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In this issue

Regular features

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

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Editor's Note

Keeping Our Eye on The Ball!

Christopher Hughes, PT, PhD, OCS

Let me briefly cite the mission and focus of *Orthopaedic Physical Therapy Practice* (*OP*).

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

Content/Focus: *OP* is an expanded newsletter containing non-peer reviewed articles of clinical interest, abstracts of scientific literature, and book reviews. Recognized special interest groups—Occupational Health, Foot & Ankle, Performing Arts, Pain Management, Imaging, and Animal Physical Therapists—also publish their newsletters within *OP*.

Since I took over as Editor of *OP*, I have seen many types of articles and topics come across my desk. Despite the variety in content, we have always tried to adhere to one standard: *Is this work something that would be of interest to our readers so that they can apply the information to their practice?*

We are not of the same research rigor as the *Journal of Orthopaedic and Sports Physical Therapy* (*JOSPT*) nor should we be. We function as more of an "interest reviewed" publication with an attempt at trying to put forth valid and credible clinical information that allows readers to reflect on their practice and relate to the patients they treat. We see our role as complementary to *JOSPT*. We feel we are meeting our objectives within the Section's strategic plan by advocating evidence-based practice. Our portion of evidence-based practice (research, expertise/experience, patient values) comes in the form of sharing clinical experience more than publishing outcomes from randomized controlled trials. On occasion we do publish case reports, small sample studies, and also systematic reviews. Their merit is still predicated on direct relevance to practice. We will try to favor content that is immediately applicable and is "need to know" versus "nice to know."

A variety of content fills *OP*. This issue is no different. We span a variety of topics. Robinson discusses treatment of hamstring injuries, Arbuckle and colleagues address the role of muscle stimulation for quadriceps strengthening, Hutcherson applies an EBP model to treatment of rotator cuff tears, Tomas conducts a review of diagnosis of SI joint pain, and Luedeka and Michener present a novel approach to therapeutic exercise for treatment of failed rotator cuff repair. Since *OP* does not solicit articles, we believe we reflect the pulse of practice and what clinicians are thinking and doing.

Past surveys indicate that readers find the publication worthy and enjoyable to read. Furthermore, I think readers know that we are an inviting publication. Anyone with a little diligence can share their experiences by publishing in *OP*. Many of our authors are first-time publishers. In fact we encourage first-timer publication by offering issues like our special faculty student issue. We hope that the accomplishment of publishing encourages authors to pursue more rigorous publication pursuits and also to continue to delve into the literature to become more "up on the literature."

The other function of *OP* is to keep you abreast of Section activities like CSM, Board, and SIG reports. Including news from the Section is vital to understanding Section governance and how the Section and SIGs attempt to meet the needs of its members.

We also feel it is important to present products and announcements that showcase various products and continuing education activities. I am appreciative of all our advertisers. Through their advertisements, they offset production costs of *OP* and trust that we will reach the audience they seek to target.

Finally I encourage you visit our *OP* archive on the Section web site. In the future we hope to deliver more digital options and also personalize your access to Section resources. As we push forward, we hope all of our efforts bring you closer to the Section and encourages your involvement.

In conclusion, we will continue to strive toward fulfilling our very straightforward mission. Throughout my tenure, I have seen a great change in not only the number of submissions but also the quality. With your help and support, we will continue to do our best in putting together an issue that is pertinent to practice and allows reflection on patient care. As we continue to work together, I am confident the future will be bright for *OP*. Thank you for your support of the Section and also your attention to *OP*!

Congratulations Orthopaedic Section Members!

Renata Salvatori was selected by APTA as an Emerging Leader Award recipient. Renata currently serves as the Membership Chair for the Orthopaedic Section.

The following members are recipients of the APTA's 2013 Honors and Awards program:

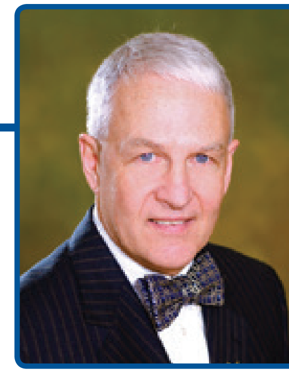
Kathleen "Jake" Kovacek, PT received the Recognition of Legislative Commitment Awards

Dean McCall, PT, DPT, OCS received the State Legislative Leadership Award

Kirk Peck, PT, PhD, CSCS, CCRT received the Recognition of Legislative Commitment Award

President's Corner

Stephen McDavitt, PT, DPT, MS, FAAOMPT



The New Vision Statement of the Physical Therapy Profession: Vision 2020, a vision of self-promotion and identity evolves now to a new outward vision refining the moral evolution of physical therapist practice; "Transforming society by optimizing movement to improve the human experience."

We all appreciate that physical therapist practice has evolved through the early to mid-1900s from dependence on physicians to independent practice under a self-governing professional model. Moving into the 1970s the benefits to society by physical therapist practice without referral was promoted by PTs as a safe, cost-effective and beneficial service to society. To enhance the professional education component of this realization, in 1979 the APTA House of Delegates prescribed post-baccalaureate education for all entry-level PT education programs. Further, the APTA House of Delegates in 1981 sanctioned practice without referral as ethical where legal. These actions expanded direct access initiatives in promoting and defending practice identity and scope of practice. Those challenges spawned the need for and development of the competency-based consensus documents *Guide to Physical Therapist Practice* and *A Normative Model of Physical Therapist Professional Education*.

Clinical practice competency advanced during the 1980s and 1990s in the arenas of education, specialization, residencies, and fellowships. These evolutionary circumstances resulted in recognizing the need to manage advancing competencies within expanding professional roles and demands as well as hone future accountabilities. In appreciation for those requisites, the 2000 APTA House of Delegates adopted the APTA Vision Statement for Physical Therapy 2020.

> *Physical therapy, by 2020, will be provided by physical therapists who are doctors of physical therapy and who may be board-certified specialists. Consumers will have direct access to physical therapists in all environments for patient/client management, prevention, and wellness services. Physical therapists will be practitioners of choice in patients'/clients' health networks and will hold all privileges of autonomous practice. Physical therapists may be assisted by physical therapist assistants who are educated and licensed to provide physical therapist directed and supervised components of interventions.*
>
> *Guided by integrity, life-long learning, and a commitment to comprehensive and accessible health programs for all people, physical therapists and physical therapist assistants will render evidence-based services throughout the continuum of care and improve quality of life for society. They will provide culturally sensitive care distinguished by trust, respect, and an appreciation for individual differences.*
>
> http://www.apta.org/Vision2020/ (Accessed 8/24/2013)

The elements (6 pillars) including autonomous practice, direct access, doctor of physical therapy, evidence-based practice, practitioner of choice, and professionalism were then embedded in all APTA plans and actions.

Vision 2020 served as APTA's official vision statement for the future of physical therapy since its inception 13 years ago. A major appreciation within and outside the profession was that it described and defined the future of physical therapy in health care as a distinguishable profession characterized by physical therapist practice having the foundation and competency for independent, self-determined, professional judgment and action. The challenges, risks, and benefits in framing and integrating relative autonomy stemming from Vision 2020 were well described in the last Presidents Corner.

This past June, the 2013 House adopted the new and now current Vision Statement of the Physical Therapy Profession that unlike Vision 2020, is more outward reaching and collaborative in the description of the profession across society. "*Transforming society by optimizing movement to improve the human experience*." This vision is supported by Guiding Principles to Achieve the Vision including identity, quality, collaboration, value, innovation, consumer-centricity, access/equity, and advocacy.

GUIDING PRINCIPLES TO ACHIEVE THE VISION

Identity. The physical therapy profession will define and promote the movement system as the foundation for optimizing movement to improve the health of society. Recognition and validation of the movement system is essential to understand the structure, function, and potential of the human body. The physical therapist will be responsible for evaluating and managing an individual's movement system across the lifespan to promote optimal development; diagnose impairments, activity limitations, and participation restrictions; and provide interventions targeted at preventing or ameliorating activity limitations and participation restrictions. The movement system is the core of physical therapist practice, education, and research.

Quality. The physical therapy profession will commit to establishing and adopting best practice standards across the domains of practice, education, and research as the individuals in these domains strive to be flexible, prepared, and responsive in a dynamic and ever-changing world. As independent practitioners, doctors of physical therapy in clinical practice will embrace best practice standards in examination, diagnosis/classification, intervention, and outcome measurement. These physical therapists will generate, validate, and disseminate evidence and quality indicators, espousing payment for outcomes and patient satisfaction, striving to prevent adverse events related to patient care, and demonstrating continuing competence. Educators will seek to propagate the highest standards of teaching and learning, supporting collaboration and innovation throughout academia. Researchers will collaborate with clinicians to expand available evidence and translate it into practice, conduct comparative effectiveness research, standardize outcome measurement, and participate in interprofessional research teams.

Collaboration. The physical therapy profession will demonstrate the value of collaboration with other health care providers, consumers, community organizations, and other disciplines to solve the health-related challenges that society faces. In clinical practice, doctors of physical therapy, who collaborate across the continuum of care, will ensure that services are coordinated, of value, and consumer-centered by referring, co-managing, engaging consultants, and directing and supervising care. Education models will value and foster interprofessional approaches to best meet consumer and population needs and instill team values in physical therapists and physical therapist assistants. Interprofessional research approaches will ensure that evidence translates to practice and is consumer-centered.

Value. Value has been defined as "the health outcomes achieved per dollar spent."[1] To ensure the best value, services that the physical therapy profession will provide will be safe, effective, patient-centered, timely, efficient, and equitable. Outcomes will be both meaningful to patients and cost-effective. Value will be demonstrated and achieved in all settings in which physical therapist services are delivered. Accountability will be a core characteristic of the profession and will be essential to demonstrating value.

Innovation. The physical therapy profession will offer creative and proactive solutions to enhance health services delivery and to increase the value of physical therapy to society. Innovation will occur in many settings and dimensions, including health care delivery models, practice patterns, education, research, and the development of patient-centered procedures and devices and new technology applications. In clinical practice, collaboration with developers, engineers, and social entrepreneurs will capitalize on the technological savvy of the consumer and extend the reach of the physical therapist beyond traditional patient-therapist settings. Innovation in education will enhance interprofessional learning, address workforce needs, respond to declining higher education funding, and, anticipating the changing way adults learn, foster new educational models and delivery methods. In research, innovation will advance knowledge about the profession, apply new knowledge in such areas as genetics and engineering, and lead to new possibilities related to movement and function. New models of research and enhanced approaches to the translation of evidence will more expediently put these discoveries and other new information into the hands and minds of clinicians and educators.

Consumer-centricity. Patient/client/consumer values and goals will be central to all efforts in which the physical therapy profession will engage. The physical therapy profession embraces cultural competence as a necessary skill to ensure best practice in providing physical therapist services by responding to individual and cultural considerations, needs, and values.

Access/Equity. The physical therapy profession will recognize health inequities and disparities and work to ameliorate them through innovative models of service delivery, advocacy, attention to the influence of the social determinants of health on the consumer, collaboration with community entities to expand the benefit provided by physical therapy, serving as a point of entry to the health care system, and direct outreach to consumers to educate and increase awareness.

Advocacy. The physical therapy profession will advocate for patients/clients/consumers both as individuals and as a population, in practice, education, and research settings to manage and promote change, adopt best practice standards and approaches, and ensure that systems are built to be consumer-centered.

http://www.apta.org/Vision/
(Accessed 8/24/2013)

I view commissioning this new vision as moving forward through the next step in the moral evolution of our practice. Thirteen years ago, Ruth Purtilo PT, PhD, FAPTA, in her 31st Mary McMillan address[1] identified 3 periods in physical therapy's history setting the moral foundation for our practice development, resulting in stages of our ethical identity. According to Dr. Purtilo, these periods of ethical identity have no defined barriers and once started remain ongoing with various inter-reliant relationships where one phase directly contributes to the next. The "period of self-identity" enabled us to be individually recognized within professional relationships across various health care providers. The "patient focused identity" period framed the moral foundation character we achieved through professional relationships with our patients and clients. This new externally directed vision spring boards us forward through the next phase in our moral evolution that Dr. Purtilo labels as the "period of societal identity." It is in this phase we as physical therapists will need to foster relationships beyond our professional colleagues or patients and establish moral foundations for "true partnering within the larger community of citizens and institutions." We need to partner and be recognized as being a patient-focused, evidence-based, and inter-collaborative health care profession that provides both selective expertise and value to those individuals and groups in society that can benefit from our proficiency.

As we move forward in the advancement of physical therapist practice in Orthopaedics and the strategic plan for the Orthopaedic Section, we should recognize and embrace the direction and flavor of the new vision as an aspiration for our commitment to society. Even though Vision 2020 is no longer an APTA active document, the values and inter-dependent relationships from the elements of Vision 2020 including autonomous practice, direct access, doctor of physical therapy, evidence-based practice, practitioner of choice, and professionalism will remain influential to the new vision as part of the companion document and guiding principles. Also, much of the remaining unfinished business from Vision 2020 will continue to be completed since its elements remain embedded in the APTA goals and strategic plan. Currently as we move to proclaim and demonstrate our added value in health care reform, engaging in this new vision will further refine and enhance our moral identity to society. This level of identity will authorize our relative autonomy and accountability while participating in multi-interdisciplinary collaborative practice models of the future as we address the movement systems for improving the health of society. I look forward to considering, implementing, and advocating this new vision as we advance through our "societal identity phase" in our evolution of orthopaedic physical therapy practice.

REFERENCE

1. Purtilo RB. Thirty-First Mary McMillan Lecture. A time to harvest, a time to sow: ethics for a shifting landscape. *Phys Ther*. 2000;80:1112-1119.

Tendinopathy and Application to Hamstring Strain Injuries

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ABSTRACT

Background and Purpose: Hamstring strains are a common injury among the athletic and active populations and have a high recurrence rate. This has led to speculation regarding what specific rehabilitation strategies should be used. Injury to this muscle group, whether chronic or acute, is difficult to treat and should be based on the histological progression of healing connective tissue. The goals of this article are to review normal tendon composition and hamstring anatomy, examine tendinopathy and hamstring strain injuries, discuss the factors involved with tendon healing, and explore rehabilitation methods based on the histological progression of healing connective tissue. **Method and Findings:** A review of the literature revealed that management of strains and tendinopathies is still not fully understood and poses many rehabilitation challenges. The goals of rehabilitation are often hard to achieve. Eccentric strengthening, lumbopelvic muscular control, and specific modalities are among the many therapeutic methods suggested to aid the healing processes of hamstring tendinopathies. **Clinical Relevance:** Hamstring strains are common but difficult injuries to treat and often are associated with acute or chronic tendinopathy. Clinicians should be aware of the histological progression of connective tissue and use this factor as the basis for determining modalities of choice and exercise progression during each rehabilitation phase.

Key Words: rehabilitation, eccentric strengthening, core strengthening, mobilization

INTRODUCTION

Hamstring strains are a common injury among athletic and active populations. Hamstring injuries have a high recurrence rate. This has led to speculation regarding what specific rehabilitation strategies should be used.[1-4] Injury to this muscle group, whether in the chronic or acute stage, is difficult to treat. Research has been done in this area; however, there are still inconsistencies in the literature. Strains to the hamstring muscle group can involve the muscle itself, the tendon, or a combination of both. Injury to the tendon leads to a cascade of events for tissue healing and repair. Tendinopathy (tendinitis and tendinosis) is also common and can be debilitating in functional activities. Acutely, tendinopathy involves microtears and inflammation. Chronically, degeneration and cellular changes are present.[4,5] Classic cases of noncontact eccentric activities involving the hamstrings cause strain, such as sprinting or kicking; however, muscular overuse from activities such as dance, yoga, and martial arts can lead to chronic tendinopathy and susceptibility to a strain.[4] Repetitive activities without proper rest may cause tissue maladaption and cellular abnormalities that alter normal tissue mechanics and further increase the risk for more serious injury.[6] Adhesions from chronic injury can interfere with mobility of the sciatic nerve, which travels deep to the hamstrings and innervates all muscles of the lower extremity, and cause additional symptoms distal to the original injury.[7]

Management of tendon injuries is still not fully understood and poses many challenges for clinicians. The goals of rehabilitation although clear are often hard to achieve; clinicians must appreciate injury mechanics, and also the histological changes that accompany injury. The goals of this article are to review normal tendon composition and hamstring anatomy, examine tendinopathy and hamstring strain injuries, discuss the factors involved with tendon healing, and promote rehabilitation methods based on the histological progression of healing connective tissue.

TENDON COMPOSITION AND STRUCTURAL ORGANIZATION

Tendinous tissue is composed of 70% water and 30% dry mass.[8] The dry mass is further broken down into type 1 collagen and elastin. Type 1 collagen is a fibrous protein that is the basic building block of connective tissue. An appropriate proportion of elastin allows deformation under tension and compression while allowing return to its original state after force removal.[8] Tenoblasts, or immature tendon cells, transform into tenocytes that synthesize collagen and components of the extracellular matrix (ECM) network.[5] The extracellular matrix surrounds collagen and tenocytes and is composed of several components for specific functions such as proteoglycans, glycoproteins, and tenascin-C.[9] Proteoglycans are formed of glycosaminoglycan subunits, long polysaccharide chains containing amino sugars, and are strongly hydrophilic to allow rapid diffusion of water-soluble molecules and easy migration of cells. Glycoproteins consist of fibronectin and thrombospondin and function as adhesive structures for repair and regeneration. Tenascin-C functions as an elastic protein and may play a role in collagen fiber orientation and alignment. Tendinous tissue also presents with a small vascular supply and sensory innervations.[5]

Tendon structure is broken down into fibers and bundles surrounded by tendon sheaths[5] (Figure 1). Tropocollagen is a triple helix polypeptide chain that unites into collagen fibrils, which then form a collagen fiber. Fibers then combine into primary, secondary, and tertiary bundles, and finally the tendon itself. Epitenon surrounds the tendon and houses the vascular, lymphatic, and nerve supplies to the tendon; as it extends inward to encase the bundles, it is known as the endotenon. Paratenon surrounds the epitenon superficially and is composed of loose areolar connective tissue as well as sensory and autonomic nerve fibers.[10] Tendinous collagen fibrils insert into myocyte depressions that allow tension from the muscle to transmit to the tendon. This tendon-to-muscle structure does not function individually, but rather as a continuous complex during all activities. While this specific architecture allows reduced tensile stress on the tendon, the myotendinous junction is still a weak area in the muscle-tendon unit and vulnerable to injury.[5,11,14]

ANATOMY AND FUNCTION OF THE HAMSTRING MUSCLE COMPLEX

The biceps femoris, semitendinosus, and semimembranosus constitute the hamstring muscular complex. The biceps femoris has a long head that originates from the ischial tuberosity and a short head from the lateral

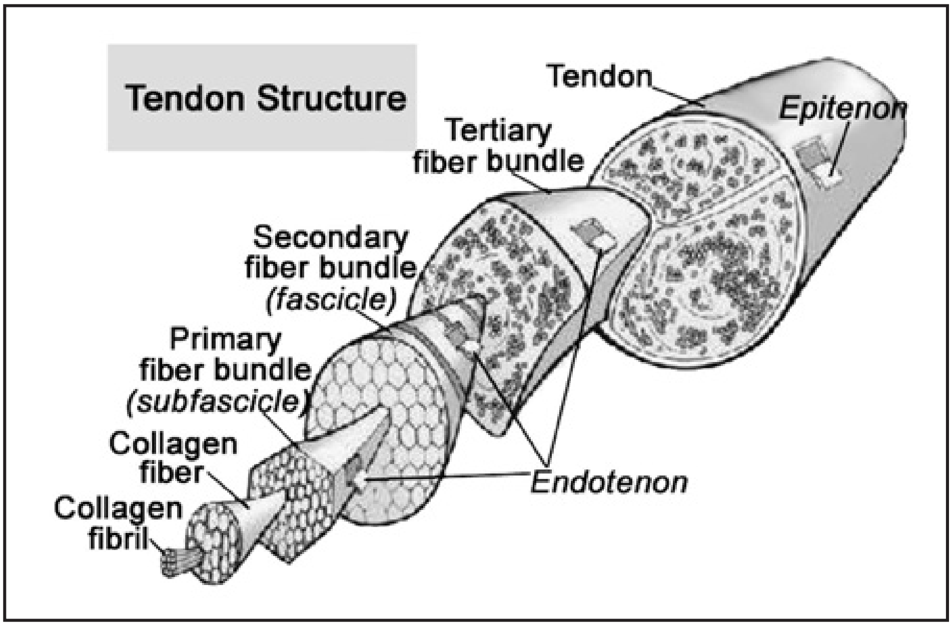

Figure 1. Normal tendon anatomy. Reprinted with permission from the *Journal of Bone and Joint Surgery*.[5] Copyright 2005, Journal of Bone and Joint Surgery.

linea aspera, lateral supracondylar line, and intramuscular septum. The common tendon inserts on the fibula, lateral tibial condyle, and leg fascia. The tibial portion of the sciatic nerve innervates the long head and the peroneal division innervates the short head. The biceps femoris is the most commonly strained hamstring muscle, possibly due to its biarticular nature and its dual innervation from the tibial and common peroneal nerves.[12] The semitendinosus arises from the ischial tuberosity by a conjoined tendon with the biceps femoris and inserts on the medial tibia at Gerdy's tubercle. Finally, the semimembranosus originates on the ischial tuberosity beneath the semitendinosus and inserts onto the medial tibial condyle, posterior oblique ligament, arcuate ligament, and posterior joint capsule. The semimembranosus and semitendinosus are both innervated by the tibial division of the sciatic nerve. Many anatomic variations exist with these muscles, which may predispose patients to injury.[12]

The hamstrings have several functions during a normal gait cycle. Prior to heel contact, this muscle group decelerates knee extension and hip flexion to prepare for foot contact with the ground. The initial 10% of stance phase requires the hamstrings to be active for hip extension and provides stability to the knee through coactivation for dynamic stabilization. During pre-swing, active hip flexion causes passive knee flexion, although the short head of the biceps femoris may assist with knee flexion during this phase, in addition to slight gastrocnemius activation.[13]

Activities such as running, jumping, kicking, dance, and martial arts all require the hamstrings to eccentrically decelerate knee extension and hip flexion while rapidly switching roles to concentrically control hip extension. Running velocity changes the pattern of movement and joint kinematics; fast running or sprinting requires greater movement velocity and amplitude.[13] During the second half of the swing phase in running, the hamstrings are actively lengthening and absorbing energy while decelerating the limb; the biceps femoris has the greatest musculotendon stretch during this phase.[4] Although this is the anatomic function of the muscle, injury occurs from excessive repetition of these movements without enough recovery time or eccentric overload.

