benefits of residency and fellowship education. Additionally, the ORF-SIG has focused on a better understanding of mentorship within residency and fellowship education.

Teaching and Learning Models: CoVid-19 likely placed the greatest strain on the traditional in-person educational infrastructure. It is here, where many programs were forced to re-invent some of their educational delivery and mentorship processes. Thankfully, several orthopedic programs already had a level of hybrid learning in place. Back in 2016, the ORF-SIG surveyed programs regarding their program model and educational delivery process. At this time, only 13% of the orthopaedic onsite programs had an online presence. Thanks to the collaboration and development of the CoVid-19 resource manual as well as several other resources provided by online educators, I would suspect this number is much higher.

Initially the hybrid learning model was highly scrutinized, however as time has gone by, we have come to realize that educational delivery does not need to be face-to-face 100% of the time. Nor does learning have to be 100% synchronous, removing several of the significant costs associated with in-person education. Technology via the use of online file sharing systems, video call services and various other communication platforms have truly redefined the way education and mentorship can and will occur. It is my hope that these innovations continue to allow programs to provide innovative practice-based learning models built to meet each of their learners needs.

Professional Progression: The future of residency and fellowship education is in our hands. It is our association that provides the vision and the resources to move forward however it is us down on the ground working through the daily grind that make these things happen. The minds of administrators need to be changed to invest in the rigorous process of accreditation and post professional education, students and clinicians need to be shown the value of ongoing mentorship and post-professional growth in their career. It is this balance of educators and accrediting bodies reducing the economic burden of the physical therapy educational process. The time is NOW to find more economical means for residency and fellowship education.

To assist in this process, the ORF-SIG will continue to serve as a community where programs can collaborate and share ideas and resources. We will continue to educate potential residents and fellows regarding the benefits of residency and fellowship education. Additionally, we will create opportunities for our members programs to connect with potential applicants.

Thank you again to all our members as it has been and will be your work that carries our profession's vision forward with putting a residency or fellowship in every town.

Thank you!
Matt Haberl
President, ORF-SIG

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2. 2020 Aggregate Program Data: Fact Sheet- Physical Therapist Residency and Fellowship Education Programs. ABPTRFE.

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

ORF SIG 2021 CALL FOR CANDIDATES

We are seeking qualified applicants to continue what the ORF-SIG has started!

President

- Work with AOPT Leadership in meeting their strategic goals and initiatives
- Effectively collaborate with the VP and Committees on ORF SIG updates
- Lead Membership and Committee Meetings
- Meet Amazing People!
- Requirements: must be an AOPT Member, serve a 3-year term

Nominating Committee Member

- Identify qualified members of our ORF SIG to serve in one of three elected positions: President, VP and Nominating Committee
- Assist in Sub Committee Positions
- Gain invaluable experience with ORF SIG leadership
- Requirements: must be an AOPT Member, serve a 3-year term

For more information, contact Bob Schroedter at bob@movethrurehab.com

COMMITTEE UPDATES

Research: Kathleen Geist, Mary Kate McDonnell

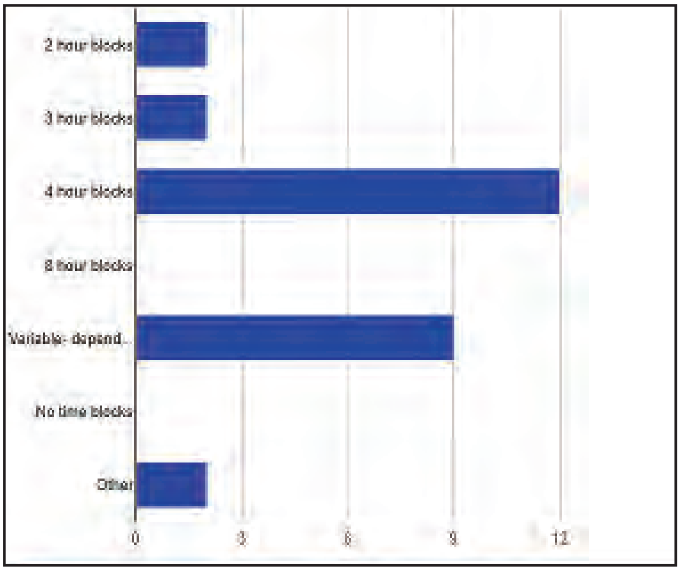
We would like to thank the residents and fellows who participated in the virtual ORF-SIG poster presentations during CSM. The research committee enjoyed the presentations and seeing the level of quality research opportunities that are occurring in residency and fellowship programs across the country. The winners of the $250 prize were to Dr. Jonathan Goldfarb from the Sacred Heart University Orthopaedic Residency Program and Dr. Mackenzie Garreth from the University of South Florida's Orthopedic Residency Program. Dr. Goldfarb's presentation was entitled" Utilizing Scapular Stabilization Exercises in a Patient with Medial Epicondylalgia: A Case Report. Dr. Garreth's presentation was entitled," Rehabilitation of Failed Forefoot Surgery in an Adolescent Female." Both winners will have the formal write up of their presentations in an upcoming *OPTP* publication.

