EXAMINING A REGIONAL INTERDEPENDENCE APPROACH FOR THE TREATMENT OF ACUTE AND CHRONIC MUSCULOSKELETAL DYSFUNCATION: A DISSERTATION OF CLINICAL PRACTICE IMPROVEMENT (DoCPI)

A Dissertation
Presented in Partial Fulfillment of the Requirements for the
Degree of Doctor of Athletic Training
with a
Major in Athletic Training
in the
College of Graduate Studies
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by
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AUTHORIZATION TO SUBMIT DISSERTATION

This dissertation of Christy Hancock, submitted for the degree of Doctor of Athletic Training with a Major in Athletic Training and titled "Examining a Regional Interdependence Approach for the Treatment of Acute and Chronic Musculoskeletal Dysfunction: A Dissertation of Clinical Practice Improvement (DoCPI)," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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ABSTRACT

The Dissertation of Clinical Practice Improvement (DoCPI) represents my development as a research professional and clinical practitioner. In addition, while developing the DoCPI, it provided an opportunity for me to disseminate evidence of my expertise within chosen areas of advanced practice. Pertaining to my DoCPI, Chapter 2 is a demonstration of my advanced-practice clinical knowledge presented in an *a priori* case study that was developed during my clinical residency. In the case study, I used a regional interdependence approach, a new concept in my clinical practice, to successfully categorize and treat a plantar fascia pain patient. Chapter 3 is an analysis of my patient care during my clinical residency. Throughout the chapter, I present the outcomes from my patient care and highlight my clinical development within three of my advanced practice areas. Chapter 4 contains two critically appraised topic (CAT) manuscripts and serves as evidence of my ability to identify valid methodology and evidence regarding the treatment of hamstring tightness. In my literature review, I found that neurodynamic sliders and stretching increase hamstring range of motion; however, due to methodological differences and low quality evidence, the most effective treatment could not be determined. Chapter 5 is a multisite research project where we examined apparent hamstring tightness and the immediate and short-term effects of the Total Motion Release® (TMR®) Forward Flexion Trunk Twist (FFTT) compared to a sham intervention. After one application of the technique, hamstring extensibility improved which indicates that the treatment may be used to immediately address apparent hamstring tightness. Cumulatively, the DoCPI represents my development as a researcher and advanced practice clinician who can adequately prepare athletic training students for their professional careers.

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DEDICATION

I would like to dedicate this document to my family. Your love, prayers, and support have provided me the confidence to achieve my goals and succeed. I love you and appreciate the significant role you play in my life. I hope to make you proud.

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CHAPTER 1

NARRATIVE SUMMARY

An athletic trainer is a healthcare professional who provides his or her patients with emergency care as well as the prevention, diagnosis, and treatment of injuries (Prentice, 2013). Once certified, an athletic trainer must pursue continuing education to maintain the certification and to prevent his or her professional knowledge from becoming outdated (Hughes, 2005; Pitney, 1998). In my professional career, I completed continuing education (e.g., conference attendance) as required, but felt stagnant in my professional growth to move my skill set beyond the foundational professional requirements. To address this issue, I pursued the Doctor of Athletic Training (DAT) program at the University of Idaho (UI), which was developed in an effort to encourage scholarly advancement and clinical practice improvement within the athletic training (AT) profession (Nasypany, Seegmiller, & Baker, 2013). Students are challenged to increase the breadth and depth of their entry-level professional AT skills, while also developing new, advanced knowledge as the student works to become scholarly practitioners who disseminate research and advance knowledge in AT clinical practice.

Advanced practice is attained as a student gains expertise within multiple topics or areas of AT while maintaining the skill set needed for general clinical practice (Nasypany et al., 2013). For example, I chose chronic lower extremity pain as an area of advanced practice because I identified the area as a weakness in my clinical practice. To develop my expertise in this area, I completed a focused clinical residency and developed a Dissertation of Clinical Practice Improvement (DoCPI) that included design elements to develop and assess my improvement in this area of advanced practice; however, assessing this advanced practice area is only a small component of my DoCPI.

The DoCPI is the culminating product of the DAT program and provides students with an avenue by which to demonstrate their development as research professionals and clinical practitioners. It also allows students the opportunity to disseminate evidence of their expertise in their chosen areas of advanced practice. While the DoCPI includes descriptions of a clinician's experiences with a number of different components of the DAT program curriculum, two of the document's foundational concepts include the incorporation of an action research (AR) philosophy and the completion of multisite research.

In the traditional AR approach, a researcher works to improve a specific area of his or her practice through the processes of reflective analysis and action (Fuller-Rowell, 2009). In other words, a clinician identifies a local problem within his or her clinic or patient population, collects patient outcomes relating to that problem, and critically reflects upon the care that was provided to patients who exhibited that problem. Through this reflective analysis, the clinician is able to compare patient outcomes with the best available published literature and to generate knowledge by identifying connections within patient outcomes. The result is an improvement in patient care and clinical practice (Hilli & Melender, 2015).

Researchers are encouraged to recognize that within the AR process, theory can be generated through practice (i.e., practice-based evidence, or PBE) (Brydon-Miller, Greenwood, & Maguire, 2003). Theory generated during traditional laboratory research frequently lacks clinical relevancy and is often not translatable for clinical practice (Merrick & Dolan, 2010). The need for real-world knowledge and clinical applicability resulted in a charge for rehabilitation specialists (e.g., athletic trainers) to invest in the research process (Mattacola, 2010). In the DAT program, AR is often conducted through *a priori*-designed research in clinical practice. By developing the sound research questions and methodology

required to collect meaningful patient care outcomes, clinicians may generate PBE to improve their practice and generate new knowledge for the profession.

Throughout my clinical residency, I embraced an AR philosophy and examined my clinical practice, which led to an improvement in my assessment skills and in my ability to effectively categorize and treat my patients. A major component of my clinical residency was the inclusion of patient outcomes collection in my clinical practice. The integration of patient-rated outcomes (PROs) helped to guide my treatment decisions, track patient progress, and determine the efficacy of the treatments I choose to perform. During my professional education, I was only exposed to clinician-based outcomes (CBOs), such as measuring a patient's range of motion or performing manual muscle testing. These outcome measures are limited, because they are based on the clinician's perspective and objectively assess the patient's response to treatment without considering the patient's perspective (McLeod et al., 2008). The process analyzing CBOs within my developing perspective in the DAT program, helped me to realize that if I wanted to perform effective, patient-centered, holistic healthcare, I would need to also incorporate PRO measures into my clinical practice, too (McLeod et al., 2008).

Patient-centered care (PCC) is considered a component of high-quality healthcare in which clinicians place the patient at the center of the care process through holistic (i.e., totality of the condition), collaborative (i.e., patient engagement and self-management), and responsive (i.e., individualized) care (Robinson, Callister, Berry, & Dearing, 2008; Sidani et al., 2014). Collecting PROs fosters a PCC philosophy, and, through the assessment of multiple factors within the patient's recovery process (e.g., physical function, psychosocial well-being, global health judgements), helps the clinician to consider what is valuable to the patient (McLeod et al., 2008; Snyder et al., 2008; Snyder Valier, Jennings, Parsons, & Vela,

2014). In an effort to transition to a PCC approach, I incorporated both CBOs and PROs into my patient care during my residency. The use of a PCC approach heightened my awareness of each patient's perspective regarding his or her recovery and held me accountable in assessing patient progress as a means to guide and evaluate my clinical performance.

The PCC approach compliments the systematic nature of my patient care and has helped me to develop as a scholarly practitioner. Using an AR philosophy and PCC has allowed me to identify questions in my clinical practice pertaining to my patient care. In addition, I developed methods for testing my hypotheses. The *a priori* case studies that resulted not only served as valuable narratives upon which I could reflect for my personal and professional development; they were also meaningful examples of scholarly PBE that were worthy of dissemination to my profession. The development of my abilities as a scholar has been important for my career development; as a graduate faculty member in my current employment position, scholarship production is an expectation. Prior to entering into the DAT program, I was unfamiliar with the research process and ill-equipped to meet the scholarship requirement. As evidenced in my DoCPI, I have developed the skills to conduct research, answer important questions, and disseminate the knowledge I have gained to others in the AT profession.

Another benefit of my clinical residency was increased effectiveness in preparing and mentoring students to become leaders within the professional AT program. Without the advanced-practice clinical knowledge that I developed through my residency and applied clinical research, I would have remained dependent on the narrow perspective that I had gained during my entry-level education and adhered to while training professional athletic-training students. My clinical residency, new patient care philosophy, and research have helped me to better comprehend all that being an athletic trainer involves, both as a scholar

and as a clinician. As a result of this improved understanding of my role in the profession, I can better prepare my students, who are future AT professionals, to meet the healthcare needs of their patients, just as the DAT faculty have helped me to meet the needs of mine.

An example of this growth is found in Chapter 2 of this DoCPI and includes an *a priori* case study that was developed through an AR philosophy within my clinical practice. The purpose of this case study was to assess the effectiveness of a regional interdependence approach, in combination with multidimensional outcomes instruments, in examining, classifying, and treating a patient diagnosed with plantar fasciitis. I chose to disseminate the case study because the methods were replicable and the outcomes were meaningful to clinical practice. I submitted the case study manuscript to the *International Journal of Athletic Therapy and Training* (*IJATT*), and it was recommended for publication in the spring of 2016.

Further evidence of my development as a scholarly practitioner who utilizes an AR philosophy during clinical practice is found in Chapter 3 of this DoCPI. In Chapter 3, I provide a narrative of and reflection upon my clinical residency. My first experience examining my clinical practice while incorporating PROs collection into my patient care occurred during the fall of 2014. Through successes, failures, and reflection, I became acutely aware of my clinical strengths and weaknesses, which was something I had not anticipated prior to entering the DAT program. It was also something I had not previously considered and certainly could not articulate. Through the first residency course, however, I discovered that my assessment skills needed to be refined. This led to an improvement in my patient categorization and to the performance of more effective treatments.

I also learned that I needed to better understand the factors influencing the pain response. I was frequently guilty of assuming that inflammation was the primary causative factor in many of my patient cases, when in actuality, pain is much more dynamic and

complex. Through the completion of a clinical residency, I improved in my ability to perform holistic assessments, which, in turn, helped me to identify factors contributing to a patient's pain. Identifying these factors (e.g., neural tension) allowed me to effectively categorize and treat each patient. Evidence of my clinical practice progress is presented in Chapter 3 of this DoCPI. There, I focus my reflection and assessment on my advanced practice areas (e.g., chronic pain) while highlighting the changes (e.g., use of PROs) and improvements I have made in my patient care.

While my patient care and research abilities continued to evolve during my clinical residency, they were not enough to complete my development as a scholarly practitioner who could answer important questions and advance knowledge in AT clinical practice. For this to occur, I needed to participate in multisite research projects. Multisite research allows a team of clinicians to use the same methodology to collaboratively investigate a clinical practice problem in a way that is more effective and meaningful than single-site studies. For example, multisite research increases the external validity of a project due to the inclusion of a more diverse population (i.e., multiple sites vs. single site) and as a result, the researchers produce outcomes that are more generalizable to the AT profession (Flynn, 2009). In addition, I discovered multisite research to be beneficial because it provided a supportive environment in which I and other researchers were able to collaboratively conduct a research project and improve our patient care. The positive environment also led to improved research quality and the motivation to disseminate results. As a multisite research team, we developed and disseminated multiple scholarly products to the profession, which exposed a larger audience to the results of our research. The development of multisite research teams helps each student to achieve global philosophical learning outcomes of the DAT, including the transformation

of each student into a scholarly practitioner who produces original research and advances AT knowledge.

Historically, a lack of scholarship production has limited the AT profession's ability to develop in a manner that is comparative to other healthcare professions (Knight & Ingersoll, 1998). The DAT faculty and students make efforts to reduce this deficit by establishing research teams and disseminating multisite scholarship that is focused on patient care and the resolution of clinical problems. During my time in the DAT, I have worked with a research team that has developed multiple projects and presentations, three of which are expounded upon in Chapters 4 and 5 of this DoCPI.

Chapter 4 contains two critically appraised topic (CAT) manuscripts and serves as proof of my ability to review the literature and to identify valid methodology and evidence. After planning the article search strategy and developing our Patient, Intervention, Comparison, Outcome (PICO) questions, my multisite research team and I investigated the effect of neurodynamic (NDS) sliders and stretching on hamstring tightness. The selected studies were validated using the Physiotherapy Evidence Database (PEDro) scale, which is a rating process that helps to guide clinical practice through the identification of valid evidence and outcomes (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003). The two CAT manuscripts contained in Chapter 4 highlight the PICO questions and investigative process, provide a critical review of the articles in the literature search, and give recommendations for clinical practice and future research.

Chapter 5 is a multisite manuscript designed to examine apparent hamstring tightness and the immediate and short-term effects of the Total Motion Release® Forward Flexion Trunk Twist on the condition. The chapter illustrates my ability to investigate a problem, design and implement a research study into clinical practice, and produce scholarship that is

clinically relevant. By conducting this research project, I developed expertise in the assessment and treatment of hamstring tightness and assessed the effects of a novel treatment paradigm that is based upon a regional interdependence approach—a new concept in my clinical practice. Cumulatively, the research project laid the foundation for a line of research that will continue throughout my professional career.

Completing the DoCPI provided me with the opportunity to critically reflect on my professional transformation. My efforts to become an advanced-practice clinician have enlightened my perspective on the AT profession and my role as a clinician and graduate AT faculty member. As a clinician, I am a healthcare professional who has transitioned past my entry-level education, developed focus areas of advanced clinical practice, and continues to diligently follow an established plan for my personal and professional development. In addition, I have become a scholarly practitioner who generates knowledge and develops scholarship based on PBE. As a graduate AT faculty member, I must continue in my clinical and academic roles and help my students to develop the skills necessary to confidently provide PCC and advance the AT profession through clinically meaningful scholarship. Cumulatively, developing the DoCPI has equipped me to reach my fullest potential as a professional who is an expert in her field, generates evidence from patient care, produces scholarship that is clinically meaningful, and prepares AT students for their professional careers.

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CHAPTER 2

TREATMENT OF PLANTER FASCIA PAIN WITH JOINT MOBILIZATIONS AND POSITIONAL RELEASE THERAPY: A CASE STUDY

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Key points:

- A regional interdependence perspective should be utilized in the evaluation of plantar fascia patients.
- Collecting patient outcomes helped guide clinical decision making throughout the rehabilitation process.
- A deficit in the arthrokinematics of the talocrural and subtalar joint must be considered as a possible mechanism causing mechanical stress of the plantar fascia and pain.
- A combined intervention of Joint Mobilizations and Positional Release Therapy can successfully treat plantar fascia cases.

Plantar fasciitis is a term utilized to describe inflammation that originates at the medial calcaneal tubercle[1,2] and most often affects the athletic and sedentary populations.[3-5] Accounting for 15% of all adult foot complaints, plantar fasciitis has been asserted as the most common foot injury treated by clinicians.[6] Plantar fasciitis is more often a degenerative or non-inflammatory condition and is more appropriately termed plantar fasciosis in most cases.[7] The diagnosis of this condition is typically made based on the patient history and clinical examination.[2,3,5] The signs and symptoms most commonly associated with the condition are an insidious onset, palpable pain on the plantar surface of the foot near the medial calcaneal tubercle,[3,6,8-10] and pain with the first steps in the morning, after periods of inactivity, and with prolonged weight bearing.[3,6,8-10] Common risk factors associated with

plantar fascia pain are a decrease in talocrural dorsiflexion and subtalar eversion,[3,5,6,10,11] poor footwear,[6,10,11] pes planus,[10] tight achilles tendon complex,[8,10] obesity,[3,5,6,11] and overuse.[3,5,8,10]

Plantar fasciitis treatment has traditionally been directed to eliminate inflammation, support the longitudinal arch and stretch tissue. Conservative therapy typically includes rest, cryotherapy, non-steroidal anti-inflammatory drugs (NSAIDS), orthotics, night splints, tape application, intrinsic/extrinsic foot muscle strengthening, and static stretching of the plantar fascia;[1,4,6] however, most evidence only supports transient effectiveness of these treatments.[3,8,10,12] Complete resolution of plantar fasciitis symptoms has been reported to take six to twelve months.[13] The limited effectiveness of local treatments in many cases supports the potential need for using a holistic approach to improve patient outcomes.[14] To provide a more successful treatment, a regional interdependence (RI) perspective should be utilized in the evaluation of the condition.[15] Within this perspective, the clinician considers multiple body systems (i.e., musculoskeletal, biopsychosocial, neurophysiological, and somatovisceral) and/or regional body segments that may be contributing to the pain sensation.[15] The RI perspective allows the clinician to assess other areas of dysfunction that may be the root cause of the patient's present complaint and address all areas of patient disablement. The clinician, however, must also utilize the appropriate outcome measures to assess patient improvement and validate the efficacy of the treatment interventions. The purpose of this case report is to highlight the use of a RI approach in the examination, classification, and treatment of a diagnosed case of plantar fasciitis, combined with the use of multidimensional outcomes instruments to assess the effectiveness of care.

CASE REPORT

A 20-year-old football tight end reported pain on the plantar surface of his right foot during practice. The patient reported an insidious onset and rated his pain a 6 out of 10 on the

Numeric Rating Scale (NRS).[16] The patient reported pain on the medial calcaneal tubercle but did not report any other tenderness to palpation. The patient did not report any previous injury to this area and visible signs of inflammation and deformity were not present. Based on the location of pain, the patient was initially diagnosed with plantar fasciitis. The injury was initially treated with an arch tape with padding adhered to the painful area that the patient wore during practice. The patient also received the following interventions once daily prior to practice: therapeutic nonthermal ultrasound (3MHz/.8 W/cm^2/50%) applied for five minutes to the plantar fascia, intrinsic foot musculature strengthening that included marble pick-ups, and three to five minutes of effleurage massage applied to the plantar surface of the foot.

While receiving the aforementioned treatment, the patients' pain remained a consistent 6 out of 10 on the NRS scale which was recorded daily prior to treatment. No other outcomes measures besides the NRS scales was utilized initially to document patient progress. The patient continued to participate while receiving this care and his pain remained consistent until it reached its greatest intensity (8 out of 10 on the NRS) during a football game two weeks after the initial injury. At that time, the sports medicine staff instructed the patient to wear a walking boot for two days until he could be evaluated by the team's orthopedic physician. During this exam, the physician diagnosed the patient with plantar fasciitis, discontinued the use of the walking boot, and instructed him to continue with his current therapy program without activity restriction.

After four weeks of the aforementioned treatment interventions, the patient continued to be symptomatic. At that point, the patient was reevaluated by a consulting Certified Athletic Trainer. At this time, the patient reported 2 out of 10 pain in the morning and when walking, and 4 out of 10 pain during practice. No observable signs of edema, ecchymosis, or erythema were noted. Visual observation of the Achilles tendon alignment indicated a neutral

position. Palpable tender points were noted on the plantar surface of the medial calcaneal tubercle and in the medial head of the gastrocnemius. The clinician utilized clinical practice guidelines reported by Martin et al.,[6] as she evaluated the patients' range of motion. Goniometric measurements were recorded for active range of motion of the talocrural and subtalar joints and deficits were noted (Table 1.1). Arthrokinematic hypomobility was further identified with the use of talocrural and subtalar accessory glide testing.[17] Manual muscle tests of the lower extremity musculature were performed and no deficits (pain or weakness) were noted. Tinel's Sign, Dorsiflexion-Eversion Test, Feiss Line, and Windlass Test were each negative during this exam.[18]

Table 1.1: Clinician-Based Outcome: Active Range of Motion

Joint Motion Involved Side	Initial Exam Day 1	Discharge Exam Day 8	Joint Motion Uninvolved Side
Dorsiflexion	5°	10°	12°
Plantarflexion	Not tested	Not tested	Not Tested
Inversion	10°	15°	14°
Eversion	2°	4°	5°

The Selective Functional Movement Assessment (SFMA) was then utilized to determine dysfunctional movement patterns that could be the root source of the patient's complaints.[14,19] The most dysfunctional pattern presented by the patient was the overhead deep squat. To further evaluate the dysfunctional pattern, further motion testing using prone passive dorsiflexion and seated ankle inversion/eversion was performed and range of motion deficits were noted. The SFMA, goniometry measurements, and joint glide testing helped to determine a deficit in talocrural dorsiflexion and subtalar motion. Based on the evaluation, the clinician hypothesized that these dysfunctions were a primary cause of the patient's plantar fascia pain.[6]

TREATMENT PLAN

The patient's treatment plan included grade 3 joint mobilizations and Positional Release Therapy (PRT). Treatment selection was based on the clinician's clinical experience

and treatment indications.[20] To address hypomobility of the talocrural and subtalar joints, the clinician planned to perform three sets of each mobilization (30 sec/set and two oscillations/sec). To eliminate the tender points (TP) identified in the plantar surface of the foot and medial gastrocnemius, the clinician planned to hold each muscle in a position of ease for 60 to 90 seconds or until the muscle fasciculation at the TP had subsided.