HAMSTRING STRAINS AND TENDINOPATHY

Tissue damage occurs when a force exceeds the tissue's deformation capacity. Hamstring strain injuries are common among athletes due to excessive and repetitive eccentric loads on the muscle group during the gait cycle. By understanding the stress/strain curve, one can appreciate and apply these principles to forces on tendons (Figure 2). At rest, collagen fibers and fibrils are arranged in a crimped fashion. Initial force application leads to flattening of the crimped fibers and is referred to as the toe region. The physiological range refers to a linear progression of force application; the tendon maintains elastic properties and returns to original length when the force is unloaded. Beyond the physiological range, microscopic or macroscopic failure occurs from damage and slippage between adjoining molecules.[5]

At terminal swing phase the hamstrings lengthen and absorb energy to decelerate the limb and prepare for heel strike, but eccentric loads beyond the physiological range can lead to microscopic or macroscopic failure.[4] Strain injuries are common at the musculotendinous junction, the weakest point in the muscle-tendon unit.[14] Athletes participating in dynamic activities such as track, football, soccer, or dance are susceptible to this type of injury.

Hamstring strains involving the tendon may correlate with hamstring tendinopathy.[4] In acute injury this involves microtears and inflammation that causes edema, warmth, redness, and pain.[14] The grade of muscle strain is determined by the symptoms present. Grade 1 strains involve some pain with minimal range of motion or strength loss. Grade 2 strains involve more significant muscle fiber disruption, thus more pain and limited function. Grade 3 strains are the most severe and involve complete muscle disruption and complete loss of strength and function.[4]

If the tendinopathy is a chronic issue, cellular degeneration and collagen abnormalities are present.[5,6,10,15] More specifically, this includes failure of the ECM to adapt to changes, disordered healing with the absence of inflammatory cells, and fiber disorientation.[5,16,17] Repetitive loading can be detrimental if the poorly-vascularized tendon does not have time to heal and prevent further injury. Tissue maladaption progresses over time, leading to a disorganized and immature matrix.[5] Chronic pain may be due to altered sensory-sympathetic innervation. Normal innervation of the paratenon and surrounding connective tissue consists of a specific ratio of sensory and autonomic nerve fibers that regulate pain, inflammation, and repair. However, repeated microtrauma can lead to an in-growth of sprouting substance P fibers, which is an expression of sensory nerve in-growth.[10] While this is necessary for normal tendon healing, an increased amount is considered pathologic and associated with tendinopathy.

Degenerative changes in the tendon may be present before any symptoms are present.[3,4,5,10,15,18] Strains or tendinopathy to the hamstring muscle group caused by running

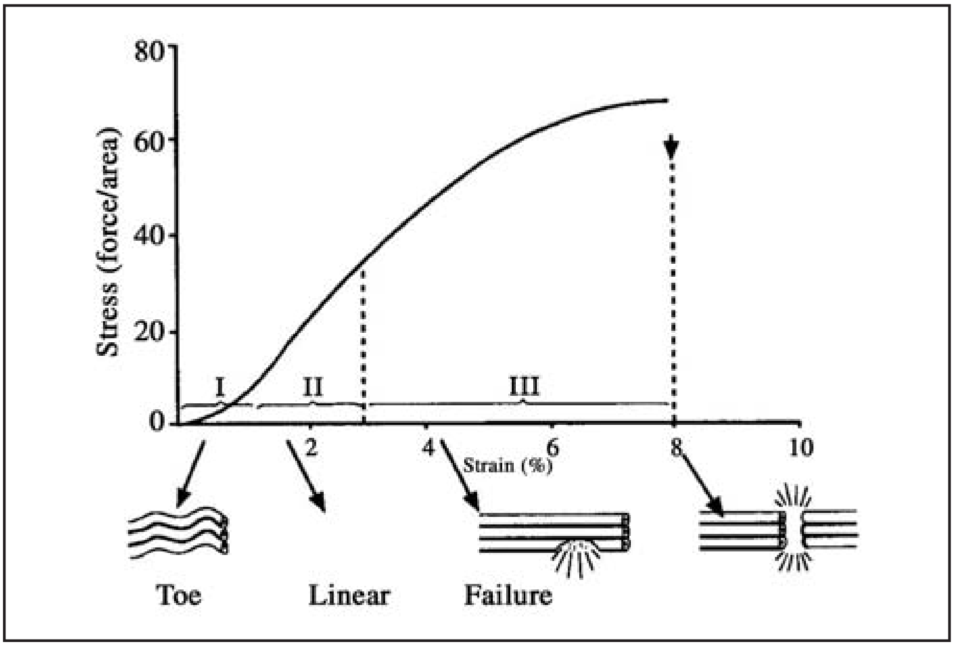

Figure 2. Stress/strain curve. Reprinted with permission from the *Journal of Bone and Joint Surgery*.[5] Copyright 2005, Journal of Bone and Joint Surgery.

sports usually affects the biceps femoris long head and occurs from repetitive eccentric loading.[4,14] Dance, yoga, and martial arts also require repetitive and excessive lengthening of the hamstrings and usually affect the semimembranosus.[4,14] When clinicians see patients engaged in these types of activities, length of time involved with the sport and prior symptomatic complaints should be considered to determine whether the current injury is acute, chronic, or an acute injury caused by chronic tendinopathy. Histological changes can occur before any symptoms are present if the patient is placing too much stress on the tendon over time.

CONSIDERATIONS FOR TENDON HEALING

Several factors are responsible for poor healing of tendinous tissue. Oxygen consumption by tendons and ligaments is 7.5 times lower than skeletal muscle.[19] The ability to carry loads and maintain tension for a prolonged time is possible because of the low metabolic rate and well-developed anaerobic energy generation. While this is beneficial for decreasing the risk of ischemia and necrosis, low metabolic rate means slower healing time after injury. Tendons receive blood supply from intrinsic and extrinsic systems; however, vessels from muscle usually do not extend beyond the proximal third of the tendon. Blood supply is also limited from the osteotendinous junction.[5]

Adhesion formation is a common issue with chronic cases. Disruption of the synovial sheath allows granulation tissue and tenocytes from surrounding tissues to invade the injured site, which results in adhesion formation. Even though remodeling occurs, the biochemical and mechanical properties are never the same as normal tendon tissue. Adhesion formation may affect the sciatic nerve, which travels deep to the hamstrings and close to the proximal tendons. A study by Turl & George assessed neural tension using the slump test in a group of male rugby players with a history of grade 1 repetitive hamstring strain and compared them to an injury-free control match group. They found that 57% of the test group had positive slump tests, suggesting the presence of adverse neural tension; none of the control group had positive results. Scarring from tendinopathy may interfere with normal sciatic mobility, and adverse sciatic nerve tension may be a large contributor to chronic symptoms.[7] Since the sciatic nerve affects the entire lower extremity, symptoms distal to the injured site are often present if the sciatic nerve is involved. However, if distal symptoms are present, clinicians should always screen the lumbopelvic area for abnormalities and not assume the pain is from adhesion formation.

Risk factors for reinjury include weakness in the injured and surrounding muscles, residual scar tissue, sporting movement and biomechanical gait adaptations, muscle imbalances, and poor control of the lumbopelvic muscles.[4] To prevent reoccurring strains, clinicians should incorporate eccentric exercises to increase peak hamstring eccentric strength and shift peak force development to longer muscle lengths.[20] As with all interventions, a gradual increase in load and intensity is necessary to minimize delayed onset muscle soreness. Neuromuscular control is also important for injury prevention, specifically targeting lower extremity and lumbopelvic musculature.[2,21] Exercises should focus on postural control, power development, and a gradual increase in intensity.

REHABILITATION STRATEGIES

Trunk Stabilization

When examining patients with hamstring injuries, particular attention should be paid to the pelvis, lumbar spine, and trunk musculature, in particular with gait. Gait abnormalities may have actually been a precipitating factor in causing injury, or be a result of compensation. Because the pelvis is the origin for the hamstrings, neuromuscular control of the lumbopelvic musculature is necessary for optimal hamstring function. All movements begin at the lumbo-pelvic-hip complex otherwise known as the core. The lumbo-pelvic-hip complex contains 29 muscle attachments and proper force-couple relationships directly rely on normal length-tension relationships. The entire kinetic chain depends on optimal function of the lumbo-pelvic-hip complex. For example, weak core musculature cannot fully stabilize strong muscle efforts from the extremity musculature. This imbalance can lead to inefficient movements that hinder normal function and possibly cause serious injury. Changes in pelvic position cause changes in hamstring length, thus altering the length-tension and force-velocity relationships of this muscle complex. Anterior tilting of the pelvis causes lengthening of the hamstrings compared to posterior pelvic tilting that causes shortening.[22] Controlling anterior and posterior tilting during exercises and sport-specific movements through training can help athletes develop proximal stability, which is a precursor for distal mobility.[23]

Trunk stabilization and progressive agility training programs can be effective in rehabilitation and lead to earlier return to activity, possibly due to better control of the lumbopelvic musculature. Sherry & Best[2] compared the effectiveness of two rehab programs for acute hamstring strains. Athletes were randomly assigned to group one that included static stretching, progressive isolated hamstring resistance exercises, and ice, or group two that included progressive agility and trunk stabilization exercises and ice. They found that the group performing progressive agility and trunk stabilization exercises returned to sport earlier and had less recurrent strains than the stretching and isolated strengthening group.

Eccentric Loading

Controlled and therapeutic eccentric loading is beneficial for improving musculotendinous responses by acting as a protective adaptation.[4,20] Muscle is structured to eccentrically lengthen and perform negative work. Negative work occurs when external force (load) exceeds the muscle force production leading to muscle lengthening. Chronic tendinopathy results from excessive and repetitive activities often involving eccentric forces; however, controlled eccentric loads in a rehabilitative fashion can lead to stronger tendons, increased fibroblast activity, thickened collagen fibers, increased tropocollagen cross-links, and an optimal alignment of tendon fibers.[20] Knobloch & colleagues[15] demonstrated that a 12-week eccentric training program reduced abnormally high peritendinous blood flow in Achilles tendinopathy by 45% and decreased pain levels.

Muscles adapt to imposed demands, and controlled eccentric strengthening exercises can allow muscle fibers to become more compliant and function at longer lengths. When eccentric action occurs immediately before concentric action, musculotendon units behave like springs, meaning the elastic strain energy is stored and recovered. Stretch-shorten contractions are substantially important in many sporting activities involving running and jumping, and for that reason plyometric exercises have become common in athletic training regimens. LaStayo & colleagues[20] examined high-force eccentric training on muscle power output in vertical jumps. They compared basketball players separated into a high-force eccentric training group and a weight-training control group. After 6 weeks of training, they found a significant increase in vertical jump heights in the eccentric training group. They concluded that gains in muscle power and increases in muscle spring stiffness can occur from controlled high-force eccentric training.

Treating Proximal Tendon Injuries

Even though evidence shows that injury location and mechanism have different recovery periods, this has not been considered regarding rehabilitation strategies. Most rehab programs are designed for running-related strains involving primarily muscular tissue. There is often an increased recovery period when the injury involves the proximal tendon, is close in proximity to the ischial tuberosity, or covers a large cross-sectional area.[4] Injury to the intramuscular tendon and adjacent muscle fibers initially presents as more severe compared to proximal tendon injuries, but the latter usually involves a much longer recovery period.[24] Future investigations should focus on rehabilitation strategies for proximal tendon injuries. Until evidence becomes available it is recommended that tendon strains be treated as if treating a tendinopathy.[4]

The Orthopaedic Section of the American Physical Therapy Association (APTA) suggests certain interventions for treating tendinopathies.[14] These recommendations may also be applied to hamstring tendon injuries. Eccentric loading, iontophoresis, and nonthermal ultrasound are appropriate for acute strains. Interventions for chronic conditions include thermal ultrasound and soft tissue mobilization for collagen alignment and breakdown of adhesions. However, it should be noted that based on the current literature the effectiveness of iontophoresis for treating tendinopathy is questionable and requires further investigation.[25]

Ultrasound

During the initial phases of healing, studies have shown that nonthermal ultrasound can enhance connective tissue healing.[27-29] A possible mechanism is the acoustic micro-streaming phenomena. Acoustic streaming produces changes in diffusion rates and membrane permeability that may accelerate the rate of collagen synthesis.[27] Fu & colleagues[26] found that low-intensity pulsed ultrasound (1.5 MHz frequency, 20% duty cycle) stimulates matrix synthesis and enhances fibrillogenesis and fiber alignment only when applied during the early stages of healing. Junior & colleagues[28] demonstrated increased tendon cross-sectional area, increased collagen fibers, and local grouping of repair cells with nonthermal ultrasound (1.0 MHz frequency, 20% duty cycle) during the early healing stages. Freider & colleagues[27] found similar results, with a greater number of fibroblasts and dense collagen fibrils uniformly longitudinal. Specifically, these studies examined tendinous connective tissue and found that the benefits of nonthermal ultrasound occur only within the early stages of healing.

Therapeutic ultrasound has also been used to enhance muscle regeneration after injury, such as a muscular hamstring strain; however, evidence to support this is lacking and there is not yet a clear consensus on beneficial effects of muscle healing.[4] In addition, thermal ultrasound may be beneficial for chronic tendinopathy. Thermal ultrasound may increase tissue extensibility, decrease pain and muscle spasm, increase blood flow, and induce an inflammatory response to resolve the chronic injury.[18]

Soft-tissue Mobilization

Specific application of soft-tissue mobilization techniques can aid clinicians in promoting tissue healing. For an acute injury, the goal is to promote collagen synthesis. For a chronic injury, the focus is to break up scar tissue. In both cases creating an environment for proper fiber orientation is important. Soft-tissue mobilization techniques have been advocated to enhance blood flow, thus increasing oxygen delivery and aiding the healing process.[29] Friction massage, myofascial release, active release technique, and augmented soft tissue mobilization therapy (ASTM) are examples of soft-tissue mobilization for treating tendinopathy. In theory, these treatments create controlled microtrauma to stimulate the healing process, create an inflammatory response, and remodel the collagen with additional therapy. A study by Gehlsen & colleagues[30] investigated the morphological changes in rat Achilles tendons with ASTM therapy after inducing injury. Augmented soft tissue mobilization therapy was performed with variations in pressure for 6 sessions at 3 minutes each. They found that the group receiving heavy pressure ASTM had statistically significant greater numbers of fibroblast activity than the other groups, suggesting that heavy pressure promotes the healing process more effectively than light or medium pressure. However, caution should be warranted with applying animal studies to human treatment. Maffulli & colleagues[31] suggested that ASTM as well as deep friction massage may be beneficial in the treatment of chronic Achilles tendinopathy, due to the controlled microtrauma and subsequent fibroblast proliferation. Regardless of the method chosen, it is imperative that clinicians advance treatment based on tissue-healing.

Platelet-rich Plasma Therapy

The promising results of platelet-rich plasma (PRP) are emerging and they are being applied to many different types of injuries, including damage to tendons, muscles, and ligaments. There are many different types and concentrations of PRP and its clinical use is expanding rapidly. High concentrations of growth factors are present in PRP, including platelet derived growth factor, transforming growth factor beta, vascular endothelial growth factor, and epidermal growth factor, all of which function in tissue regeneration.[32] The intrinsic growth factors and cytokines found in PRP are present during the inflammatory phases of tissue healing, thus the goal of PRP injections during the early phases is to decrease tissue healing time.

The use of PRP in athletes with hamstring injuries is being clinically investigated. For example, Mejia & Bradley[32] found that injecting professional football players with PRP 24 to 48 hours after sustaining hamstring strains reduced healing time and number of games missed. There were no complications with the injections and zero recurrences of hamstring strains. Platelet-rich plasma has also been used to treat chronic tendinopathies that are resistant to conservative treatment. Significant improvements have been seen in treating tennis elbow, jumper's knee, and Achilles tendinopathy.[33] In chronic cases, PRP is injected to initiate a healing response, induce reparative cells to the injured site, improve tendon vascularity, and enhance the biomechanical properties of normal tendon.[34]

The roles of growth factors in tissue healing processes are expanding and the clinical use of PRP is growing rapidly; however, clinical trials on humans regarding efficacy and application still need to be investigated thoroughly. Because the term *platelet-rich plasma* includes a large variety of products, there are subsequently many different protocols for clinical use. Certain concentrations of PRP are used for different situations; however, clinical evidence is not yet conclusive and the use of PRP to augment tissue healing remains controversial.[34]

PHASES OF REHABILITATION AND TISSUE HEALING

The following 3-phase rehabilitation suggestions are adapted from Heiderscheit et al[4] and Sherry and Best,[2] which emphasize a gradual progression of exercise interventions to encourage healing and protect the injured area. These interventions correlate with the phases of tissue healing, and the following progressive phases are adapted from Sharma and Maffuli.[5] The exercises chosen should stress neuromuscular control and proper form to minimize further damage. While rest is often advocated after injury, early mobilization is important to limit the adverse effects of scar tissue formation and promote realignment of fibers. Pain may prevent the clinician from accurately assessing the injured patient, thus caution is warranted to avoid over-stretching and causing further damage to the tissue.

Phase 1

Phase 1 of rehabilitation correlates with homeostasis, inflammatory, and proliferative phases of healing, so one must consider the general steps occurring in these phases when deciding what treatment interventions are appropriate. During hemostasis, platelets initiate clot formation. Fibrin and fibronectin form cross-links with collagen fibers to form weak bonds, which helps to reduce the hemorrhage. Phagocytic cells clear away debris from damaged and devitalized tissue. Chemocytic mediators attract inflammatory white blood cells, and histamine and bradykinin are released to increase vascular permeability. During the inflammatory and proliferative phases of healing, fibroblasts and vascular buds migrate and proliferate from the surrounding connective tissue to form granulation tissue. Granulation tissue is composed of connective tissue cells and ingrowing young vessels that form from healing wounds of soft tissue. Fibroblasts secrete soluble type 3 collagen molecules that form fibrils. New extracellular matrix is formed, and immature collagen fibrils are oriented and rearranged in random alignment, which functionally means limited strength.

Phase 1 should focus on minimizing pain and edema; ice may be used as the modality of choice for this initial phase. Nonthermal ultrasound for accelerating the rate of collagen synthesis and soft-tissue mobilization for realigning collagen fibers and promoting collagen synthesis are also appropriate during the early stages of healing. Patients may also talk to their physicians about PRP therapy to decrease healing time. Scarring from tendinopathy may interfere with normal sciatic mobility so some stretching is advised. However adverse sciatic nerve tension may be a large contributor to chronic symptoms.[7] Thus over-stretching the injured area is not advised.

Performing low-intensity and painfree exercises, particularly in the frontal plane, are encouraged to avoid atrophy and protect the newly forming scar. Examples of low-intensity exercises in the frontal plane are side-step and grapevine, both in a painfree range. Although these exercises are often incorporated as agility drills for sport, it is important to note that in this phase of rehabilitation they are performed slowly and with low-impact force. Exercises involving the entire lower extremity and lumbopelvic region should also be emphasized, such as prone body bridge (Figure 3), side body bridge (Figure 4), supine bent knee bridge (Figure 5), and single-leg balance. Prior to performing these exercises, clinicians should educate patients on how to perform anterior/posterior pelvic tilts and maintain pelvic neutral in a supine position (Figure 6), then educate on maintaining pelvic neutral during exercises and controlling anterior/posterior pelvic tilting. Because pelvic position changes hamstring length, it is important to strengthen the lumbopelvic region for better control of these muscles during activity-specific movements.

Phase 2

Interventions in the later phases of healing must be chosen based on the cellular changes occurring. During tissue maturation and remodeling, immature type 3 collagen is replaced by mature type 1 collagen. Tenocytes and collagen fibers align in the direction of applied stress. After about 10 weeks the fibrous tissue gradually turns to scar-like tendon tissue and continues over the next year. The newly formed connective tissue has increased amounts of minor collagens, decreased collagen cross-links, and increased amounts of glycosaminoglycans, thus it is functionally weaker and biomechanically compromised. Scar tissue is stiffer than the contractile tissue it replaces and alters the musculotendon contraction mechanics. There is a decrease in series compliance, which shifts peak force development to shorter musculotendon lengths.

Because the tenocytes and collagen fibers align in the direction of applied stress, the exercises chosen should help aid the tissue to align properly in a parallel fashion. Continuation of soft-tissue mobilization may help align collagen fibers in conjunction with exercise. Gradual return to full range of motion is encouraged in phase 2. However, if weakness persists, end-range lengthening should be avoided because the damaged musculotendon unit may not have normal protective-guarding capabilities.

The goals are to progressively increase movement speed and continue to develop neuromuscular control of the trunk and pelvis. Eccentric exercises are introduced in this phase, such as single-leg stance with forward trunk lean and opposite hip exten-


Figure 3. Body bridge.