We look forward to poster submissions by residency and fellowship ORF-SIG members for CSM 2022. The abstract submission dates will be provided on the ORF-SIG website.

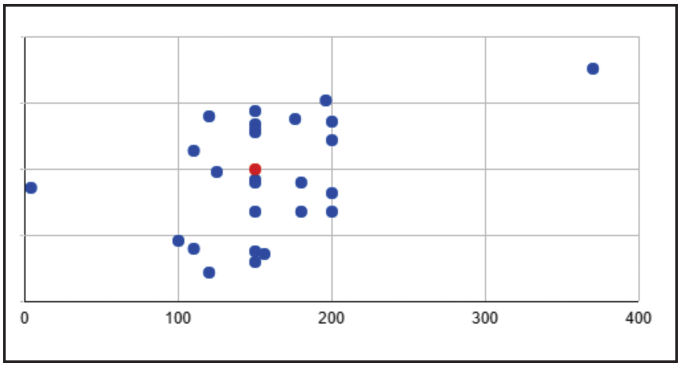
Practice/Reimbursement: Darren Calley and Kirk Bentzen

A mentorship survey to identify how mentoring is delivered across orthopaedic residency and fellowship programs has been sent and completed by 32 program directors. Thank you to the members of the Practice/Reimbursement committee for their efforts with developing this survey and to all who have participated. With this survey data, we have better identified how mentoring is currently implemented across programs, which will give ORF-SIG programs ideas for how others are delivering mentoring and provide comparisons for future mentor development. Some examples of data collected include:

1. What blocks of time are scheduled for 1:1 mentoring? 4-hour blocks (n=12), Variable (n=9)



How many total hours of 1:1 resident/fellow mentoring does your program schedule during the length of the program? mean hours = 157.6 (60.3 SD)



The ORF-SIG Practice/Reimbursement committee is pursuing dissemination of the results from the mentor survey.

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

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

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

Check out these documents here:
- Policy 13.5
- Medical Condition List FAQ
- RF-PTCAS/Program Sustainability
- CoVid-19 Modifications

Membership: Bob Schroedter, Tyrees Marcy

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

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

Additionally, we are working with the AOPT PR Committee to deploy several new social media initiatives that can help orient the newcomer to the realm of residency/fellowship education. Look for these on Facebook, Instagram, and Twitter pages of AOPT. Take advantage of our member only communication forums to share and develop ideas.

AOPT ORF-SIG Communities HUB

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

bit.ly/orsig-communityhub

Nominating: Bob Schroedter, Tyrees Marcy, Molly Malloy

A big welcome to the new ORF-SIG Vice President, Kirk Bentzen, Nominating Committee Member, Molly Malloy and our new AOPT Board Liaison Derrick Sueki. We are excited to have these wonderful individuals in pivotal positions of the ORF-SIG, building our community of excellence in residency and fellowship education. For more information on the board, committee, and subcommittee members, go to https://www.orthopt.org/content/special-interest-groups/residency-fellowship/get-involved.

The ORF-SIG has been successfully implementing Microsoft Teams to enhance our committee and subcommittee communication for project development. From online meetings to real-time chats to file repository organization this platform has greatly improved the efficiency of the SIG's productivity in a short timeframe.

SUBCOMMITTEE UPDATES:

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

Spring is winding down and summer is upon us. A couple of deadlines related to RF-PTCAS occur during the summer. Generally, program updates on the pre-launch website need to be completed in July or August. You should receive notification of this about a month prior to the deadline. Secondly, final decisions for the 2021 admission cycle will likely be due in early August. Please watch your e-mail and the APTA Hub Communication for these important announcements. Please contact Carrie Schwoerer (cschwoerer@uwhealth.org) with questions.

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

One big problem facing programs over the years is the ability to sustain consistent applicant bases despite using, or not using, RF-PTCAS. Based upon your feedback, we have created two surveys to aid in this effort.