OUTCOMES COLLECTION

To assess the effectiveness of the treatment, clinician-based and patient-reported outcomes measures were utilized to objectively monitor patient progress. Clinician-based outcomes (CBOs) assess the patient's response to treatment.[21] These outcomes are based on the clinician's perspective and related to the injuries pathophysiology.[21] In this patient case, CBOs such as ROM, manual muscle testing, and the SFMA were utilized. To provide patient-centered care, the patient's perception of the recovery process (i.e., societal limitations, functional loss) must be evaluated.[21]

Patient-reported outcomes (PROs) measures obtain information from the patient concerning multiple factors such as physical function, psychosocial well-being, and global health judgements.[21] Assessing the patient's perceived improvement from a multidimensional perspective (e.g., globally versus region-specific, pain versus function) is imperative for the clinician to fully assess patient improvement and guide treatment progression. The PROs utilized were the Numeric Rating Scale (NRS), the Disablement in the Physically Active (DPA) Scale, Lower Extremity Function Scale (LEFS), Global Rating of Change (GRC) and Patient-Specific Functional Scale (PSFS) (Table 1.2). The outcomes scales have been determined to be reliable and valid and each has an established minimal clinically important difference (MCID).[16, 22-25]

Table 1.2: Patient-Reported Outcomes

Patient Outcomes Collection Scales	Initial Exam Day 1	Discharge Exam Day 8	Follow-up Exam Day 15
Numeric Rating Scale (NRS)	4	**0	0
Disablement in the Physically Active Scale (DPA)	21	**12	10
Lower Extremity Functional Scale (LEFS)	69	71	72
Global Rating of Change (GRC)	*N/A	Somewhat (+3)	**Moderately (+4)
Patient Specific Functional Scale (PSFS)	6	**8	9

** The GRC scale is not indicated during an initial patient evaluation.[34]*
*** MCID achieved*

TREATMENT

Grade 3 joint mobilizations were used to address hypomobility of the talocrural and subtalar joints. Posterior talar glides were utilized to increase dorsiflexion.[26] The patient maintained a supine position while a posterior force was applied to the anterior aspect of the talus gliding it posteriorly. With the patient in a side-lying position, subtalar joint medial and lateral glides were utilized to increase eversion and inversion.[26] Three sets of each mobilization were performed (30 sec/set and two oscillations/sec).

Positional release therapy was also applied to eliminate the tender points (TP) identified during the physical exam that may have been affecting his ankle motion.[27] The TP on the plantar surface of the patients' foot was located at the anterior calcaneus along the plantar fascia. To eliminate the TP, the patient was positioned prone, with knee flexion and ankle plantarflexion. His foot rested on the clinician's shoulder (Figure 1.1). The metatarsals and calcaneus were passively moved into a flexed position. The second TP was located in the medial gastrocnemius head. To eliminate the TP, the patient was placed prone with knee flexion and subtalar inversion (Figure 1.2). Each position was held for 60 to 90 seconds or until the muscle fasciculation at the TP had subsided.

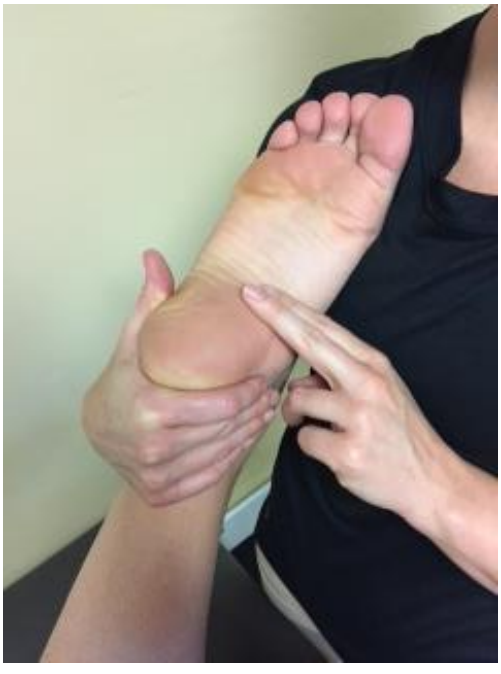

Fig. 1.1: PRT of Plantar Calcaneus tender point.

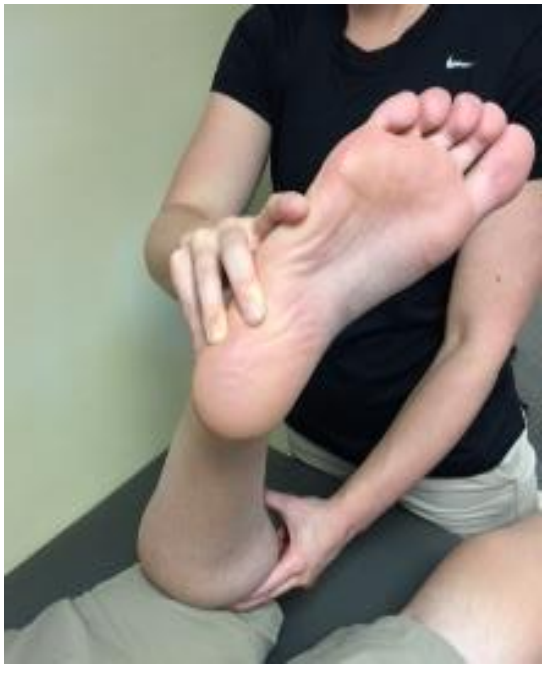

Fig 1.2. PRT of medial gastrocnemius tender point.

RESULTS OF TREAMENT

Treatment using only joint mobilizations and PRT was applied on back-to-back days and resulted in the patient reporting a complete resolution of his pain on the NRS. During the course of treatment, the patient was able to practice unrestricted. The following day, the patient was able to compete in full game competition and did not report any recurrence of symptoms without additional treatment. The patient was allowed to participate in the next week of practice without further treatment to assess continued resolution of his symptoms.

One week after the initial assessment, a follow-up examination was completed. During this exam, the patient reported resolution of his pain and demonstrated increased range of motion measurements within normal limits for subtalar and talocrural motion bilaterally (Table 1.1). The dysfunctional movement patterns originally present during the initial SFMA exam were also eliminated. Based on the exam findings, the patient was discharged at this time and continued with full activity participation without treatment. After discharge, a one

week follow-up was conducted to determine if any changes had occurred in his symptomology or patient-reported outcomes. At this time, the patient reported a continued resolution of his complaints and continued improvement on his patient reported outcomes (Table 1.2).

The initial exam to discharge exam spanned over the course of eight days. During this time frame, the patient received two treatments. The time span between the initial and discharge exam was due to the patient's schedule and game day travel. Outcomes collection occurred during the initial exam (day 1), discharge exam (day 8), and follow-up exam (day 15) (Table 1.3). Over the course of treatment, the patient demonstrated improvement on most outcomes measures (Tables 1.1 and 1.2).

Table 1.3: Treatment Progression and Outcomes Collection

*Day	Treatment	Outcomes Collected
1: Initial Exam	PRT and Joint Mobilizations	NRS, DPA, LEFS, PSFS ROM, MMT, SFMA
2: Treatment	PRT and Joint Mobilization	NRS
** 3 to 7: No Pt. Care	N/A	N/A
8: Discharge Exam	N/A	NRS, DPA, LEFS, GRC, PSFS ROM, MMT, SFMA
15: Follow-up Exam	N/A	NRS, DPA, LEFS, GRC, PSFS

Numeric Pain Rating Scale (NRS), Disablement in the Physically Active Scale (DPA), Lower Extremity Functional Scale (LEFS), Global Rating of Change Scale (GRC), Patient-Specific Functional Scale (PSFS), Range of Motion (ROM), Manual Muscle Testing (MMT), Selective Functional Movement Assessment (SFMA)
**Days 1 to 15 are consecutive days.*
***Days 3 to 7: Due to game day travel and class schedule conflicts, Pt. did not report to the clinic and did not receive treatment. Outcomes were not collected.*

DISCUSSION

Traditional interventions for plantar fasciitis have mixed outcomes in regards to efficacy of treatment and may take up to 12 months.[3,8,10,13] Considering the lack of a "gold-standard" treatment and the various underlying factors that could result in plantar fascia pain, the condition should be evaluated and treated from a broader perspective than the inflammatory model. A potential model for improving treatment of plantar fasciitis is including a regional interdependence perspective within an orthopedic injury assessment.[28,29]

Regional interdependence allows the clinician to assess corresponding regions within the kinetic chain and identify contributing factors leading to the patients primary complaint and pain.[28] The assessment and patient outcomes collection helps guide treatment decisions.

In this case study, the patient exhibited plantar heel pain that could have been caused by an inflammatory condition or movement dysfunction producing a mechanical overload leading to the primary complaint.[30] The latter theory was supported in this case because he did not present with common signs association with inflammation and the patient demonstrated dysfunctional movement patterns when using the SFMA. The performance of a movement screen led to focusing on the movement dysfunction at the ankle and foot, which led to a more detailed assessment identifying talocrural and subtalar motion.[6] These limitations can lead to excessive foot pronation during gait, compensation by distal foot joints, and a decreased medial longitudinal arch, leading to mechanical stress on the plantar fascia.[6,11] The clinician provided joint mobilizations to address the accessory joint motion deficit to restore normal motion and reduce excessive stress on the plantar fascia.

Additionally, the patient presented with local and proximal somatic dysfunction classified through the identification of TPs. The development of myofascial TPs and decreased muscle strength and range of motion are directly related to the myotatic reflex arc that occurs post injury.[11,27] The tissues natural response to injury is directly related to the observable signs that are associated with somatic dysfunction.[27] Additionally, after injury, the pain threshold is reduced and efficiency of afferent sensory impulses to the central nervous system is increased.[31] These events, known as central sensitization, should dampen after the injury heals. The continued pain impulses to the brain amplify the sensation of pain and produce a false representation of the tissue state.[32] Elimination of the facilitated TPs with the use of PRT, will impact the central nervous system dysfunction associated with central

sensitization.[27] Therefore, the goal of the PRT intervention was to treat global somatic dysfunction versus local tissue dysfunction.[27]

The PRT application decreased the painful sensation located on medial calcaneal tubercle. The immediate change in patient response by using PRT would support the theory that the fascia was not inflamed or that the inflammatory process was not the source of the patient's complaint or dysfunction. Further supporting the theory that PRT provides a systemic benefit are researchers who have used PRT to improve strength, ROM and overall function.[33] In this case study, the patient was treated and immediately returned to unrestricted activity without return of symptoms, which does not support the traditional recommendation of providing the patient with 24-48 hours of recovery time to prevent muscular soreness.[27] The result in the case, and that of Baker et al.,[33] provides preliminary evidence that clinicians may be able to use PRT and immediately return physically active patients to activity without a return of their symptoms. In both cases, the patients were collegiate athletes presenting with acute palpable tender points and altered range of motion. The technique has demonstrated greater efficacy in acute and subacute cases.[33]

Another key component of this case study was the use of PRO's as a guide for assessing the effectiveness of patient classification and treatment. The NRS was selected because pain was the chief complaint of the patient and the scale was designed to measure pain intensity (i.e., avg. of current, best, and worst pain over 1 day).[16] In this case, the patient's NRS scores improved each session (Table 1.2) and resolved his pain complaint after two treatments, when the previous interventions had failed to resolve his complaint over 6 weeks of care. The 15-point GRC scale was used to quantify the patient's progress overtime based on treatment effect and injury status.[34] In this patient case, his primary concern was being pain free during sport. Using the GRC outcome, the patient was asked to rate the

overall change in his plantar fascia pain during sport from the time that he began treatment. The patient reported change met the established MCID for the scale and he reported a +4 (moderately better) rating during the follow-up exam.[35]

The DPA Scale provided insight into different dimensions of the disablement process (i.e., impairments, functional limitations, disability, and health-related quality of life).[22, 35] The patient's final score of 10 (i.e., initial score of 21) was within the range for a non-injured population and provides support for the patient experiencing global improvement in his condition.[22] The LEFS was used to evaluate activity limitations of lower extremity due to musculoskeletal injuries.[24] In this case, the patient did not achieve the MCID, but reported improvements on this scale (i.e., initial 69/discharge 72). Scores closer to 80 indicate better function[36] and the lack of improvement may be attributed to a ceiling effect or lack of sensitivity for this type of injury.[24] Another PRO, such as the Foot and Ankle Ability Measures (FAAM), may have been more sensitive for evaluating the progress of the patient's foot injury.[6] The PSFS was used to assess changes in functional activities that were important to the patient.[23] The patient reported an eight (i.e., 10 indicating same level as before injury) on the scale after two treatment sessions despite continued participation in sport. One week after discharge, the patient continued participation for 12 days without treatment, but reported continued improvement on the PSFS (Table 1.2).

SUMMARY

In the case presented, the combined use of PRT and joint mobilizations produced immediate clinically significant improvement across multiple outcome scales, resolved the patients' symptoms, and restored normal movement patterns in the SFMA exam in two treatments. The patient was able to finish football season without further limitation or pain. Utilizing the regional interdependence perspective aided the clinician in identifying factors

outside of the painful segment that appeared to be the causes of his condition. The identification of the contributing factors led to more precise treatment and elimination of the dysfunction, which had not occurred with traditional plantar fasciitis treatment previously applied for over 6 weeks. Patient outcomes collection helped the clinician identify efficacy of treatment and treatment progression. The evaluative and treatment methods presented in this report may help clinicians better evaluate and treat patients with similar presentations of plantar fascia pain.

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CHAPTER 3

OUTCOMES SUMMARY, RESIDENCY FINDINGS, AND IMPACT

EMBRACING CHANGE

A major focus of the first semester of the Doctor of Athletic Training (DAT) program was evaluating and critically reflecting upon clinical practice. To this end, students were required to articulate their rehabilitation philosophies. Several failed attempts to effectively articulate my philosophy led me to the realization that I was disconnected from my patient care and had failed to develop a guiding philosophy in my patient care. Since this time, I have incorporated the additions of patient outcomes collection and critical reflection into my patient care. These changes have helped me to become more aware of my strengths and weaknesses as a clinician.

Throughout my time in the DAT program, I chose to focus my outcomes collection on specific populations (e.g., chronic pain, acute lower extremity pain, and acute shoulder pain) that I had identified as weaknesses in my clinical practice. This approach helped me to identify injury trends, develop treatment philosophies, evaluate my clinical practice, and become more effective at eliminating each patient's chief complaint.

IDENTIFYING AND OVERCOMING BARRIERS

Barriers are circumstances within the student's residency site that may prevent him or her from fulfilling the requirements (e.g., collecting patient outcomes) of the DAT program and developing professionally. In preparation for the Fall 2014 semester, I identified the barriers that existed within my residency site and strategized a plan to overcome them. The first barrier I identified was that I was employed as a full-time faculty member without a clinical assignment. As a volunteer in the sports medicine clinic, I was concerned that I would not meet the residency standard regarding direct patient care (i.e., minimum of six patients

seen every two weeks), because I did not have adequate patient access. To overcome this barrier, I met with my attending clinician (AC), and we determined that I would provide care for football and softball patient populations.

The second barrier I identified was my inability to effectively articulate my new professional goals and patient care philosophies to my colleagues. I was anxious to make changes to my clinical practice and was eager to share the insights I had gained; however, I failed to acknowledge that change is difficult and my colleagues may not be ready for change. To overcome this barrier, I waited for my colleagues to pursue my input, at which time I tactfully provided insight and suggestions. I learned that maintaining healthy professional relationships is paramount when trying to encourage change.

The third barrier I identified was my inability to overcome discouragement after I experienced failure in my patient care. To overcome this barrier, I worked to develop a new belief that, during patient care, an integrated relationship exists between success, failure, critical reflection, and growth. Late in the Fall 2014 semester, I began to critically reflect upon my patient care and started incorporated journaling into my daily routine. The reflection process helped me to realize that some of my most challenging patient cases, in which failure had been consistent, had led me to make valuable changes in my clinical decision-making process. This, in turn, had led to positive changes in my clinical practice.

The fourth barrier I identified was that of establishing an effective system for patient outcomes collection. When I first began to collect patient outcomes, I lacked an understanding of how they could help me during patient care. I felt that the data they produced was cumbersome, and the process for the collection of that data was ambiguous. To overcome this barrier, I focused my outcomes collection on only a few injuries that I had determined were weaknesses (e.g., chronic pain) in my clinical practice. This focused approach helped me to

select appropriate outcome measures for those patient populations and develop a systematic plan (i.e., collect outcomes at specified time points, complete hard-copy patient forms, participate in daily reflection) for the implementation of those outcome measures into patient care. Cumulatively, the system allowed me to collect outcomes efficiently and to draw meaningful conclusions from my clinical practice.

CLINICAL DECISION MAKING AND PATIENT-RATED OUTCOMES (PROs) COLLECTIONS

Throughout my time in the DAT program, I was exposed to multiple treatment paradigms and philosophies that were new to me. I discovered that in order for me to understand and effectively execute these new treatments, I needed to focus on only a few paradigms during patient care. From semester to semester, and as my new clinical practice developed, I also had to change the focus of my developmental plan. The majority of my efforts were spent studying, implementing, and reflecting upon the selective functional movement assessment (SFMA), the Mulligan Concept (MC), positional release therapy (PRT), and Total Motion Release® (TMR®).

The SFMA is a movement-based system that is used to assess musculoskeletal pain and dysfunction (Cook, 2010). I found the SFMA to be helpful in identifying factors outside of the painful segments that were causing pain. A diagnostic category within the SFMA is a joint mobility dysfunction (JMD). A JMD is the reduced mobility of articular surfaces and tissues (Cook, 2010). In my clinical practice, I identified ankle and spinal JMDs most frequently. To treat these JMDs and to decrease pain and increase range of motion (ROM), I commonly used the MC mobilizations with movement (MWM) (Mulligan, 2010). In the application of the MC MWM, I provided a sustained joint mobilization while the patient performed active range of motion (AROM) at the joint (Mulligan, 2010).

As my new clinical skills developed, I found that I began to use PRT and TMR® as my primary interventions to treat chronic- and acute-pain patients. These paradigms were influential in developing my ability to differentially diagnose during injury assessment. Positional Release Therapy was designed to eliminate tender points and to address the somatic dysfunction that often develops because of the myotatic reflex arc that occurs post-injury (D'Ambrogio & Roth, 1997). Most frequently, I used PRT to differentiate between inflammation and mechanical stress as well as between muscular strain and spasm. Total Motion Release® was designed to globally assess and treat for neural and/or fascial restrictions in all planes of motion (Dalonzo-Baker, 2012). I found TMR® to be useful when I tried to differentiate between true tissue pathology and fascial and/or neural dysfunction in my patient population.

While my anecdotal evidence provided me with confidence in my new clinical skills, I knew that I would not be able to truly determine the effectiveness of my patient care until I took a systematic approach to assessing my patient outcomes. To accomplish this task, I integrated patient-rated outcomes (PROs) into my clinical practice. Each PRO evaluated a different aspect of the recovery process and provided a multidimensional perspective on patient progress and treatment selection. The PROs that I utilized during my clinical residency were the Numeric Rating Scale (NRS), the Disablement in the Physically Active (DPA) Scale, the Lower Extremity Function Scale (LEFS), the Disabilities of the Arm, Shoulder, and Hand Score (QuickDASH), the Global Rating of Change (GRC), and the Patient-Specific Functional Scale (PSFS).

I selected the NRS because my patients complained, chiefly, of pain, and the scale was designed to measure pain intensity (i.e., average of current, best, and worst pain over one day) (Hawker, Mian, Kendzerska, & French, 2011). The DPA Scale evaluates global factors

(i.e., functional limitations, health-related quality of life) that the patient experiences during recovery (Vela & Denegar, 2010a; Vela & Denegar, 2010b). Because I was trying to implement a more global approach into my patient care, the DPA Scale was an appropriate addition.

The LEFS and QuickDASH are self-reported, region-specific outcome measures. The LEFS was used to evaluate lower extremity activity limitations that result from musculoskeletal injuries (Binkley, Stratford, Lott, & Riddle, 1999). In an effort to effectively identify whether a patient's upper extremity pain and restrictions were improving, I added the QuickDASH to my outcomes collection. The QuickDASH is a self-reported, region-specific tool that assesses the perceived level of disability among patients with arm, shoulder, or hand injuries (Mintken, Glynn, & Cleland, 2009).

I incorporated the GRC scale into my patient care because I wanted to quantify a patient's progress, in regards to treatment effect and injury status, over time. The PRO allowed me to decide whether or not a treatment was addressing a patient's primary concern.

I used the PSFS to assess changes over time in the functional activities (e.g., squatting) that were important to a patient (Horn, Jennings, Richardson, Van Vliet, Hefford, & Abbott, 2012).