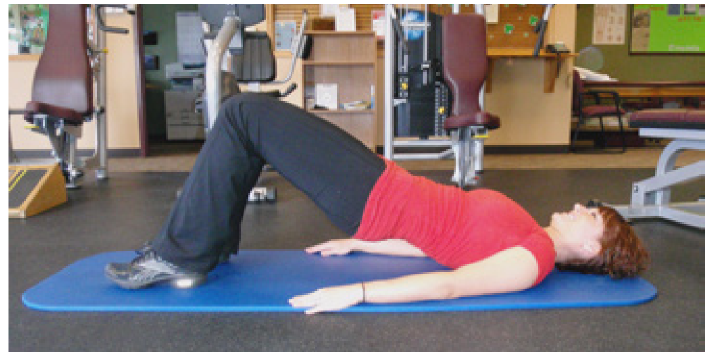
Figure 5. Supine bent knee bridge.


Figure 4. Side body bridge.


Figure 6. Pelvic tilts with neutral spine.

sion (Figure 7). Clinicians can incorporate manual eccentric strengthening of the hamstrings so the applied manual resistance is controlled for each patient's specific needs. Simple agility drills are initiated, such as side shuffle (Figure 8), grapevine jog (Figure 9), and boxer shuffle (Figure 10). As with phase I, stride and speed should be maintained in a painfree range and progressed as tolerated. Trunk stabilization exercises are progressed from phase I, with strong emphasis on neuromuscular control. Some examples are adding rotation to prone body bridge, adding walk-outs to supine bent knee bridge, and lunge walks with trunk rotation.

Phase 3

During phase 3, full and unrestricted ROM should be present. If there is suspected adhesion formation, more aggressive soft-tissue mobilization may be used to break up scar tissue and realign the collagen fibers. For chronic cases, thermal ultrasound may help to decrease tissue extensibility and enhance blood flow for continued promotion of tissue healing.

Eccentric strengthening and trunk stabilization exercises continue to progress, such as adding resistance or advancing to unilateral positions. More aggressive and sport-specific movements are incorporated involving technique training and quick direction changing movements; however, sprinting and explosive acceleration movements should be initiated with caution until the athlete is ready to return to sport. Side-shuffle, grapevine jog, and boxer shuffle can be progressed to higher intensities, still within a painfree range. Skipping, forward-backward accelerations, and plyometrics are appropriate as long as stiffness and pain are not present. At this level, specificity is important. Clinicians should create exercises that are sport-specific and incorporate postural control and progressive speed; thus understanding what movements are necessary for the patient's sport or activity is necessary for optimal training. Return to prior level of activity and sports are considered when there are no complaints of pain or stiffness with full range of motion, strengthening exercises, functional activities, and replication of sport-specific movements.

CONCLUSION

Tendinopathy can lead to many different cellular and pathological changes that must be considered prior to choosing interventions for a therapeutic rehabilitation program. Hamstring injury can be caused by excessive strain and/or degenerative changes from repetitive loading. Following hamstring injury, musculotendon remodeling can occur for many months with the formation of adhesions. Scar tissue alters force-length properties and may lead to biomechanical adaptations and negatively impact future activities. Emphasis on gradual eccentric loading, lumbopelvic strengthening, and neuromuscular control are suggested for prevention and rehabilitation of hamstring strains and tendinopathies. Additional forms of therapy, such as ultrasound, soft tissue mobilization, and PRP may be investigated and used when appropriate. Clinicians should not only treat the injured extremity, but also treat the noninjured areas to prevent additional problems. Performing a thorough examination is crucial prior to treating the patient, including the areas proximal and distal to the injured hamstring. Since tissue maladaptions can occur from repetitive activities, listening to patients during the subjective history is crucial. Statements indicating the possibility of tendinopathy on the contralateral limb or in surrounding tissues should be treated accordingly to minimize the risk of injury in those areas. Rehabilitative treatment begins at the cellular level,

Figure 7. Stabilizing single leg trunk lean with hip extension.

Figure 8. Side shuffle.

Figure 9. Grapevine jog.

Figure 10. Boxer shuffle.

thus future research should continue to investigate the effectiveness of current rehabilitation programs based on the phases of tissue healing and strategies for decreasing recurrent injury.

REFERENCES

1. Sole G, Milosavljevic S, Nicholson H, Sullivan SJ. Selective strength loss and decreased muscle activity in hamstring injury. *J Orthop Sports Phys Ther*. 2011;41(5):354-363.
2. Sherry M, Best T. Comparison of 2 rehabilitation programs in the treatment of acute hamstring strains. *J Orthop Sports Phys Ther*. 2004;34:116-125.
3. Silder A, Thellen DG, Heiderscheit BC. Effects of prior hamstring strain injury on strength, flexibility, and running mechanics. *Clin Biomech*. 2010;25(7):681-686.
4. Heiderscheit BC, Sherry MA, Silder A, Chumanov ES, Thelen DG. Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention. *J Orthop Sports Phys Ther*. 2010;40(2):67-81.
5. Sharma P, Maffuli N. Tendon injury and tendinopathy: healing and repair. *J Bone Joint Surg Am*. 2005;87:187-202.
6. Maganaris CN, Narici MV, Almekinders LC, Maffuli N. Biomechanics and pathophysiology of overuse tendon injuries. *Sports Med*. 2004;34(14):1005-1017.
7. Turl SE, George KP. Adverse neural tension: a factor in repetitive hamstring strain? *J Orthop Sports Phys Ther*. 1998;27:16-21.
8. Goodman CC, Fuller KS. *Pathology: Implications for the Physical Therapist*. Add city, state: Saunders Elsevier Inc.; 2009:233-235.
9. Maffulli N, Kader D. Tendinopathy of tendo achilles. *J Bone Joint Surg*. 2002;84-B(1):1-8.
10. Lian O, Dahl J, Ackermann PW, Frihagen F, Engebretsen L, Bahr R. Pronociceptive and antinociceptive neuromediators in patellar tendinopathy. *Am J Sports Med*. 2006;12(12):1-8.
11. Sharafi B, Ames EG, Holmes JW, Blemker SS. Strains at the myotendinous junction predicted by a micromechanical model. *J Biomech*. 2011;44(16):2795-2801.
12. Koulouris G, Connell D. Hamstring muscle complex: an imaging review. *Radiographics*. 2005;25:571-586.
13. Newman DA. *Kinesiology of the Musculoskeletal System*. St. Louis, MO: Mosby Inc; 2009:653, 673-675.
14. Rehorn M, Blemker SS. The effects of aponeurosis geometry on strain injury susceptibility explored with a 3D muscle model. *J Biomech*. 2010;43:2574-2581.
15. Knobloch K, Kraemer R, Jagodinski M, Zeichen J, Meller R, Vogt P. Eccentric training decreases paratendon capillary blood flow and preserves paratendon oxygen saturation in chronic achilles tendinopathy. *J Orthop Sports Phys Ther*. 2007;37(5):269-276.
16. Leadbetter WB. Cell-matrix response in tendon injury. *Clin Sports Med* 1992;11:533-78.
17. Selvanetti A, Cipolla M, Puddu G. Overuse tendon injuries: basic science and classification. *Oper Tech Sports Med*. 1997;5:110-117.
18. Carcia CR, Martin RL, Houck J, Wukich DK. Achilles pain, stiffness, and muscle power deficits: Achilles tendinitis. *J Orthop Sports Phys Ther*. 2010;40(9):A1-A26.
19. Vailas AC, Tipton CM, Laughlin HL, Tcheng TK, Matthes RD. Physical activity and hypophysectomy on the aerobic capacity of ligaments and tendons. *J Appl Physiol*. 1978;44:542-546.
20. LaStayo PC, Woolf JM, Lewek MD, Snyder-Mackler L, Reich T, Lindstedt SL. Eccentric muscle contractions: their contribution to injury, prevention, rehabilitation, and sport. *J Orthop Sports Phys Ther*. 2003;33:557-571.
21. Kirkland A, Garrison C, Singleton S, Rodrigo J, Boettner F, Stuckey S. Surgical and therapeutic management of a complete proximal hamstring avulsion after failed conservative approach. *J Orthop Sports Phys Ther*. 2008;38(12):754-760.
22. Sullivan MK, Dejulia JJ, Worrell TW. Effect of pelvic position and stretching method on

hamstring muscle flexibility. *Med Sci Sports Exerc*. 1992;(24)12:1383-1389.
23. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. *J Sports Med*. 2006;36(3):189-198.
24. Askling C, Saartok T, Thorstensson A. Type of acute hamstring strain affects flexibility, strength, and time to return to preinjury level. *Br J Sports Med*. 2006;40:40-44.
25. Maffulli N, Renstrom P, Leadbetter W, eds. *Tendon Injuries: Basic Science and Clinical Medicine*. Springer-Verlag London Limited; 2005:237.
26. Fu S, Hung L, Shum W, et al. In vivo low intensity pulsed ultrasound (lipus) following tendon injury promotes repair during granulation but suppresses decorin and byglycin expression during remodeling. *J Orthop Sports Phys Ther*. 2010;40(7):422-429.
27. Freider S, Weisberg J, Fleming B, Stanek A. A pilot study: the therapeutic effect of ultrasound following partial rupture of Achilles tendon in male rats. *J Orthop Sports Phys Ther*. 1988;10(2):39-46.
28. Junior SL, Camanho GL, Bassit AC, Forgas A, Ingham S, Abdalla RJ. Low intensity pulsed ultrasound accelerates healing in rat calcaneus tendon injuries. *J Orthop Sports Phys Ther*. 2011;41(7):526-531.
29. Tiidus PM. Manual massage and recovery of muscle function following exercise: a literature review. *J Orthop Sports Phys Ther*. 1997;25(2):107-112.
30. Gehlsen GM, Ganion LR, Helfst R. Fibroblast responses to variation in soft tissue mobilization pressure. *Med Sci Sports Exerc*. 1999;31(4):531-535.
31. Maffulli N, Sharma P, Luscombe KL. Achilles tendinopathy: aetiology and management. *J R Soc Med*. 2004;97:472-476.
32. Mejia HA, Bradley JP. The effects of platelet-rich plasma on muscle: basic science and clinical application. *Oper Tech Sports Med*. 2011;19:149-153.
33. Geaney LE, Arciero RA, DeBerardino TM, Mazzocca, AD. The effects of platelet-rich plasma on tendon and ligament: basic science and clinical application. *Oper Tech Sports Med*. 2011;19:160-164.
34. Mishra A, Gosens T. Clinical indications and techniques for the use of platelet-rich plasma in the elbow. *Oper Tech Sports Med*. 2011;19:170-76.
35. Arnoczky SP, Delos D, Rodeo SA. What is platelet-rich plasma? *Oper Tech Sports Med*. 2011;19:142-48.

Breaking News...

We have asked you to save the Date for the 2014 Annual Orthopaedic Section Meeting in St. Louis (see page 205 for more information). If you like the St. Louis Cardinals, we have just learned that with the release of the 2014 Cardinals baseball schedule, they will be playing both the Chicago Cubs and the Atlanta Braves at home during the same dates as our Annual Orthopaedic Section Meeting. Now you also have a "fun" reason to join us in St. Louis. Save the date and we look forward to seeing you!

Comparison of Surface Electromyography Activated Muscle Stimulation to the Biphasic Neuromuscular Electrical Stimulation Method of Quadriceps Muscle Strengthening

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ABSTRACT

Background: Surface electromyography activated muscle stimulation (sEMG:AMS) is a modality in which the patient must contract a muscle to a certain threshold before the electrical stimulation will start. **Purpose:** To evaluate the effectiveness of quadriceps strengthening using sEMG:AMS compared to traditional biphasic electrical stimulation. **Methods:** Twelve subjects received either biphasic neuromuscular electrical stimulation (NMES) or sEMG:AMS NMES to their nondominant quadriceps twice a week for 5 weeks. Pre- and posttest isokinetic assessments were performed at 60° and 180°/sec to assess peak quadriceps torque. **Findings:** Peak torque data was not significantly different at the two test speeds. p = 0.5 at 60°/sec; p = 0.18 at 180°/sec. **Clinical Relevance:** Although not statistically significant, the data demonstrates greater strength gains at both speeds tested when training with sEMG:AMS NMES compared to biphasic NMES as per the group means. Future research using different methodology may show benefit.

Key Words: electrical stimulation, electromyography, peak torque, Biodex, quadriceps

INTRODUCTION

The application of neuromuscular electrical stimulation (NMES) has frequently been used clinically for pain control, to improve muscle strength, prevent atrophy in immobilized patients, and increase girth measurements by increasing muscle size by neuromuscular reeducation.[1-19] Electrical stimulation causes motor unit recruitment and strength gains through the enlistment of type 2 muscle fibers, known as fast twitch fibers. In comparison, a voluntary muscle contraction first recruits type 1, slow twitch muscle fibers, followed by type 2 fibers.[2,3,13,17] Using electrical stimulation early after an injury has resulted in a more rapid recovery, a decrease in acute pain, and an increase in strength gains as compared to volitional exercise routines alone.[2,3] Surface electromyography activated muscle stimulation (sEMG:AMS) is a new technology that ensures that a subject contracts voluntarily to a given percent of their maximum voluntary isometric contraction (MVIC) before the electrical stimulation will assist with the muscle contraction.[20]

The purpose of this study is to evaluate the effectiveness of sEMG:AMS compared to the commonly used biphasic NMES. We hypothesize that healthy subjects between the ages of 18 and 64 will show greater gains in strength with sEMG:AMS than those undergoing intervention with traditional biphasic NMES without EMG activation.

METHODS

Experimental Design and Subjects

Approval for this research study was provided by the Saint Francis University (SFU) Institutional Review Board. The participants were selected through convenience sampling from the SFU population. The individuals were recruited through campus wide E-mails and promotion in undergraduate physical therapy classes. Male and females 18 to 64 years old, from the SFU community were included in the study. Any individuals who had a pathology that prevented participation, had an injury to the lower extremity (LE) within 6 months prior to the start of the study, those involved in a LE exercise program, and those with any contraindications to electrical stimulation were excluded from involvement in the study. Exclusion criteria specific to the use of electrical stimulation included pacemakers, cardiac arrhythmias, history of malignancy, open wounds, decreased sensation, hemorrhaging, fever, injections, clots, location of surgical pins or metal implants, undiagnosed pain, and pregnancy.

The subjects were placed into groups by matched distribution based on gender in order to control for gender strengthening differences.[1,21] Subjects signed an informed consent to demonstrate that they understood the purpose and procedures of the study, potential benefits, and the risk of potential discomfort from the electrical stimulation prior to involvement. They were informed that they would not be compensated for participation in the study and were encouraged to ask questions at any time while participating in the study. Participants were also instructed to notify the researchers of any pain experienced throughout the treatment session. All individuals had the freedom to cease involvement in the study at any time without question.

The subjects completed an intake questionnaire in order to collect basic demographic information including height, weight, and any contraindications limiting participation in the study. After completion of the intake process, the subjects were labeled by a numerical identifier to maintain their anonymity throughout the study.

The subjects were informed of the procedure that they were undergoing, but were not given information about the other group's procedure. Similarly, they were instructed not to discuss the process with other test subjects. These steps were taken in order to avoid subject bias and to control for validity of results by decreasing the possibility of diffusion or imitation of treatments, along with compensatory rivalry or resentment among subjects.

Experimental Protocol

All pre- and posttesting of the quadriceps musculature took place in the DiSepio Institute for Rural Health and Wellness Center for Rehabilitation using the Biodex System 4

(Biodex Medical Systems, Inc. Shirley, New York). The Biodex was used to measure isokinetic peak torque of the quadriceps muscle of the subjects' nondominant LE.[5,9,20] Peak torque was assessed over 5 repetitions at 60°/sec and 10 repetitions at 180°/sec, as per the Biodex pre-programmed protocol.[3,12]

The subjects were divided into a control group and an experimental group. Each group consisted of 6 total participants, 4 females and 2 males. The control group received biphasic NMES and the experimental group received sEMG:AMS. The intervention was administered at the DiSepio Institute for Rural Health and Wellness Center for Rehabilitation twice a week for 5 weeks with the application of the assigned intervention according to their group assignment. The Chattanooga Vectra Genisys Four Channel Electrotherapy system (DJO Global, Inc. Vista CA) was used to administer the intervention to both groups.

Each subject's lower extremity was prepped with alcohol wipes to clean the skin of oil and ensure that the electrodes had sufficient contact with the skin during each session. The subjects were placed in a long sitting position with their back supported against a wall and the knee in full extension. The distance between the anterior superior iliac spine (ASIS) and the patella was measured.[5] The placement of the 1.5"x 3.5" electrodes was determined by calculating percentages of total surface area of the quadriceps of each participant as described by Golestani et al.[5] The superior electrode was placed 20% of the distance inferior to the ASIS, while the inferior electrode was placed 10% superior from the base of the patella.[5] The electrodes were placed parallel to the muscle fibers.[5] The sEMG:AMS group also had an additional biofeedback electrode placed between the superior and inferior electrodes in order to read the electrical current generated.

The biphasic parameters were set at a frequency of 50 pulses per second (pps), on/off time of 10/30 seconds, phase duration of 200 microseconds, and a two-second ramp time for a total of 15 minutes.[1,3,6] The sEMG:AMS group followed the same parameters as the biphasic group, with the addition of setting the MVIC. The MVIC was determined using the Chattanooga Vectra Genisys Four Channel Electrotherapy system ((DJO Global, Inc. Vista CA) by having the subject contract the nondominant quadriceps maximally for 10 seconds. The machine then calculated each subject's average MVIC within one trial for a 10 second period. During the implementation of sEMG:AMS, the machine initiated the current when the subject reached 65% of their individualized MVIC. The intensity of the electrical stimulation was set to a point that created a muscle contraction that was as intense as the patient could tolerate. After 5 weeks of strengthening, the Biodex System 4 was used to posttest both the control and experimental groups. Isokinetic peak torque was assessed using the same settings as the pretest protocol.[22]

Data Collection

The subjects were scheduled times to report to the DiSepio Institute of Rural Health and Wellness Center for Rehabilitation for isokinetic pre- and posttesting in the first and last week of the study respectively. Age, height, weight, BMI, and initial strength were recorded. Isokinetic strength of subjects' nondominant limb was recorded at 60°/sec and 180°/sec as per procedures used by Bowen et al.[15] The subjects were positioned on the Biodex with the axis of the dynamometer placed at the axis of the tibiofemoral joint with a right angle at the hip and pads strapped across the thigh and ankle complex. The subject then was asked to extend their lower extremity with the maximal force possible.

The subjects reported twice a week for 5 weeks to the DiSepio Institute of Rural Health and Wellness Physical Therapy Clinic for strengthening with biphasic electrical stimulation or sEMG:AMS electrical stimulation. After the 5 weeks of strengthening, the subjects scheduled times to record post-test strength values on the Biodex as described for the pretest. During the application and the following treatments, the subjects were asked the level of pain or discomfort if experienced and monitored throughout testing to ensure each participant's safety.

Data Analysis

Measurements of strength were obtained by analyzing peak torque of the pretest values compared to posttest values following 5 weeks of strength training to each group. The values were input into tables for each individual to compare with their posttest values recorded following the 5 weeks of strength training. An independent group's t-test was performed on pretest data to determine if significant differences existed in the baseline scores for each group. A nonsignificant finding would ensure that both groups were equivalent prior to calculating change.

The data was entered into a Microsoft Excel 2010 application. A post-hoc analysis of the variables was performed in order to determine whether a correlation between the experimental and control group was found. Peak torque change and percent change was then calculated from the results. This information was analyzed for each individual and group as represented as a statistical mean and standard deviation. T-tests performed were determined to be significant for a p value of 0.05 or less.

RESULTS

Participant Demographics

Demographic data for study participants is presented in Table 1. The experimental and control groups were demographically similar presenting with no significant differences between variables in these groups.

Level of Significance for Control and Experimental Groups

A T-test on baseline data did not reveal statistical significance between the groups.

Table 2 and Figure 1 demonstrate peak torque change between control and experimental groups. The mean peak torque change demonstrated a less but statistically insignificant gain for the control group at 60°/sec, ($p = 0.5$). The peak torque change for the control group compared to the experimental group at 180°/sec was also less but not statistically significant ($p = 0.2$)

DISCUSSION

This pilot study did not demonstrate statistically significant differences between the experimental group compared to the control group on the dependent measures. However, the data reveals a trend demonstrating greater strength gained at both 60°/sec and 180°/sec when training with sEMG:AMS NMES than training with biphasic NMES alone. The results of our study partially support our hypothesis; however, the difference among the groups does not demonstrate statistical significance.