1. The first is to become a contact list library for our member programs of physical therapists and physical therapist students interested in learning more about orthopaedic residency and fellowship programs.
2. The second is specifically for those qualified applicants who are good and have already been vetted but applied to a program that does not have any additional spots available. The program denying admission may then provide the applicant with a flyer explaining the database and providing them the option to participate. Member programs may then access these qualified, vetted applicants as needed by contacting Steve Kareha (stephen.kareha@sluhn.org) and updates on numbers of candidates in this list will be provided quarterly to the membership.

Residency & Fellowship Interest

http://bit.ly/2OH6zdX

Residency & Fellowship Qualified Applicants

http://bit.ly/3u0JR0s

LIAISON UPDATES:

ORF-SIG-AAOMPT Updates: Bob Schroedter

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

OTHER RESOURCES:

bit.ly/orfsig-covidresourcemanual

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

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

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

Rehabilitation of Failed Forefoot Surgery in an Adolescent Female

Mackenzie Garreth, PT, DPT
Aimee Klein, PT, DPT
Craig Vecchiarelli, PT, DPT
Matt Lazinski, PT, DPT

University of South Florida, Tampa, FL

INTRODUCTION

Forefoot disorders are a common pathology encountered in physical therapy practice. These pathologies include deformities such as metatarsalgia, hallux valgus or rigidus, claw or hammer toes, or sesamoiditis may cause impairments as well as activity limitations or participation restrictions. For some patients, the clinical presentation may be mild and go untreated. However, these disorders often have a progressive nature that can lead to severe pain, mobility loss, gait restrictions, and even disability. Patients can improve with conservative management, including physical therapy and/or shoe modification, but may require surgical intervention depending on severity, patient preference, and medical expertise.[1,2] All of the above health conditions, the impairments identified, and their respective interventions have one thing in common: research on the role of physical therapy and effective interventions is limited.

Hallux valgus (HV) is the most common foot deformity with an incidence of 35% in elderly adults and may result in pain, particularly with weight-bearing. While less common, HV may also be present in adolescents and younger adults. Conservative treatment for HV traditionally includes footwear modification such as a wider toe box, toe spreaders, or bunion shields to improve alignment and reduce pain. Surgery is considered when conservative treatment fails to alleviate symptoms or functional limitations.[1,3-5] Many surgical options exist, but evidence for physical therapy intervention following surgery is scarce. Schuh et al[6] demonstrated that multi-modal physical therapy intervention can reduce disability and improve plantar pressure following surgical osteotomy for HV correction.

Hammertoe, mallet toe, and claw toe may be seen in isolation or in patients with HV as the 1st metatarsalphalangeal (MTP) position may impede on the lesser toe's mobility and function. Similar conservative interventions to those described for HV, such as footwear modification, may be beneficial in reducing the impairments due to a hammertoe deformity.[1,7] Surgical management includes the sequential release of the MTP joints and toes affected with or without pin fixation with physical therapy addressing range of motion (ROM) and foot intrinsic strength post-operatively.[8]

The sesamoid bones function to transmit load during weight-bearing activities, act as a mechanical lever for foot intrinsic musculature during gait, and stabilize the 1st ray. Sesamoids are at risk for pathology including fracture, chondromalacia, and osteonecrosis from trauma or overuse due to the continuous demands and suboptimal blood supply.[9,10] The focus of conservative treatment is to reduce pain and/or mitigate external stress on the sesamoid complex through a trial of reduced or non-weight-bearing gait, footwear modification or padding, taping, use of non-steroidal anti-inflammatory drugs, injection, or any combination of these interventions.[9] However, excision of one or both sesamoid bones may be necessary in severe cases when necrosis occurs or conservative treatment fails. The primary research question regarding intervention has been whether removal of sesamoids will alter the mechanics of the foot in gait.[10,11,12] A cadaver study by Aper et al[11] concluded that partial or complete removal of the medial sesamoid had minimal effect on the flexor hallucis brevis while removal of both the medial and lateral sesamoids may cause profound deficits. Similarly, studies by Saxena and Krisdakumtorn,[13] Bichara et al,[14] and Biedert and Hintermann[15] have shown high return to pre-operative daily or sport activities following removal of a single sesamoid, but these studies provided limited guidance on the role of physical therapy post-operatively.

Forefoot pathologies are commonly encountered in physical therapy practice, and often do not appear in isolation. Rather, these pathologies may occur simultaneously or in accompaniment to a proximal chain pathology. Physical therapists are frequently involved in conservative care, but they may also play a large role in post-operative management. However, there is a paucity of evidence for physical therapy following surgical intervention, and available studies do not include adolescent patients, those with multiple pathologies, or desire to return to high levels of function.