DATA ANALYSIS, RESULTS, AND REFLECTIONS

Treating Chronic Pain and Overuse Pathologies

I chose to focus my clinical practice on the treatment of chronic pain, because this condition is prevalent in my practice. Unfortunately, my professional education had not prepared me to effectively understand or treat chronic pain patients. Therefore, when I first began to encounter patients who presented with this condition, I was unable to treat them with any real success. I did, however, suspect that treatments that focused primarily on the painful

segment would not be effective. But I needed to spend time investigating this population in order to learn how to thoroughly assess and correctly identify the factors contributing to their pain.

Throughout my time in the DAT program, I was a participant in multiple discussions that focused on the complexity of chronic pain. I learned that chronic pain cannot be effectively treated using traditional rehabilitation strategies that are focused, primarily, on the painful site and the musculoskeletal system (Grieve & Schultewolter, 2014). Rather, a clinician who treats a chronic pain patient must consider the physiological, psychological, and social factors involved in the condition (Casey, 2014). As I treated chronic pain patients, I discovered that if I wanted to effectively treat all of these factors, I had to evaluate and treat my patients using a holistic perspective.

Fall 1, 2014

During the Fall 2014 semester, I found patient care to be a challenge. Based on the reflection that I had performed during the Summer 2014 semester, I knew that my clinical practice needed to improve, and I felt very uncomfortable and overwhelmed while providing patient care. My lack of confidence affected my ability to perform a thorough assessment. This hesitancy was apparent as I assessed a patient (Patient 1) who had previously been diagnosed with chronic patellar tendinitis. My assessment consisted of a basic history, observation, palpation, and special tests that included an overhead squat assessment (OHSQ). The assessment lacked depth; therefore, developing a treatment plan was a challenge. At that point, patient categorization—specifically, tendon pain categorization (i.e., tendinitis, tendinopathy, tendinosis)—was a concept that was foreign to my clinical practice. I was discouraged by the assessment. In an effort to formulate a treatment plan, I searched for published evidence and found that cross-friction tendon massage and eccentric quadriceps

strengthening were common treatment choices for the condition. I decided to implement these treatments. To track patient progress, I chose the NRS, PSFS, and GRC as my outcome measures, because the scales were easy to implement and were appropriate for my patient.

My poor assessment and treatment plan did not improve the patient's chief complaint (pain during activity) over the course of his sport season (Table 2.1). The patient's case encouraged me to reflect on and identify weaknesses within my assessment process. I realized that I could not successfully eliminate a chronic pain condition by focusing treatment on the painful segment. Instead, a regional interdependence (RI) assessment was needed. However, I had yet to determine what elements composed an RI assessment, and I lacked the skills to perform one. Due to my patient's chronic pain presentation and the lack of an effective diagnosis or treatment, I theorized that the SFMA would help categorize my patient; but I lacked confidence in implementing the assessment into my clinical practice. During the patient case, I discovered that I was a novice at SFMA implementation. In addition, I had not progressed passed my entry-level education regarding the treatment of chronic pain and patellar tendinopathy; however, in order to progress as a clinician, I needed to continue treating the chronic pain population.

Table 2.1: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial PSFS	Discharge PSFS	GRC
1	32	7	7	0

With that mindset, I overtook the care of a chronic Achilles tendinitis patient (Patient 2). The patient had endured Achilles tendon pain for 2 years prior to the point where I began to oversee her care, and she would frequently experience a 6-7/10 for pain on the NRS during activity. She had been diagnosed with Achilles tendinitis and had received ineffective treatment (i.e., Achilles tape, active release therapy, self-myofascial release, heel lifts, and modalities) from a consulting athletic trainer.

I incorporated the SFMA, TMR®, tender point scan, and running gait analysis into the patient's assessment. I found that the patient had an ankle JMD, an asymmetrical seated straight leg raise, a knee-dominant running gait, and tender points within her adductors and gastrocnemius. The thorough assessment helped me to formulate a more effective treatment plan for this patient. However, after 12 treatments, the patient's progress plateaued. Her pain had decreased from a 6-7/10 to a 1-4/10 on the NRS during activity, but she had never achieved pain-free status. In an effort to reflect on and gain insight into her case, I wrote the following blog post:

> *I started reading about the Graston® Technique. I had blogged about my fear of trying the intervention. But then I realized that I honestly did not think her achilles was inflamed. Besides pain, she did not demonstrate the signs and symptoms associated with the inflammatory process. Papa et al., (2012) articulates the pathogenesis of achilles tendinopathy in that the inability of the achilles to fully recover leads to a breakdown of the tendon at the cellular level. The achilles struggles to heal due to a poor blood supply and ongoing breakdown (Papa, 2012). The Graston intervention is utilized to "restart" the inflammatory process within the tendon encouraging fibroblastic activity (Miners & Bougie, 2011).*
>
> *My patient responded favorably to the Graston intervention. I performed Graston two times per week for four weeks. During this time, the patients' warm-up pain decreased from a 5 of 10 to a 3 of 10 during warm-up. She consistently had 0-3 of 10 pain during running. Over the past week, she has had consistent 0 of 10 pain during running and no pain during warm-up.*

Based on the patient's positive response to the instrument-assisted soft-tissue mobilization (I was not certified in the Graston® Technique), I categorized the patient with tendinosis. Within six treatments of IASTM, the patient's pain was eliminated during activity. The process was prolonged (i.e., 18 treatments, total) because of my unfamiliarity with the IASTM intervention and with categorizing tendon pain patients.

Table 2.2: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial LEFS	Discharge LEFS	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
2	18	78%	100%	6/6	10/10	33	16	6

Through reflecting on these patient cases, and, as a result, challenging myself to continue to treat chronic tendon pain, my clinical practice improved. I was reminded that inflammatory signs, which are present in tendinitis patients, accompany inflammation; however, neither of the aforementioned patients (Patient 1, Patient 2) demonstrated inflammatory signs. Prior to my oversight of their care, they had been categorized incorrectly, and I theorized that their treatments had been ineffective, as a result. To further my development in treating chronic pain and overuse pathologies, I set the following goals for the next semester: pursue chronic pain patients, use the SFMA, and categorize patients to help guide treatment.

Spring 1, 2015

During the Spring 2015 semester, I assessed and treated two lower extremity chronic pain patients. The first patient (Patient 3) had chronic bilateral medial tibial stress syndrome (MTSS). I incorporated the SFMA into his assessment and categorized the patient with an ankle JMD. Implementing the SFMA and successfully categorizing a patient was empowering, because the process helped to guide me in making treatment choices for this patient. Based on the JMD categorization, I applied the MC MWM to increase dorsiflexion. In identifying that an ankle JMD could perpetuate MTSS symptoms, I confirmed the value of evaluating beyond the painful segment during an injury assessment. In addition, the patient's assessment findings, as related to joint function, provided validity for the joint-by-joint theory within my clinical practice (Boyle, 2011).

During my assessment of Patient 3, I also identified tender points along the medial tibia and within the gastrocnemius. To address the patient's palpation pain and somatic dysfunction, I applied PRT. In preparation for treating the patient, I studied PRT in more depth and learned that the treatment is theorized to influence the nervous system, which is

valuable when treating chronic pain (D'Ambrogio & Roth, 1997). Prior to working with Patient 3, I had mistakenly categorized PRT as a local treatment and had underestimated its global effect. With the addition of a thorough assessment, patient categorization, and treatment, I successfully eliminated the patient's pain within six treatments and achieved a minimal clinically important difference (MCID) on all PROs (Tables 2.3 and 2.4). The treatment duration was much shorter than that of the lower extremity chronic pain patients (Patient 1 and Patient 2), whom I had treated during the Fall 2014 semester.

Table 2.3: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
3	MC MWM: Ankle Dorsiflexion PRT: Gastrocnemius/Tibialis Posterior	8	4	4

Table 2.4: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial LEFS	Discharge LEFS	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
3	6	63%	*100%	1/1/1	*10/10/9	59	17	*+7

*Note. * = scale achieved an MCID*

My second patient of the Spring 2015 semester (Patient 4) had been diagnosed with chronic bilateral patellar tendinitis and had received ineffective treatments. I approached the patient with a more thorough assessment than had been conducted by her previous clinicians. However, my assessment was chaotic, and it took several treatments to decrease her pain (Tables 2.5 and 2.6). I blogged about the patient, my treatment attempts, and my clinical decision-making process, as follows:

> *<u>First intervention:</u> On observation, the tibial tuberosity was positioned more laterally than the uninjured side. I hypothesized that the pain could be due to a positional fault between the tibia and femur. I decided to have the patient squat. Her squat was DN. She demonstrated prominent external rotation and the foot during the squat. Based on these findings, I decided to perform PRRT to eliminate the tender areas, inhibit the ITB/facilitate medial HS, and perform rotation MWMS at the knee. I could eliminate her pain during the MWM but could not create the PILL effect. I tried several different positions to attain the PILL effect – kneeling vs. squatting, internal and external hip rotation, internal and external tibial rotation, more/less fibular involvement, more/less pressure, positioning my hands more proximal/distal on the*

tib/fib, mobilizing the femur instead of the tibia. I tried the tape application which helped a little at the beginning of practice but would slowly stop working – I have even tried the basic McConnell tape application – the patient does not like how it feels. Outcomes – some days the pain would drop to a 3 of 10 vs. 5 of 10 during activity.

<u>Second intervention</u>: Performed the SFMA. I found JMD of the ipsilateral ankle and internal rotation SMCD of the right shoulder. I also assessed neural tension. The patient demonstrated positive femoral nerve tension. I applied sliders and then progressed to tensioners. Outcomes – same as above. More 5 of 10 days than 3 of 10 days.

<u>Third intervention:</u> Obviously, the patient is experiencing a chronic injury so I decided to try PRRT primals and the plantar reflex in combination with MC PRPS. I can eliminate her pain with PRPS however the pain is only eliminated during the technique and not during activity. Outcomes – same as above.

The patient's case (specifically, the lack of positive outcomes from the treatments I provided) helped me to recognize that if a patient is not making progress, it is because I have not categorized the patient correctly, and/or I am applying the technique that corresponds to that categorization incorrectly. I needed to resist applying multiple interventions; instead, I should have been intentionally reflecting on my assessments. I should have used the SFMA from the beginning and allowed the assessment to guide treatment. My haphazard approach was ineffective.

Upon further reflection, I also realized that I had instructed the patient to perform the neural sliders incorrectly, which may have aggravated her condition. In regards to the MC MWM, I could not achieve the PILL effect (**p**ain free, **i**nstant result, **l**ong **l**asting), which indicates that my execution of the MC MWM was poor (Mulligan, 2010). However, the MC MWM was the only treatment that actually decreased her pain. Because I was completely frustrated and confused by this patient case, I continued to apply the MC MWM with the tape application, since it provided some pain relief (i.e., 5/10 to 3/10 NRS).

Table 2.5: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
4	MC MWM w/ McConnell tape	5	5	5

Table 2.6: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial LEFS	Discharge LEFS	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
4	24	56%	*90%	3/5/5	*9/8/8	42	25	*+5

*Note. * = scale achieved an MCID*

My understanding of tendon pathologies and chronic pain continued to grow throughout my time in the DAT program. During the Spring 2015 semester, my clinical practice was significantly impacted by an upper-extremity chronic-pain patient (Patient 5). As I indicated previously, a majority of my practice has been focused on the lower extremity; however, the upper-extremity patient case is worth mentioning, because of the insight I gained during the care of that patient.

A consulting athletic trainer and physician had originally diagnosed the patient with bilateral rotator cuff tendinitis. The patient's pain had not responded to traditional interventions (i.e., rest and cortisone injection) indicated for inflammation. During my initial assessment of the patient, I identified sympathetic dysfunction (i.e., hyperalgesia and a history of trauma). With light palpation, the patient reported 8/10 pain, bilaterally, on the NRS scale. The patient's hyperalgesia had been triggered by a traumatic event—in this case, the death of a family member. To address the patient's heightened sensitivity to pain, I used Reflexercise® and PRT during treatment. I chose Reflexercise® because the treatment is a sympathetic modulator that is designed to oppose the fight or flight response and eliminate chronic pain (Musgrave & Quinlisk, 2011). I chose to use PRT to down-regulate the nervous system and to localize the patient's pain to the proximal biceps tendon. One application of the treatment decreased her pain from an 8/10 to a 4/10 on the NRS scale (Table 2.7). I eliminated her pain in four treatments and achieved an MCID on all PROs (Table 2.8).

Table 2.7: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
5	Reflexercise®, PRT	8	4	4

Table 2.8: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial QuickDASH	Discharge QuickDASH	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
5	4	93%	*25%	2	*9	42	*22	*+6

*Note. * = scale achieved an MCID*

The Spring 2015 semester brought valuable insights into my clinical practice development. I saw how efficient a thorough assessment was when coupled with appropriate treatment. I also learned more about how the pain response is impacted by the sympathetic nervous system and how trauma on the sympathetic nervous system can be detrimental to the pain response. As I prepared to enter into the Fall 2015 semester and planned to continue treating the chronic lower extremity pain population, I felt more confident than I had during the previous semester.

Fall 2, 2015

As a result of my desire to become more effective at treating tendon pain, I invested time in reading the literature on this topic during Fall 2015. In my study of the literature, I discovered that researchers used terms such as *tendinitis, tendinopathy*, *tendinosis*, and *tendonalgia* in an effort to categorize and treat patients with tendon pain (Baker, Van Riper, Nasypany, & Seegmiller, 2014; Kaux, Forthomme, Le Goff, Crielaard, & Croisier, 2011; and Waugh, 2005). The traditional treatment for these tendon conditions included NSAIDS, rest, cryotherapy, ultrasound therapy, corticosteroid injections, and eccentric exercise (Andres & Murrell, 2008; Cook & Purdam, 2009; Kaux et al., 2011; Maffulli, Longo, Loppini, & Denaro, 2010). The efficacy of these traditional interventions is questionable, because the elimination of symptoms may take 4 to 12 weeks of therapy (Andres & Murrell, 2008; Cook & Purdam, 2009; Kaux et al., 2011; Maffulli et al., 2010).

During the Fall 2015 semester, I treated three patients (Patient 6, Patient 7, Patient 8) with chronic knee tendinopathy (Tables 2.9 and 2.10). Prior to the point where I began to

oversee their care, the patients received treatments to eliminate apparent inflammation but experienced no change in their symptoms. However, I observed that the patients did not demonstrate signs of inflammation; therefore, I did not classify them as having tendonitis. During each patient evaluation, I used the SFMA, breathing pattern dysfunction assessment, and nerve tests to determine my plan of action (Butler, 2005; Chaitow, 2014; Cook, 2010).

The patients were diagnosed with spinal JMD, lower extremity stability motor-control dysfunction (SMCD), and breathing-pattern dysfunction. In an effort to eliminate the JMD, I focused my treatments on the lumbar spine. During the multi-segmental flexion assessment, each patient demonstrated a flat lumbar spine and an inability to touch their toes. Because the lumbar nerves innervate the musculature and tendons surrounding the knee, interventions to address the lumbar spine dysfunction were indicated. The reactive neuromuscular training (RNT) intervention was effective at eliminating the SMCD that was demonstrated as the patients performed single- and double-leg squats.

A major component of my success with these patients was my awareness of their breathing pattern dysfunctions. At this point in my studies for my doctoral degree, I had studied sympathetic dysfunction and understood the reaction of the respiratory muscles during the stress response (Berceli, 2005; Berceli & Napoli, 2006). I also knew the diaphragm's role within stabilization, movement, and pain development (Hodges, Holm, Holm, Ekström, Cresswell, Hansson, & Thorstensson, 2003; Perri & Halford, 2004). I made efforts to correct my patients' breathing pattern dysfunctions prior to applying other interventions. In my clinical experience, I found interventions to be less effective if I did not address the breathing pattern dysfunction first.

During the Fall 2015 semester, I felt confident enough in my knowledge of tendon pain to categorize each patient (Patient 6, Patient 7, Patient 8) after the first day of treatment.

Based on the treatment effects, I categorized each patient with tendonalgia. The tendonalgia diagnosis encompasses the multi-factorial nature of tendon pain and highlights the complexity of the condition (Waugh, 2005). One factor that perpetuated the tendon pain of my patient population (Patient 6, Patient 7, Patient 8) was dysfunction in the core and hip musculature.

Within five treatments, I achieved an MCID on most PROs and eliminated my patients' chief complaint (i.e., pain during activity) (Table 2.10). The outcomes from my tendonalgia patient population were significantly different from the published outcomes for the condition (Andres & Murrell, 2008; Cook & Purdam, 2009; Kaux et al., 2011; Maffulli et al., 2010); however, my outcomes indicate that the treatment selection had been appropriate and directed at the source of the problem.

Table 2.9: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
6	MC Lumbar SNAG, PRRT (diaphragm), RNT	4	2	2
7	MC Lumbar SNAG, PRRT (diaphragm), RNT	5	2	0
8	PRT, PRRT (diaphragm), RNT	6	3	1

Table 2.10: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial LEFS	Discharge LEFS	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
6	5	73%	100%	8/5/6	*10/10/10	12	10	*5
7	5	66%	100%	8/7	9/9	27	*15	*4
8	4	68%	100%	5	*10	36	*13	*6

*Note. * = scale achieved an MCID*

From the Fall 2014 semester to the Fall 2015 semester, I made huge strides in my clinical practice in regards to the categorization and treatment of chronic pain and overuse pathologies. During that time, I identified a variety of outcome measures that helped me to evaluate my patients' progress in multiple areas of their recovery processes. I also found patient categorization and global assessments to be assets to my evaluation and treatment methods. Most importantly, I learned to be aware of and to assess sympathetic dysfunction in chronic pain patients. My exposure to these patients kickstarted the development of my

chronic lower extremity pain philosophy. For the remainder of my professional career, I will continue to pursue expertise in chronic lower extremity pain and will work to strengthen my philosophy in this area.

Treating Acute Lower Extremity Pain

Another focus area in my clinical residency was treating acute lower extremity injuries. By reflecting on my clinical practice, I discovered that acute and chronic pain responded favorably to the PRT intervention. By late in the Fall 2014 semester, I had begun experimenting with PRT and had started palpating for tender points as a regular part of my patient assessments. Positional Release Therapy brought me an awareness of the prevalence of post-injury tender points in my patient population. To share the success I experienced incorporating PRT into my patient care, I blogged about PRT and its initial impact on my clinical practice:

> *I took on the PRT challenge this week after Monday night's class. I have been providing trigger point release via ischemic compression resulting in good patient outcomes (decreasing pain). Using ischemic compression was not a method I used much before the DAT. I was excited to use the method after reading the Travell and Simons text (Myofasical Pain and Dysfunction – The Trigger Point Manual) regarding the technique. I have also been encouraged by a colleague of mine who worked in a PT clinic that religiously utilized ischemic compression during patient care.*
>
> *I think in the beginning when I returned from Idaho to start patient care and collect outcomes, I was intimidated and a bit overwhelmed striving to find my "system"…new evaluation method and perspective + new treatment paradigms + collecting patient outcomes. I did try PRT in the beginning, but felt I was sometimes flustered and with limited time – I wasn't patient enough and probably not mindful enough (stress!!) to apply PRT effectively. Now that I have established more of a system, I thought I would try it again.*
>
> *For lack of a better phrase – PRT has been money! :) I've had a lot of success with PRT this week on the hamstrings, adductors, glute and gastroc. I have felt fasciculations and heat release from the tender points. As I reflect, I'm thinking, "this is pain free for the patient and my hands don't ache when I'm done…win win." My goal now is to compare ischemic compression and PRT methods.*
>
> *For my chronic pain patients – could the utilization of the ischemic compression (inducing pain) possibly "feed" the central sensitization dysfunction that my patients are already struggling with?? I'm assuming the pain free PRT method would be better and more appropriate for my chronic pain patients. Just a thought.*

Over time, PRT became a valuable asset to my clinical practice as I sought to improve my ability to differentially diagnose.

Fall 1, 2014

My first experience using PRT to help guide my differential diagnosis was with a patient (Patient 9) who had previously been diagnosed with plantar fasciitis. Traditional interventions (i.e., therapeutic ultrasound and rest) to combat the inflammatory response had failed to eliminate his pain. During my assessment of the patient, I used PRT to differentiate between inflammation and pain due to mechanical stress. The patient had point tenderness on the medial calcaneal tubercle, but no inflammatory signs. During the evaluation, I placed the patient's foot in a position of ease for approximately 90 seconds, which eliminated his point tenderness. At that point, I hypothesized that the pain was due to the patient's restricted subtalar/talocrural joint accessory motion, which was causing the plantar fascia to be mechanically stressed during gait.