Although sEMG:AMS research has not been documented to date, prior research has demonstrated favorable protocols for the application of electrical stimulation for muscle strengthening. The 65% MVIC used as a parameter in our sEMG:AMS protocol was supported by prior experimentation in which strength gains were made at 45% to 60% or greater in healthy individuals with biphasic NMES.[3,6,8] Similarly the use of the parameters of a pulse frequency of 35-80 pps, a pulse duration of 200-350 micro-

Table 1. Demographics of Both Control and Experimental Groups (mean ± standard deviation)

All Subjects (n=12)		
	Control (n=6)	Experimental (n=6)
Age (years)	21.3 ± 1.5	21.5 ± 1.6
Height (m)	63.3 ± 11.9	68.1 ± 10.2
Weight (kg)	1.6 + 0.1	1.7 ± 0.1
BMI (kg/m^2)	22.6 ± 2.4	23.2 ± 3.1

Table 2. Mean ± Standard Deviation Peak Torque Change of the Experimental and Control Group at 60°/sec and 180°/sec

Group Participants	60°/sec (Nm)	180°/sec (Nm)
Control	1.4 + 15.8	9.4 + 13.5
Experimental	12.4 + 34.7	24.3 + 20.8

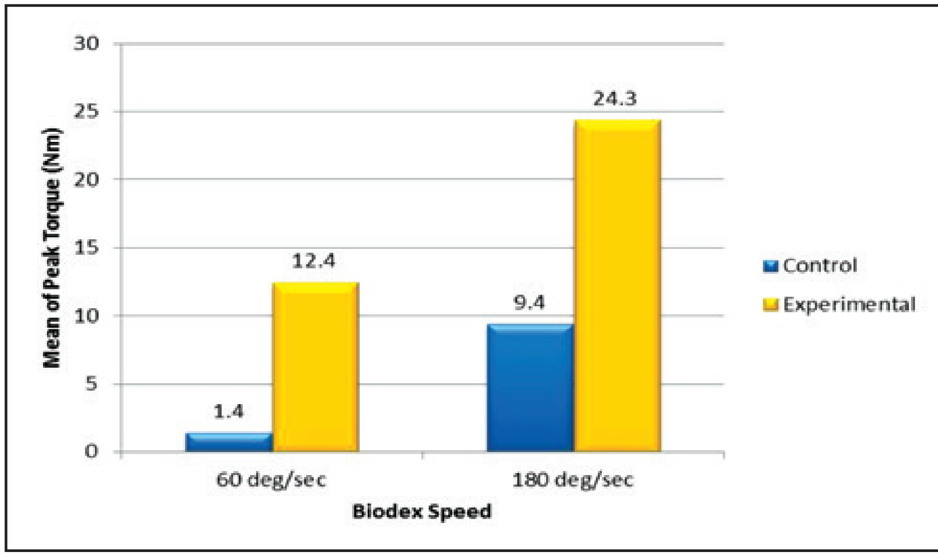

Figure 1. Mean peak torque change (Nm) in control and experimental groups at 60°/sec and 180°/sec.

seconds for large muscles, an on:off time of 6-10:50-120 seconds for muscle relaxation, and a treatment time lasting 10 to 20 minutes to produce 10 to 20 repetitions have demonstrated strength gains through the use of electrical stimulation.[3,8,12]

Dudley and Gorgey[6] suggested that a pulse duration of 500 microseconds has up to 40% greater torque output to that of 150 microseconds. Therefore, increasing the pulse duration could potentially increase strength gains in both groups. Using this increased pulse duration may, however, produce greater pain production.[6] As noted through our literature review, biphasic NMES has been shown to be better tolerated by subjects than the application of Russian NMES.[2] For this reason, Russian NMES is typically used in the clinical setting for elite athletes, as it is less tolerable to patients, while biphasic is used more often in the general population. However, both Russian and biphasic NMES have been effective in producing strength gains within the quadriceps musculature.[17] Therefore, this new technology of sEMG:AMS in combination with Russian or biphasic NMES may be potentially more effective than Russian and biphasic NMES alone.

The importance of the findings of this study is that the trends noted in our data suggest that sEMG:AMS may produce greater strength gains in the nondominant quadriceps than biphasic NMES alone within a 5-week time frame. Considering the constraints often imposed by insurance companies and increased cost-sharing required of patients, quicker objective gains are important in physical therapy today. These quicker strength gains could potentially speed up the rehabilitation process and promote more efficient use of services. With more effective strengthening technology, physical therapists can potentially decrease the number of visits necessary to achieve objective and functional goals.

Based on our findings in this pilot study, further investigations using this equipment with larger sample sizes as well as populations with musculoskeletal and/or neuromuscular impairments is warranted. If additional investigation with larger sample sizes and pathological populations produces similar results, it may support the purchase of this type of technology in some practice settings allowing patients to maximize treatment gains.

There are several limitations noted within this study. Our research's first limitation dealt with the population available during the research experiment. Testing only subjects ages 19 to 23 limits our ability to generalize the results among a variety of age groups. Another limitation is the relatively small sample size. A post-hoc power analysis was performed using a threshold of 80%. This method revealed the need for 51 subjects per group as a sample size that may determine statistical significance between groups. Larger sample sizes also limit the effect of outliers and allow for the comparison of more incremental changes. Similarly we were unable to accurately compare results between female and male participants due to the small enrollment size. Further studies should also be conducted on patients who have a specific pathology in order to determine sEMG:AMS's effectiveness in a population other than a healthy one.

There were also limitations with the protocol that was used. The short timeline of only 5 weeks for data collection was a limitation that was unavoidable due to the population and environment used within our study. The next limitation is limb positioning used throughout the study. We tested an isometric contraction in a long sitting position, therefore only strengthening in this range.[3,24] For certain pathologies and presentations, physical therapists may find other positions more advantageous for rehabilitation. Lastly, subject lifestyle is a limitation because we were unable to account for small variations in each subject's daily life, which could influence the strength gains achieved.

In review, the results of this study do not demonstrate statistical significance. However, they do show a trend that sEMG:AMS produced larger gains in strength than biphasic NMES alone in our sample. Further studies are needed on larger populations with pathologies in order to determine if this new technology produces statistically significant outcomes over other forms of neuromuscular education.

REFERENCES

1. Alon G, Leininger PM, Ries JD, Laufer Y. Quadriceps femoris muscle torques and fatigue generated by neuromuscular electrical stimulation with three different waveforms. *Phys Ther*. 2001;81(7):1307-1316.
2. Cameron T. Physical Agents in Rehabilitation: From Research to Practice. Oregon

Health and Science University. St. Louis, MO: Saunders Elsevier; 2009.
3. Carmack JA, McLoda TA. Optimal burst duration during a facilitated quadriceps femoris contraction. *J Athl Train*. 2000;35(2):145-150.
4. Cigdem B, Ozlem S, Ozlen P, et al. Efficacy of two forms of electrical stimulation in increasing quadriceps strength: a randomized controlled trial. *Clin Rehabil*. 2002;16:194-199.
5. Golestani S, Hill S, Holcomb W. A comparison of knee-extension torque production with biphasic versus Russian current. *J Sports Rehabil*. 2009;9:229-239.
6. Dudley GA, Gorgey AS. The role of pulse duration and stimulation duration in maximizing the normalized torque during neuromuscular electrical stimulation. *J Orthop Sports Phys Ther*. 2008;38(8):508–516.
7. Chattanooga Group. Vectra® Genisys 4 Channel Electrotherapy System with Cart. 2010. http://www.chattgroup.com/product.asp?pr=1987&ln=1&cn=5. Updated January 14, 2011. Accessed October 18, 2010.
8. Laufer Y, Elboim M. Effect of burst frequency and duration of kilohertz-frequency alternating currents and of low-frequency pulsed currents on strength of contraction, muscle fatigue, and perceived discomfort. *Phys Ther*. 2008;88:1167-1176.
9. Schroeder RV, Romero JA, Sanford TL, Fahey TD. The effects of electrical stimulation of normal quadriceps on strength and girth. *Med Sci Sports Exerc*. 1982;14(3):194-197.
10. Arkov V, Abramova T, Nikitina T, et al. Cross effect of electrostimulation of quadriceps femoris muscle during maximum voluntary contraction under conditions of biofeedback. *Bull Exp Biol Med*. 2010;149:93-95.
11. Bailey SL, Delitto A, Stralka SW, Snyder-Mackler L. Strength of the quadriceps femoris muscle and functional recovery after reconstruction of the anterior cruciate ligaments. *J Bone Joint Surg Am*. 1995;77:1166-1173.
12. Brooks ME, Smith EM, Currier DP. Effect of longitudinal versus transverse electrode placement on torque production by the quadriceps femoris muscle during neuromuscular electrical stimulation. *J Orthop Sports Phys Ther*. 1990;11(11):530-534.
13. Currier DP, Mann R. Muscular strength development by electrical stimulation in healthy individuals. *Phys Ther*. 1983;63(6):915-921.
14. Currier DP, Nitz AJ, Rooney JG. Effect of variation in the burst and carrier frequency modes of neuromuscular electrical stimulation on pain perception of healthy subjects. *Phys Ther*. 1992;7(11):800-806.
15. Bowden J, Fornusek C, Harvey L, et al. Electrical stimulation plus progressive resistance training for leg strength in spinal cord injury: A randomized controlled trial. *Spinal Cord*. 2010;48:570-5.
16. Causey J, Marshall T, Scott W. Comparison of maximum tolerated muscle torques produced by 2 pulse durations. *Phys Ther*. 2009;89:851-7.
17. Ladin Z, Schepsis AA, Snyder-Mackler L, Young JC. Electrical stimulation of the thigh muscles after reconstruction of the anterior cruciate ligament: Effects of electrically elicited contraction of the quadriceps femoris and hamstring muscles on gait and on strength of the thigh muscles. *J Bone Joint Surg Am*. 1991;73:1025-1036.
18. Shkuartova N, Ward A. Russian electrical stimulation: The early experiments. *Phys Ther*. 2002;82(10):1019-1030.
19. Jubeau MM, Maffiuletti NA, Zory RF. Contractile impairment after quadriceps strength training via electrical stim. *J Strength Cond Res*. 2010:458-464.
20. Gallach JE, Gomis M, Gonzalez LM, Toca-Herrera JL. Cross-education after one session of unilateral surface electrical stimulation of the rectus femoris. *J Strength Cond Res*. 2008;22(2):614-618.
21. Currier DP, Soo CL, Threlkeld AJ. Augmenting voluntary torque of healthy muscle by optimization of electrical stimulation. *Phys Ther*. 1988;68(3): 333-337.
22. System 4 Biodex. Biodex Medical Systems, Inc. 2010. Available at http://www.biodex.com/rehab/system4/system4_feat.htm. Accessed on October 20, 2010.
23. Drouin JM, Gansneder BM, Perrin DH, Schultz SJ, Valvoich-mcLeod TC. Reliability and validity of the biodex system 3 pro isokinetic dynamometer velocity, torque, and position measurements. *Eur J Appl Physiol*. 2004;90(1):22-29.
24. Aitkens SG, Bernauer EM, Lord JP, McCrory MA. Isometric and isokinetic measurement of hamstring and quadriceps strength. *Arch Phys Med Rehabil*. 1992;73(4):324-330.

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Evidence-based Physical Therapy Protocol for Conservative Treatment of Full-Thickness Rotator Cuff Tear

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ABSTRACT

Background and Purpose: Full thickness rotator cuff tears (FTRCT) are a common shoulder pathology seen in outpatient physical therapy clinics. The purpose of this article is to review outcomes of conservative physical therapy for FTRCT in existing literature and develop a subsequent conservative physical therapy protocol for FTRCT. **Methods:** A literature search and review was conducted. Primary research articles published in peer reviewed journals were included in the review. A conservative physical therapy protocol for treatment of FTRCT was developed based on the evidence from the literature review. **Results:** Outcomes from the literature reviewed suggest that conservative physical therapy treatment of FTRCT can yield satisfactory subjective and objective results for patients. Positive outcomes such as improvements in pain, range of motion (ROM), and function may potentially be maintained for a period of up to years after the course of treatment. The most successful physical therapy protocols within the review respected the stage of tissue healing and progressed the patient's treatment according to patient response. **Clinical Relevance:** A conservative, physical therapy protocol based on the literature review was developed. Physical therapy compares favorably to other treatment approaches and should be considered the logical first choice for treatment of FTRCT.

Key Words: full thickness rotator cuff tear, supraspinatus tear, rotator cuff physical therapy, rotator cuff rupture

BACKGROUND

Among shoulder pathologies, rotator cuff tears are the most common[1-4] In fact, during the routine examination of 683 patients, rotator cuff tears were found to be present in 20.7% of those cases.[2] The incidence of tears increases with advanced age.[2] Approaches to treatment for rotator cuff tear fall into two categories: nonconservative and conservative. Nonconservative treatment involves surgical intervention performed either arthroscopically or as an open procedure. Conservative treatment is nonsurgical and includes any combination of oral nonsteroidal anti-inflammatory (NSAID) medications, corticosteroid injections, activity limitation, ultrasound, electrotherapy, and therapeutic exercise. Physical therapy interventions are categorized as conservative treatment.

The best treatment protocol for patients with symptoms of rotator cuff tear can be difficult for a health care practitioner to determine for various reasons. First, the severity of the tear may range from partial-thickness rotator cuff tear (PTRCT) to a full-thickness rotator cuff tear (FTRCT). Second, the patient may be asymptomatic regardless of the extent or severity of the tear. Additionally, while the supraspinatus muscle is most likely to be involved, the tear may involve any of the 4 separate muscles of the rotator cuff. The purpose of this article is to determine, based on the outcomes reported in existing literature, the most effective physical therapy protocol for FTRCT.

METHODS

A search for research articles that address physical therapy for FTRCT was completed in December 2011. The following databases were employed in this search: CINAHL, Highwire Press, JSTOR, PubMed, PEDro, and SCOPUS. The following search terms were used: rotator cuff tear, rotator cuff rupture, supraspinatus muscle tear, rotator cuff tear exercise, and physical therapy for rotator cuff tear. Primary research articles published in peer reviewed journals, written in English, and investigating conservative therapy for FTRCT were included in this review (Table 1). Review articles and case studies were excluded and there were no randomized controlled trials found during this literature search.

RESULTS

A total of 31 studies were identified that address conservative therapy for rotator cuff tears. Twenty-four of these were rejected following review of abstracts. Seven articles met the inclusion criteria for this review. The studies reviewed were published between 1992 and 2009. The length of patient treatment ranged from 12 weeks to 26 months with two studies not reporting the length of treatment. One study reported patient outcomes immediately post treatment while the remaining 6 studies included follow up periods that ranged from 6 months to 7.6 years.

Ainsworth[5] documented the effectiveness of the Torbay rehabilitation program in a pilot study. The Torbay rehabilitation program is a 12-week rehabilitation protocol designed to address FTRCT. The program emphasizes patient education and scapular positioning. The program particularly targets backward tilting of the scapula to improve the subacromial space. Strengthening of the anterior deltoid along with activation and strengthening of the teres minor, and functional elevation to reduce impingement of the humeral head under the acromion process. Ten participants with FTRCT were included in the study. All 10 of the patients were over the age of 18, had ultrasonic confirmation of their FTRCT, and were deemed cognitively able to participate in research. Patients were excluded from the study if they had a diagnosis of a neurological abnormality affecting the shoulder complex, involvement in any industrial claim, or if their FTRCT was deemed operable. Conservative treatment consisted of patient education, posture training, neuromuscular re-education, strengthening, stretching, and proprioceptive training. Exercises were initiated in a supine position and progressed to sitting and standing. Particular focus was placed upon eccentric control of muscle action throughout training. Outcome measures included the Oxford Shoulder Disability Questionnaire (OSDQ) and the Short Form Health Survey (SF-36), which were both administered prior to and at the conclusion of the course of treatment. Descriptive statistics were used to assess improvements posttreatment. All patients showed improvement in OSDQ score after treatment. The SF-36 results showed improvement in the categories of pain and role limitation due to

Table 1. Summary of Literature Review

Study	Conservative Treatment	Patient Population
Ainsworth[5] Treatment Time: 12 weeks Long-term Follow-up: None	Patient education, posture correction, neuromuscular re-education, strengthening, stretching, and proprioception training.	10 patients with FTRCT mean age=76 4 male/6 female
Itoi & Tabata[6] Treatment Time: Mean=26 months Long-term Follow-up: Mean=3.4 years	Rest, anti-inflammatory drugs, analgesic injections, steroid injections, stretching, and strengthening.	54 patients with FTRCT (62 shoulders) mean age=63 32 male/22 female
Baydar et al[7] Treatment Time: Not Reported Long-term Follow-up: 6 months, 1 year, 3 years	3 phase HEP including Codman's exercises & posterior capsule stretches. Strengthening exercises for the rotator cuff muscles, deltoid, muscle, & scapular stabilizing muscles.	20 patients with FTRCT mean age=60.9 7 male/13 female
Goldberg et al[8] Treatment Time: Ongoing HEP Long-term Follow-up: Mean=2.5 years	HEP including shoulder stretching of forward elevation, external rotation, internal rotation, & horizontal adduction. Strengthening consisted of progressive supine press and rotator cuff specific exercises.	46 patients with FTRCT mean age=65 22 male/24 female
Bokor et al[9] Treatment Time: Not Reported Long-term Follow-up: Mean 7.6 Years	NSAID medication, steroid injections, stretching, and strengthening.	52 patients with FTRCT mean age=62.2 40 male/12 female
Wirth et al[10] Treatment Time: Ongoing HEP Long-term Follow-up: Minimum of 2 years	3 phase HEP including Codman's exercises, passive ROM, wall walks, and posterior capsule stretches. Strengthening of the rotator cuff muscles, deltoid muscle, and scapular stabilizing muscles.	60 patients with FTRCT mean age=64 years 38 male/22 female
Hawkins & Dunlop[11] Treatment Time: 4 months Long-term Follow-up: Mean=3.8 years	HEP program consisting of internal/external rotation, short arc flexion/extension, bilateral scapular retraction, arm abduction from an internally rotated and flexed position, long arc flexion/extension, and diagonal PNF patterns with weights.	33 patients with FTRCT mean age=60 27 male/6 female

Abbreviations: FTRCT, full thickness rotator cuff tear; OSDQ, Oxford Shoulder Disability Questionnaire; SF-36, short form health survey; ROM, range of motion;………………… proprioceptive neuromuscular facilitation

physical health. Patients did, however, report a decline in the categories of perceived general health and limitation due to emotional health as reported on the SF-36. Ainsworth[5] attributed the reported decline in perceived physical and emotional health to co-morbidities associated with the patients' advanced age rather than the rigors of the treatment program. The results of this study should be viewed with caution, as it was a pilot study with a small sample size. The outcomes of this study do, however, support the notion that conservative treatment of FTRCT may be effective in reducing pain and increasing function.

Itoi and Tabata[6] conducted a retrospective study to examine the long-term outcomes of conservative treatment of FTRCT. Sixty-two shoulders of 54 patients were evaluated before treatment and at a follow up after conclusion of a conservative treatment program. Specific inclusion and exclusion criteria were not described. Conservative treatment initially consisted of rest, anti-inflammatory agents, and local steroid injections. The treatment was progressed to stretching and strengthening after patients' symptoms were sufficiently relieved. The mean treatment time was 26 months. Subjective reports of pain and function were collected prior to and at follow up using the Wolfgang criteria for clinical assessment. The mean follow up length was 3.4 years. Objective measures of strength and range of motion (ROM) measures were also recorded at follow up. Significant improvements in pain, ROM, and function were reported ($p = 0.001$, $p = 0.05$, $p = 0.001$); however, strength gains were not found to be significant. Itoi and Tabata[6] found that patients maintained the significant improvements in pain, ROM, and strength for periods of one to 3 years. Subsequent measurements taken after 3 years did not show maintenance of the previously mentioned improvements. The researchers did not delineate specific therapeutic exercises or dosages prescribed for each exercise within the protocol. The lack of detail regarding exercise is a notable limitation of this study; however, the evidence found during this investigation highlights the potential for positive, long-term outcomes for conservative treatment of FTRCT.

Baydar et al[7] investigated the efficacy of conservative treatment in patients with symptomatic FTRCT. Twenty patients with FTRCT confirmed by MRI participated in a 3-phase home exercise program (HEP). Total treatment time was not reported.

Outcome Measures	Clinically Relevant Results
OSDQ SF-36	The OSDQ score improved in all patients. The SF-36 results had improvement in pain and role limitation due to physical health. Patients reported a decline in perceived general health and limitation due to emotional health as reported on the SF-36.
Wolfgang's criteria ROM Strength	Significant improvements to pain, ROM, and function (p = 0.001, 0.05, 0.001). Nonsignificant improvements to strength. Improvements were maintained up to 3 years. Longer follow-up duration did not show maintenance of treatment results.
ASES questionnaire ROM Constant-Murley score SF-36 Strength Patient response	Significant improvement to ROM, ASES score, and Constant-Murley score (p < 0.01). Significant improvements to shoulder strength. Improvements to pain and function scores were maintained at the 3-year follow-up. Strength and Constant-Murley score were not reassessed at follow-up.
SST SF-36	Significant improvements found in two variables on SST at follow-up (p < 0.01). Significant improvements found to 5/10 variables on the SF-36 at follow up (p < 0.01). Long-term maintenance of conservative treatment may have been impaired by poor overall general health.
ASES questionnaire ROM Strength	74% of patients reported only minimal shoulder discomfort after treatment. Patients treated within 3 months of their initial symptom onset reported better outcomes than patients with symptoms for over 6 months.
ASES questionnaire UCLA end result criteria	At final follow-up (minimum of 2 years) patients had mean improvement in UCLA score from 13.4 to 29.4 (alpha level not reported). The authors reported a significant improvement to 14/15 measures in the ASES score (alpha level not reported).
ASES questionnaire Constant-Murley score	Significant improvement to Constant-Murley score reported at follow-up for patients who were satisfied with treatment(0.038). Patient satisfaction was most correlated with reduced pain, ability to carry a 10-15 lb object, functional use of the arm at shoulder level, and capability to eat with a utensil. Rotator cuff strength and range of motion were not predictors of overall patient satisfaction.

……….ASES, American Shoulder and Elbow Surgeons' questionnaire; HEP, home exercise program; SST, simple shoulder test; NSAID, nonsteroidal antiinflammatory drugs, PNF,

Patients were excluded from the study if they had inflammatory rheumatic diseases, concomitant cervical radiculopathy, or history of fracture to the shoulder area. The first phase of the HEP consisted of passive Codman's exercises, active assisted ROM, and posterior capsular stretches. Participants were progressed to the second phase after full, painless ROM was achieved. The second phase targeted strengthening of the rotator cuff muscles, scapular stabilizers, and deltoid. Exercises included internal and external rotation, abduction, extension, forward flexion, push-ups, shoulder shrugs, and shoulder press-ups. The patients were monitored by appointment during rehabilitation and the exercises were progressed to the third and final phase of conservative treatment according to each patient's clinical presentation. The goal of the final phase of exercise was to return the patient to full participation in regular daily activities and recreation, but specific exercises and dosages were not stated. Pain and function were measured using the American Shoulder and Elbow Surgeons' (ASES) questionnaire. Additional outcome measures included ROM, Constant-Murley Score, SF-36, isokinetic shoulder strength, and patient response. All outcome measures were recorded prior to initiation of treatment and 6 months after the conclusion of the conservative treatment. The researchers reported significant improvements ($p < 0.01$) in ROM, ASES score, and Constant-Murley score at the time of follow up. The researchers also reported significant gains to isokinetic shoulder strength ($p < 0.01$) in abduction, internal rotation, and external rotation measured by the same examiner using a Cybex Norm dynamometer at angular velocities of 60°/s and 180°/s. The significant improvement ($p < 0.01$) to ASES score was maintained at a one-year follow up assessment, but the other object measures were not repeated at that time. According to the authors, this was the first study to employ use of a dynamometer to measure strength gains rather than manual muscle testing. The investigators stated that the choice to employ dynamometers in their study was purposeful and meant to make the outcome measure more objective. At completion of the study, the authors concluded that conservative treatment using their protocol yielded satisfactory subjective and objective results in the long term.