The purpose of this case report was to describe the multi-modal treatment of an adolescent female following failed multi-procedure repair of idiopathic HV, hammertoes, and sesamoid avascular necrosis with a severe extension contracture of the 1st toe.

CASE DESCRIPTION

History

The patient was a 19-year-old female who reported a 6-year, complex history of right 1st MTP joint pain, which was exacerbated by standing and walking. The patient stated that physician examinations and radiographs revealed HV and hammertoe deformities in toes 2-4. The patient reported seeking treatment from several physicians including generalists, orthopedic surgeons, and podiatrists. In the spring of 2019, the patient was examined by a neurologist to rule out pathology, such as spina bifida, as the cause of pain and forefoot deformities. Patient was prescribed 2 different types of custom-fit semi-rigid orthotics without improvement before seeking surgical intervention. On May 23, 2019, the patient underwent an outpatient hammertoe release of toes 2-4. The patient continued to have limiting symptoms at 1st MTP during ambulation and a corticosteroid injection was administered to the medial 1st MTP joint on August 8, 2019; with boot immobilization post-procedure. Due to continued symptoms, the patient underwent a chevron osteotomy with distal interphalangeal fixation on December 12, 2019, to reduce the HV; at that time, it was determined that her tibial sesamoid bone was necrotic prompting removal. The most updated pre-operative x-rays were taken on December 6, 2019, while post-operative radiographs were taken on February 2, 2020 (**Figure 1**). Upon fusion of the 1st toe DIP joint, the hardware removal and scar tissue debridement of hallux extensor tendon was performed on February 21, 2020, secondary to extension contracture of extensor hallucis. Following these procedures, the patient remained in the boot for 2 additional weeks and was weight-bearing as tolerated in a Controlled Ankle Motion walker boot (United Ortho; Fort Wayne, IN) from August 8, 2019, to March 6, 2020, a total of 7 months.

Examination

The initial evaluation was 2.5 months post initial surgery after podiatrist referral to reduce great toe extension contracture and strengthen the flexor hallucis muscles. The patient reported pain under the 1st metatarsal head that increased with walking, (6/10 during evaluation, 4/10 at best, 8/10 at worst per Numeric Pain Rating Scale or NPRS). Activity of daily living (ADL) restrictions included her inability to wear a tennis shoe or sandal, walk without pain and deviation, walk on uneven surfaces, or participate in recreational activities such as playing with dog, running, or walking on the beach. Additionally, the patient noted distress about cosmetic appearance of her foot secondary to extension contracture.

Her perceived disability was demonstrated by the Lower Extremity Functional Scale (LEFS, score 45/80, MCID = 9 points[16]) and Patient Specific Functional Scale (PSFS; 0 – running, 1 – standing, walking, stairs, hobbies; MCID not available for patient population). Patient-reported and functional outcomes measures are displayed in **Table 1**.

The patient's standing weight-bearing postures revealed symmetrical foot posture, including moderate arch height, neutral forefoot position relative to hindfoot, and mild decreased calcaneal eversion. However, the great toe remained elevated from the ground into extension in weight-bearing postures and weight was shifted to the lateral aspect of the foot (**Figure 2**). She tended to bear weight primarily on lateral aspect of foot during the stance phase of gait.

Figure 1. Pre-operative and Post-operative Radiographs of the Patient in this Case Report Taken on December 16, 2019 and February 3, 2020

Objective measures from the examination, reassessment and discharge visits are reported in **Table 2**. The patient presented with decreased active and passive great toe ROM, inability to perform active great toe flexion, hypomobility of 1st MTP, no mobility at 1st distal interphalangeal (DIP) joint (fused), and point tenderness at the plantar surface of MTP joint. Post-operative incisions on medial side of great toe and dorsal aspect of DIP joint demonstrated proper healing. The patient demonstrated an antalgic gait, specifically with a reduced stance and weight transfer to the lateral foot thus reducing toe off, as pain limited weight-bearing through the distal end of 1st metatarsal.

Proximally, the patient showed decreased strength in the bilateral hip and right ankle musculature, decreased ankle dorsiflexion ROM with talocrural and subtalar hypomobility, and decreased flexibility of gastroc-soleus complex.

Balance testing revealed impaired single leg balance as she was unable to bear weight on the medial foot at 1st MTP. Aforementioned impairments also led to altered squat and stair mechanics. The remainder of the physical examination was unremarkable.