My success eliminating this patient's point tenderness was a significant moment in my clinical practice. First, I realized that an intervention could be used during the assessment process to guide treatment (i.e., treatment-based classification). Second, I was reminded that pain and inflammation are not synonymous. Over the course of two treatments, I eliminated the patient's chief complaint (i.e., pain during activity) and achieved an MCID on all PROs (Tables 2.11 and 2.12). Based on my successful outcomes, I submitted the case study for publication. It is also presented in Chapter 2 of this DoCPI.

Table 2.11: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
9	PRT and Joint Mobilizations	4	2	2

Table 2.12: Global Outcomes – Initial and Discharge

Patient	Treatments	Initial LEFS	Discharge LEFS	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
9	2	86%	90%	6	9	21	*10	+4

My success with the plantar fascia-pain patient encouraged me to apply PRT to patients who presented with apparent muscular strain. As had been the case with the plantar fascia patient, many of the muscular strain patients presented with somatic dysfunction (i.e., trigger points, muscle spasm, and decreased ROM and strength), which is an indication for PRT (D'Ambrogio & Roth, 1997). During Fall 2014, the first patient (Patient 10) upon whom I applied PRT to eliminate muscular pain had been categorized with an acute hamstring strain. While sprinting, the patient had felt a sharp pain in his proximal hamstring. He immediately stopped activity and sought treatment. During my evaluation of the patient, he demonstrated 4 out of 5 strength (hamstrings and gluteals) and no signs of inflammation or deformity. My hypothesis was that the patient's muscle was not strained, but in spasm. I eliminated his palpation and activity-related pain with one PRT treatment (Table 2.13).

As I applied PRT to my patient population, I identified that diffuse pain would often localize, post-application. I hypothesized that this localizing effect was due to the impact of PRT on the facilitated nerve segments that occur post-injury (D'Ambrogio & Roth, 1997). As I prepared to begin the Spring 2015 semester, I continued to develop my apparent muscular strain philosophy and pursue acute lower extremity conditions.

Table 2.13: Initial "Change in Pain" – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
10	PRT	6	0	0

Spring 1, 2015

During the Spring 2015 semester, I successfully treated five patients with acute lower extremity muscular strain (three hamstrings, two quadriceps) (Table 2.14). Three of the patients (Patient 11, Patient 12, Patient 13) responded favorably to one PRT application. The application of PRT, however, only eliminated the palpation pain (and not the activity-related pain) of two of the patients (Patient 14 and Patient 15). I hypothesized that neural or fascial

restrictions could be causing these two patients' remaining pain. Because TMR® was created to eliminate movement asymmetries in all planes of motion (Gamma, Baker, Iorio, Nasypany, & Seegmiller, 2014), I chose to incorporate TMR® as an adjunct therapy to treat the patients. I used the Fab 6 assessment and Grades 1-2 of the TMR® system to eliminate the patients' pain within four treatments and to achieve an MCID on all PROs (Table 2.15). This discovery—that TMR® could effectively treat two of my patients' more complex conditions (Table 2.15)—was valuable information that I incorporated into my muscular strain philosophy. However, later in the Spring 2015 semester while treating muscular strain patients, I discovered that the PRT/TMR® combination was not effective for every muscular strain case, and I could not depend on a prefabricated treatment plan. I needed to continue to study, critically reflect on my practice, and develop my assessment process.

Table 2.14: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
11	PRT	6	0	0
12	PRT	6	0	0
13	PRT	7	0	0
14	PRT	6	2	2
15	PRT	7	3	3

Table 2.15: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial LEFS	Discharge LEFS	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
14	**4	74%	*95%	5/7/7	*10/9/10	28	*12	*+7
15	**4	74%	*91%	4/3/5	*8/9/10	33	*14	*+6

*Note. * = scale achieved an MCID*
*Note. **Day 1 = PRT, Days 2-4 = TMR*

Fall 2, 2015

During the Fall 2015 semester, I discovered additional factors that could be causing the muscle strain sensation in my patient population. Previously, I had discovered that PRT could be used to differentially diagnose between muscular strain and spasm. I had also discovered that I could effectively eliminate activity-related pain and restriction using the TMR® assessment and treatment. When my patients did not respond to the aforementioned

treatments, I discovered that neural tension and positional faults could also perpetuate the strain sensation.

I successfully treated six patients (Patient 16 – Patient 21) with acute lower extremity muscular strain (one hamstring, two groin, three quadriceps) during the Fall 2015 semester (Table 2.16). I used one application of PRT to eliminate pain in three of the patients (Patient 16, Patient 17, and Patient 18), one application of NDS to eliminate pain in two of the patients (Patient 19 and Patient 20), and one application of MC MWM to eliminate pain in one of the patients (Patient 21).

The neural tension sensation has often been misinterpreted as muscular tightness, pain, or restriction in my patient population. I found that patients complained of muscular strain symptoms, but did not exhibit inflammatory signs or palpation pain. This presentation was a unique addition to my patient care. My exposure to NDS helped me to realize that the sensation that my patients were feeling may have been neural tension. I successfully used femoral nerve sliders to treat two of my patients (Patient 19 and Patient 20) who presented with apparent quadriceps strains (Table 2.16).

The last patient (Patient 21) whom I treated for acute muscular pain had been categorized with an acute hamstring strain. He presented with activity-related distal biceps tendon-pain after he planted his foot and rotated at the knee during a football game. Based on my clinical experience, I have come to realize that patients rarely present with strained distal muscle tendons; rather, they present with strained muscle bellies. During my assessment of this patient, he exhibited 4 out of 5 strength of the hamstrings, negative ligamentous tests, negative nerve tests, no palpation pain, and no inflammatory signs or deformity. Upon reflecting on his mechanism of injury, I hypothesized that a positional fault had occurred between the tibia and femur, placing mechanical stress on the biceps tendon. I applied an

external rotation MC MWM on the tibia and fibula while the patient performed his offending motion (i.e., squat). Through this treatment, I was able to eliminate the patient's pain (Table 2.16).

Table 2.16: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
16	PRT	5	0	0
17	PRT	6	0	0
18	PRT	6	0	0
19	NDS	4	0	0
20	NDS	5	0	0
21	MC MWM	6	0	0

The time spent critically reflecting on, assessing, and treating acute lower extremity injuries was valuable to me, because the injury is common and had previously been a weakness in my clinical practice. Providing care for the acute lower extremity pain population helped me to identify the robust effects of PRT, the value of treatment-based classification (TBC), and the numerous factors that can cause the strain sensation. I learned to use my clinical experience when treating the acute lower extremity pain population; but I also learned to be open-minded and unattached to interventions that had worked for me previously. Overall, I learned to be consistent and thorough during patient assessments and to use TBC to guide patient treatments.

Treating Acute Shoulder Pain

Prior to my enrollment in the DAT program, I lacked confidence in assessing and treating shoulder pain patients. I was intimidated by the intricacies of multi-joint kinematics and by the amount of musculature that surrounded the area. In my clinical practice, I had avoided shoulder patients; therefore, I had not developed a sound clinical decision-making process as I approached the population. I was dependent on orthopedic special tests to help formulate a diagnosis. However, based on my evaluation, outside of possible tissue pathology, the tests did not provide enough information to assist in categorizing the patient.

As I progressed clinically in the DAT program, TBC became invaluable to my assessment process. For example, to guide me in selecting treatments for patients, I often incorporated TMR® into my assessments. Over the course of three semesters, I identified a trend among shoulder pain patients that included a presentation of pain and decreased ROM without underlying tissue pathology. Prior to entering the DAT program, I did not know how to treat this type of patient. My exam would have indicated that these patients were orthopedically intact even if the patient complained of pain and/or dysfunction. Since that time, I have discovered that both neural and fascial dysfunctions can perpetuate pain and decreased ROM. In my entry-level education, I had not learned to identify these dysfunctions; therefore, this realization had a valuable impact on my clinical practice.

Fall 1, 2014

The mentoring I received while in the DAT program encouraged me to start viewing pain differently. First, I began to mentally separate pain from inflammation during patient care. The realization that pain and inflammation are not synonymous completely changed my assessment process. During each semester of my clinical residency, I discovered multiple factors (e.g., neural tension) that caused pain in my patient population. Prior to my enrollment in the DAT program, I had been unaware of these factors and had generally treated patients under the assumption that inflammation was the primary cause of their pain. Second, I began to identify how pain could negatively affect the neuromuscular system and lead to a presentation of apparent weaknesses versus true weakness in my patient population. This new way of viewing pain led me to successfully treat my first shoulder pain patient (Patient 22) in three treatments (Tables 2.17 and 2.18).

The patient presented with an apparent rotator cuff strain. During his assessment, he exhibited no inflammatory signs, 3/10 pain (posterior scapula) during activity on NRS, 4 out

of 5 strength of the rotator cuff, decreased ROM in flexion/abduction, and a tender point located inferior to the lateral scapular spine. The information I obtained from the orthopedic special tests was suspect, due to the patient's restricted ROM and pain. However, his mechanism of injury (i.e., the patient had hit the ground with the shoulder in full flexion), led me to hypothesize that his shoulder structures were intact. To help me identify the factors causing his chief complaints (i.e., pain and decreased ROM), I incorporated the TMR® Fab 6 assessment, which determined asymmetries in the arm-raise and push-up. With one TMR® treatment, I eliminated his ROM deficit and decreased much of his pain (Table 2.17). To eliminate the remainder of his pain, I treated him for two additional days and included PRT and dynamic neuromuscular stabilization in my treatments (Table 2.18).

Upon reflection, I did not use the TMR® system correctly. Because I had success with the intervention, I should have continued progressing my patient through the TMR® grades; however, I stopped after one treatment. Although I still needed to improve the manner in which I used the TMR® system, I submitted the clinical case to the American College of Sports Medicine (ACSM) and presented at their annual meeting in June of 2015. The patient case impacted my clinical practice in multiple ways: First, I applied TMR® during patient care and produced good outcomes; second, I learned to use TMR® as a complete system; third, I began developing my shoulder pain philosophy; and fourth, I had the opportunity to present at a national conference. My experience provides an example of how the DAT faculty encourage their students' professional development while guiding them to become clinical scholars.

Table 2.17: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
22	TMR®	3	1	1

Table 2.18: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
22	***3	5/6/6	*10/9/9	16	*1	*+5

Note. * = scale achieved an MCID
*Note. **Day 1 = TMR®, Day 2-3 = PRT and DNS*

Spring 1, 2015

My goal for the Spring 2015 semester was, in accordance with Tom Dalonzo-Baker's suggestion (Dalonzo-Baker, 2012), to use TMR® as a complete system and to progress each of my patients through Grade 4 of the system, at the very least. One advantage of TMR® is that the system is presented as a home exercise program in which the patient is educated on how to perform self-treatment. I considered this an advantage because in fall of 2014, while studying chronic pain, I learned that I could enhance my patients' recovery if I gave them more control over the recovery process. I hypothesized that my acute pain patients may also respond favorably to self-treatment. Providing a TMR® self-treatment plan was a new addition to my clinical practice, but it proved to be a valuable addition. Over the course of the semester, three of my patients (Patient 23, Patient 24, Patient 25), each of whom played softball, added the TMR® intervention to their warm-up routines.

I learned how to hold my patients accountable for their individual self-treatment plans by establishing a system in which the instruction of the new TMR® grade would occur on Mondays, after practice. The TMR® exercises were performed in the clinic so I could provide feedback and document outcomes. With one application of TMR®, all patients reported an improvement in their quality of motion during pitching (Tables 2.19 and 2.20). The patients also reported less frequent sensations of soreness and tightness throughout their season.

Table 2.19: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
23	TMR®	4	*2	2
24	TMR®	6	*2	2
25	TMR®	3	*0	0

Table 2.20: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Initial QuickDASH	Discharge QuickDASH	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
23	3	37%	*17%	6/7	10/10	32	*15	*+6
24	3	45%	*15%	8/7	10/10	28	*12	*+5
25	1	41%	*13%	7/8	10/10	36	*14	*+7

*Note. * = scale achieved an MCID*

Fall 2, 2015

During the Fall 2015 semester, I was able to apply what I learned from the previous semesters to better implement TMR® into the treatment of my shoulder pain population. On two separate occasions, two patients (Patient 26 and Patient 27) reported to the sports medicine clinic exhibiting signs and symptoms that were similar to the shoulder pain patient (Patient 22) whom I had treated during the Fall 2014 semester: rotator cuff pain and decreased ROM. The two new patients were orthopedically sound, otherwise (i.e., the shoulder structures were intact). The first patient (Patient 26) presented with bilateral shoulder pain and decreased ROM. Because the patient had bilateral dysfunction, my approach was different than it had been during previous patient cases. I instructed this patient to focus on trunk and lower extremity asymmetries and to stay away from the painful upper extremity segments. His chief complaints were eliminated in five treatments, and we progressed through Grade 2 (Table 2.22). This successful outcome helped me to convince the patient to continue to progress through Grade 4 as part of his daily warm-up. The second patient (Patient 27) exhibited unilateral pain, and his symptoms were eliminated after the first TMR® treatment (Table 2.21). Although the patient was non-compliant in continuing his TMR® progression to Grade 4, his symptoms did not return for the remainder of the season.

Table 2.21: Initial "Change in Pain" NRS – Day 1

Patient	Treatment	Pre-Treatment	Post-Treatment	24-Hour Follow-up
26	TMR® Fab 6	6	3	3
27	TMR® Fab 6	5	0	0

Table 2.22: Global Outcomes Collection – Initial and Discharge

Patient	Treatments	Intial QuickDASH	Discharge QuickDASH	Initial PSFS	Discharge PSFS	Initial DPA	Discharge DPA	GRC
26	5	65%	*17%	5/5/5	*10/10/10	36	*10	*+6

*Note. * = scale achieved an MCID*

Prior to my enrollment in the DAT program, I lacked experience assessing and treating patients who presented with shoulder pain. Treating and reflecting upon the acute shoulder pain population helped to strengthen this particular area of weakness in my clinical practice. In an effort to develop my shoulder pain philosophy, I incorporated TMR® into my assessment and learned how to differentially diagnose. I also identified a particular trend among shoulder pain patients in which there is a consistent presentation of neural inhibition and fascial restriction. The successful outcomes I produced encouraged my efforts to pursue the population and to continue to develop my acute shoulder pain philosophy.

FINAL REFLECTION AND IMPACT OF RESIDENCY

The DAT program was my first experience with examining my clinical practice. Each semester included a process wherein success, failure, and reflection contributed to the overall development of my new patient care philosophies and to the advancement of my clinical practice. Exposure to multiple new treatment paradigms and expert viewpoints changed my perspective toward pain and toward injury assessment, and critical reflection and outcomes collection helped me to identify and overcome weaknesses in my patient care.

In writing Chapter 3, I have become acutely aware of the growth that has occurred in my clinical practice and the impact I have made on my residency site. First, as I collected outcomes and reflected upon specific injury populations (e.g., acute shoulder pain), I developed new insights regarding patient treatment. When I reflected on my clinical experience prior to my time in the DAT program, I realized that I had failed to effectively assess and treat certain patient presentations (e.g., acute shoulder pain). Treating multiple patients with similar pathologies while enrolled in the DAT program has helped me to

identify injury patterns (e.g., movement dysfunctions), which has contributed to the development of my clinical decision-making process. Second, outcome measures collection has made me more accountable when identifying and addressing weaknesses within my clinical practice. Becoming aware of my weaknesses (e.g., clinical decision making) has provided me with the opportunity to pursue continuing education and mentorship in these areas. Third, outcomes collection and the generation of evidence has given me an opportunity for scholarship development that is meaningful to the athletic training (AT) profession as a whole. Within Chapter 3, I provided two case studies from my patient care that developed into scholarship (Patient 9 and Patient 22). Throughout my professional career, I will have the opportunity to continue this line of research. Fourth, examining my clinical practice and developing as a clinician has impacted my role as a graduate AT faculty member. Because of the professional growth I have experienced while developing the DoCPI, I can now prepare my AT students for their professional careers and encourage their clinical practice development. The knowledge I have gained while in the DAT program will be integrated into the graduate AT courses that I teach and the manner in which I prepare my students. In addition, the mentoring I received from the DAT faculty regarding AT education (e.g., evidence-based practice, practiced-based evidence, patient-centered care) can be integrated into the curriculum as I help to develop the graduate AT program.

Upon reflection, critically evaluating my practice has impacted my role as a clinician and graduate AT faculty member. Outcomes collection and critical reflection has allowed and will continue to allow me to generate evidence that leads to scholarship development. Throughout Chapter 3, I highlighted the insights that developed as I assessed, treated, and reflected upon specific populations that I had previously considered to be “weaknesses” in my clinical practice. Overall, examining my clinical practice provided me with the opportunity to

progress past my entry-level education, overcome my clinical weaknesses, and develop patient care philosophies and skills within my clinical practice. Ultimately, it will lead me to developing advanced practice in AT. This professional transformation will allow me to positively impact my residency site (i.e., AT program, students, patients) and thrive as a clinician for the remainder of my professional career.

Table 2.23: Fall 2014 Global Outcomes Collection

Patient	Tx. #	Location	NRS Pre	NRS Post	DPA Pre	DPA Post	GRC	Intervention	Outcome
1	32	Knee	7	7	N/A	N/A	0	Massage, quadriceps strengthening	Negative
2	18	Ankle	6	0	33	16	+6	PRT, IASTM, MC	Positive
9	2	Foot	4	0	21	10	+4	PRT, MC	Positive
10	1	Thigh	6	0	N/A	N/A	N/A	PRT	Positive
22	3	Shoulder	3	0	16	1	+5	TMR®, PRT, DNS	Positive

Table 2.24: Spring 2015 Global Outcomes Collection

Patient	Tx. #	Location	NRS Pre	NRS Post	DPA Pre	DPA Post	GRC	Intervention	Outcome
3	6	Lower Leg	8	0	59	17	+7	PRT, MC MWM	Positive
4	24	Knee	5	2	42	25	+5	MC MWM	Negative
5	4	Shoulder	8	0	42	22	+6	Reflexercise®, PRT, RNT	Positive
11	1	Thigh	6	0	N/A	N/A	N/A	PRT	Positive
12	1	Thigh	6	0	N/A	N/A	N/A	PRT	Positive
13	1	Thigh	7	0	N/A	N/A	N/A	PRT	Positive
14	4	Thigh	6	0	28	12	+7	PRT, TMR®	Positive
15	4	Thigh	7	0	33	14	+6	PRT, TMR®	Positive
23	3	Shoulder	4	0	32	15	+6	TMR®	Positive
24	3	Shoulder	6	0	28	12	+5	TMR®	Positive
25	1	Shoulder	3	0	36	14	+7	TMR®	Positive

Table 2.25: Fall 2015 Global Outcomes Collections

Patient	Tx. #	Location	NRS Pre	NRS Post	DPA Pre	DPA Post	GRC	Intervention	Outcome
6	5	Knee	4	0	12	10	+5	MC SNAG, PRRT, RNT	Positive
7	5	Knee	5	0	27	15	+4	MC SNAG, PRRT, RNT	Positive
8	4	Knee	6	0	36	13	+6	PRT, PRRT, RNT	Positive
16	1	Thigh	5	0	N/A	N/A	N/A	PRT	Positive
17	1	Thigh	6	0	N/A	N/A	N/A	PRT	Positive
18	1	Thigh	6	0	N/A	N/A	N/A	PRT	Positive
19	1	Hip	4	0	N/A	N/A	N/A	NDS	Positive
20	1	Hip	5	0	N/A	N/A	N/A	NDS	Positive
21	1	Thigh	6	0	N/A	N/A	N/A	MC MWM	Positive
26	5	Shoulder	6	0	36	10	+6	TMR®	Positive
27	1	Shoulder	5	0	N/A	N/A	N/A	TMR®	Positive

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CHAPTER 4

CHANGES IN HAMSTRING RANGE OF MOTION FOLLOWING PROPRIOCEPTIVE NEUROMUSCULAR FACILIATION STRETCHING COMPARED WITH STATIC STRETCHING: A CRITICALLY APPRAISED TOPIC

CLINICAL SCENARIO

Stretching is commonly used in the medical, health, and fitness fields, as well as in school and military settings to increase flexibility and range of motion (ROM) at various joints.[1-3] Static stretching has been used for many years and requires the individual to lengthen the muscle to end range and hold this position for varying amounts of time.[4-6] Numerous studies have been performed to understand appropriate stretch duration; however, treatment application varies between five to 60 seconds.[4,7-9] Proprioceptive neuromuscular facilitation (PNF) stretching is another type of stretching used frequently to increase ROM.[5,10] A combination of contraction and relaxation of either agonist or antagonist muscles is used during PNF stretching.[5,6,10,11] Although both static and PNF stretching techniques have been touted as effective, there remains a need to identify whether one method is more effective than the other when focusing on the hamstrings musculature.