Goldberg et al[8] investigated the long-term results of nonoperative treatment for FTRCT. Forty-six patients with a mean age of 65 were all placed on a HEP to strengthen and stretch the muscles of the rotator cuff, deltoid, pectoralis major, and trapezius. Each patient had confirmation of the FTRCT by a radiologist using ultrasound, MRI, or arthrogram. Patients were excluded from the study if they had previous rotator cuff surgery, acromial surgery, or a Worker's Compensation claim. Stretching exercises included forward elevation, external rotation, internal rotation, and horizontal adduction. Strengthening consisted of progressive supine press and rotator cuff specific exercises. These exercises were dosed according to patient's symptoms. Patients were instructed to add repetitions for each exercise until they were able to complete 20 repetitions for each exercise prescribed. The Simple Shoulder Test (SST) and SF-36 were administered at initial evaluation, 6 months after conclusion of treatment, and at least one year after conclusion of treatment. Immediate results after intervention were not reported. For the SST, only two out of the 10 variables were significantly improved ($p < 0.01$) at final follow-up (mean = 2.5 years); patient's ability to sleep on the affected side and patient's ability to place the hand behind the head. Five of the 10 SF-36 variables were significantly improved ($p < 0.01$) in the same time frame after conservative treatment when compared to pretreatment scores. These variables were comfort, vitality, physical function, general health, and physical component summary. Participants in this study reported only modest long-term outcomes after conservative treatment of FTRCT. At initial evaluation, patients were administered the SF-36 to assess health related quality of life. Five of the 8 parameters from the participants' SF-36 scores were significantly lower ($p < 0.01$) than age and gender matched controls indicating that the participants in this study may have had poor overall general health prior to treatment initiation. The results of this investigation gives moderate support for positive, long term outcomes following conservative treatment of FTRCT.

Bokor et al[9] retrospectively reviewed the long-term outcomes of 53 patients who were treated conservatively for FTRCT. Patients were included in the study if they had pain or weakness in the shoulder, FTRCT confirmed by arthrogram, and selection of nonoperative treatment by patient and physician. Patients who had previously undergone surgery to the affected shoulder were excluded from the study. The protocol for conservative treatment and the length of the course of treatment was not reported. Patients were interviewed or re-examined at a mean of 7.6 years after the conclusion of treatment and descriptive statistics were generated for both initial outcomes and long term results. Patients were divided into one of two groups based on the length of time prior to treatment: those with symptoms lasting less than 3 months and those with symptom duration of greater than 6 months. Pain and function were rated using the ASES questionnaire. Eighty six percent of patients who received treatment within 6 months of symptom onset rated their pain as only slight. Only 56% of patients who received treatment after 6 months of symptom duration rated their pain as slight. A majority of the participants demonstrated improved ability to participate in activities of daily living (ADL) at follow-up. The researchers concluded that the long term prognosis was better for conservative treatment of FTRCT when the treatment was initiated within 6 months of symptoms onset.

Wirth et al[10] investigated the long term outcomes of a physician directed, 3 phase, HEP for FTRCT. Sixty patients with radiographically documented FTRCT participated in the study. Specific exclusion criteria were not given. The mean symptoms duration reported at the time of initial evaluation was 19 months. In the first phase of treatment, Codman's pendulum exercises were initiated followed by passive ROM movements in the available ranges of forward flexion, abduction, extension, internal rotation, and external rotation. Pulleys were employed to increase the passive stretching movements. Manual therapy in the first phase of treatment included posterior capsule stretches. Patients were cautioned to avoid using the affected arm in the painful range of movement for prolonged amounts of time and ice and heat were used alternately to reduce pain and inflammation. The second phase of treatment included exercises to strengthen the remaining muscles of the rotator cuff, the deltoid, and the scapular stabilizing muscles. The treatment program began with the use of 6 different resistance levels TheraBand graded from one to 6 pounds in resistance. The patient assumed a starting position of 90° of elbow flexion with the shoulder in a neutral position consisting of 0° flexion, abduction, and external rotation. From the starting position, the patient completed 5 repetitions of 5 exercises, 3 times a day. The 5 exercises were shoulder extension, internal rotation, external rotation, abduction, and flexion. Once the patient was able to complete all 5 exercises with 6 pounds of TheraBand resistance, another group of exercises were added. The second set of exercises included shoulder press ups, shoulder shrugs, push ups, and shoulder extension with a pulley. The shoulder shrugs were initiated with 10 pounds of resistance and gradually increased in two pound increments. The mean time spent in phase two was 3 months, and patients were progressed according to clinical presentation. During the second treatment phase, patients continued all of the stretching activities from the first phase of treatment and they were cautioned to strictly stay within their pain free ROM. The last phase of treatment reincorporated normal ADLs for the patient. During this phase, the patient transitioned to a maintenance exercise and stretching program consisting of all previously prescribed treatment. The researchers did not report the exact activities added during the third phase as they were specific to the individual patient. Outcome measures included the ASES questionnaire and the UCLA end-result criteria. The follow up period was at least two years. The researchers reported significant improvement to UCLA score and the ASES questionnaire, but did not report the alpha level or analysis method that was used. The mean pretreatment and follow up UCLA score was 13.4 and 29.4 points respectively. The ASES questionnaire had improvements to 14 of 15 ADL measures. The authors concluded that conservative treatment for FTRCT is effective for decreasing pain, increasing strength, and improving function.

Hawkins and Dunlop[11] investigated the long term outcomes of conservative treatment for FTRCT. Fifty participants with FTRCT participated in the study and 33 patients participated in the follow up. All participants had their FTRCT confirmed by arthrogram. The only reported criterion was that the patient must live within a reasonable travelling distance due to the large geographic practicing area for the clinic. Outcome measures included the ASES questionnaire and the Constant-Murley score. Both of these measures were taken at initial evaluation but only Constant-Murley score results were repeated at follow up. The mean follow up time was 3.8 years. Conservative treatment lasted for 4 months and consisted of a HEP that was supervised via periodic physical therapy appointments. The 6 exercises included in the HEP were internal/external rotation, short arc flexion/extension, bilateral scapular retraction, shoulder abduction with internally rotated starting position, long arc flexion/extension, and diagonal proprioceptive neuromuscular facilitation (PNF) patterns with weights. The participants added one additional exercise weekly until they were performing the entire protocol by week 6. The patients performed 3 sets of 10 repetitions daily until the tenth week of treatment. At week 10, dosage was reduced to 3 times per week. To analyze the follow up data, the participants were divided into two groups. Group I (n=19) consisted of patients satisfied with conservative treatment and group II (n=14) consisted of patients dissatisfied with conservative treatment. For group I, comparison of initial and follow up Constant-Murley score showed significant improvement for strength (p=0.008) and total score (p=0.038). Patients in group II showed a slight decline in Constant Murley score from initial (73.4) and follow up (72.2) but this decline was not significant. Hawkins and Dunlop concluded that conservative treatment was effective for FTRCT in patients who were satisfied with treatment. A further analysis was completed to determine the factors that contribute to patient satisfaction and that information is included in the discussion.

SYNTHESIS OF RESEARCH AND RECOMMENDATIONS FOR TREATMENT

Treatment Protocol for Conservative Physical Therapy Treatment of FTRCT

All 7 of the studies reviewed suggest that conservative treatment of FTRCT can result in satisfactory subjective and objective outcomes for patients. Additionally, positive outcomes such as improvements in pain, ROM, and function may be maintained for a period of up to 3 years after the end of the course of treatment.[6,7] Some factors that may influence the prognosis of long-term outcomes include the duration of symptoms prior to treatment,[9] initial tissue quality,[8] and overall health of the individual patient.[8] The most successful physical therapy protocols included in this review were those that respect the stage of tissue healing,[5-7,10,11] and progressed the patient's treatment program according to patient response to treatment.[5-8,10,11] Two of the investigations that reported positive long term outcomes divided their conservative treatment into phases to more specifically address the factors of tissue healing and irritability of symptoms.[7,10] The participants were only progressed to the next phase of treatment after they could accomplish a predetermined task without pain or exacerbation of symptoms.[7,10] Establishing a task-oriented requirement for treatment progression provides a functional level that patients should accomplish to demonstrate their readiness to enter the next phase of treatment.

The following treatment plan is divided into 3 phases that are meant to reflect the patient's stages of healing: the acute stage, the subacute stage, and the reintegration stage. Advancement of the patient to the next treatment phase should be guided by clinical signs of tissue healing and patient symptoms rather than strict adherence to time frames suggested within the program. In addition, the dosage of therapeutic activity should be adjusted in response to irritability of the patient's symptoms.[8,10,11] The dosages presented here are meant to be a guideline for clinicians rather than a definitive requirement for rehabilitation and treatment is meant to be patient centered.

Phase 1: Acute Stage of Tissue Healing

During the acute stage of tissue healing, the patient is likely to have symptoms of inflammation including hemarthrosis, pain with rest, and pain that may wake the patient from a deep sleep.[5-7,10] This phase of treatment may last 4 to 6 weeks,[10] but could be abbreviated or extended according to patient response. Within this stage of treatment, there are several precautions that should always be observed. Grade 3 joint mobilizations must be postponed until all inflammation subsides and are usually reserved for the second and third treatment stages.[7,10] The patient should limit all therapeutic exercises to the painfree ROM. Complex regional pain syndrome (CRPS) is a serious complication that can arise from excessive immobilization of the affected arm.[12] To prevent CRPS, patients should be advised to keep their distal joint as mobile as possible and elevate their affected arm if any edema is observed in the hand.[12]

Goals

- Control pain[5-11]
- Restore full, passive ROM[5-11]
- Restore normal accessory motion[5-7,10,11]
- Prevent atrophy[5-11]
- Maintain soft tissue joint integrity[7,11]

Patient education

Patient education should focus on full explanation of the goals of conservative treatment and instruction in therapeutic exercise.[5] The patient may be using a splint or sling to encourage tissue healing and relieve pain.[6] Use of the sling should be reduced as symptoms improve to avoid loss of ROM and complications of immobilization.[12] Patients should also begin posture education and training.[5]

Therapeutic exercise

Appropriate therapeutic exercises include self assisted ROM with the use of a cane in all available ROM.[5-8,10,11] Scapular pinches are included to address potential postural deviations and scapulothoracic stabilization.[7,10,11] Codman's pendulum exercises are not included in the acute phase of rehabilitation due to the possible excess tensile forces to the healing tissues.[13] Ball squeezes are included in all stages of this treatment protocol as a preventative measure to prevent secondary complications that can arise from immobilization.[12] The specific therapeutic exercise prescription including dosage and frequency is detailed in Table 2. The frequency and intensity of exercises listed in the table are meant to be an example of how the exercises could be prescribed.

Manual therapy

Appropriate manual therapy techniques for this phase are grade 1 and 2 joint distraction and glides as defined by Maitland.[7,10] More aggressive manual techniques should be postponed to later treatment phases. During this phase decreasing inflammation of the glenohumeral joint is a priority.

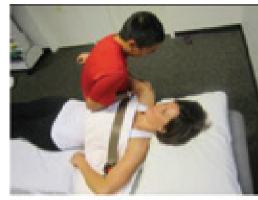
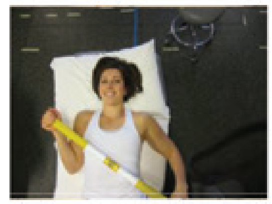
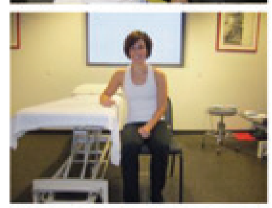
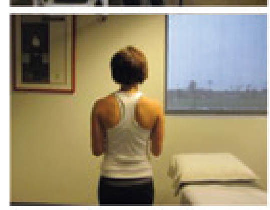
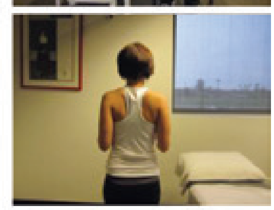
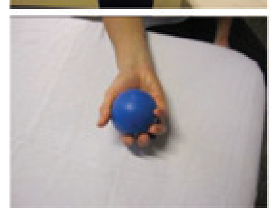
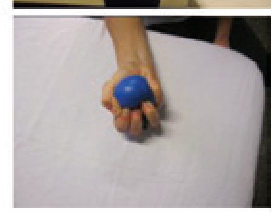
Criteria for progression

It is safe to progress the patient from phase 1 to phase 2 when full, painless, passive ROM has been achieved,[7,11] the patient has no pain with resisted isometric exercises,[6,11] and the patient is able to perform most waist level ADLs without pain.[10]

Phase 2: Subacute Stage of Tissue Healing

The subacute stage of tissue healing is characterized by a decrease in pain and increase in shoulder passive ROM.[7,11] Due to the increase in resistive therapeutic exercise included in this treatment phase, patients may continue to experience some joint inflammation or edema.[11] Patients commonly progress to phase 2 at week 7 and remain in the subacute phase until week 12 during conservative treatment.[10] The patient should continue to limit activities to the painfree ROM. All of the therapeutic exercise and activities should be painfree and any activity that causes pain should be adapted or abandoned.[7,10,11]

Table 2. Phase 1: Acute Stage of Tissue Healing

Patient Education				
Full explanation of the goals of conservative treatment				
Detailed instruction of therapeutic exercise				
Explain the purpose of immobilization (if used)				
Posture education and training				
Therapeutic Exercise	**Dosage**	**Frequency**	**Starting Position**	**Ending Position**
Passive joint distraction and mobilization	Grade 1& 2	3x weekly		
Passive assist ROM with cane all ranges	15 reps	3-4x daily		
Table slides within painless range	15 reps	3x daily		
Scapular pinches 20s hold	10 reps	1x daily		
Ball squeezes with affected hand	20 reps	1x hourly		

Goals

- Modify faulty joint mechanics[7,10]
- Strengthen the remaining muscles of the rotator cuff[5-10,11]
- Strengthen the scapular stabilizing muscles [5,7,10,11]

Patient education

Patient education should continue to focus on posture training and detailed explanations of therapeutic exercise prescription.[5]

Therapeutic exercises

Stretching and strengthening exercises should be performed within the full ROM, which should now be restored and pain-free. Codman's pendulum exercises may be initiated at this stage of treatment.[7,10] Isotonic exercises are emphasized in this stage of treatment and performed in all available ranges of glenohumeral movement to improve strength and stability.[5-10,11] Resisted shoulder flexion, abduction, and external rotation are all examples of appropriate exercises for this phase. Scapular pinches continue in this stage to encourage and enhance appropriate scapulothoracic motion and stability.[5,7,10,11] Active wall clock exercises may be included to encourage internal and external rotation at the glenohumeral joint.[5,8,10,11] Therapeutic exercises and manual therapy techniques employed in this treatment phase are detailed in Table 3. The frequency and intensity of exercises listed in Table 3 is presented as one example of how the exercises could be prescribed.

Manual therapy

Within the second phase of treatment, joint mobilizations provided by the physical therapist can now be performed at grade III if needed.[7,10] During this phase inflammation of the glenohumeral joint has resolved. Grade III joint mobilizations are appropriate during this phase to address any arthrokinematic deficiencies and improve osteokinematic motion providing they do not cause pain.

Criteria for progression

None of the studies specified parameters for progressing the patient to the third and final phase of treatment. The third phase of treatment is usually tailored to the patient's individual ADLs and the criteria for progression should be determined by the patient's prior level of function and individual physical therapy goals.[11]

Phase 3: Reintegration to Regular Activities

At the beginning of the reintegration phase, patients should have reduced pain, increased passive ROM, increased active ROM, and increased strength.[5-7,11] Patients commonly enter this treatment phase at week 12, but progression should be determined by individual patient's progress.[10] In phase 3, the patient should be progressing to more independence, however, the supervising physical therapist should continue to monitor the patient for increased pain or irritability as a wide range of exercises may be added to the treatment protocol during this phase.[12] New therapeutic activities with combined motions may provoke joint inflammation or edema.[11]

Goals

- Modify faulty joint mechanics[7,10]
- Strengthen the remaining muscles of the rotator cuff[5-10,11]
- Strengthen the scapular stabilizing muscles[5,7,10,11]
- Reintegrate normal hobbies and activities[7,11]

Patient education

Patient education will continue to focus on posture training and detailed explanation of exercise prescription.[5] Instruction for good body mechanics with specific daily activities required by the individual patient's life should be included in phase 3.

Therapeutic exercise

During this phase, the clinician should begin to incorporate more functional demands into the therapeutic exercise protocol in order to facilitate the return to regular sports and activities.[10] In addition to exercises that mimic the patient's ADLs, this phase of therapy may still include Codman's pendulum exercises performed with hand weights.[7,10] TheraBand exercises may be included for scapular retraction and combined motions.[11] Proprioceptive neuromuscular facilitation (PNF) patterns of D1 and D2 performed with pulleys are also added during this stage.[11] Closed chain exercises may be incorporated with the affected extremity using a wobble board while assuming a quadruped position to improve proprioception.[5] The specific therapeutic exercise prescription including dosage and frequency is detailed in Table 4.

Manual therapy

Joint mobilizations provided by the physical therapist can be performed at grade III if indicated.[7,10] These joint mobilizations will continue to address arthrokinematic deficiencies and improve osteokinematic motion as needed.

Criteria for discharge

As patients regain their normal level of function, there is a natural tendency to discontinue rehabilitation exercise.[10] It is imperative to encourage the patient to continue an independent exercise program to maintain positive outcomes.[8,10] Prior to discharge, patients should be cautioned that complete discontinuation of exercise will likely result in a return of their symptoms.[8,10]

DISCUSSION

The conservative treatment protocol outlined within the previous section reflects the evidence found in the review of literature conducted in December 2011. The evidence found during this review also revealed 3 unexpected factors that may influence patient outcomes following conservative treatment of FTRCT. These influencing factors were patient satisfaction, delay of intervention, and patient selection.

Hawkins and Dunlop[11] investigated the relationship between patient satisfaction and outcome measures following conservative treatment of FTRCT. Patient satisfaction was positively correlated with self-reported outcome measures such as improved pain scores and improved patient report of functional use of the affected extremity. Functional use of the upper extremity was defined as the ability to carry a 10 to 15 pound weight with full elbow extension and the ability to eat using a utensil. Patient satisfaction was not correlated with more objective measures of treatment outcomes such as increased rotator cuff muscle strength or increased active ROM. Of the 33 patients in the study, 14 patients reported dissatisfaction with conservative treatment at the time of their follow-up. The time period for follow-up was not standard between patients. The mean time period for follow-up was 3.8 years posttreatment. Twelve of the 14 patients who were dissatisfied opted for a surgical intervention following conservative treatment. This study highlights the notion that even the best treatment protocol can be affected by a patient's perception of treatment effectiveness. Physical therapists should strongly consider monitoring and documenting patient satisfaction throughout the treatment cycle as it has the potential to affect overall patient outcome. Treating physical therapists might also consider regularly communicating improvements to patients and relating them to the functional goals of the patients. Improvements in functional goals may have more meaning to patients than more traditional outcome measures such as increased ROM or strength.

The second factor that may influence patient outcomes is length of time prior to intervention. Ioti and Tabata[6] identified symptom duration prior to treatment onset as a predictor of outcome of conservative treatment of FTRCT. Significant improvements in pain, ROM, and function were found if patients received treatment within one year of symptom onset ($p < 0.01$). The researchers stated that longer delays prior to conservative treatment should be avoided and are associated with poorer outcomes. In addition, the appearance of fatty infiltration in torn rotator cuff tendons has been documented to occur an average of 3 years after the onset of symptoms.[14] The correlation between length of symptoms, poorer outcomes, and reduced tissue quality highlights the need for early screening, intervention, and prevention protocols for FTRCT.