Clinical Impression

Based on subjective and objective data, the patient's impairments were forefoot pain, mobility, and stability deficits following great toe chevron osteotomy, tibial sesamoid removal, and hammertoe release with subsequent great toe extensor contracture. Priority impairments at the time of the evaluation included restoring functional great toe ROM and improving weight-bearing tolerance. Secondary impairments were also present as a result of prolonged boot use that impacted the plan of care. The patient had moderate symptom irritability and presented in the subacute stage of healing based on incision appearance, pain levels, and ability to mobilize with pain at end range. The patient was expected to have a fair prognosis based on the positive influence of young age with no other comorbidities and high motivation. Negative factors included previous failure of conservative treatment, extensive immobilization, and post-operative complication of the extensor hallucis contracture.

INTERVENTION

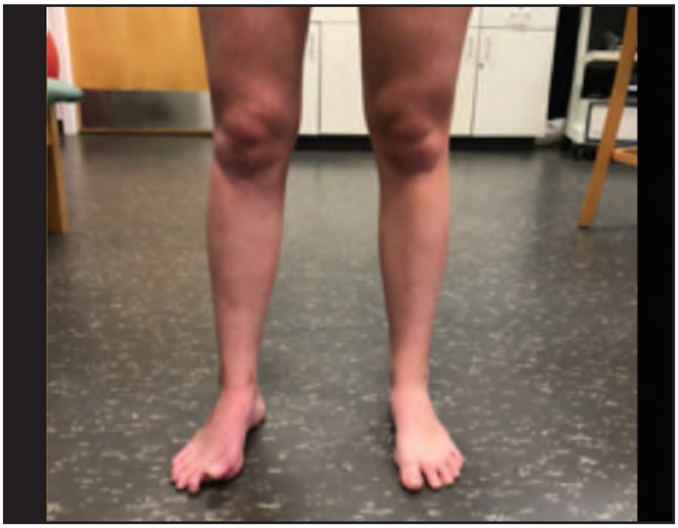
The patient was seen for 18 visits over 12 weeks. Initial physical therapy intervention focused on improving 1st MTP mobility.

Table 1. Functional and Self-Report Outcomes Measures

Measure	Initial Evaluation	Discharge
Lower Extremity Functional Scale	44% disabled	31% disabled
Patient-Specific Functional Scale	92% disabled	28% disabled
Comfortable 10MWT (shoes on)	Deferred	1.1 m/s
Comfortable 10MWT (shoes off)	Deferred	1.2 m/s
Fast 10MWT (shoes on)	Deferred	1.6 m/s
Fast 10MWT (shoes off)	Deferred	1.4 m/s
6MWT	Deferred	780 feet

Abbreviations: 6MWT, 6-meter walk test; 10MWT, 10-meter walk test

Figure 2. Standing Foot Posture with Right Great Toe in Extension and Increased Weight Bearing on Lateral Aspect of Right Foot (pictured April 20, 2020)



During the first 8 physical therapy sessions, instrument-assisted soft tissue mobilization at extensor hallucis muscle belly and tendon, passive ROM, low load long duration stretching, and joint mobilization at 1st MTP joint was used to decrease the extension contracture. The patient supplemented these interventions at home with passive ROM and self-stretching daily. Use of a Velcro brace, prescribed by the podiatrist, at night to promote MTP joint flexion was not successful. Additional interventions included weight-bearing activities to normalize plantar pressures and foot intrinsic strengthening focused on maximizing the mechanical advantage of the flexor hallucis muscles. Patient was cued to increase emphasis on weight-bearing through medial aspect of the foot to improve great toe push off and normalize gait as weight-bearing tolerance improved.

Mild improvements in active and passive MTP flexion were made within sessions following manual therapy and stretching, but there was no carry-over between visits. On the fifth visit, the physical therapist added the use of a Joint Active Systems (JAS) Dynamic Toe splint (JAS; Effingham, IL) to focus on low load, long duration of stretching of extensor hallucis between physical therapy sessions. The patient started the use of the splint one-month post-second surgery (**Figure 3**) and was educated to gradually increase wear time and intensity per tolerance. Once the patient was able to tolerate prolonged wearing of splint, 3 to 6 hours per day depending on schedule, the focus of physical therapy sessions shifted from manual therapy to proximal chain strengthening and improving balance/proprioception.