Several researchers have performed comparison studies to determine the most effective stretching technique and protocol for increasing ROM measures. A previous systematic review of PNF was performed to complete general comparisons for PNF and static stretch techniques for range of motion gains. The previous systematic review was published in 2006, and included studies that were not exclusive to hamstring ROM.[12] Therefore, there was a need to critically appraise the literature regarding the effects of PNF and static stretching on hamstring ROM. Critically appraising the efficacy of static versus PNF stretching in

individuals with tight hamstrings may offer important insight into use of these techniques in clinical practice when treating individuals presenting with tight hamstrings.

FOCUSED CLINICAL QUESTION

In individuals with hamstring tightness, what is the effect of using PNF stretching compared to static stretching on traditional measures of hamstring ROM?

SEARCH STRATEGY

A computerized search was completed in April 2015 (Figure 3.1).

Terms Used to Guide Search Strategy

- **P**atient/ Client group: Healthy adults with or without hamstring tightness
- **I**ntervention/Assessment: PNF OR proprioceptive neuromuscular facilitation
- **C**omparison: static stretching
- **O**utcome: flexibility OR range of motion

Sources of Evidence Searched

- CINAHL Plus
- Health Source
- SPORTDiscus
- PubMed Central
- Additional references obtained via reference list review and hand search

Inclusion Criteria

- Limited to studies that compared PNF stretching to static stretching
- Limited to studies that included individuals classified with tight hamstrings but absent of any additional pathology. Tight hamstrings are defined as 20° from vertical on the knee extension angle (KEA)[5] or active knee extension (AKE)[6,10] measurement with the hip at 90° of flexion.

- Limited to articles written in the English language
- Limited to articles written in the last 10 years (2005-2015)
- Limited to Level 4 evidence or higher

Exclusion Criteria

- Studies that used minors as participants
- Studies that used an injured population as participants
- Studies that did not compare PNF stretching to static stretching
- Studies that did not include pre- and post-treatment mean ROM outcomes

EVIDENCE QUALITY ASSESSMENT

Validity of the selected studies was assessed using the Physiotherapy Evidence Database (PEDro) scale (Table 3.2). The three included articles were identified on the PEDro website with accepted and approved scores; these scores were utilized in this critically appraised topic (CAT).[13]

RESULTS OF SEARCH

Three relevant studies were located using the search terms identified in the *Search Strategy* section. As described in Table 3.1, the studies selected for inclusion in this CAT were identified as the best evidence. The authors of these Level 2 studies considered the effects of static stretching in comparison to PNF stretching on traditional measures of ROM in individuals classified with hamstring tightness.

Summary of Search, Best Evidence Appraised, and Key Findings

- The literature search identified 202 studies; two randomized controlled trials (RCT) and one comparative crossover study met the inclusion and exclusion criteria (Table 3.1).

- In all of the studies that met inclusion and exclusion criteria, PNF stretching was compared to static stretching, with hamstring range of motion measurements as a primary outcome measure. In one study, an additional comparison was made to active self-stretch.[5]
- In the three studies that met inclusion/exclusion criteria, hamstring tightness was determined by the AKE [6,10] or KEA.[5] Tight hamstrings are defined as 20° from vertical on the KEA[5] or AKE[6,10] measurement with the hip at 90° of flexion.
- In all three studies, ROM measurements were taken with the participants in supine with the contralateral limb secured to the table with Velcro straps. The involved limb was placed in a 90° of hip and knee flexion. The participants actively extend the knee[5, 10] or an examiner passively extended the knee to record the measurement.[6] The AKE[6,10] or KEA[5] measurements were recorded using a digital inclinometer[5,6] or a manual protractor.[10]
- The PEDro scores were obtained from the Physiotherapy Evidence Database. Although the studies selected for inclusion in this CAT were identified as the best evidence, the average PEDro score for included articles was 4.33/10 which indicates low-quality evidence.
- Of the articles included, the authors of two studies[6,10] indicated that both PNF and static stretching resulted in significant gains on the AKE[6,10] with no significant difference between techniques; however, the authors of one study[5] reported that static stretching was more effective. The best evidence for stretching techniques to increase ROM in individuals with tight hamstrings remains inconclusive.

RESULTS OF THE EVIDENCE QUALITY ASSESSMENT

As indicated previously, the PEDro scores provided guidance in determining the validity of each article. Evaluating the articles based on the PEDro criteria indicated lower validity with scores of three[5] and five.[6,10] Areas such as eligibility criteria,[5,10] concealing allocation of subjects,[5,6] blinding (subjects/therapists),[5,6,10] follow-up,[5,6,10] and an intent to treat analysis[5,6,10] were non-existent in the majority of the articles leading to the lower PEDro scores (Table 3.2).

CLINICAL BOTTOM LINE

For individuals with hamstring tightness, there is low quality evidence to suggest either PNF or static stretching are more effective at increasing ROM. The effectiveness of PNF stretching compared to static stretching is inconclusive. Researchers in one[5] of the three included studies found that static stretching was more effective than PNF stretching, while the other two groups of researchers determined that both methods were equally effective at increasing ROM measures in healthy individuals with tight hamstrings.

Strength of Recommendation

Grade D evidence exists that PNF stretching performs as well as static stretching at increasing measures of hamstring ROM in individuals with limited hamstring flexibility. The Oxford Center for Evidence-Based Medicine recommends a grade of D for troubling inconsistent or inconclusive studies as found within this CAT.[14]

IMPLICATIONS FOR PRACTICE, EDUCATION, AND FUTURE RESEARCH

In the appraisal of the three included studies in this CAT, Davis et al.[5] found static stretching to be more effective at increasing KEA measurements than PNF-R (i.e., agonist contraction) and active self-stretch. The researchers attributed the superior ROM gains of the static stretch intervention to the facilitation of the GTO during the static stretch, whereas the active contraction of the agonist muscle during the PNF-R stretch may facilitate the hamstring

muscles, limiting the muscles' ability to relax and elongate.[5,12] In contrast, Lim et al.[10] found both static stretch and PNF hold-relax technique to be effective at increasing AKE measurements acutely; however, no significant difference was found between the stretching techniques. These outcomes were comparable to Puentedura et al.[6] who compared similar stretch interventions.

The lack of significant findings between interventions could be attributed to the variance in methodology for both the static stretch and PNF stretching interventions. First, for the static stretch intervention, Lim et al.[10] and Puentedura et al.[6] performed a single treatment session consisting of one[10] or two[6] sets of 30 second stretches. Davis et al.[5] utilized two sets of 30 seconds performed three times per week for a duration of four weeks. Davis et al.[5] asserted that significant hamstring length cannot be achieved utilizing a protocol that includes a duration of less than two weeks and a 30 second stretch intervention. Other researchers have supported this theory by suggesting that a single, same-day series of an acute static stretch intervention will produce only transient ROM gains.[15-18]

Due to the lack of consistent methodology and results within the static stretching literature, comparison between the studies is difficult and clinical relevance of the results is questionable. Davis et al.[5] applied a passive straight leg raise (PSLR) to the point of a strong, but tolerable stretch sensation for the subject. Similarly, Lim et al.[10] also applied a PSLR; however, the stretch was applied to the point of light tolerable pain for the subject. Puentedura's et al.[6] methods were significantly different as they included a warm-up and may lack clinical relevance due to the inclusion of a pulley system that applied an arbitrarily chosen amount of torque to provide the passive stretch.

The lack of significant findings between interventions may also be attributed to the variance in methodology for the PNF stretching technique. Davis et al.[5] utilized an agonist

contraction method for PNF stretching that involved a single 10 second active concentric contraction of the quadriceps muscle followed by a 30 second static stretch hold. In contrast, Lim et al.[10] incorporated a PNF hold-relax technique where subjects isometrically contracted their hamstrings against resistance for six seconds followed by a five second relaxation period, for a total of three sets.[10] Additionally, Puentedura et al.[6] also utilized the PNF hold-relax technique with a 10 second isometric contraction followed by a 10 second passive stretch for four total sets.

Based on the appraisal of the available evidence and identifying inconsistent stretch intervention methodology, determining a superior stretch intervention when comparing static to PNF stretching cannot be accurately accomplished based on the current literature. A comparison of the studies is difficult due to methodological differences. Additional high quality studies with standardized PNF and static stretching protocols are needed to determine the most effective stretching intervention. Further, if researchers are hoping to impact clinical practice and determine most effective stretching interventions that will translate to individual care, the application of the techniques that can be used within a clinic should be considered when determining methodology.

Based on the findings of the researchers, it appears that clinicians may utilize either static stretching or PNF stretching to achieve acute modest gains in range of motion; however, more high-quality research must be performed utilizing consistent methodology to determine the clinical efficacy of each stretching intervention. Additionally, both PNF and static stretching techniques should be compared to other techniques aimed at increasing ROM to determine the most effective intervention for clinical practice. Future studies should be focused on identifying the most effective stretching protocol for increasing ROM, both short and long term, using a high quality blinded randomized control trial. The current CAT should

be reviewed in two years to identify whether additional evidence exists that may alter the clinical bottom line of this clinical question.

FIGURES AND TABLES

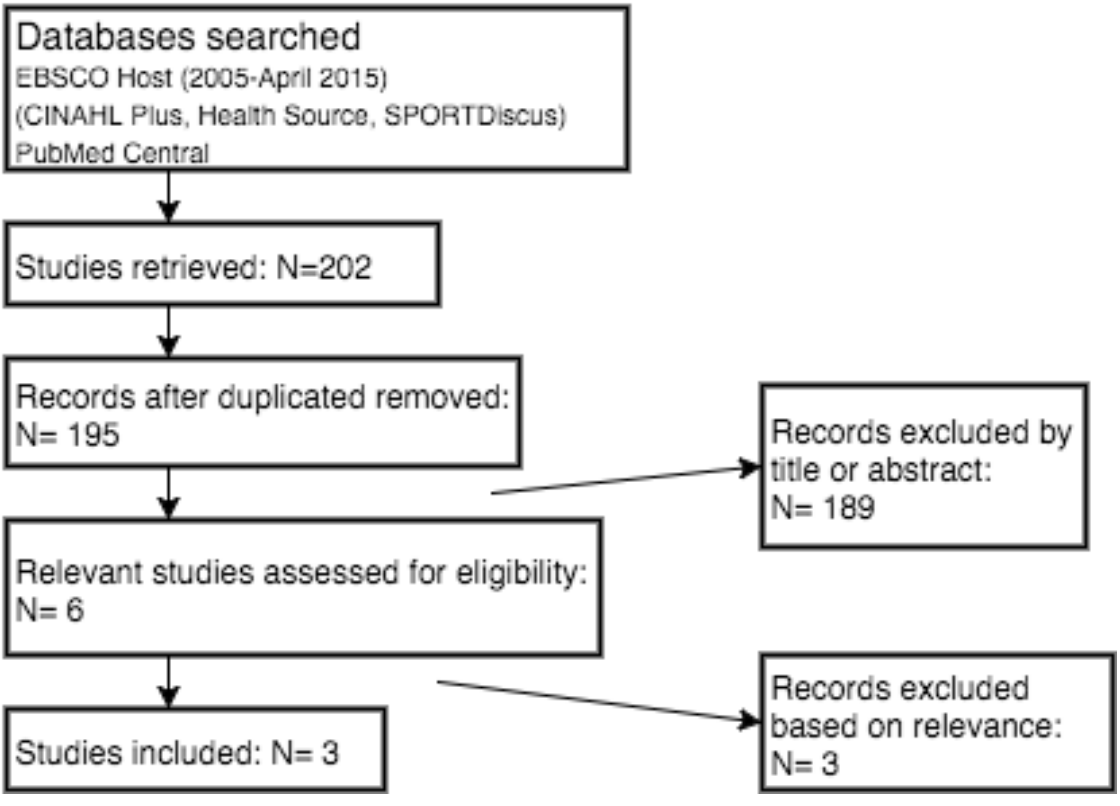

Figure 3.1. Search strategy

Table 3.1: Characteristics of Included Studies

Authors	Davis et al[5]	Lim et al[10]	Peuntedura et al[6]
Title	The Effectiveness of 3 Stretching Techniques on Hamstring Flexibility using Consistent Stretching Parameters	Effects on Hamstring Muscle Extensibility, Muscle Activity, and Balance of Different Stretching Techniques	Immediate effects of quantified hamstring stretching: Hold-relax proprioceptive neuromuscular facilitation versus static stretching
Study Design	Randomized Control Trial	Randomized Control Trial	Comparative Study
Participants	19 subjects (11 males, 8 female) ages 23.1±1.5, range 21-35 years	48 Adult males, age range 20-30; static stretch (n=16) 22.25±2.29, PNF (n=16) 23.50±2.16, and control (n=16) 22.38±2.31	30 subjects (17 male / 13 female) mean age 25.7±3.0, range 22-17 years
Inclusion and Exclusion Criteria	Inclusion: Tight hamstring as defined by a 20° Knee Extension Angle (KEA) with the hip in 90° of hip flexion; between 18 and 40 years of age. Exclusion: Previous history of lower-extremity pathology, which may adversely affect hamstring flexibility length	Inclusion: Male adults in their 20s and 30s; Extensibility of hamstring muscle reduced by 20° as measured by the Active Knee Extension (AKE) Test. Exclusion: History of injury which could have affected hamstring muscle extensibility: herniated intervertebral disk, cruciate ligament damage, femoral muscle or hamstring muscle damage, sciatic neuralgia, etc. as well as dose who were or a history of surgery nervous or musculoskeletal systems, within the last 5 years, currently engaged in exercises such as stretching, yoga, Pilates, etc. for improving flexibility.	Inclusion: Not listed Exclusion: (possible) pregnancy, hamstring injury within the past year, exceeding 80° in the initial Active Knee Extension (AKE) test, and/or participation in sports that required regular hamstring stretching.
Interventions Investigated	Group 1 (active self-stretch): Supine, hip actively flexed to 90°, knee actively extended for 30 seconds, repeated bi-laterally; 3 x per week, 4 weeks Group 2 (manual static stretch): Supine, Passive Knee Extension (PKE)'point of strong but tolerable stretch,' 30 second hold; repeated bi-laterally; 3 x per week, 4 weeks Group 3 (Proprioception Neuromuscular Facilitation (PNF)-Reciprocal Inhibition): Supine, PKE to 'point of strong but tolerable stretch',	Static Stretch Group: Supine, Passive Straight Leg Raise (PSLR) - 1 set of 30 second PNF Stretch Group: Hold-Relax Technique – Supine with PSLR, then 6 second contraction of hamstring, leg then lowered to table for 5 seconds repeated for total of 3 sets Control Group: No intervention specified	Static Stretch (SS) Group: 2 sets of 30 second stretches, 10 second rest interval between PNF Stretch Group: Hold-Relax Technique – Supine with leg raised to end range, 4 sets of 10 second isometric contraction with 10 second passive stretch intervals Stretching interventions were applied using a custom pulley-weight system (weight proportional to 5% of

	10 second knee extension contraction; reposition to new 'point of strong but tolerable stretch' and 30 second hold; repeated bi-laterally; 3 x per week, 4 weeks Group 4 (control): No intervention		subjects body mass and discomfort rating mean of 8.29 PNF, 8.06 SS)
Outcomes Measures	Range of Motion (ROM) using Knee Extension Angle	ROM using Active Knee Extension (AKE) Maximum voluntary isometric contraction using surface electromyography Static Balance using force measuring plate	ROM using AKE
Main Findings	At week 2, no significant increase of ROM in all four groups compared to control group. Static stretch showed significant increase over baseline. At week 4, all three treatment groups show an increase of ROM over baselines, but only static stretch had significant increase over control group from baseline (Static Stretch: Mean Difference 23.7°, Control Group: Mean Difference 3.2°). Achieved a *MCID. Significant interaction between intervention and length of program ($p < .0016$)	Significant increase of ROM in both stretching groups ($p < 0.05$) compared to control No significant difference between stretching interventions. (Static Stretch: Mean Difference 9.62°, PNF Stretch: Mean Difference 11.87°) Achieved a *MCID. No significant differences in muscle activation or balance between groups.	Significant increase of ROM compared to control condition (PNF/Control $p < .0005$; SS/Control $p = .011$) No significant difference between stretching interventions. (PNF: Mean Difference 8.9°±7.7, Static: Mean Difference 9.1°±8.9, Control: Mean Difference 1.5°±9.3) Achieved a *MCID.
Level of Evidence	1b	1b	2b
Validity Score	PEDro 3/10	PEDro 5/10	PEDro 5/10
Conclusion	Static stretching was more effective than PNF stretching in individuals presenting with hamstring tightness.	Both static and PNF stretching are effective at increasing range of motion in individuals presenting with hamstring tightness.	Both static and PNF stretching are effective at increasing range of motion in individuals presenting with hamstring tightness.

***The Minimal Clinically Important Difference (MCID) is a difference of 5 degrees.*[19]

Table 3.2: Results of PEDro scale for each article

	Davis et al[5]	Lim et al[10]	Puentedura et al[6]
1. Eligibility criteria specified (yes/no; not included in overall score)	No	No	Yes
2. Subjects randomly allocated to groups (yes/no)	Yes	Yes	Yes
3. Allocation was concealed (yes/no)	No	Yes	No
4. Groups similar at baseline (yes/no)	No	Yes	Yes
5. Subjects were blinded to group (yes/no)	No	No	No
6. Therapists who administered therapy were blinded (yes/no)	No	No	No
7. Assessors were blinded (yes/no)	Yes	No	Yes
8. Minimum 85% follow-up (yes/no)	No	No	No
9. Intent to treat analysis for at least 1 key variable (yes/no)	No	No	No
10. Results of statistical analysis between groups reported (yes/no)	Yes	Yes	Yes
11. Point measurements and variability reported (yes/no)	No	Yes	Yes
Overall Score (out of 10)	3/10	5/10	5/10

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CHANGES IN HAMSTRING RANGE OF MOTION FOLLOWING NEURODYNAMIC SCIATIC SLIDERS: A CRITICALLY APPRAISED TOPIC

Submitted for consideration in the *Journal of Sports Rehabilitation*

CLINICAL SCENARIO

Hamstring tightness (HT), a common condition across all age groups[1], has classically been thought to be caused by a reduction in tissue length leading to muscular strain and dysfunctional or restricted movement. Traditionally, HT has been addressed via static, dynamic, and proprioceptive neuromuscular facilitation (PNF) stretching techniques aimed at increasing range of motion (ROM) by treating what is assumed to be a tissue length issue in the hamstring muscle group.[2] Recently, researchers have questioned the efficacy of stretching as a treatment method for increasing ROM compared to other techniques.[3]

Neurodynamic Sliding (NDS) integrates both the musculoskeletal and nervous systems through a "flossing" of the nerves to achieve pain reduction or increased ROM in the extremities.[4] The use of NDS has recently been proposed as an alternative to stretching for patients with HT by addressing the neural factors of tightness without stretching the hamstring muscle tissue.[5,6,7] Several recent studies have examined the effectiveness of stretching compared to NDS.[5,6,7] Therefore, examining the evidence for NDS interventions versus traditional stretching techniques may offer more insight into practical clinical techniques for addressing patients with HT.

FOCUSED CLINICAL QUESTION

In an active population, what is the effect of using NDS compared to static or PNF stretching on traditional measures of hamstring ROM?

SUMMARY OF SEARCH, BEST EVIDENCE APPRAISED, AND KEY FINDINGS

- The literature search identified 6 studies. Of the 6 studies, one study was excluded as a duplicate study, two studies were excluded based on their title or abstract, and no studies were excluded based on lack of relevance to the critically appraised topic (CAT) (Figure 3.2).
- Two randomized controlled trials (RCT) and one comparative study met the inclusion and exclusion criteria (Table 3.3).
- All studies compared NDS targeting the sciatic nerve to stretching, with hamstring ROM measurements as a primary outcome measure. Both PNF[5] and static[6,7] stretching were included as comparisons.
- In the included studies, all researchers agreed that NDS targeting the sciatic nerve resulted in significant gains in ROM; however, only one group of researchers[6] reported NDS to be more effective than stretching. The double-blinded RCT had a large sample size and was the highest quality study included in the CAT,[6] according to the Physiotherapy Evidence Database (PEDro) scale.
- The authors of this CAT independently completed the PEDro scale and a consensus was obtained and determined for each article. The average score for included articles was 5/10.

CLINICAL BOTTOM LINE

Evidence exists to support the use of NDS to increase measures of hamstring ROM in participants who present with limited hamstring flexibility; however, the effectiveness of NDS compared to traditional stretching is inconclusive. The authors of one of the three studies[6] demonstrated NDS was more effective than static stretching at increasing hamstring

ROM measurements, while the authors of a second study[7] reported no difference between NDS and static stretching. The authors of the third study[5] evaluated in the CAT reported PNF stretching was superior to NDS at increasing hamstring ROM.

Strength of Recommendation

Grade B evidence exists that NDS performs as well as traditional stretching techniques at increasing measures of hamstring ROM on participants with limited hamstring flexibility. The Strength of Recommendation Taxonomy[8] recommends a grade of B for inconsistent Level 1 evidence or Level 2 evidence.