The third factor that may affect patient outcome is patient selection. Appropriate patient selection models can be quite nebulous. The American Academy of Orthopedic Surgeons' (AAOS) clinical guidelines illustrate the difficulty in synthesizing the evidence to support clinical decision making in the treatment of RCT.[15] Of the 31 guidelines approved in 2010, 19 were determined to lack supporting evidence. The remaining 12 guidelines ranged from moderately supported by existing research to being supported by expert clinical opinion. For patients with chronic symptoms, nonsurgical treatment of FTRCT remains the most

Table 3. Phase 2: Subacute Stage of Tissue Healing

Patient Education
Detailed instruction of therapeutic exercise Posture education and training

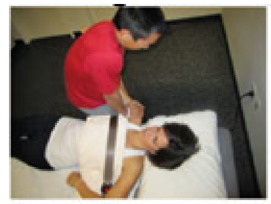
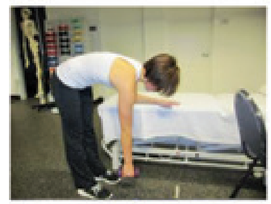
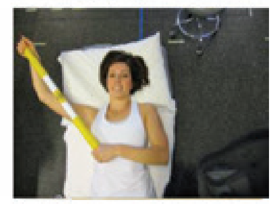
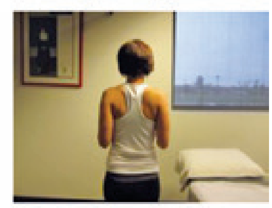
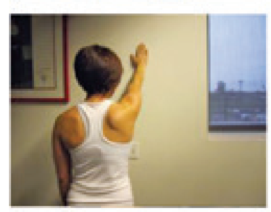
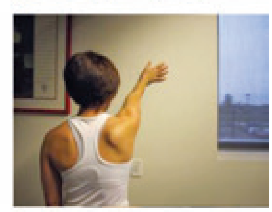
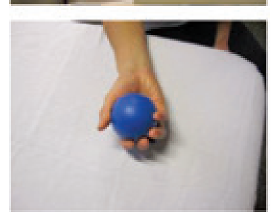
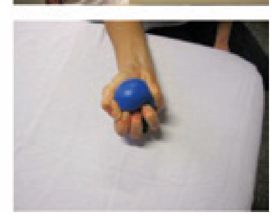
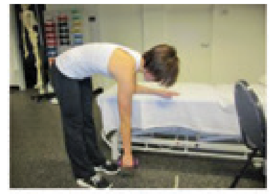
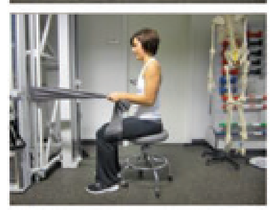
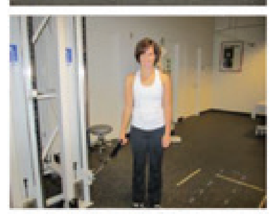
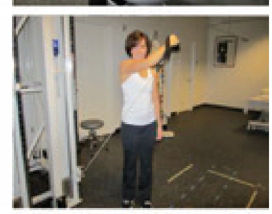
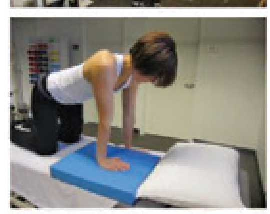
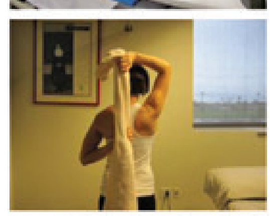
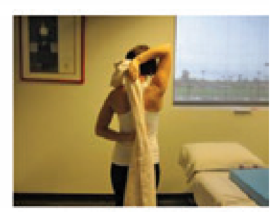
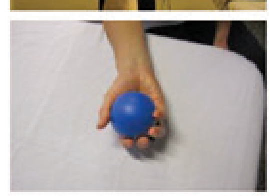
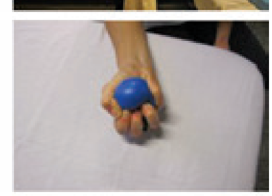
Therapeutic Exercise	**Dosage**	**Frequency**	**Starting Position**	**Ending Position**
Passive joint distraction and mobilization	Grade 3	3x weekly		
Weighted pendulum exercises all ranges	15 reps	3-4x daily		
Passive assist ROM with cane	15 reps	3x daily		
Glenohumeral isometric strengthening all ranges	15 reps	3x daily		
Scapular pinches 20s hold	10 reps	1x daily		
Wall clock exercises	15 reps	2x daily		
Ball squeezes with affected hand	20 reps	3x daily		

Table 4. Phase 3: Reintegration to Regular Activities

Patient Education				
Detailed instruction of therapeutic exercise Posture education and training				
Therapeutic Exercise	**Dosage**	**Frequency**	**Starting Position**	**Ending Position**
Weighted pendulum exercises all ranges	15 reps	3-4x daily		
Passive assist ROM with cane all ranges	15 reps	3-4x daily		
Scapular retraction with TheraBand 5s hold	10 reps	3x weekly		
Combined motions with Thera-Band 5s hold	10 reps	3x weekly		
PNF with pulley (D1 & D2)	10 reps	3x weekly		
Quadruped with wobble board 10s hold	5 reps	3x weekly		
Towel stretch 30s hold	5 reps	2x daily		
Ball squeezes with affected hand	20 reps	3x daily		

common first step in treatment and surgery is reserved for appropriate candidates when conservative treatment fails.[15] Frequently, the decision to intervene surgically depends on the patient's prior level of function, daily physical demands, age, results of conservative treatment, and patient choice.[15] Often times these factors are used to rule out individuals that will not be good surgical candidates. Goldberg et al[8] included an ad hoc analysis to determine which patients included in their study were most likely to have favorable or unfavorable outcomes following conservative treatment for FTRCT. They found that patients with positive outcomes were more likely to have a FTRCT to their dominant extremity ($p = 0.02$). Patients presenting with lower functional scores such as a lower SST score ($p = 0.05$) or difficulty tucking their shirt behind their back ($p = 0.04$) were more likely to have success with conservative treatment. The researchers also investigated which patients were least likely to have a favorable outcome. Patients with lower social scores on the SF-36 were more likely not to improve with nonsurgical treatment ($p = 0.03$). The evidence within the investigation performed by Goldberg et al[8] can be helpful to inform decision making regarding patient selection for conservative treatment, but should not be considered absolute predictors of patient success.

CONCLUSION

Under the best circumstances, optimal treatment of FTRCT is complex. There are many factors outside of the control of the treating physical therapist that can negatively impact a patient's prognosis and outcome. While there is not conclusive evidence to advocate for conservative treatment over surgical intervention, there is evidence that suggests that a thoughtful, conservative physical therapy program can yield functional improvements for patients in the short and long term. Physical therapy is the most likely first choice of treatment in cases of FTRCT. Developing treatment protocols such as the program presented here can be very useful for clinicians and serve as a place to begin when planning patient care.

Patients with a FTRCT are more likely to be over the age of 60 and may likely have co-morbidities that keep them from being good surgical candidates.[4] Increasing age has been shown to negatively impact surgical outcomes in rotator cuff repairs.[16] In patients for whom surgery is not an option, a thoughtful, conservative physical therapy program may be able to significantly improve the patients' level of function and enrich their lives.[5-10,11] Additionally, candidates for surgery are likely to have an interval of delay from the onset of symptoms to the surgical intervention. The delay interval prior to surgery provides an opportunity to initiate conservative treatment even if it is delivered on a trial basis. Physical therapy interventions that are patient centered and respect the stages of tissue healing can improve a patient's function by decreasing pain, increasing ROM, and increasing muscular strength.[5-10,11] If these outcomes are achieved prior to a surgical intervention, the need for surgery may be negated and all possible surgical complications avoided. In conclusion, conservative physical therapy compares favorably to other treatment approaches and should be considered the logical first choice for treatment of FTRCT.

REFERENCES

1. Uhthokk HK, Sarkar K. An algorithm for shoulder pain caused by soft-tissue disorders. *Clin Orthop Relat Res*. 1990;254:121-127.
2. Yamamoto A, Takagishi K, Osawa T, et al. Prevalence and risk factors of a rotator cuff tear in the general population. *J Shoulder Elbow Surg*. 2010;19:116-20.
3. Rudzki J, Adler R, Warren R, et al. Contrast-enhanced ultrasound characterization of the vascularity of the rotator cuff tendon age: Age-and activity-related changes in the intact asymptomatic rotator cuff. *J Shoulder Elbow Surg*. 2007;17(1S):96-100.
4. Seida J, LeBlanc C, Schouten J, et al. Systematic Review: Nonoperative and operative treatments for rotator cuff tears. *Ann Intern Med*. 2010;153:246-255.
5. Ainsworth R. Physiotherapy rehabilitation in patients with massive, irreparable rotator cuff tears. *Musculoskelet Care*. 2006;4(3):140-151.
6. Itoi E, Tabata S. Conservative treatment of rotator cuff tears. *Clin Orthop Relat Res*. 1992;275:165-173.
7. Baydar M, Akalin E, Ozlem E, et al. The efficacy of conservative treatment in patients with full-thickness rotator cuff tears. *Rheumatol Int*. 2009;29:623-628.
8. Goldberg BA, Nowinski DO, Matsen FA. Outcome of nonoperative management of full-thickness rotator cuff tears. *Clin Orthop Related Res*. 2001;382:99-107.
9. Bokor DJ, Hawkins RJ, Huckell GH, Angelo RL, Schickendantz M. Results of nonoperative management of full-thickness tears of the rotator cuff. *Clin Orthop Related Res*. 1993;29103-110.
10. Wirth M, Basamania C, Rockwood C. Nonoperative management of full-thickness tears of the rotator cuff. *Orthop Clin North Am*. 1997;28(1):59-67.
11. Hawkins RH, Dunlop R. Nonoperative treatment of rotator cuff tears. *Clin Orthop Related Res*. 1995;321:178-188.
12. Allen G, Galer B, Schwartz L. Epidemiology of complex regional pain syndrome: a retrospective chart review of 134 patients. *Pain*. 1999;80:539-544.
13. Murphy C, McDermott W, Peterson R, Johnson S, Baxter S. Electromyographic analysis of the rotator cuff in postoperative shoulder patients during passive rehabilitation exercises. *J Shoulder Elbow Surg*. 2013;22:102-107. doi:10.1016/j.jse.2012.01.021
14. Melis B, DeFranco MJ, Chuinard C, Walch G. Natural history of fatty infiltration and atrophy of the supraspinatus muscle in rotator cuff tears. *Clin Orthop Relat Res*. 2010;469:1498-1505.
15. Pedowitz RA, Yamaguchi K, Ahmad CS. AAOS clinical practice guidelines summary: Optimizing the management of rotator cuff problems. *J Am Acad Orthop Surg*. 2011;19:398-379.
16. Bjornsson HC, Norlin R, Johansson K, Adolfsson L. The influence of age, delay of repair, and tendon involvement in acute rotator cuff tears. *Acta Orthopaedica*. 2011;82(2)187-192.

Sacroiliac Joint Pain Diagnosis: The Past and the Future

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ABSTRACT

The sacroiliac joints (SIJ) have been identified as potential sources of low back pain. The primary intent of this commentary is to review the current understanding of diagnosing pain originating from the SIJ in a clinical setting. A brief history of the SIJ is presented to show the progression of knowledge over time, focusing on the last 20 years. Different types of diagnostic tests and their value in making a diagnosis are discussed. This review covers the use of pain provocation tests to identify a subgroup of patients that are more likely to have SIJ pain. Using a clinical prediction rule, it is possible to screen and provide more appropriate care to these patients based on the clinical findings, improve their outcomes, and avoid unnecessary invasive surgical interventions.

Key Words: low back pain, physical examination, physical therapy

INTRODUCTION

Intervertebral disks, facet joints, and the sacroiliac joints have been identified as potential sources of low back pain. Pain in the sacroiliac joint (SIJ) can have many causes including inflammatory conditions leading to sacroiliitis and ankylosis, osteoarthritis, trauma, posttraumatic arthritis, infection, tumor, iatrogenic conditions, metabolic disorder, and SIJ joint dysfunction.[1]

Although there is no accepted gold standard for the diagnosis of pain stemming from the SIJ (or from intervertebral discs and facet joints for that matter), the current reference standard is fluoroscopically guided, contrast enhanced, intraarticular anesthetic blocks.[2,3] Using controlled comparative local anesthetic blocks, the SIJ has been identified in 10% to 27% of patients with low back pain as a source of their primary pain.[4-6] Unfortunately, these diagnostic interventions are invasive and costly, and therefore not necessarily ideal for clinical use.

The diagnostic accuracy has also been questioned, with the effects of blocks being identical in only 60% of cases when performed consecutively.[7] When performing blocks, the extraarticular sources of SIJ ligamentous pain are not identified since only the internal SIJ structures are anaesthetized during the procedure.[8] In a recent systematic review by Rupert et al,[9] diagnostic accuracy of SIJ injections was indicated as level II-2 (well-designed cohort or case-control studies, preferably from more than one center or research group) on a modified U.S. Preventive Services Task Force rating.

As there is no gold standard, any validity of tests for SIJ pain could be questionable and should be regarded with caution. It is important to keep this in mind as this paper discusses the history of SIJ pain and current evidence of diagnosing SIJ pain in a clinical physical therapy setting, since the blocks are regarded as the current reference standard to which other diagnostic criteria are compared.

A BRIEF HISTORY OF THE SIJ

There has been interest in the SIJ for many years. Many published papers that make reference to Lynch,[10] whose research on "The Pelvic Articulations During Pregnancy, Labor, and the Puerperium – An X-ray Study" was published in 1920. Lynch makes reference to Hippocratic doctrine (fifth century B.C.) and noted a "woman's pelvis separated in her first labor and remained so thereafter." No reference was provided by Lynch to substantiate this Hippocrates doctrine. Lynch also references Le Gallois,[11] who was researching female guinea pigs in 1812, and demonstrated that the pelvis was only half the size of the fetal head, and that parturition could only occur if the size of the pelvis increased. Other 'older' references to the SIJ include Dimmerbroch[12] from 1689 that refers to some form of mobility in the SIJ in subjects who are not pregnant. At any rate, interest in the joint has been around for quite some time.

In the early 20th century, the SIJ was an accepted source of low back pain. In 1905, Goldthwait and Osgood[13] published a paper that identified the SIJ as a source of low back and leg pain. In another paper by Yeoman,[14] published in 1928, SIJ arthritis is identified as the cause of 36% of all ischialgia.

The *era of the disk* was unleashed in 1934, when Mixter and Bar,[15] in their landmark paper, claimed that ischialgia is due to the rupture of the intervertebral disk and that disk disruption can cause impingement on the local nerve root resulting in distal pain. Pain stemming from the SIJ was further disregarded, when Platt[16,17] and Ghormley,[18] in 1948 and 1951 respectively denied all mobility of the SIJ and contended that low back pain cannot result from SIJ dysfunction. The era of the disk continued well towards the end of the 20th century.

The 1980s and 1990s saw a shift away from the disk and the SIJ made a 'comeback,' returning as a credible cause of pain. Advances in technology allowed some thought-provoking research to progress knowledge. In 1989, Sturesson et al[19] began his assault on the SIJ, using radiostereometric analysis of pelvic motion and embedded metal (tantalum) balls into various locations in the pelvis of subjects. The movement of the SIJ is measured 3-dimensionally at a mean of 2.5° (0.8 – 3.9) rotation and 0.7 mm (0.1 -1.6) translation, with no significant difference in motion between symptomatic and asymptomatic subjects.[19-23] This is supported by Jacob and Kissling[24] who found 1.7° of rotation and 0.7 mm of translation using a similar technique. It is therefore not surprising, with the motion of the SIJ being found to be so small, that Platt[16,17] and Ghormley[18] were not able to identify any movement in the SIJ given the limited technology available in the 1940s. The reference standard of fluoroscopically guided, contrast enhanced, intraarticular anesthetic blocks was developed throughout the 1990s, but noninvasive diagnosis of SIJ pain remained elusive.[2,3,5]

ANATOMY OF THE SIJ

The SIJ is in part synovial (25% of its surface) and in part syndesmosis. It is a "C" or ear shaped diarthrodial joint, with the caudal part consisting of the articular surface and the upper dorsal portion containing interosseous ligaments[25] (Figure 1). It is covered anteriorly with articular cartilage on the sacral side that is concave, and with fibrocartilage on the iliac side that is convex and also has small ridges on its surface.[25]

The morphology varies in size, shape, and contour from side to side, and between

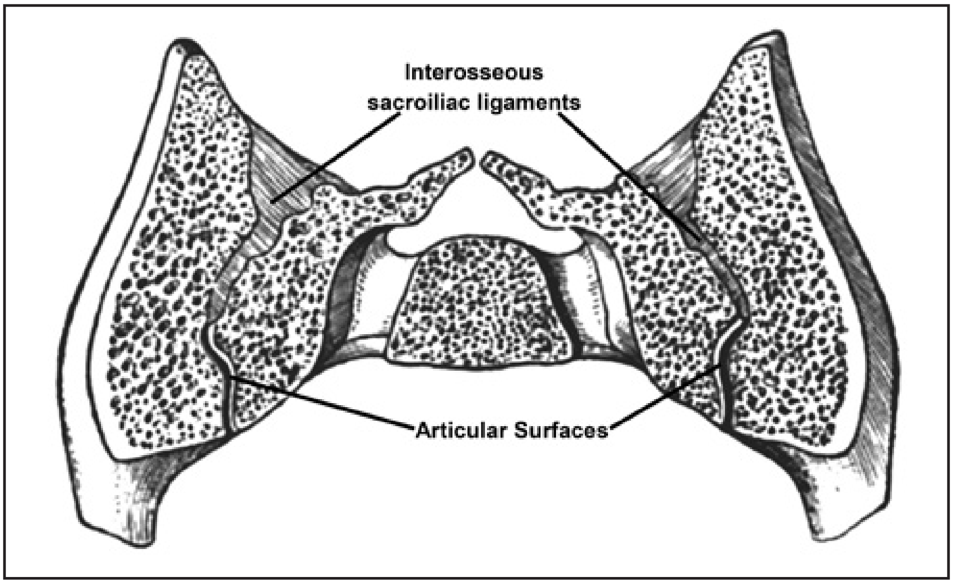


Figure 1. Cross section through second sacral segment. The very thick posterior interosseous sacroiliac ligaments and articular surface are noted. Image was adapted from the public domain.

individuals and changes with aging.[26] The surface of the SIJ is flat until puberty, with bony ridges developing by the age of 30 and becoming more pronounced in the iliac cartilage.[27] With aging, the synovial surface erodes and the synovial cleft becomes narrower; 1 mm to 2 mm in individuals aged 50 to 70 and 0 mm to 1 mm in individuals over the age of 70. The motion of the SIJ progressively decreases with aging in men between 40 and 50 and in women over the age of 50.[27,28]

Ligaments affect the stability of the SIJ. These include the iliolumbar, sacrotuberous, and sacrospinous ligaments, as well as the interosseous ligament. The interosseous ligament forms the posterior border of the SIJ and has been described as the strongest ligament in the human body.[25,27] The gluteus maximus and medius muscles blend with the anterior and posterior SIJ ligaments through fibrous expansions. The muscles that cross the joint can also have an effect on the joint's stability through their contraction, creating shear and compressive forces (force closure) through the SIJ.

The SIJ has a varied innervation. The synovial capsule has unmyelinated free nerve endings; the posterior aspect of the joint receives innervation from L3-S3 and the anterior aspect from L2-S2. The posterior ligaments receive innervation from the lateral branches of the posterior primary rami of L4-S1 and anterior rami of L2-S1.[1]

NONINVASIVE DIAGNOSTIC SIJ TESTS

The main types of noninvasive diagnostic tests for SIJ related pain that have been explored have included:

- position palpation tests to evaluate the position of the pelvic bones relative to each other,[29]
- movement tests to evaluate the motion of the pelvic bones relative to each other,[29,30]
- tenderness tests of various structures that indicate SIJ involvement (ie, the iliopsoas, sacral sulcus),[30]
- location of pain using pain maps,
- subjective medical history such as aggravating and easing factors, and
- pain provocation tests that place various stresses on the joint.[9,31-33]

Position palpation and movement tests

Sturesson et al[19-23] state that because SIJ motion is small, it is highly implausible to detect either motion or position by palpation and movement testing. This has been confirmed by the lack of inter-examiner reliability and specificity when performing these types of tests[34-36] (Table 1). The research by Sturesson et al[19-23] also questions the validity and relevance of these tests as there was no difference in magnitude of motion between symptomatic and asymptomatic subjects.

Subjective Medical History and Tenderness Tests

No subjective medical history, such as aggravating and/or relieving factors (ie, walking, sitting, lying down, coughing/sneezing, bowel movements, high heels/boots, and job activities), and tenderness and palpation tests have been identified as being of value to diagnose SIJ pain compared to anesthetic blocks.[34] Radiating pain into the groin was shown to be a discriminating feature of SIJ pain in a study by Schwarzer et al,[3] but this has not been reproduced in injection studies since.

Pain Maps

A retrospective review of 156 patients by Depalma et al,[37] who underwent discography, facet joint blocks, and SIJ joint blocks, found that the likelihood of SIJ or facet joint pain is increased if the location of low back pain is isolated para-midline (positive likelihood ratio for SIJ 1.24 [95% CI 1.02, 1.42]), and mildly reduces the likelihood of internal disk disruption. A study by Jung et al[38] evaluating pain distribution pattern assessment found only a 46% correlation of SIJ pain to anesthetic blocks using 'pain distribution pattern templates.' Fortin et al,[39,40] in his two-part injection study, used volunteers and symptomatic patients to map out a consistent area of radiating pain from the SIJ, vertical 3 cm by 10 cm in size just inferior to the posterior superior iliac spine. van der Wurff et al[41] found that this 'Fortin' area was discriminative when using intensity mapping only and therefore, not useful for diagnostic purposes.

In the study by Dreyfuss et al,[34] pain from the SIJ did not commonly refer above the spinous process of L5. Otherwise, the pain referral pattern of the SIJ could not be differentiated from that of other structures that may cause low back pain, with and without referral down the leg(s), eg, the zygapophyseal joints,[42] the intervertebral disks,[43] and extraarticular ligaments.[44]

Due to the variability of the SIJ pain pattern and the overlap with pain referred from other structures, it does not appear that pain mapping is a valid method of diagnosing pain from the SIJ.[41,45] This is likely due to the complexity of the innervations, sclerotomal pain referral, other structures adjoining the joint that may be affected, and possibly as the result of the location of injury within the SIJ itself.[45]

Pain Provocation Tests

These tests aim to generate stress to various aspects of the SIJ to reproduce or aggravate the patient's pain. The pain provocation tests have shown poor results when performed individually, lacking correlation with anesthetic blocks as a diagnostic tool.[5,8,32,46,47] Three positive SIJ provocation tests were shown to be a reliable indicator of symptomatic SIJ when compared to fluoroscopically guided double local anesthetic blocks in independent studies,[32,46,47] resulting in similar results, with a sensitivity of 0.94[32] and 0.85[47] and specificity of 0.78[32] and 0.79,[47] respectively. Comparison of the diagnostic accuracy of both of the studies is shown in Table 2.

The diagnostic accuracy (Figure 2) of the study by Laslett et al[32] is improved by eliminating potential false positives that can result from discogenic pain. By using repeated movement testing that results in centralization of pain,[48-50] and eliminating those patients from the calculation, the sensitivity is 0.91 (95% CI 0.62, 0.98) and specificity 0.83 (95% CI 0.68, 0.96), the positive likelihood ratio 6.97 (95% CI 2.39, 20), and the negative likelihood ratio 0.10 (95% CI 0.02, 0.68)[46,51] (Figure 3).