During the middle phase, visits 8 to 13, interventions addressed ankle mobility and strength deficits from prolonged boot use and ongoing hip weakness. Instrument-assisted and manual soft tissue mobilization was used with subsequent stretching to improve gastroc-soleus muscle flexibility. Additionally, the patient benefited from joint mobilization including grades III and IV posterior glides at talocrural joint, grades III-V combined distraction of subtalar and talocrural joints, and talocrural mobilization with movement to improve mobility, particularly dorsiflexion, during gait and squats. Calf raises were initiated in late March, progressing from sitting to standing and bilateral to unilateral as medial forefoot weight-bearing tolerance improved. Strengthening of hip musculature was initiated with specific muscle training using progressive resistance straight leg raise, clamshells, and sidelying hip abduction, and gluteal bridges with an emphasis on regular performance of home strengthening between sessions. Balance intervention included static and dynamic training on firm, uneven, and non-compliant surfaces.

The latter phase, visits 14-18, focused on return to function activities that included progressive hip and ankle strengthening. Extensive time was spent on normalizing gait and squat mechanics. Squatting was deferred at initial evaluation, but the patient was able to perform and presented with unsymmetrical weight-bearing (35% Right/65% Left) and excessive frontal plane motion secondary to ankle dorsiflexion and hip strength deficits at this time; squatting mechanics did improve with verbal and tactile cuing along with support under heels (**Figure 4**). The patient was able to jog approximately 50 feet within the clinic without pain. She demonstrated a bilateral heel strike running pattern with reduced stance time as she did not achieve full toe push off. She was educated on initiating a progressive return to jumping and running protocol. The patient was unable to continue with in-person clinic sessions to work on return to running or cueing for running mechanics due to changes in campus housing during the COVID-19 pandemic. Finally, she was educated on the importance of performing her comprehensive home exercise program (HEP) addressing mobility, stability, and functional deficits following therapy discharge. The patient was placed on hold at that time, but she was encouraged to return to the clinic once she returned to campus.

OUTCOMES

Following the first phase of physical therapy, the patient had an increased ability to actively contract the flexor hallucis muscles, but the great toe remained significantly limited both actively and passively by an extension contracture. By the fifth visit, the physical therapist requested the JAS splint to promote low load, long duration stretching at home. The focus of physical therapy interventions shifted on the eighth visit once the patient had received her splint.

Between the second and third phases of intervention, the patient demonstrated increased ankle mobility and mild improvements in hip strength. However, her hip strength did remain limited overall, which led to impaired squatting mechanics. The patient's tolerance to walking on level surfaces had improved, but she remained limited when ambulating quickly or on uneven surfaces.

At discharge (18th visit), the patient demonstrated improved

Table 2. Impairment Based Measures at Baseline, Midpoint, and Discharge for the Patient in this Case Report

	Initial Assessment		Mid-Plan of Care (3/30/2020)	Discharge	
	Right	Left	Right	Right	Left
Great toe MTP extension ROM	48° (54°)	WNL	50° (55°)	50° (62°)	WNL
Great toe MTP flexion ROM	Unable to actively flex (lacking 39° from neutral*)	WNL	Resting in 32° extension AROM lacking 25° from neutral (10° from neutral)	Resting in 35° extension AROM lacking 25° from neutral (10° past neutral)	WNL
Great toe DIP joint ROM	Not assessed due to fusion	WNL^	Not assessed due to fusion	Not assessed due to fusion	WNL
Toes 2-4 ROM	50% normal limits (WNL)	WNL	WNL	WNL	WNL
Ankle dorsiflexion ROM	3° (5°)	15° (20°)	5° (10°)	10° (20°)	15° (20°)
Ankle plantar flexion ROM	54° with anterior tightness (61°)	70°	65°	65°	72°
Ankle inversion ROM	32°	WNL	WNL	WNL	WNL
Ankle eversion ROM	14°	WNL	WNL	WNL	WNL
Soleus muscle length	11° with posterior tightness	24°	15°	18°	20°
Ankle dorsiflexion strength	5/5	5/5	5/5	5/5	5/5
Ankle plantar flexion strength	Unable to test functionally; 3/5 in non-weight bearing	5/5	3/5	4/5	5/5
Ankle inversion strength	4/5	5/5	4/5	4 /5	5/5
Ankle eversion strength	4-/5	5/5	4/5	4+/5	5/5
Great toe flexion strength	0/5	2-/5	Trace contraction	2-/5	2+/5
Hip flexion strength	4/5	4+/5	4/5	4+/5	4+/5
Hip extension strength	4-/5	4/5	4-/5	4/5	4+/5
Hip abduction strength	4-/5	4/5	4-/5	4/5	4+/5
Hip internal rotation strength	4-/5	4/5	4/5	4+/5	4+/5
Hip external rotation strength	4-/5	4/5	4/5	4+/5	4+/5
TTP at plantar surface of MTP joint (1st toe)	3/4	NA	2/4	1/4	NA
1st MTP joint mobility	1/6 (moderate to severe hypomobility)	3/6 (normal)	3/6 (normal)	3/6 (normal)	3/6 (normal)
Single leg stance Right LE	Unable to perform	>30 sec with eyes open	5 sec with moderate sway on flat surface	20 sec on flat surface 5 sec on compliant surface	>30 sec on flat or compliant surface
1st MTP circumferential measurement	20.3 cm	19.5 cm	20 cm	20 cm	19.4 cm