SEARCH STRATEGY

A computerized search was completed in April 2015 (Figure 3.2).

Terms Used to Guide Search Strategy

- **P**atient/ Client group: hamstring tightness; hamstring
- **I**ntervention/Assessment: neurodynamic or slider or sciatic*
- **C**omparison: static stretching; PNF stretching
- **O**utcome: flexibility or range of motion

Sources of Evidence Searched

- CINAHL Plus
- Health Source
- MEDLINE
- SPORTDiscus
- Additional references obtained via reference list review and hand search

Inclusion Criteria

- Limited to studies that compare NDS targeting the sciatic nerve to stretching

Excluded studies based on criteria

- Trampas A, Kitsios A, Sykaras E, Symeonidis S, Lazarou L. Clinical massage and modified proprioceptive neuromuscular facilitation stretching in males with latent myofascial trigger points. *Physical Therapy in Sport*. 2010;11(3):91-98.
- Szlezak AM, Georgilopoulous P, Bullock-Saxton JE, Steele MC. The immediate effect of unilateral lumbar Z-joint mobilization on posterior chain neurodynamics: A randomized controlled study. *Manual Therapy*. 2011;16(6):609-613.
- Limited to articles written in the English language
- Limited to articles written in the last 10 years (2006-2015)
- Limited to humans

Exclusion Criteria

- Studies that used minors as participants
- Studies that used an injured population as participants
- Studies that used sciatic tensioners instead of sciatic sliders
- Studies that combined sciatic sliders with stretching as treatment
- Studies that did not include pre- and post-treatment mean range of motion outcomes

RESULTS OF SEARCH

Three relevant studies were located using the above search terms (Table 3.3). Validity of the selected studies was identified using the PEDro scale (Tables 3.4 & 3.5). Each author independently reviewed the studies and completed the checklist. All authors met to determine agreement for each item on the checklist.

BEST EVIDENCE

As described in Table 3.3, the studies selected for inclusion in this CAT were identified as the best evidence. The authors of these level 2 or higher studies considered the use of NDS targeting the sciatic nerve on traditional measures of ROM in comparison to traditional stretching.

IMPLICATIONS FOR PRACTICE, EDUCATION AND FUTURE RESEARCH

The studies included in this CAT were conducted to identify the effect of NDS targeting the sciatic nerve compared to stretching on hamstring ROM measures in a healthy population. In regards to the indications for use of NDS for the treatment of HT, heightened neural mechanosensitivity may cause pathomechanical dysfunction, such as muscular tightness.[4] The "tightness" reported by the patient may be based on a perception of tightness, rather than a tissue length issue.[9] Addressing the neural component within the muscle tissue may result in increased measures of ROM.[4] Therefore, NDS s have been offered as a method to increase ROM compared to traditional stretching within rehabilitation programs.

The researchers of the three studies examined in this CAT identified NDS to be effective as a stand-alone treatment; however, the efficacy of using sciatic sliders compared to stretching in the treatment of hamstring tightness is inconclusive. In the highest quality study[6] available, researchers randomized 120 individuals with bilateral complaints of HT and decreased ROM on the passive straight leg raise test (PSLR). Following statistical analysis, the researchers reported that the use of NDS was more effective at increasing ROM than stretching, and that both NDS and stretching were more effective at increasing ROM than a placebo group.[6] The findings were in contrast to those of researchers who conducted less rigorous studies[5,7] and found there was either no difference[7] or that stretching was more effective than NDS in the treatment of participants with apparent HT.[5] The researchers[5,6,7] who compared NDS directly to stretching, however, have not utilized consistent

methodologies, which makes it difficult to assess outcomes across the limited evidence available. For example, when evaluating the three studies included in this CAT, three of the primary inconsistencies are variations in the method of assessment, application of the stretching intervention, and the application of NDS sliders.

The assessment methodology differed between the three studies. The active knee extension (AKE) was the method of assessment in one study[5] while the PSLR was utilized in the other studies[6,7] included in this CAT. The methodological discrepancies in assessment of hip flexion angle and knee extension angle are important, because they are two methods that are commonly thought to represent HT. The tension of the hamstring musculature may be a limiting factor for both the AKE and PSLR, and may differ between passive and active motions, possibly translating to differences in effectiveness of the treatment intervention between the studies.

In addition to assessment type, the number of treatment sessions and type of intervention differed between the studies. Some researchers found that a single application of NDS was more effective at increasing ROM than static stretching[6] while others determined both NDS and static stretching significantly increased ROM equally following three sessions over a one week period.[7] Another group of researchers also used three treatment sessions, but had participants perform hold-relax PNF as the comparison treatment rather than static stretching.[5] The researchers determined that both PNF and NDS interventions were effective at increasing ROM; however, the PNF stretching demonstrated greater efficacy.

The last inconsistency in the studies is observed in the difference between the applications of the NDS treatment. In the application of NDS, two researchers[5,7] used a seated position while the third[6] used a supine position. Similarly conflicting, overpressure was only used in one study,[5] possibly contributing towards the differences identified between NDS

and PNF treatments. Lastly, each of the three researchers also chose to mobilize different joints within their sciatic slider treatments. Mobilizing different joints may affect the amount of nerve excursion, possibly affecting the treatment outcome.[10]

Clinicians should use caution when interpreting these results in an injured population as all three of the studies used subjects categorized with HT but who were otherwise apparently healthy. Based on the studies examined in this CAT, additional high quality studies are needed to determine the effects of NDS sciatic sliders on ROM measures in various populations. Injured populations (such as those with altered nervous system function) should be examined to determine their response to NDS treatments. Future researchers should identify the most effective NDS protocol for increasing ROM. Further, the researchers should identify the immediate, short and long-term effects of the intervention. The current CAT should be reviewed in two years to identify whether additional evidence exists that may alter the clinical bottom line of this clinical question.

FIGURES AND TABLES

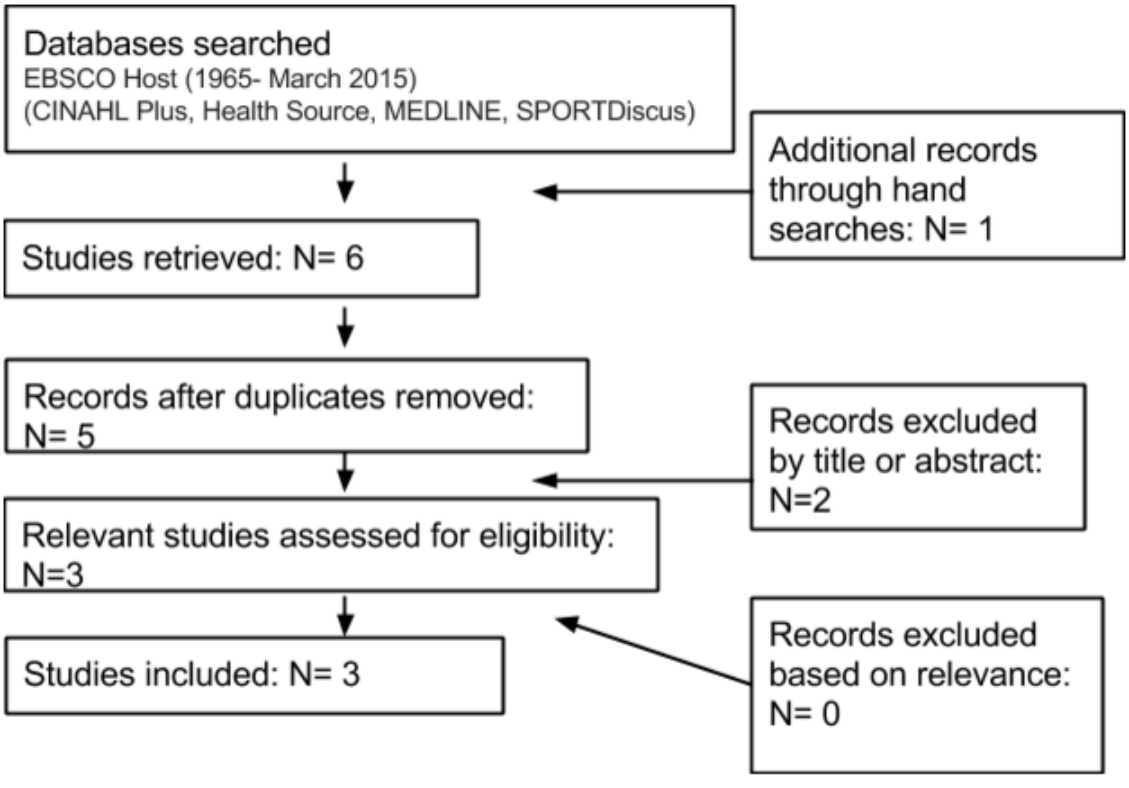

Figure 3.2: Search Strategy

Table 3.3: Summary of Study Designs of Articles Retrieved

Level of evidence	Study design	Number located	Reference
1b	Randomized, double-blinded controlled trial	1	Castellote-Caballero et al[6]
1b	Randomized, controlled trial	1	Pagare et al[7]
2b	Comparative Study	1	Vidhi et al[5]

Table 3.4: Characteristics of Included Studies

Authors	Castellote-Caballero et al[6]	Pagare et al[7]	Vidhi et al[5]
Study Design	Randomized, double-blinded controlled trial	Randomized, controlled trial	Comparative study
Participants	120 patients (60 female, 60 male; mean age 33.4 ± 7.4, range 20–45 years) with decreased PSLR ROM, otherwise apparently healthy.	30 male football players (NDS group 20.87 ± 2.89; stretch group 22.47 ± 2.48 years) with decreased PSLR ROM, otherwise apparently healthy.	60 patients (mixed males and females – number not specified) with decreased AKE ROM, otherwise apparently healthy.
Interventions Investigated	NDS Group: Supine with neck/thoracic flexion. Hip/knee flexion alternated with hip/knee extension. Perform for 180 seconds. Stretching Group: Supine, PSLR hamstring stretch. Perform 5x30 seconds. Placebo Group: Supine with passive intrinsic foot joint mobilization.	NDS Group: Seated slump position (no overpressure) with active cervical and knee flexion/ankle plantarflexion alternated with cervical and knee extension/ankle dorsiflexion. Perform 5x60 seconds with 15sec rest for three days over one week period. Stretching Group: Modified hurdler's position with flexion at hip. Hold for 30sec three days over one week period.	NDS Group: Seated slump position (overpressure by clinician) with passive knee extension/ankle dorsiflexion alternated with knee flexion. Perform 3x30 reps on 3 consecutive days Stretching Group Hold-relax PNF (Supine with 10sec stretch, 6sec static hold/contract, 30sec stretch). Perform 3 reps on 3 consecutive days
Outcomes Measures	ROM using PSLR test	ROM using PSLR	ROM using AKE
Main Findings	Significant improvement in ROM in NDS and stretching groups compared to placebo ($p<0.001$). NDS group significantly greater improvements than stretching group ($p=0.006$)	Significant improvement in ROM in both groups ($p<0.001$). No difference between groups ($p=0.057$).	Significant improvement in ROM in both groups (p-value not reported). Stretching group significantly greater improvements than NDS group ($p=0.0435$).
Level of Evidence	1b	2b	2b
Validity Score	PEDro 7/10	PEDro 4/10	PEDro 4/10
Conclusion	Both static stretching and neurodynamics were effective, with neurodynamic treatment being the most effective method to increase range of motion.	Range of motion improvements were not different between groups.	Both PNF stretching and neurodynamics were effective, with PNF stretching being the most effective method to increase range of motion.

Abbreviations: PSLR, Passive Straight Leg Raise; AKE, Active Knee Extension; ROM, Range of Motion; PNF, Proprioceptive Neuromuscular Facilitation; NDS; Neurodynamic Sliders.

Table 3.5: Results of PEDro scale for each article

	Castellote-Caballero et al[6]	Pagare et al[7]	Vidhi et al[5]
1. Eligibility criteria specified (yes/no; not included in overall score)	Yes	Yes	Yes
2. Subjects randomly allocated to groups (yes/no)	Yes	Yes	Yes
3. Allocation was concealed (yes/no)	Yes	Yes	No
4. Groups similar at baseline (yes/no)	Yes	Yes	Yes
5. Subjects were blinded to group (yes/no)	Yes	No	No
6. Therapists who administered therapy were blinded (yes/no)	No	No	No
7. Assessors were blinded (yes/no)	Yes	No	No
8. Minimum 85% follow-up (yes/no)	No	No	No
9. Intent to treat analysis for at least 1 key variable (yes/no)	No	No	No
10. Results of statistical analysis between groups reported (yes/no)	Yes	Yes	Yes
11. Point measurements and variability reported (yes/no)	Yes	No	Yes
Overall Score (out of 10)	7/10	4/10	4/10

Item 1 not included in overall score

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CHAPTER 5

APPLIED CLINICAL RESEARCH: HAMSTRING EXTENSIBILITY FOLLOWING TOTAL MOTION RELEASE® FORWARD FLEXION TRUNK TWIST VERUS SHAM TREATMENT

Key points:

- Traditional evaluation and treatment techniques of apparent hamstring tightness (AHT) fail to consider alternative causative factors, such as neural drive or fascial restriction, when addressing movement dysfunction.
- The Total Motion Release® (TMR®) forward flexion trunk twist (FFTT) may effectively address the underlying neural or fascial causes of AHT by utilizing multi-planar movement at the trunk and lumbopelvic complex.
- Participants categorized with AHT significantly improved on measures of ROM immediately after a single treatment of the TMR® FFTT compared to a sham group.

ABSTRACT

Context: Hamstring tightness is a common condition typically treated by stretching interventions. Limited evidence exists to support the use of the Total Motion Release® (TMR®) forward flexion trunk twist (FFTT) as a holistic approach to resolving hamstring tightness.

Objective: To assess the immediate and short-term effects of the TMR® FFTT on measures of hamstring extensibility.

Design: Multisite randomized controlled clinical trial.

Setting: University athletic training clinics.

Patients or Other Participants: Sixty (34 male, 26 female) healthy, physically active individuals presenting with signs of AHT.

Intervention(s): Participants were randomized into one of two groups: (1) treatment (TMR® FFTT) or (2) sham group.

Main Outcome Measure(s): Hamstring ROM was assessed using the active knee extension (AKE), passive straight leg raise (PSLR), finger to floor distance (FFD), and v-sit and reach (VSR) tests. All measures were performed at baseline, immediately post-treatment, and at one day follow-up. Repeated measures ANOVAs were utilized to assess both within group and between groups differences. Holm's sequential Bonferroni corrections were performed to determine differences between groups. Statistical significance was considered at $p<.05$

Results: The TMR® FFTT group demonstrated significantly more improvement in ROM than the sham group immediately post-treatment for the AKE-Most Restricted (MR) (6.4° ± 4.8° vs. 2.7° ± 6.6°, p = 0.018, Cohen's d = 0.65, 95% CIs: 0.66°, 6.8°), PSLR-MR (5.8° ± 4.2° vs. 2.2° ± 4.5°, p = 0.002, Cohen's d = 0.85, 95% CIs: 1.7°, 6.4°), FFD (4.6cm ± 3.4cm vs. 2.0cm ± 4.1cm, p = 0.01, Cohen's d = 0.73, 95% CIs: 0.67cm, 4.7cm), and VSR (4.4cm ± 3.1cm vs. 1.7cm ± 2.9cm, p = 0.001, Cohen's d = 0.92, 95% CIs: 0.93cm, 4.0cm). No between-group differences were found at the one day follow-up.

Conclusions: The TMR® FFTT effectively increased ROM on measures of hamstring extensibility immediately following a single intervention compared to a sham treatment that consisted of a sub-optimal form of static stretching. In an effort to promote clinical relevance and increase external validity, the methodology of the study featured materials and methods readily available in athletic training clinics; however, limitations of the study may have hindered the magnitude of effect identified in the results. Future researchers should consider more stringent inclusion criteria and the response of various ROM measures following TMR® FFTT treatment.

Key Words: Regional interdependence, hamstring, tightness, stretching

INTRODUCTION

Hamstring tightness, commonly defined as a lack of hip flexion range of motion (ROM) with a concomitant feeling of restriction in the posterior thigh, has been documented across all age groups as a potential problem leading to dysfunctional or restricted movement.[1–9] The term hamstring tightness denotes that a lack of hip flexion or knee extension ROM is due to a tissue length deficit; however, researchers have drawn attention to multiple causal factors such as neural tension,[10–13] fascial restriction,[14] lumbopelvic dysfunction,[15,16] and/or joint or tissue length restrictions[17–20] that may contribute to this lack of ROM or tissue extensibility. Thus, the term apparent hamstring tightness (AHT) may be a better descriptor of the hamstring tightness phenomenon because the underlying cause may not be related to tissue length, and immediate gains in hamstring extensibility may be experienced following an intervention that does not address a tissue length deficit.

Tissue length deficits have been proposed to result from deformation in the elastic or plastic regions of connective tissue, leading to restricted joint motion.[19,21,22] Traditionally, AHT has been assessed using tests thought to measure the length of the hamstring muscle tissue, such as the active knee extension (AKE),[10,23–26] passive straight leg raise (PSLR),[27–31] finger to floor distance (FFD),[32] and sit and reach (SR)[33] tests. Likewise, treatment techniques commonly used for AHT were focused directly on muscle tissue (e.g., length changes) and include static, proprioceptive neuromuscular facilitation (PNF), and dynamic stretching.[34,35] Researchers have postulated that a stretching intervention may change tissue length due to the properties of viscoelastic deformation, plastic deformation, sarcomere adaptation, and neuromuscular relaxation.[21,22] The variance in repetitions, frequency, and duration of stretch protocols has led to inconsistent efficacy throughout the literature,[36–38] resulting in a lack of consensus regarding the most effective stretching protocol.

In light of the questionable efficacy and appropriateness of stretching to treat AHT, clinicians have been encouraged to rethink the classical approach to addressing AHT and consider factors other than tissue length deficits that may contribute to the perceived tightness.[39] Researchers examining alternative treatments involving more comprehensive movement patterns and lumbopelvic exercises have demonstrated promising results for increased knee ROM[40] and prevention of recurrent hamstring strain.[16] One novel technique that has yet to be studied extensively is Total Motion Release® (TMR®), a treatment philosophy based on regional interdependence in which the clinician assesses and treats imbalances throughout the body.

The regional interdependence theory is the idea that dysfunction or pain perceived in one area of the body may be influenced by a dysfunction or restriction in the neural, musculoskeletal, or fascial systems, amongst others.[41,42] A specific TMR® intervention, the TMR® forward flexion trunk twist (FFTT), has been proposed to treat AHT.[43,44] While the TMR® FFTT lacks a direct focus on lengthening hamstring musculature, improvements in both active hip flexion and knee extension ROM have been demonstrated after performing the technique.[44] Despite the paucity of research conducted on the TMR® FFTT, the technique may be a beneficial intervention for patients categorized with AHT. Therefore, the purpose of this study was to assess the immediate and short-term effects of the TMR® FFTT compared to a sham group on measures of hamstring ROM among healthy, physically active individuals presenting with signs and symptoms of AHT.

METHODS

Participants

Participants were recruited from five different research sites across the country [athletic training clinics and student bodies at universities (2 NCAA Division I, 1 NCAA

Division II, 1 NCAA Division III, and 1 NAIA)]. Physically active was defined as performing physical activity for at least 150 minutes a week or an average of 30 minutes a day five days per week.[35] Participants were active in a variety of settings (36 intercollegiate, 22 recreational, and 2 club sports) with the most common sports after recreational activity (22) being soccer (9), baseball (6), and track/field (6). A total of 70 physically active individuals (35 men: 20.8 ± 1.7 years; 35 women: 20.4 ± 1.4 years) volunteered to participate in this multisite research study and were screened for the following inclusion criteria: AKE angle of at least 20°, a TMR® FFTT asymmetry of at least 5 points, and a score of at least 1 on the Perceived Tightness Scale (PTS). The AKE was performed bilaterally and the leg with the most restricted motion was identified as the "most restricted" (MR) leg for ROM measurements throughout the study.

The following exclusion criteria were applied: (1) lower extremity injury in the previous six weeks; (2) lumbar pathology including back injury in the previous six weeks, known lumbar spine pathology limiting ROM (e.g., discogenic), prior lumbar spine surgical procedures, known lumbosacral spine physical impairments limiting ROM and function; (3) lower extremity surgery within last six months; major ligamentous surgery within last one year; (4) vestibulocochlear disturbances/concussion (5) joint hypermobility syndrome (Beighton Score of four or higher); (6) connective tissue disorders (e.g., Marfans, Ehlos Danlos); or (7) lower extremity neurovascular pathology, including numbness, tingling, and loss of sensation. A total of 10 participants were excluded from the study. One participant did not meet the physically active requirement; two participants had bilateral AKE angle measurements of less than 20°; five participants did not have a TMR® FFTT asymmetry; one participant reported low back pain; and one participant reported a lower extremity injury in the prior six weeks.