In the recent systematic review by Rupert et al,[9] SIJ pain provocation tests, interpreted in combination with 3 or more positive tests, were graded at a level of II-3 (evidence obtained from multiple time series with or without the intervention), on a modified U.S. Preventive Services Task Force rating.

Laslett et al[32] suggested that adequate sensitivity and specificity of 0.88 and 0.78 respectively, can be achieved using a clinical prediction rule involving two positive tests of distraction, thigh thrust, compression, and sacral thrust. The diagnostic process begins with the two tests that have the highest positive predictive value and specificity (distraction test) and negative predictive value and sensitivity (thigh thrust) (Table 3) for identifying SIJ pathology. If the distraction test and thigh thrust are both positive for creating familiar pain at the SIJ, further tests are not indicated. If one of these tests is negative, then the sacral thrust test is performed and if it results in reproduction of the patient's pain, then SIJ pathology is likely. If the sacral test does not create familiar pain, then the compression test is performed. If the compression test causes familiar pain at the SIJ, then the SIJ pathology is likely to be present. The SIJ pathology is identified by two or more positive tests, with a sensitivity of 0.88 (95% CI 0.64, 0.97), specificity of 0.78 (95% CI 0.61, 0.89), positive likelihood ratio of 4.00 (95% CI 2.13, 8.08), and negative likelihood ratio of 0.16 (95% CI 0.04, 0.47). The absence of any positive provocative tests indicates no SIJ pathology and if only one test is positive, then SIJ pathology is considered unlikely to be present. This can be described by a diagnostic algorithm, as shown in Figure 4.

Table 1. Intertester Reliability of Palpation Sacroiliac Joint Function Tests[35]

Palpation Test	Intertester Agreement (%)
Palpation of iliac crest levels in standing	35.29
Palpation of iliac crest levels in sitting	41.18
Palpation of PSIS levels in standing	35.29
Palpation of PSIS levels in sitting	35.29
Palpation of ASIS levels in standing	37.50
Palpation of ASIS levels in sitting	43.75
Standing Gillet test	46.67
Standing flexion test	43.75
Sitting flexion test	50.00
Supine long sitting test	40.00
Prone knee flexion test	23.53

Table 2. Comparison of Laslett et al[8] and Van Der Wurff et al[47] Findings (3 Or More Positive Provocation SIJ Tests)

	3 or More Positive Provocation Tests	
	Laslett et al	van der Wurff et al
Sensitivity	0.94 (95% CI 0.72, 0.99)	0.85 (95% CI 0.72, 0.99)
Specificity	0.78 (95% CI 0.61, 0.89)	0.79 (95% CI 0.65, 0.93)
Positive LR	4.16 (95% CI 2.10, 8.21)	4.02 (95% CI 2.04, 7.89)
Negative LR	0.12 (95% CI 0.02, 0.76)	0.19 (95% CI 0.07, 0.47)

Notes: Tests included the distraction, compression, thigh thrust, Gaenslen's test, sacral thrust, and Patrick's tests.
Abbreviations: LR, likelihood ratio; 95% CI, 95% confidence interval

DISCUSSION

How relevant is it to be able to identify the source of a patient's low back pain as stemming from the SIJ rather than from another structure in the lumbar spine? How may this impact the selection of treatment that these patients should be receiving?

Further research is needed to compare different treatment techniques on subjects with the SIJ being identified as the source of pain, using either diagnostic SIJ injections or provocation tests, and assessing their effectiveness. It has been shown that stabilization and strengthening exercises may be of benefit for treatment of pregnancy-related pelvic girdle pain, inferring the possibility that the SIJ may be responsive to such treatment.[52,53]

Lumbar multifidus atrophy has been shown to be associated with low back pain and recurrent low back pain. This appears to be due to inhibitory reflex inhibition of the multifidus that begins with pain in the spine, either due to injury[54,55] or artificially induced.[56] Specific treatment aimed at restoring normal activation and size of lumbar multifidus has been shown to decrease the recurrence of low back pain. The close relationship between lumbar spine and the SIJ, with one being able to effect the other, has been shown by changes in forces across the SIJ from the results of SIJ blocks[57] and following lumbar fusion.[58] Further research is necessary to establish the relationship and interaction of the SIJ and lumbar spine, between subjects with pain from either or both areas.

Core stabilization exercises have been shown to be of benefit for pelvic girdle pain in postpartum women, using a lumbar stabilization program.[52,53] The studies did not use diagnostic SIJ injections and only one provocation test to screen for SIJ pain. The provocation test used was the thigh thrust, in combination with palpation tests, Trendelenburg and Active Straight Leg Raising tests. Using the values of Laslett et al,[32] the thigh thrust is most effective in ruling out (SnOut) SIJ pathology, with the highest sen-

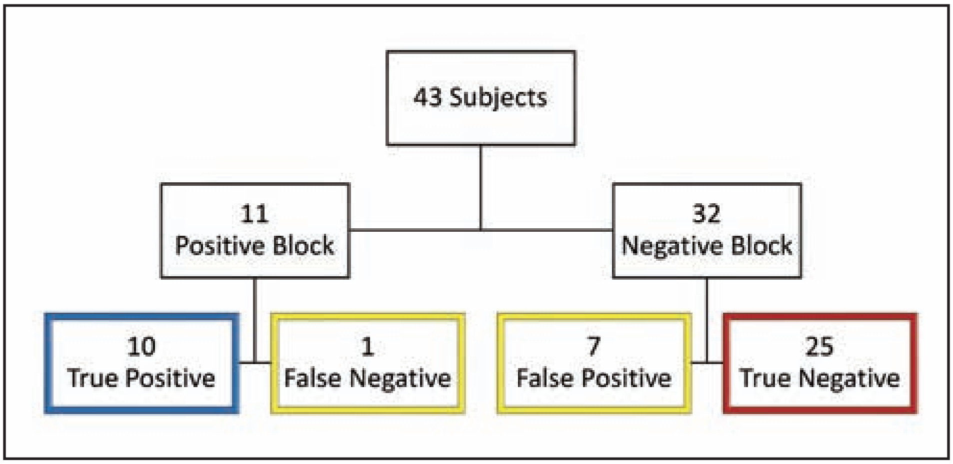


Figure 2. Diagnostic accuracy of sacroiliac joint provocation test compared to intraarticular anesthetic blocks including all subjects.[46]

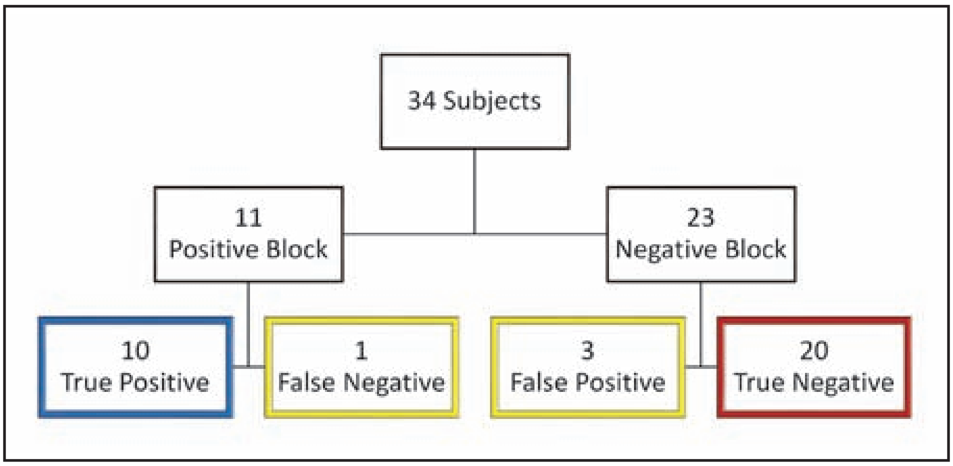


Figure 3. Diagnostic accuracy of sacroiliac joint provocation test compared to intraarticular anesthetic blocks excluding subjects who tested positive to the repeated movement testing.[46]

sitivity (0.88) and lowest negative predictive value (0.18) of the provocation tests (Table 3). Therefore it is questionable that subjects were correctly identified for the intervention groups in this study. The specific stabilizing exercise group that benefited from the intervention was treated with a program that targeted the transversus abdominis, lumbar multifidus, gluteus maximus, latissimus dorsi, and internal and external oblique muscles. This type of program would be nearly identical to a program addressing lumbar pathology, with identified deficits in multifidus cross-sectional area and transversus activation.

It is not known if exercises aimed at only strengthening muscles such as gluteus maximus and medius muscles, that blend with the anterior and posterior SIJ ligaments through fibrous expansions, and then potentially have a direct effect on SIJ stability, might be of greater benefit. Similar to the relationship of the multifidus to the lumbar spine, muscles that cross the SIJ can create shear and compressive forces through the SIJ and result in improved motor control of the neutral zone. The neutral zone is the point in spinal range of motion, during which the movement occurs against minimal internal resistance.[59] Muscles and motor control are required to create stability and prevent abnormal movement. Studies have shown that low back pain results in motor control restructuring,[60,61] although no study has demonstrated that this can be reset/normalized through stabilization exercise. Further research is required to investigate the most effective treatment for normalizing altered motor control in SIJ-related low back pain specifically associated with motor control impairments and altered motor control strategies that develop to increase force closure through the joint and pelvis.[62] Given our limited treatment time with patients, do the additional exercises involving the transversus abdominis, lumbar multifidus, latissimus dorsi, and internal and external oblique, add any value to improving the treatment outcomes for subjects with SIJ pain?

A clinical prediction rule by Hicks et al,[63] for determining patients who would likely respond positively to stabilization exercise found that the most important variables were age (younger than 40 years old), straight-leg raise (average greater than 91°), prone instability test (positive), and aberrant motions (instability catch, Gower's sign, reversal of lumbo-sacral rhythm). With 3 or more present, the positive likelihood ratio was of 4.0 (95% CI: 1.6, 10.0). Further research is needed to identify whether patients with SIJ pain are encompassed within the criteria of existing clinical prediction rules, or whether they should be classified as a separate and distinct subgroup. If SIJ pain is found to be a discrete subgroup, treatment approaches can be refined to treat these specific patients, resulting in improved treatment outcomes. In the interim, one approach would be to use the low back pain clinical prediction rule and incorporate SIJ pain provocation testing. Use of an impairment-based approach in conjunction with the clinical prediction rule may also be of benefit. More research is needed in this regard.

With some low back pain patients failing to respond to physical therapy interventions, it seems that to accurately identify the SIJ as a source of pain may be important to establish and guide a patient's treatment plan and lead to improved long-term outcomes. Nonphysical therapy interventions for SIJ pain include corticosteroid/anesthetic[57] and phenol nerve block injections,[64] prolotherapy,[65] radiofrequency neurotomy,[9] and fusion.[66] Fusion may be considered in patients with SIJ pain that have failed all other interventions, resulting in a decrease in pain and improved function.[66] Unnecessary invasive lumbar surgery and interventions may also be prevented with correct identification of the SIJ as the source of pain.

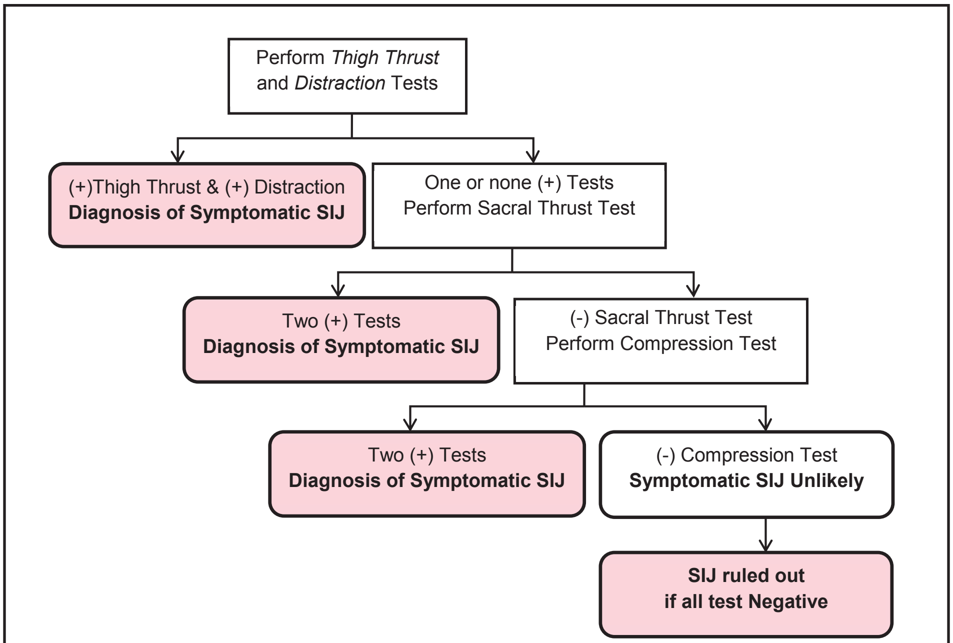
SUMMARY/CONCLUSION

The SIJ is a significant source of pain for patients referred to physical therapy clinics for treatment. From the current evidence, pain provocation tests can be used as a clinical prediction rule to identify patients who are likely to have pain originating from the SIJ. This can be accomplished using a composite of 3 positive SIJ provocative tests with the highest positive predictive values and positive likelihood ratios. A diagnostic algorithm can also be used that quickly identifies the likelihood of SIJ pathology in the pres-

Table 3. Positive Predictive Value and Negative Predictive Value of Selected SIJ Provocation Tests[32]

SIJ Provocation Test	PPV	NPV
Distraction	0.60 (95% CI 0.36, 0.80)	0.81 (95% CI 0.65, 0.91)
Thigh thrust	0.58 (95% CI 0.39, 0.76)	0.92 (95% CI 0.74, 0.98)
Sacral thrust	0.56 (95% CI 0.34, 0.75)	0.80 (95% CI 0.63, 0.91)
Compression	0.52 (95% CI 0.32, 0.72)	0.82 (95% CI 0.63, 0.92)

Abbreviations: PPV, positive predictive value; NPV, negative predictive value; 95% CI, 95% confidence interval



Abbreviations: (+), positive test; (-), negative test; SIJ, sacroiliac joint

Figure 4. Diagnostic algorithm for diagnosis of sacroiliac joint pain using 4 sacroiliac joint provocation tests: distraction, thigh thrust, compression, and sacral thrust.[32]

ence of two positive SIJ tests. As there is no gold standard for comparison, the results should be interpreted with caution.

Provocation tests such as the distraction (Figure 5), thigh thrust (Figure 6), Gaenslen (Figure 7), compression (Figure 8), and sacral thrust (Figure 9) are quick and easy to perform, and only require minimal training to perform them correctly. They are explained fully in detail in the text by Kokmeyer and Laslett.[46,67]

The SIJ pain provocation tests can be used in conjunction with current existing low back pain clinical prediction rules to screen patients for treatment that may be more appropriate for them.[68-73] Further research is required to investigate the most effective physical therapy management for the subgroup of patients with pain presumed to be originating from the SIJ.

REFERENCES

1. Zelle BA, Gruen GS, Brown S, George S. Sacroiliac joint dysfunction: evaluation and management. *Clin J Pain*. 2005;21(5):446-455.
2. Merskey H, Bogduk N. Spinal pain, section 3: Spinal and radicular pain syndromes of the lumbar, sacral, and coccygeal regions. In: Merskey H, Bogduk N, eds. *Classification of Chronic Pain: Descriptions of Chronic Pain Syndromes and Definitions of Pain Terms*. 2nd ed. Seattle, WA: IASP Press; 1994:173-181.
3. Schwarzer AC, Aprill CN, Bogduk N. The sacroiliac joint in chronic low back pain. *Spine*. 1995;20(1):31-37.
4. Manchikanti L, Singh V, Pampati V, et al. Evaluation of the relative contributions of various structures in chronic low back pain. *Pain Physician*. 2001;4(4):308-316.
5. Maigne JY, Aivaliklis A, Pfefer F. Results of sacroiliac joint double block and value of sacroiliac pain provocation tests in 54 patients with low back pain. *Spine*. 1996;21(16):1889-1892.
6. Irwin RW, Watson T, Minick RP, Ambrosius WT. Age, body mass index, and gender differences in sacroiliac joint pathology. *Am J Phys Med Rehabil*. 2007;86(1):37-44.
7. Berthelot JM, Labat JJ, Le Goff B, Gouin F, Maugars Y. Provocative sacroiliac joint maneuvers and sacroiliac joint block are unreliable for diagnosing sacroiliac joint pain. *Joint Bone Spine*. 2006;73(1):17-23.
8. Laslett M. Pain provocation tests for diagnosis of sacroiliac joint pain. *Aust J Physiother*. 2006;52(3):229.
9. Rupert MP, Lee M, Manchikanti L, Datta S, Cohen SP. Evaluation of sacroiliac joint interventions: A systematic appraisal of the literature. *Pain Physician*. 2009;12(2):399-418.
10. Lynch FW. The pelvic articulations during pregnancy, labor, and the puerperium: An x-ray study. *Surg Gynecol Obstet*. 1920;30:575-580.
11. Le Gallois M. Part II. critical analysis - experiences sur le principe de la vie. In: *The Edinburgh Medical and Surgical Journal*. Vol 10th. Edingburgh: Archibald Constable and Company; 1814:207-219.
12. Dimmerbroch I. *The Anatomy of Human Bodies*. London: Brewster; 1689.
13. Goldthwait JE, Osgood RB. A consideration of the pelvic articulations from an anatomical, pathological and clinical standpoint. *Boston Med Surg J*. 1905;152:593-601.
14. Yeoman W. The relation of arthritis of the sacroiliac joint to sciatica with an analysis of 100 cases. *Lancet*. 1928;2:1119-1122.
15. Mixter WJ, Bar JS. Rupture of intervertebral disc with involvement of spinal canal. *New Engl J Med*. 1934:211.
16. Platt H. Backache-sciatica syndrome. *Lancet*. 1948;1(6505):677.
17. Platt H. The backache-sciatica syndrome and the intervertebral disc. *Rheumatism*. 1948;4(3):218-223.
18. Ghormley RK. An etiologic study of backache and sciatic pain. *Proc Staff Meet Mayo Clin*. 1951;26(25):457-463.
19. Sturesson B, Selvik G, Uden A. Movements of the sacroiliac joints. A roentgen stereophotogrammetric analysis. *Spine*. 1989;14(2):162-165.
20. Sturesson B, Uden G, Uden A. Pain pattern in pregnancy and "catching" of the leg in pregnant women with posterior pelvic pain. *Spine*. 1997;22(16):1880-3; discussion 1884.
21. Sturesson B, Uden A, Vleeming A. A radiostereometric analysis of the movements of the sacroiliac joints in the reciprocal straddle position. *Spine*. 2000;25(2):214-217.
22. Sturesson B, Uden A, Vleeming A. A radiostereometric analysis of movements of the sacroiliac joints during the standing hip flexion test. *Spine*. 2000;25(3):364-368.
23. Sturesson B, Uden A, Onsten I. Can an external frame fixation reduce the movements in the sacroiliac joint? A radiostereometric analysis of 10 patients. *Acta Orthop Scand*. 1999;70(1):42-46.
24. Jacob HA, Kissling RO. The mobility of the sacroiliac joints in healthy volunteers between 20 and 50 years of age. *Clin Biomech (Bristol, Avon)*. 1995;10(7):352-361.
25. Stover MD, Mayo KA, Kellam JF. Pelvic ring disruptions, Chapter 36. In: Browner BD, Jupiter JB, Levine AM, Trafton PG, Krettek C, eds. *Skeletal Trauma*. 4th ed. Philadelphia,

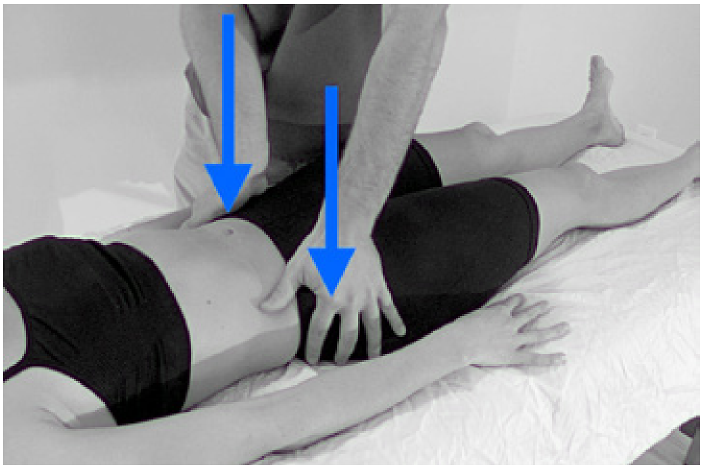


Figure 5. Distraction provocation sacroiliac joint test. Note: pressure applied vertically through the anterior superior iliac spines in a dorsal direction, resulting in distraction of the anterior sacroiliac joint surface.

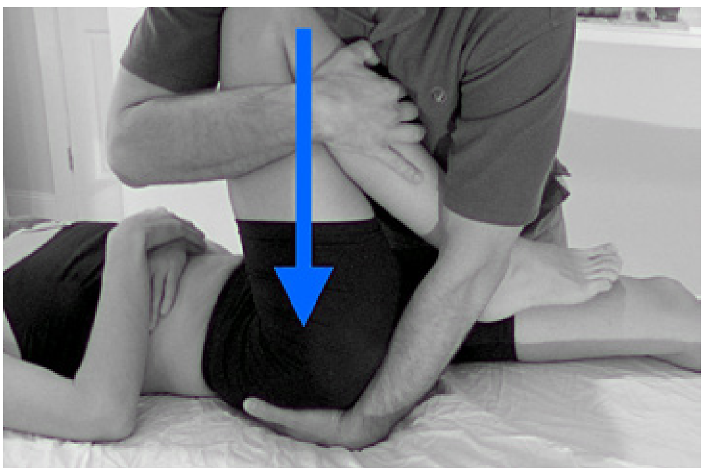


Figure 6. Thigh thrust sacroiliac joint provocation test. Note: pressure applied vertically through the long axis of the femur, resulting in anterior-to-posterior shear on the same side (right side in example).