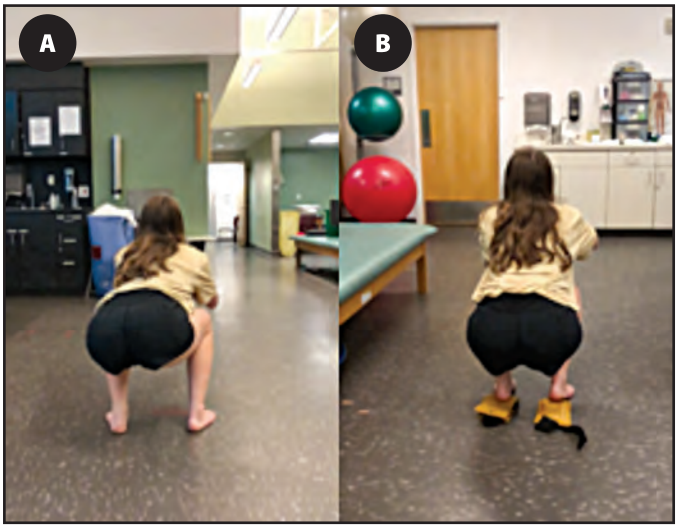
Abbreviations: DIP, distal interphalangeal joint; LE, lower extremity; ROM, range of motion; TTP, tenderness to palpation; WNL, within normal limits
Pain indicated by "*". ROM values are listed with active first followed by passive in parentheses,measured in degrees using goniometer.[19]
Muscle strength assessed per guidelines proposed by Kendall for muscle grading.[20] TTP assessed using 4 point scale.[21] Joint mobility assessed using 6-point scale.[22]

great toe flexion ROM, increased bilateral hip strength, increased right foot and ankle strength, ability to actively flex 1st MTP in non-weight-bearing and weight-bearing positions, improved static and dynamic balance/proprioception, and decreased pain during gait with improved toe-off. Values for clinically important change are not published for these values when used in isolation for this patient population; progress was determined by comparing baseline and discharge measurements for functional change and assessing the patient's reported satisfaction.

During the final physical therapy visit, the patient completed 10-meter walk tests at self-selected and fast speeds for 2 trials each; the average speed in meters per second is shown in **Table 2**. The 6-minute walk test was performed to assess walking endurance. Although the patient did meet age normative values for distance, her time per lap increased with each additional lap performed. The patient demonstrated a normal gait speed of 1.1 m/s and 1.2 m/s during the comfortable walk test, shoes on and off, respectively. The patient exhibited a gait speed of 1.6 m/s and 1.4 m/s during

Figure 3. Joint Active System Splint to Promote Flexion of Great Toe for the Patient

Figure 4. Squat Mechanics of the Patient



A, Before Lift Intervention. B, After heel lift intervention.

the fast walk test, shoes on and off, respectively. The patient was able to jog 50 feet in the clinic with decreased stance and minimal toe off, without pain.

The patient was able to squat to 90° with reduced hip drop and pelvic rotation but still required verbal, tactile, or external cueing in the form of a wedge under the bilateral heels for consistent performance. The patient demonstrated symmetrical weight bearing on Biodex Balance System SD (Biodex; Shirley, NY) during squatting activities by discharge.

The patient showed improvements on the PSFS (64%), and LEFS (12.5%), and Global Rating of Change ("quite a bit better") Scale indicating reduced perceived disability. The PSFS scored on items of standing, walking, stair navigation, running, and hobbies. The patient verbally noted improved function with walking, stairs, squats, and jogging in daily life.