In total, 60 participants met the inclusion/exclusion criteria; 30 were randomly assigned to the TMR® FFTT group (20.7 ± 1.7 years; 42.3° ± 7.9° AKE-MR; 35.3 ± 20.1 TMR® asymmetry) and the other 30 were assigned to the sham group (20.6 ± 1.5 years; 45.1° ± 10.1° AKE-MR; 27.6 ± 17.8 TMR® asymmetry) (Table 4.1). Dropout criteria determined *a priori* included pain that developed during treatment; verbal request by participant to discontinue the study; and non-compliance (i.e., failure to return for one-day follow-up testing). Based on these criteria, two of the 60 participants dropped out of the study due to pain during the treatment (1) and noncompliance (1), leaving a total of 58 participants (TMR® FFTT = 28, sham = 30) who completed all stages of the study.

Prior to beginning the study, the research procedures were explained to each participant. All participants provided written consent to participate in this study and the study was approved by the Institutional Review Board of XXXXXX along with the Institutional Review Board at each of the five research sites.

Experimental Procedures

The principal investigators (n = 5) administered all ROM measurements and interventions at their respective sites. Prior to initiating the study, the clinicians completed the TMR® training courses and conducted a pilot study to validate their methods and establish consistency of treatments and measurements. To ensure measurement reliability amongst all clinicians participating in this multisite research study, the intra-rater and inter-rater reliabilities of the AKE, PSLR, FFD, and v-sit and reach (VSR) were assessed prior to beginning this study. All measurements had high intra-rater and inter-rater reliability assessed with Intraclass Correlation Coefficients (ICC) (3,1), with absolute agreement (Table 4.2).[45] The high reliability was consistent with the intra- and inter-rater values reported in the literature for the AKE,[23,31,46,47] PSLR,[46,48] FFD,[32] and VSR.[49] The standard error of

measurement (SEM) and minimal detectable change (MDC) values were also calculated for each dependent variable from the reliability testing data performed prior to this study (Table 4.2). Standard measurement error was derived using the interrater ICC and the following formula: SEM=SD × √((1)-ICC).[50] Minimum detectable change for this study was subsequently calculated using the formula MDC=1.96 × √2 × SEM (Tables 5.2 - 5.3).[50]

Group allocation of the participants was concealed from the clinician until after baseline measurements were taken, at which point group assignment was revealed by opening a sealed, opaque envelope containing the participant's group assignment. All baseline measurements were performed in a pre-determined, randomized order using a random number generator (random.org) with no rest break between measurements. After baseline measurements, participants completed the treatment intervention according to their group assignment. Following the intervention, immediate post-treatment and one day follow-up measurements were recorded in the same order as baseline measures.

Total Motion Release® (TMR®) Forward Flexion Trunk Twist (FFTT) Treatment

The TMR® FFTT treatment intervention began with a screening procedure by having the participant stand with feet together and arms crossed in front of the chest. The participant was instructed to flex forward at the waist into a neutral position or just prior to the point of discomfort (Figure 4.1a) and then twist to the right, return to the neutral position and then twist to the left. The participant was shown a TMR® grading scale (0-100) in which a score of zero equals "no problems at all" and a score of 100 equals "the worst" in regards to how the motion felt (i.e., pain, tightness, ROM, strength, tension, nervousness, and quality). The participant was asked to score the difference between twisting to the right versus twisting to the left by identifying a difficult side and indicating a percent difference between the difficult and easy sides. For the feet apart position, the participant was asked to stand with feet apart,

flex forward at the waist over the right leg (Figure 4.2a), return to the starting position, and then flex forward at the waist over the left leg noting which leg "felt better" to flex forward over (i.e., the good leg). Following this, the participant forward flexed at the waist over the leg that "felt worse" and twisted towards midline, returned to the neutral position over the "bad leg," and then twisted away from midline. The participant then identified which direction was more difficult and scored the motion in the same way as described above for the feet together position.

Following the screening procedure, each participant in the TMR® FFTT group performed two sets of 10 repetitions of the feet together FFTT to the side previously identified as the "easy side" during the screening procedure.[44,51] After twisting, the participants were instructed to slowly release anything felt to be preventing further movement (e.g., bending the knee, extending the trunk, looking over the shoulder) which would allow for further twisting motion with each repetition (Figure 4.1b). The participant was given 30 seconds to rest between sets. Following the TMR® FFTT treatment with feet together, the participant repeated the same procedure with feet apart, twisting in the "more difficult" direction over the good leg, as identified in the screening procedure (Figure 4.2b).[51] The participant performed two sets of 10 repetitions in the feet apart position with the same "twist and then release" instructions provided. Immediately following the TMR® FFTT treatment, all participants completed post-treatment measurements.

Sham Treatment

The sham treatment required each participant to maintain a position of forward trunk flexion, without the twisting motion present in the TMR® FFTT, simulating a position often utilized in static stretching. Each participant randomized into the sham treatment group was instructed to stand with the feet together and arms crossed in front of the chest. The

participant was then instructed to forward flex at the waist to approximately 90° or just prior to the point of discomfort to ensure that maximal, end-range stretching was avoided (Figure 4.1a). Each participant held this position for 30 seconds and then returned to the starting position. A total of four repetitions with 30 second holds were performed and 30 seconds of rest was provided between each repetition. Immediately following the sham treatment, all participants completed post-treatment measurements.

Range of Motion Measurement Methods

An inclinometer application (Clinometer, https://www.plaincode.com/products/clinometer/) was installed on an iPhone or Android smartphone device by each researcher. The Clinometer application was utilized to collect the AKE and PSLR measures and was calibrated before each participant's arrival. While not utilized in the lower extremity literature, the Clinometer application has been found to be reliable for measuring shoulder ROM [ICC (2,1) = .8].[52] Prior to collecting ROM measurements, a mark was placed on the anterior tibia (three inches below the tibial tuberosity) and on the anterior thigh (six inches above the tibial tuberosity) of each leg for all participants to ensure accurate and consistent placement of the smartphone for use of the Clinometer app. A cloth tape measure was used for the FFD and VSR tests. For all tests requiring unilateral measurements (AKE, PSLR), the right leg was assessed first, followed by the left leg. A total of three measurements were taken for all tests and the average of the three was reported, with the exception of the VSR, in which the third measure stood as the final score.[53]

Active Knee Extension (AKE) Measurement

The AKE was measured by the clinician with the participant in a supine position with one leg in a 90-90 position as an assistant stabilized the contralateral leg in an extended

position (Figure 4.3a). The clinician placed one hand on the posterior thigh four inches superior to the knee while the other hand placed the smartphone inclinometer on the participant's anterior thigh with the top of the phone in line with the marking on the participant's thigh to assess maintenance of 90-degree positioning. The participant was then instructed to actively extend the knee to the point of discomfort, while maintaining 90 degrees of hip flexion. When the participant reached the point of discomfort (i.e., an uncomfortable amount of tension),[54] the clinician relocated the smartphone inclinometer from the anterior thigh to the mark at the mid-anterior tibia, making sure to keep the other hand on the posterior thigh to maintain 90 degrees of hip flexion (Figure 4.3b).

Passive Straight Leg Raise (PSLR) Measurement

The PSLR was measured by the clinician as the participant lay supine with the legs extended. The clinician passively flexed the participant's hip while maintaining knee extension and monitoring for pelvic rotation until the point of discomfort was reached. An assistant stabilized the contralateral leg in an extended position during the procedure (Figure 4.4). The ROM measurement was recorded with the smartphone inclinometer placed at the mark on the thigh.

Finger to Floor Distance (FFD) Measurement

The FFD test was performed with the participant standing on a 20 cm box with the feet together and the toes positioned at the edge of the box. The participant flexed at the waist with hands on top of one another, reaching for the toes, and stopping at the point of discomfort (Figure 4.5). The clinician visually ensured the participant's knees did not flex while performing the movement. The clinician measured from the top edge of the box to the tip of the middle finger of the top hand in centimeters. A measurement of "0" indicated the fingertip was in line with the edge of the box. A positive number indicated that the fingers had

not reached the edge of the box, while a negative number indicated the fingers were past the edge of the box. Measurements were rounded to the nearest half centimeter.

V-Sit and Reach (VSR) Measurement

A cloth tape measure was affixed to the floor using pieces of tape to assess the participant's ROM. A piece of tape denoting the baseline "zero" point was placed at the 40 cm mark of the cloth tape measure. On the baseline tape strip, two marks were placed 15 cm on either side of the tape measure to denote the spot where the participant's feet would be placed (Figure 4.6).

The participant was instructed to sit on the floor with the legs extended, the feet spaced 30 cm apart, and the plantar surface of the feet touching a box to keep the ankle joints in a neutral position.[53] An assistant stabilized one leg on the floor in an extended position, while the clinician stabilized the other leg. The participant placed one hand over top of the other and flexed at the waist towards the toes to the point of discomfort. The motion was performed three times and the measurement was taken on the third attempt. The clinician measured from the edge of the baseline "zero" tape line to the tip of the middle finger. A measurement of "0" indicated the fingertip was in line with the edge of the baseline "zero" tape line. A negative number indicated that the fingers had not reached the edge of the line, while a positive number indicated the fingers were past the edge of the line. Measurements were rounded to the nearest half centimeter.

Perceived Tightness Scale (PTS)

The participant's perception of tightness was identified using the Perceived Tightness Scale (PTS) which was adapted from the 0-10 numeric rating scale (NRS). The NRS is a numerical ranked scale that measures the intensity of the participant's pain;[55] however, in this study, the participants were asked to rate their amount of perceived hamstring tightness at

baseline, immediately following the treatment, and at one day follow-up. On the PTS, a score of 0 indicated “no perceived tightness” and a score of 10 indicated “extreme tightness.”

DATA ANALYSIS

Statistical analysis was performed using SPSS statistical software (version 23; SPSS Inc., Chicago, IL). Each dependent variable was assessed for outliers by treatment group using estimates of skewness and kurtosis, visual inspection through histograms, as well as with Levene’s test and the Shapiro-Wilk test. One-way within subject repeated measures analysis of variance (RM-ANOVAs) were performed to assess the effect of the TMR® FFTT on each dependent variable over time. Bonferroni comparison testing was used for post-hoc analysis. Significance was considered to be $p \leq .05$. Between-groups effects were assessed using RM-ANOVAs for each dependent variable. Independent sample t-tests were used to assess between group differences at each time point (baseline-post treatment; baseline-one day follow-up). A Holm's sequential Bonferroni correction was performed to establish new alpha levels (i.e., .025, .05) for significant findings. Differences at baseline were assessed using independent t-tests; if a baseline difference was discovered, the variable was assessed using an independent t-test on the difference scores rather than with the RM-ANOVA. To determine the treatment effect size, the Cohen’s d statistic was calculated, with small $\geq .2$, medium $\geq .5$, and large $\geq .8$.[56]

Effect size indicates the magnitude of difference between two groups, with moderate to large differences associated with increased clinical meaningfulness of the results.[56] Additionally, a conservative Holm’s sequential Bonferroni adjustment results in a decreased risk of Type I error, but also results in low power.[57] Low statistical power is associated with an increased risk of making a Type II error.[58] Therefore, our conservative statistical choices

reduce the risk of incorrectly concluding the two groups are statistically different when they actually are not, but the tests may not have the power needed to detect differences that exist.[57]

RESULTS

Active Knee Extension (AKE) - Most Restricted (MR) Leg

There were no differences at baseline in AKE-MR measurements ($t_{(56)} = -0.93$, $p = .354$, 95% CIs: -7.0°, 2.5°) between TMR® FFTT (42.9° ± 7.7°) and sham treatment (45.1° ± 10.1°). The between-subjects time*group interaction was significant ($\lambda = 0.9$, $F_{(2,55)} = 3.21$, $p = .048$, partial eta squared = 0.1, power = 0.59) (Table 4.4). Utilizing the Holm's sequential Bonferroni adjustment for follow-up testing, there was a significant difference between TMR® FFTT (mean difference = 6.4° ± 4.8°) and sham treatment (mean difference = 2.7° ± 6.6°) immediately post-treatment ($t_{(56)} = 2.43$, $p = .018$, Cohen's d = 0.65, 95% CIs: 0.66°, 6.8°). There were no significant differences between groups at one day follow up ($t_{(56)} = 1.65$, $p = .105$, Cohen's d = 0.44, 95% CIs: -0.53°, 5.5°).

The within-subjects time main effect for the TMR® FFTT group was significant ($\lambda = 0.31$, $F_{(2,26)} = 29.11$, $p < .001$, partial eta squared = 0.69, power = 1.0) (Table 4.5). Bonferroni post-hoc testing revealed a significant increase in ROM from baseline to post-treatment (mean difference = 6.4°, SEM = 0.91°, $p < .001$) and from baseline to one day follow-up (mean difference = 5.0°, SEM = 1.1°, $p < .001$). Between time points within the TMR® FFTT group, participants maintained 79% of their post-treatment changes at the one day follow up for the AKE.

Passive Straight Leg Raise (PSLR) - Most Restricted (MR) Leg

There were no significant differences at baseline in PSLR-MR measurements ($t_{(58)} = -1.95$, $p = .056$, 95% CIs: -15.8°, 0.2°) between TMR® FFTT (51.6° ± 14.8°) and sham treatment (59.0° ± 14.1°). The between-subjects time*group interaction was significant ($\lambda =$

0.85, $F_{(2,55)}$ = 4.98, p = .01, partial eta squared = 0.15, power = 0.79). Following the post-hoc assessment, a significant difference between TMR® FFTT (mean difference = 5.8° ± 4.2°) and sham treatment (mean difference = 2.2° ± 4.9°) was identified immediately post-treatment ($t_{(58)}$ = 3.2, p = .002, Cohen's d = 0.85, 95% CIs: 1.6°, 6.0°). There were no significant differences between groups at one day follow up ($t_{(56)}$ = 1.6, p = .115, Cohen's d = 0.43, 95% CIs: -0.86°, 7.7°).

The within-subjects time main effect for the TMR® FFTT group was significant (λ = 0.34, $F_{(2,26)}$ = 25.32, p < .001, partial eta squared = 0.66, power = 1.0). Bonferroni post-hoc testing revealed a significant increase in ROM from baseline to post-treatment (mean difference = 5.8°, SEM = 0.8°, p < .001) and from baseline to one day follow-up (mean difference = 4.4°, SEM = 1.5°, p = .023). Between time points within the TMR® FFTT group, participants maintained 76% of their post-treatment changes at the one day follow up for the PSLR.

Finger to Floor Distance (FFD)

Outlier assessment revealed a skewness value of 1.11 (SE = 0.43) with a kurtosis value of 2.16 (SE = 0.83) for the sham group at baseline. Histogram, box plot, and visual inspection of the data revealed two possible outliers; data for the FFD was removed for these participants prior to further analysis. Following outlier removal, skewness for the baseline FFD was -0.199 (SE = 0.44) and kurtosis was -1.05 (SE = 0.86). There was a significant difference at baseline in FFD measurements ($t_{(56)}$ = 2.48, p = .016, 95% CIs: 1.2cm, 11.2cm, power = 0.57) between TMR® FFTT (10.5 cm ± 10.5 cm) and sham treatment (4.3 cm ± 8.1 cm). Independent sample t-tests were used and revealed a significant difference between TMR® FFTT (4.6 ± 3.4cm) and sham treatment (2.0 ± 4.1cm) immediately post-treatment ($t_{(54)}$ = 2.67, p = .01, Cohen's d = 0.73, 95% CIs: 0.67 cm, 4.7 cm). There were no significant

differences between groups at one day follow up ($t(54) = 1.4$, $p = .155$, Cohen's d = 0.39, 95% CIs: -0.73 cm, 4.5 cm).

The within-subjects time main effect for the TMR® FFTT group was significant ($\lambda = 0.34$, $F_{(2,26)} = 25.64$, $p < .001$, partial eta squared = 0.66, power = 1.0). Bonferroni post-hoc testing revealed a significant increase in ROM from baseline to post-treatment (mean difference = 4.6 cm, SEM = 0.64 cm, $p < .001$) and from baseline to one day follow-up (mean difference = 2.9 cm, SEM = 0.87 cm, $p = .008$). Between time points within the TMR® FFTT group, participants maintained 63% of their post-treatment changes at the one day follow up for the FFD.

V-Sit and Reach (VSR)

There were no differences at baseline in VSR measurements ($t_{(58)} = -0.9$, $p = .374$, 95% CIs: -7.4 cm, 2.8 cm) between TMR® FFTT (-13.5 cm ± 11.0 cm) and sham treatment (-11.2 cm ± 8.3 cm). The between-subjects time*group interaction was significant ($\lambda = 0.81$, $F_{(2,55)} = 6.3$, $p = .003$, partial eta squared = 0.19, power = 0.88). Post-hoc testing using independent t-tests and a Holm's sequential Bonferroni adjustment revealed a significant difference between TMR® FFTT (4.4 cm ± 3.1 cm) and sham treatment (1.7 cm ± 2.9 cm) immediately post-treatment ($t_{(58)} = 3.45$, $p = .001$, Cohen's d = 0.92, 95% CIs: 1.1 cm, 4.3 cm). There were no significant differences between groups at one day follow up ($t(56) = 2.0$, $p = .054$, Cohen's d = 0.53, 95% CIs: -0.04 cm, 4.6 cm).

The within-subjects time main effect for the TMR® FFTT group was significant ($\lambda = 0.3$, $F_{(2,26)} = 31.018$, $p < .001$, partial eta squared = 0.71, power = 1.0). Bonferroni post-hoc testing revealed a significant increase in ROM from baseline to post-treatment (mean difference = -4.4 cm, SEM = 0.6 cm, $p < .001$) and from baseline to one day follow-up (mean difference = -2.2 cm, SEM = 0.6 cm, $p = .005$). Between time points within the TMR® FFTT

group, participants maintained 49% of their post-treatment changes at the one day follow up for the VSR.

Perceived Tightness Scale (PTS)

Outlier assessment revealed no significance at baseline for either the TMR® FFTT group (Shapiro-Wilk = 0.93, p = .068) or the sham group (Shapiro-Wilk = 0.97, p = .591). The non-parametric Mann Whitney U was not significant for baseline (U = 368.5, p = .417), immediate post-treatment (U = 332, p = .162) or one day follow-up (U = 337.5, p = .194).

DISCUSSION

In this exploratory study, the TMR® FFTT produced significant improvements in ROM on the AKE, PSLR, FFD, and VSR to a greater extent than the sham treatment immediately following a single session. No significant differences were found to suggest the TMR® FFTT had an effect on ROM measures at a one day follow-up. Although statistically significant gains in ROM were produced, further analysis of the data highlighted the clinical meaningfulness of the results. Moderate (0.65) to large (0.92) Cohen's *d* effect sizes were identified post-treatment, suggesting the TMR® FFTT treatment was clinically relevant with a moderate to large effect on ROM immediately following treatment.

The clinical relevance of this study is also enhanced due to the methodological decisions and a focus on external validity. For example, all participants were active individuals with complaints of AHT who presented to clinicians within collegiate athletic training clinics, with each ROM measurement completed utilizing methods and materials commonly located within clinics. Additionally, the Clinometer application used to record ROM is available for both Android and iPhone users. While participants were asked not to change their activity level during the study, their outside activities were not controlled between the immediate post-treatment measurements and the one day follow-up

measurements by the clinicians at any of the five research sites. Therefore, the effects of a single treatment of TMR® FFTT after one day must be interpreted with caution due to the potential for confounding variables as well as the large standard deviations associated with the baseline-one day calculations.

Although the immediate results of the TMR® FFTT were statistically significant, the gains in ROM that the participants experienced were moderate by clinical standards on all measures. One explanation for why the gains in ROM were not greater may be that participants were only required to present with restricted ROM on the AKE to be included. As a result, several participants were included who did not display restrictions in ROM on the PSLR (TMR® FFTT = 2, Sham = 3), FFD (TMR® FFTT = 7, Sham = 9), or VSR (TMR® FFTT = 4, Sham = 5). In addition, the lack of restriction in ROM on the PSLR, FFD, and VSR may have contributed to the low percentage (0%, 9.5%, and 2%, respectively) of individuals who achieved functional levels of ROM on each measure immediately following treatment. Although in this preliminary study, the TMR® FFTT demonstrated only moderate results immediately following treatment and no changes after one day, the technique has been explored in other research.

The inclusion of the TMR® FFTT as a regionally interdependent treatment for AHT is supported in the literature in the form of a case study in which the patient gained 20°-30° on the AKE after a single TMR® FFTT treatment.[44] A possible explanation for the greater gains in ROM on the AKE compared to our study is that the case described by Baker et al.[44] featured a patient with a history of lumbar spine pathology with chronic AHT symptoms (over 5 years), and a large TMR® FFTT asymmetry at initial exam. Additionally, the patient's baseline AKE measurements were 13-17° more restricted than the average baseline AKE in our study, which may contribute to the greater gain in ROM achieved on the AKE following a

single treatment. Although the patient's changes in AKE ROM were different from our findings, her changes on the SR (4.9cm) were similar to our results for the VSR (4.2cm). The VSR results may be more similar to the SR as both assessments require attention not only to isolated tissue tension, but also to the lumbopelvic and thoracic movements that occur with active trunk flexion. Likewise, increases in hamstring extensibility have been demonstrated on other measures (e.g., AKE, PSLR) with the application of regionally interdependent treatments focused on joint mobility[59,60] and the nervous system.[61]

Similar to the TMR® FFTT, the Mulligan Concept and neurodynamics are treatment paradigms demonstrated to address AHT through a regionally interdependent approach. Neural tension[10,13] and lumbopelvic dysfunction may result in restricted extensibility by creating a perception of hamstring tightness. Treatment of the lumbopelvic complex through Mulligan Concept hip mobilizations with movement effectively increased ROM on the PSLR by 13°-17° in individuals classified with tight hamstrings.[59, 60] Additionally, neurodynamic sliders of the sciatic nerve have also been found to be significantly more effective (9.9° ± 2.5°, 95% CIs: 9.1°, 10.7°) than static stretching (5.5° ± 1.6°, 95% CIs: 5.0°, 6.0°, p=0.006) at improving hip flexion ROM on the PSLR.[61] Compared to the results of these studies, we observed a 5.8° increase in hip flexion ROM on the PSLR immediately following one treatment of the TMR® FFTT. Although the specific mechanism by which the TMR® FFTT affects AHT is unknown, the technique has been proposed to increase hamstring extensibility using the theories of neural coupling[62-64] and biotensegrity.[65] Aside from treatments with a holistic approach, stretching is perhaps the most common local treatment used for addressing AHT.

In several studies, static stretching of the hamstrings musculature has resulted in knee extension and hip flexion ROM gains.[24,36–38,66] DePino et al.[24] found a 5-6° improvement of

knee extension ROM on the AKE after four consecutive 30-second static stretches. De Weijer et al.[66] conducted a similar study, identifying a 13° increase in extensibility on the AKE using three 30-second hamstring stretches performed following a warm-up. In addition to a warm-up, variation in methodologies between the two studies include that participants in the De Weijer group were passively stretched in an AKE test position with an adjustment made to increase the stretch if the participant became acclimated after 15 seconds, while participants in the DePino study performed active stretching in a standing position with no adjustments. The TMR® FFTT resulted in gains in ROM on the AKE that were similar to the DePino study (6.4°), but not as drastic as the De Weijer study. The methodological variation in the De Weijer study may help to explain the increased ROM compared to both the DePino study and this study, neither of which included a warm-up or passive stretch with an adjustment for stretch tolerance. Within both the DePino et al. and De Weijer et al. studies, the gains lessened as time progressed, with decreases in motion occurring three[24] to 15 minutes[66] after the cessation of the stretching intervention. The duration of static stretching effect is conflicting in the literature, with return to baseline scores ranging from shortly after treatment to more than one day following treatment. Following the cessation of the stretch intervention, only 4.5% of the extensibility gains were maintained at nine minutes,[24] compared to other reports of 59% maintained after 24 hours.[66]

Although the TMR® FFTT group had statistically significant and clinically meaningful results in comparison to the sham group, the sham group also demonstrated gains in ROM on the AKE immediately post-treatment (2.7°±6.6°) and at a one day follow-up (2.6°±5.5°). A possible explanation for the ROM gains in the sham group is that the forward flexed position may have placed a low-grade static stretch on the musculotendinous and neural structures of the posterior chain. According to the sensory theory,[22] the application of a

short-duration stretching technique may perpetuate an increase in stretch tolerance, producing ROM gains over time. Despite the sham group demonstrating gains in ROM and maintaining those gains at one day follow-up, the relatively small ROM gains are within the SEM on the AKE (3.28°) and are likely not clinically meaningful.

In the current study, all participants were identified to have an asymmetry based on the TMR® FFTT evaluation, which may aid in identifying the underlying factors of AHT beyond tissue length deficits. Traditional evaluation of AHT accounts for the joint and tissue length restriction via assessments that include the AKE and PSLR, leading to treatment choices such as stretching. By incorporating a regionally interdependent approach to evaluation, such as the TMR® FFTT, clinicians may be able to more effectively classify patients and provide treatments that address alternative causal factors perpetuating AHT. Therefore, we propose that clinicians should utilize a holistic assessment that guides clinical decision making and treatment selection based on exam findings for patients with AHT.

Limitations and Future Research

Several methodological choices resulted in procedural limitations in this study, including: (a) the multi-site nature of the study, with multiple raters assessing ROM; (b) the decision to focus on a sham comparison versus a direct comparison to an established treatment; (c) no blinding of the clinician occurred in this study; (d) only the AKE was utilized as an inclusion method; (e) the outside activities of the participants were not controlled; (f) each ROM measure was assessed consecutively, with no rest in between. Other limitations include that the results of this study may not be generalized to a population outside of a healthy, young, active group of participants with restricted hamstring extensibility on an AKE assessment. As the focus of this study was on short-term efficacy of a single treatment, implications for long-term results of the TMR® FFTT, or the TMR® system, may

not be derived from this study. Additionally, the clinicians providing treatment were relative novices using TMR®, practicing the paradigm for just less than two years.

Future investigators may wish to set more stringent inclusion criteria to determine a more accurate presentation of the treatment's effect on participants who present with restrictions on multiple measures of hamstring extensibility. Similarly, it may be beneficial to identify how AHT varies across the different assessment methods and how each method responds to TMR® FFTT treatment. Furthermore, future studies should be conducted to examine the most effective method of implementing the TMR® FFTT protocol (e.g., feet together or feet apart first).

CONCLUSION

The current study represents the preliminary exploration of the effects of the TMR® FFTT on patients with limited extensibility on the AKE. The TMR® FFTT is effective at increasing ROM on measures of hamstring extensibility immediately following a single intervention compared to a sham treatment that consisted of a sub-optimal form of static stretching. Despite the many limitations of this study, the outcomes support that the TMR® FFTT may be a promising alternative intervention to the traditional methods, however, further investigation is needed to support this hypothesis.

Table 4.1. Demographic data for included participants at baseline (N=58).

	TMR® FFTT	Sham
Gender	13 F, 15 M	13 F, 17 M
Age	20.8 ± 1.7	20.6 ± 1.5
AKE (most restricted leg)	42.9º ± 7.7º	45.1º ± 10.1º
TMR® Asymmetry	36.1 ± 20.1	27.8 ± 17.8
PTS Score	5.2 ± 2.0	5.8 ± 1.8
Population	17 IC, 0 CS, 11 REC	17 IC, 2 CS, 11 REC

AKE=active knee extension; PTS=Perceived Tightness Scale; TMR®=Total Motion Release®
Activity Level: IC=intercollegiate; CS=club sport; REC=recreational

Table 4.2. Reliability data for all range of motion measurements.

Measurement	Intra-Rater ICC	Inter-Rater ICC	Inter-Rater 95% CI	SEM	MDC
AKE	0.80 - 0.89	0.94	0.90, 0.97	3.28	9.08
PSLR	0.87 - 0.91	0.88	0.77, 0.94	6.88	19.07
FFD	0.94 - 0.96	0.98	0.96, 0.99	1.54	4.26
VSR	0.94 - 0.97	0.98	0.97, 0.99	1.4	3.89

AKE=active knee extension; CI=confidence interval; FFD=finger-floor distance; ICC=intraclass correlation coefficient; MDC=minimal detectable change; PSLR=passive straight leg raise; SEM=standard error of measurement; VSR=v-sit and reach

Table 4.3. Intra-rater reliability data for all range of motion measurements.

Rater	AKE	PSLR	VSR	FFD
AZ				
ICC	0.879	0.871	.95	0.959
SEM	4.31	5.78	2.33cm	1.92cm
MDC	11.95	16.03	6.46cm	5.31cm
BB				
ICC	0.8	0.889	.957	0.935
SEM	5.42°	6.49°	2.18cm	2.56cm
MDC	15.02°	17.98°	6.05cm	7.11cm
BH				
ICC	0.894	0.914	0.951	0.949
SEM	4.30°	5.06°	2.28cm	2.16cm
MDC	11.92°	14.04°	6.31cm	5.98cm
CH				
ICC	0.867	0.872	0.943	0.947
SEM	4.33°	4.99°	2.47cm	2.13cm
MDC	12.01°	13.82°	6.86cm	5.89cm
RL				
ICC	0.861	0.902	0.965	0.954
SEM	4.86°	5.12°	1.88cm	2.00cm
MDC	13.47°	14.19°	5.22cm	5.55cm

AKE=active knee extension; CI=confidence interval; FFD-finger to floor distance; ICC=intraclass correlation coefficient; MDC=minimal detectable change; PSLR=passive straight leg raise; SEM=standard error of measurement; VSR=v-sit and reach

Table 4.4. Within-subjects effects of TMR® FFTT over time (mean ± SD).

	Baseline	Immediate Post-Treatment	One-day Follow-up
Most restricted AKE	42.9º ± 7.7º	36.5º ± 6.8º*	37.9º ± 10.2º*
Most restricted PSLR	51.6º ± 14.8º	57.4º ± 15.2º*	56.0º ± 13.6º*
FFD	10.5cm ± 10.5cm	5.9cm ± 8.8cm*	7.6cm ± 11.4cm*
VSR	-13.5cm ± 11.0cm	-9.1cm ± 11.0cm*	-11.4cm ± 11.4cm*^

**Significant difference from baseline (p≤0.05)*
^Significant difference from immediate post-treatment (p≤0.05)
AKE=active knee extension; FFD=finger-floor distance; PSLR=passive straight leg raise; VSR=v-sit and reach

Table 4.5. Between-subjects effects of TMR® FFTT vs. sham over time.

	Pre-Post (mean difference ± SD)				Pre-One Day (mean difference ± SD)			
	TMR® FFTT	Sham	p-value	95% CI of difference	TMR® FFTT	Sham	p-value	95% CI of difference
Most restricted AKE	$6.4^0 \pm 4.8^0$	$2.7^0 \pm 6.6^0$	0.018*	0.66, 6.8	$5.0^0 \pm 6.0^0$	$2.6^0 \pm 5.5^0$	0.105	-0.53, 5.5
Most restricted PSLR	$5.8^0 \pm 4.2^0$	$2.2^0 \pm 4.5^0$	0.002*	1.4, 6.0	$4.4^0 \pm 8.1^0$	$1.0^0 \pm 8.1^0$	0.115	-0.86, 7.7
FFD	4.6±3.4cm	2.0±4.1cm	0.010*	0.67, 4.7	2.9±4.6cm	1.0±5.1cm	0.155	-0.73, 4.5
VSR	4.4±3.1cm	1.7±2.9cm	0.001*	1.1, 4.3	2.2±3.3cm	-0.12±5.2cm	0.054	-0.04, 4.6

**Indicates significance using Holm's sequential Bonferroni post-hoc testing.*
AKE=active knee extension; CI=confidence interval; FFD=finger-floor distance; PSLR=passive straight leg raise; TMR® FFTT= Total Motion Release® forward flexion trunk twist; VSR=v-sit and reach

Figure 4.1. Sham treatment (A only) and TMR® FFTT feet together position (A and B).

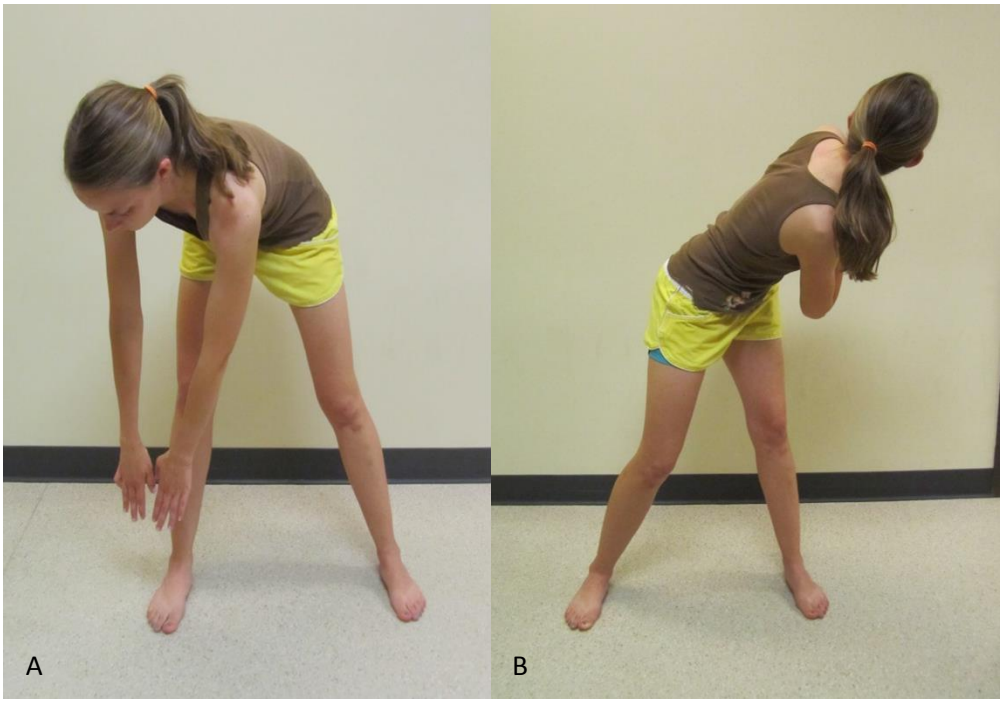

Figure 4.2. Sham treatment (A only) and TMR® FFTT feet together position (A and B).

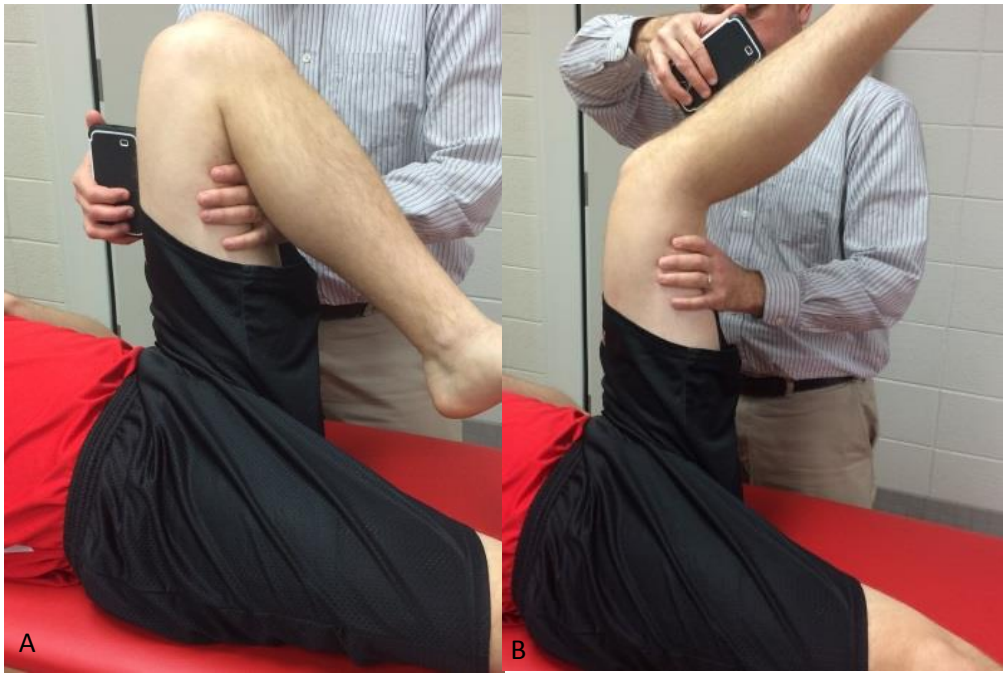

Figure 4.3. Active knee extension (AKE) assessment.

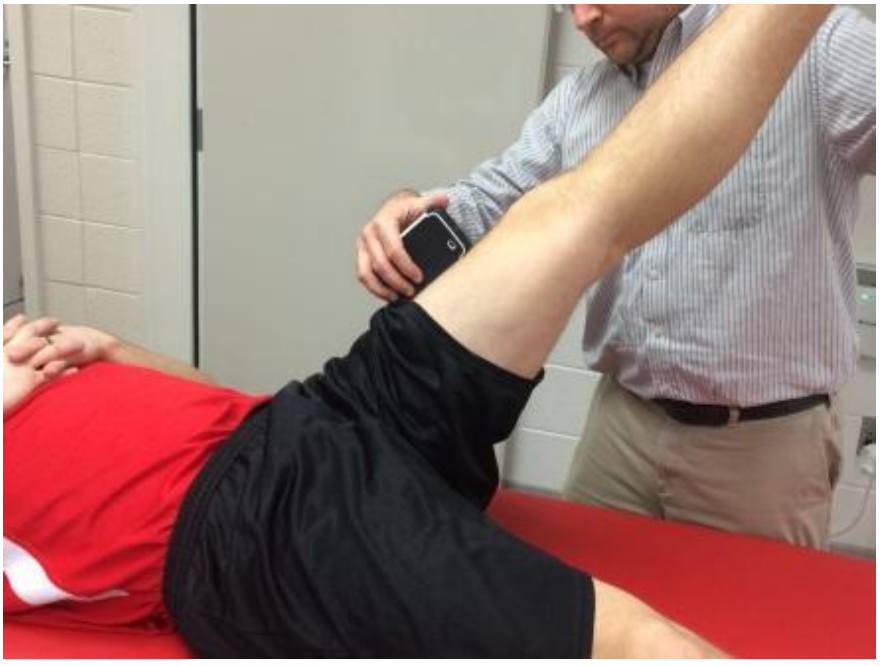

Figure 4.4. Passive straight leg raise (PSLR) assessment.

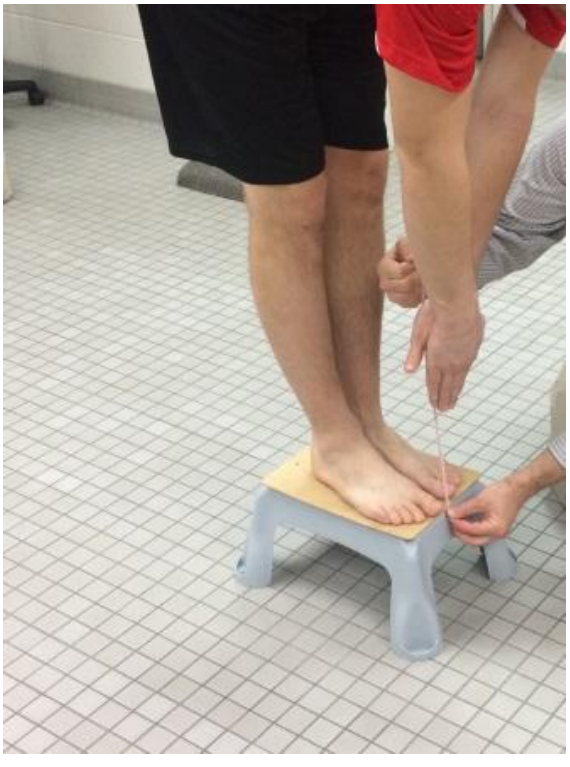

Figure 4.5. Finger to floor distance (FFD) assessment.

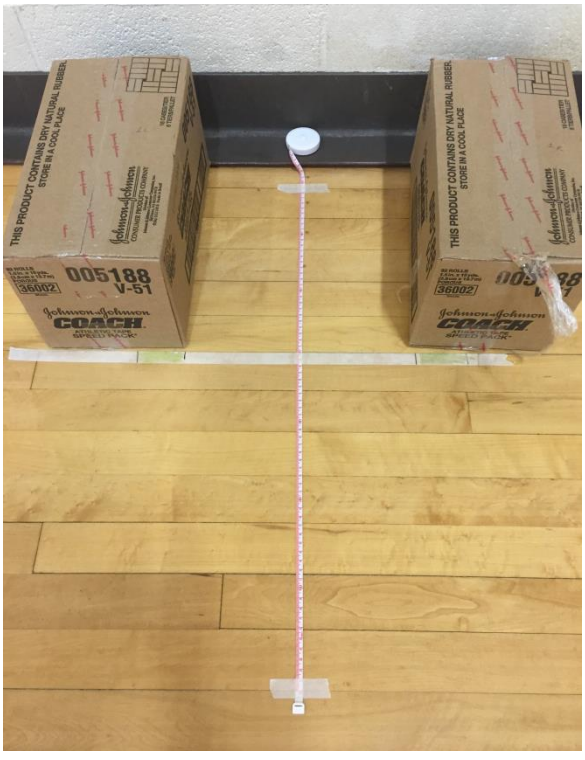

Figure 4.6. V-sit and reach (VSR) set-up.

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