The patient continued to report pain, rated as 3/10 on the NPRS, while ambulating after faster speeds or uneven surfaces. Additionally, she continued to have moderate deficits in proximal chain strength, specifically hip abduction and extension at 4/5, and great toe flexion of 2-/5, which prompted the need for continuing this within the HEP. The patient reported increased satisfaction with the appearance of the 1st toe compared to pre-operative status, but voiced frustration about the cosmetic appearance of the extension contracture.

DISCUSSION

This case report provides the post-operative physical therapy management for an adolescent female following surgical correction of hallux valgus, hammertoe, and sesamoid avascular necrosis with a subsequent extensor hallucis contracture. After 18 visits spanning 12 weeks, the patient showed improvements in pain, mobility, strength, gait, and function. The patient had a persistent great toe extension deformity but was able to return to functional and recreational ADLs with minimal limitation.

The patient's progress may have been limited as a result of the COVID-19 pandemic. The patient had limited access to the gym that affected her compliance with the advanced stages of her HEP. Physical therapy intervention was also discontinued earlier than planned in the latter stage of treatment as the patient was no longer near the physical therapy clinic due to a campus-mandated quarantine.

The results of this case report support prior research[1-15] that an individual can improve gait mechanics and function following HV correction, hammertoe release, tibial sesamoidectomy, and extensor hallucis debridement. This case report also provides a model of physical therapy intervention for an adolescent female with idiopathic forefoot deformities following multiple failed attempts at surgical intervention.

Future research including a larger number of adolescent patients wishing to return to high levels of activity is warranted to determine the success of surgical forefoot deformity correction with post-operative physical therapy.

CONCLUSION

A multi-modal approach for managing impairments and functional limitations in an active, adolescent female following multiple surgical interventions of idiopathic forefoot disorders with resultant deformity is provided. After a 12-week, multi-modal treatment, this patient demonstrated significant improvements in function, pain, mobility, and strength but with continued resultant 1st toe extension deformity.

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President's Message

Francisco Maia, PT, DPT, CCRT

I am writing this letter almost one year to the date that I assumed the President's role for our SIG, leading into some reflection time into what we have accomplished so far and where we are headed. I knew I wanted to take a "divide and conquer" type of approach as there could be only so much that we could accomplish as President and Vice President, Jenny. Therefore, we set in motion the establishment of our 4 committees: legislation, membership, research, and communication. Thanks so much for those who have volunteered their time and efforts to these committees.

The Communication Committee got to work right away on expanding our exposure on social media and helping educate the public and the physical therapy profession on what we can do in the field of animal physical therapy. You likely have now seen 2-3 social media posts every month about our field, and we have been using #PT4Animals to help with our exposure as well. The membership team got to work on setting up and sending out a survey so we could learn more about our membership and, most importantly, how we can better help you. Thanks so much for those who filled out the survey. The results were shared in detail during our SIG meeting at CSM 2021, which can be accessed on our website. The Research Committee has now implemented a research article database, which is also available on our website for our members only. The goal is to add 2-3 new articles every month so, over a long period of time, we develop a robust database that would greatly benefit our members. Finally, the Legislation Committee took the role of updating our State Liaison list which was a few years old and needed to be updated prior to us moving forward with other projects. The goal is for every state to have a liaison within the SIG, and that person would be the point of contact for any inquiries from physical therapists, physical therapist assistants, and students regarding the field of animal physical therapy in that state. Furthermore, that person would help keep us up-to-date with any legislative changes and, over time, hopefully also take the initiative to lead the charge into changing the legislation where needed. If you are a member, then you should have received an email over the last month or so as we are looking to fill that role with some states. Please do not hesitate to contact me if this is something that interests you. I honestly believe this role can take a huge part in the long-term success and growth of our field as there is just so much that we can do at the national level, and most changes will need to happen at the state level. Even if your state already has a liaison, we can always add you as a co-liaison as this is a position that all the help we can get is needed.

In the meantime, if you missed our last quarter's newsletter with Kirk Peck's article about legislative updates, please make sure to find it and read it. That is by far the #1 question we get from those interested in the field of animal physical all over the United States. Unfortunately, this is still one of the main things holding some of you back from making a full transition from humans to animals. We will need numbers for us to make the impact in our field that I want us to make. Meaning, more and more physical therapists and physical therapist assistants joining our field and in return making our voices louder. Therefore, my goal is to help make the pathway clearer for you to do so, but I (and the SIG in general) cannot do it alone. Join us and help us whichever way you can. We have had some great leaders in our field over the last 20+ years that forged the pathway for us, now it is time for a new generation of animal physical therapists to rise to the occasion.

Thank you,
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Animal PT SIG President
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OHSIG

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