Figure 7. Gaenslen's provocation sacroiliac joint test. Note: one leg is fixated in maximal hip flexion, while the contralateral leg is lowered into hip extension creating torsion through the sacroiliac joint, in example above resulting in posterior rotation of right and anterior rotation of left sacroiliac joint.

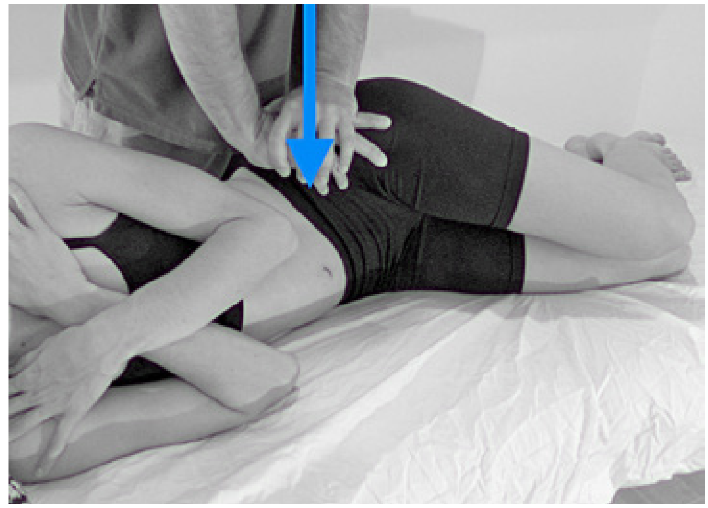


Figure 8. Compression provocation sacroiliac joint test. Notes: with hips in 45° flexion, pressure is applied vertically through the anterior edge of the iliac crest, resulting in compression of both sacroiliac joints.

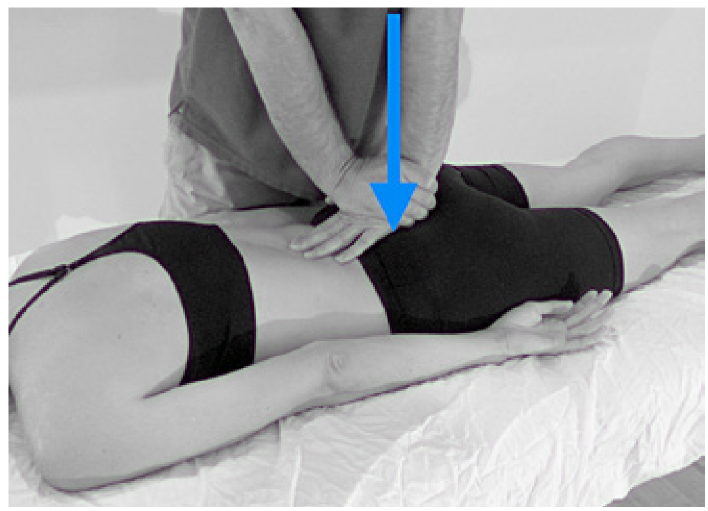


Figure 9. Sacral thrust provocation sacroiliac joint test. Notes: pressure applied to the midline vertically through the apex of the curve of the sacrum, resulting in posterior shearing with sacrum nutated.

PA: W.B. Saunders Company; 2008:1107-1169.
26. Kampen WU, Tillmann B. Age-related changes in the articular cartilage of human sacroiliac joint. *Anat Embryol*. 1998;6:505-513.
27. Dreyfuss P, Cole AJ, Pauza K. Sacroiliac joint injection techniques. *Phys Med Rehabil Clin N Am*. 1995;6(4):785-813.
28. Dar G, Khamis S, Peleg S, et al. Sacroiliac joint fusion and the implications for manual therapy diagnosis and treatment. *Man Ther*. 2008;13(2):155-158.
29. Beal MC. The sacroiliac problem: Review of anatomy, mechanics, and diagnosis. *J Am Osteopath Assoc*. 1982;81(10):667-679.
30. Grieve GP. The sacro-iliac joint. *Physiotherapy*. 1976;62(12):384-400.
31. Laslett M, Williams M. The reliability of selected pain provocation tests for sacroiliac joint pathology. *Spine*. 1994;19(11):1243-1249.
32. Laslett M, Aprill CN, McDonald B, Young SB. Diagnosis of sacroiliac joint pain: Validity of individual provocation tests and composites of tests. *Man Ther*. 2005;10(3):207-218.
33. Hancock MJ, Maher CG, Latimer J, et al. Systematic review of tests to identify the disc, SIJ or facet joint as the source of low back pain. *Eur Spine J*. 2007;16(10):1539-1550.
34. Dreyfuss P, Michaelsen M, Pauza K, McLarty J, Bogduk N. The value

of medical history and physical examination in diagnosing sacroiliac joint pain. *Spine*. 1996;21(22):2594-2602.
35. Potter NA, Rothstein JM. Intertester reliability for selected clinical tests of the sacroiliac joint. *Phys Ther*. 1985;65(11):1671-1675.
36. Herzog W, Read LJ, Conway PJ, Shaw LD, McEwen MC. Reliability of motion palpation procedures to detect sacroiliac joint fixations. *J Manipulative Physiol Ther*. 1989;12(2):86-92.
37. Depalma MJ, Ketchum JM, Trussell BS, Saullo TR, Slipman CW. Does the location of low back pain predict its source? *PM R*. 2011;3(1):33-39.
38. Jung JH, Kim HI, Shin DA, et al. Usefulness of pain distribution pattern assessment in decision-making for the patients with lumbar zygapophyseal and sacroiliac joint arthropathy. *J Korean Med Sci*. 2007;22(6):1048-1054.
39. Fortin JD, Dwyer AP, West S, Pier J. Sacroiliac joint: Pain referral maps upon applying a new injection/arthrography technique. part I: Asymptomatic volunteers. *Spine*. 1994;19(13):1475-1482.
40. Fortin JD, Aprill CN, Ponthieux B, Pier J. Sacroiliac joint: Pain referral maps upon applying a new injection/arthrography technique. part II: Clinical evaluation. *Spine*. 1994;19(13):1483-1489.
41. van der Wurff P, Buijs EJ, Groen GJ. Intensity mapping of pain referral areas in sacroiliac joint pain patients. *J Manipulative Physiol Ther*. 2006;29(3):190-195.
42. Mooney V, Robertson J. The facet syndrome. *Clin Orthop Relat Res*. 1976;115:149-156.
43. McCall IW. Lumbar herniated disks. *Radiol Clin North Am*. 2000;38(6):1293-1309.
44. Borowsky CD, Fagen G. Sources of sacroiliac region pain: Insights gained from a study comparing standard intra-articular injection with a technique combining intra- and periarticular injection. *Arch Phys Med Rehabil*. 2008;89(11):2048-2056.
45. Slipman CW, Jackson HB, Lipetz JS, Chan KT, Lenrow D, Vresilovic EJ. Sacroiliac joint pain referral zones. *Arch Phys Med Rehabil*. 2000;81(3):334-338.
46. Laslett M, Young SB, Aprill CN, McDonald B. Diagnosing painful sacroiliac joints: A validity study of a McKenzie evaluation and sacroiliac provocation tests. *Aust J Physiother*. 2003;49(2):89-97.
47. van der Wurff P, Buijs EJ, Groen GJ. A multitest regimen of pain provocation tests as an aid to reduce unnecessary minimally invasive sacroiliac joint procedures. *Arch Phys Med Rehabil*. 2006;87(1):10-14.
48. Donelson R, Silva G, Murphy K. Centralization phenomenon. its usefulness in evaluating and treating referred pain. *Spine*. 1990;15(3):211-213.
49. Donelson R, Aprill C, Medcalf R, Grant W. A prospective study of centralization of lumbar and referred pain. A predictor of symptomatic discs and anular competence. *Spine*. 1997;22(10):1115-1122.
50. Fritz JM, Delitto A, Vignovic M, Busse RG. Interrater reliability of judgments of the centralization phenomenon and status change during movement testing in patients with low back pain. *Arch Phys Med Rehabil*. 2000;81(1):57-61.
51. Laslett M. Evidence-based diagnosis and treatment of the painful sacroiliac joint. *J Man Manip Ther*. 2008;16(3):142-152.
52. Stuge B, Laerum E, Kirkesola G, Vollestad N. The efficacy of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy: A randomized controlled trial. *Spine*. 2004;29(4):351-359.
53. Stuge B, Veierod MB, Laerum E, Vollestad N. The efficacy of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy: A two-year follow-up of a randomized clinical trial. *Spine*. 2004;29(10):E197-203.
54. Hides JA, Richardson CA, Jull GA. Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. *Spine*. 1996;21(23):2763-2769.
55. Hides J, Gilmore C, Stanton W, Bohlscheid E. Multifidus size and symmetry among chronic LBP and healthy asymptomatic subjects. *Man Ther*. 2008;13(1):43-49.
56. Hodges P, Holm AK, Hansson T, Holm S. Rapid atrophy of the lumbar multifidus follows experimental disc or nerve root injury. *Spine*. 2006;31(25):2926-2933.
57. Liliang PC, Lu K, Weng HC, Liang CL, Tsai YD, Chen HJ. The therapeutic efficacy of sacroiliac joint blocks with triamcinolone acetonide in the treatment of sacroiliac joint dysfunction without spondyloarthropathy. *Spine*. 2009;34(9):896-900.
58. Ivanov AA, Kiapour A, Ebraheim NA, Goel V. Lumbar fusion leads to increases in angular motion and stress across sacroiliac joint: A finite element study. *Spine*. 2009;34(5):E162-9.
59. Fritz JM, Erhard RE, Hagen BF. Segmental instability of the lumbar spine. *Phys Ther*. 1998;78(8):889-896.
60. Hodges PW, Moseley GL. Pain and motor control of the lumbopelvic region: Effect and possible mechanisms. *J Electromyogr Kinesiol*. 2003;13(4):361-370.
61. MacDonald D, Moseley GL, Hodges PW. Why do some patients keep hurting their back? evidence of ongoing back muscle dysfunction during remission from recurrent back pain. *Pain*. 2009;142(3):183-188.
62. O'Sullivan PB, Beales DJ, Beetham JA, et al. Altered motor control strategies in subjects with sacroiliac joint pain during the active straight-leg-raise test. *Spine*. 2002;27(1):E1-8.
63. Hicks GE, Fritz JM, Delitto A, McGill SM. Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch Phys Med Rehabil*. 2005;86(9):1753-1762.
64. Ward S, Jenson M, Royal MA, Movva V, Bhakta B, Gunyea I. Fluoroscopy-guided sacroiliac joint injections with phenol ablation for persistent sacroiliitis: A case series. *Pain Pract*. 2002;2(4):332-335.
65. Kim WM, Lee HG, Jeong CW, Kim CM, Yoon MH. A randomized controlled trial of intra-articular prolotherapy versus steroid injection for sacroiliac joint pain. *J Altern Complement Med*. 2010;16(12):1285-1290.
66. Khurana A, Guha AR, Mohanty K, Ahuja S. Percutaneous fusion of the sacroiliac joint with hollow modular anchorage screws: Clinical and radiological outcome. *J Bone Joint Surg Br*. 2009;91(5):627-631.
67. Kokmeyer DJ, Van der Wurff P, Aufdemkampe G, Fickenscher TC. The reliability of multitest regimens with sacroiliac pain provocation tests. *J Manipulative Physiol Ther*. 2002;25(1):42-48.
68. Fritz JM, Brennan GP, Clifford SN, Hunter SJ, Thackeray A. An examination of the reliability of a classification algorithm for subgrouping patients with low back pain. *Spine*. 2006;31(1):77-82.
69. Brennan GP, Fritz JM, Hunter SJ, Thackeray A, Delitto A, Erhard RE. Identifying subgroups of patients with acute/subacute "nonspecific" low back pain: Results of a randomized clinical trial. *Spine*. 2006;31(6):623-631.
70. Hallegraeff JM, de Greef M, Winters JC, Lucas C. Manipulative therapy and clinical prediction criteria in treatment of acute nonspecific low back pain. *Percept Mot Skills*. 2009;108(1):196-208.
71. Cleland JA, Fritz JM, Kulig K, et al. Comparison of the effectiveness of three manual physical therapy techniques in a subgroup of patients with low back pain who satisfy a clinical prediction rule: A randomized clinical trial. *Spine*. 2009;34(25):2720-2729.
72. Teyhen DS, Flynn TW, Childs JD, Abraham LD. Arthrokinematics in a subgroup of patients likely to benefit from a lumbar stabilization exercise program. *Phys Ther*. 2007;87(3):313-325.
73. Fritz JM, Cleland JA, Childs JD. Subgrouping patients with low back pain: Evolution of a classification approach to physical therapy. *J Orthop Sports Phys Ther*. 2007;37(6):290-302.

The Use of a Modified Connective Tissue Adaptation Phase and Closed Chain PRE Program in the Treatment of a Patient With a Failed Rotator Cuff Repair: A Case Report

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ABSTRACT

Background and Purpose: Approximately 45% of rotator cuff (RC) repairs performed in the 70- to 79-year-old age group fail. With the altered shoulder mechanics associated with rotator cuff dysfunction, other pathologies develop, and lifestyle modifications are necessary. Exercise can be efficacious in treating these patients; however, there is no agreement as to the type or dosage to attain optimal outcomes. The purpose of this case report is to describe the use of a modified periodized closed chain (CC) upper extremity exercise program to improve the strength and function of a 74-year-old female who underwent two failed RC repairs. **Findings:** On examination the patient's MRI findings showed surgical failure of the RC repair, joint degeneration, and an overall poor quality of the remaining RC tissue. This being the case, another surgical repair was not warranted. Clinical examination confirmed the MRI diagnosis. The patient's Western Ontario Rotator Cuff (WORC) score was 980/2100 (2100 = max disability) at the initial exam. **Methods:** A combined supervised and independent 3-phased upper extremity CC and tendon adaptation exercise program were used to treat this patient over an 18-month period. The literature provided support for this treatment duration and method. A new exercise machine was developed to allow the appropriate load and volume for all closed chain exercises. **Clinical Relevance of the Method:** Outcomes evaluated at 18 months demonstrated clinically meaningful improvement in the WORC measure and increased upper extremity strength. As a result, the patient was able to return to recreational tennis. Closed chain (CC) upper extremity motion is theorized to improve shoulder joint stability during exercise, and therefore decrease stress on the remaining RC tissue. This may prevent tear progression, improve joint arthrokinematics, and thus decrease shoulder joint degeneration over time as shoulder function is restored. **Conclusion:** Failed RC repairs often lead to poor functional outcomes. Research has demonstrated that exercise can improve these outcomes, but there is no agreement as to optimal type or dose. Treating the patient with this new periodized CC model improved her functional outcomes and allowed for a return to recreational sport. With few options available for these patients, this model provides a new method to improve functional outcomes for patients with RC tears.

Key Words: isometric exercise, body weight off loading, supraspinatus activity, tendon, collagen, joint compression

INTRODUCTION

Shoulder pain disorders are the second most common musculoskeletal disorders for which the general population seeks medical attention. Rotator cuff (RC) problems are the most frequent cause of shoulder pain and dysfunction.[1] The RC serves to assist other shoulder muscles during glenohumeral elevation as well as external and internal rotation of the glenohumeral joint. Due to the shallow nature of the glenoid, another important function of the RC is to provide a stabilization force to control humeral head translation with physiological humeral motion.[2]

The incidence of RC failure increases with age and appears to be naturally related to the aging process.[3,4] The prevalence of partial or full thickness RC tears ranges from 31% to 70% in the 70- to 79-year-old age group.[3,5] Not all patients with RC tears are symptomatic, with limited correlation between patient symptoms and RC integrity.[6] However, the tear size does correlate with symptoms. Those with tears greater than 23 mm are more likely to experience symptoms.[4] Those with symptoms report pain, decreased shoulder function, and diminished overall quality of life due to the poor functioning of their RC.[3] A dysfunctional RC can lead to glenohumeral instability and joint cartilage damage. For patients with partial or full thickness RC tears, there is an increased likelihood of glenohumeral joint degenerative changes.[7] Patients with a nonoperatively managed massive RC tear can maintain shoulder function, but there is a risk of a repairable tear progressing to a nonrepairable tear.[8]

Surgical repair is one option for those affected by a RC tear. Surgery is not always successful. Between 30% and 45% of all RC repairs fail,[9] with an increased prevalence in the elderly population.[10] However, not all patients who suffer a rupture of the repair will be symptomatic. Open surgical repairs of massive RC tears may have a favorable outcome in a significant proportion of patients, despite a high rate of recurrent tears or failed repairs.[11] When RC tendon repair surgery fails, and symptoms return, lifestyle modifications ensue. Treatment options are nonoperative care, tendon transfer, or reverse total shoulder arthroplasty.

Nonoperative care can produce favorable outcomes, with limited research indicating that exercise can improve the shoulder function in older patients with massive tears who have not had a surgical repair. In one randomized controlled trial, comparing progressive open chain exercises to a placebo (ultrasound), greater improvements in shoulder functional outcomes were seen in the exercise group up to one year.[12] After the first year, both groups' demonstrated similar outcomes, which may be attributed to the patient education received by the control group. This may have improved their confidence in moving the affected arm and resulted in improved ability with activities of daily living and the higher subsequent scores on the Oxford Shoulder Score. Exercise therapy for full thickness RC tears has some benefit; however, there is no definitive guidance as to when to start an exercise program and what to include.[13] No studies have examined the effects of exercise in patients with full thickness RC tears or failed repairs for return to advanced activities such as recreational sports.

Closed chain (CC) exercise is defined as exercises performed with a fixed distal segment; in upper body exercise, this fixed distal segment would be the hand. With CC exercise, the force produced by the muscles does not move the fixed distal segment, and the subsequent transition of the produced force through the supported body mass allows for resisted motion to take place around this fixed distal segment.[14] Closed chain exercise may protect the shoulder joint and the RC while allowing for the gradual strengthening of the remaining vulnerable cuff tissue. Closed chain exercise may protect the RC by 3 theorized mechanisms.

1. When the arm is supporting the body weight, there are compressive forces across the glenohumeral joint that can contribute to joint stability.[15] A cadaveric study indicated that greater force was required to displace the humeral head after the joint was compressed.[16] This added stability can serve to reduce the stress on and the activity of the RC during CC exercises.[15] The cuff will not have to work as hard to stabilize the shoulder joint, thereby protecting the remaining vulnerable torn RC tissue. Also, the increased stability may lessen the humeral head translation with motion, therefore, decreasing the wear on the joint surfaces and slowing the degenerative joint disease process.
2. Studies have demonstrated that during CC upper extremity exercise there is decreased activation of the supraspinatus muscle.[14] Also, they found increased infraspinatus muscle activity that may facilitate the reduction in the supraspinatus muscle activity needed for joint stabilization.[15] The reduced supraspinatus activity may be advantageous by lessening tendon and muscle stress, leading to a decreased risk for further supraspinatus tendon damage. For those with complete tears of the supraspinatus tendon, it may allow for arm use and exercise with a decreased contribution from the supraspinatus muscle.
3. The majority of CC exercises are performed with the shoulder at 90° of forward elevation. This is an ideal position for shoulder joint stability without increased stress to the joint capsule.[17] Performing CC strengthening with the shoulder in 90° of flexion, at the time when the torque on the shoulder joint is the greatest, may help lessen the need for RC stabilization. This may serve to protect the shoulder from further damage to the tissue.

Closed chain exercise using a modified periodized progressive resistance approach may allow improved strength of the major glenohumeral joint movers. However, during most activities, the shoulder functions in an open chain without this fixed distal segment. There is evidence that CC exercise improves open chain motion performanc.[18] The addition of an external compression strap can improve shoulder joint position sense during open chain exercise for those with unstable shoulders.[19] Accepting that there will be carryover in an open chain and the use of an external strap to apply a compressive force during open chain motion, the next step in the application of this CC exercise concept is to determine exercise load and volume. Little is known about the dosage of any exercise, including CC exercise, for patients with full thickness RC tears.[20] Moreover, there is no evidence as to the effects of a CC approach for the treatment of those with massive RC tears or failed repairs.

The purpose of this case report is to describe the physical therapy and strength and conditioning treatment of a 74-year-old female who was treated with a CC modified periodized progressive resistance exercise program after two failed RC repair surgeries and who transitioned to advanced open chain activities with the use of an external compression strap. The patient experienced a clinically meaningful improvement in her disability and function.

METHODS

Experimental Approach to the Problem

Research is lacking with regard to the restoration of strength and function of the upper extremity following the diagnosis of a massive RC tear or a failed repair. This case study focused on a new training theory framework that uses gravity to lessen the need for RC stabilization. A prolonged connective tissue adaptation phase is described to allow for adaptation of the remaining cuff tendons. Due to the length of time that the subject has experienced RC dysfunction, her age, and research regarding the time needed for tendon adaptation, the case study was designed to last 18 months.

Subject

The client is a 74-year-old female with a past medical history of two right shoulder RC repair surgeries, the first one in the year 2000 and the second one in 2002. The second one was due to repair failure. The patient reported that the rehabilitation program post both repairs included passive range of motion, active assistive range of motion, stretching, and progressed to active range of motion/strengthening exercises in an open chain. Then in 2009 the patient experienced shoulder pain of 5-7/10 levels. Pain occurred with upper extremity movements requiring the arm to be outstretched from her side and during upper body exercises. An MRI showed a complete tear of the supraspinatus, a partial tear of the infraspinatus, and an intact subscapularis and teres minor. The patient reported her physicians offered no surgical treatment options due to the poor quality of the remaining tissue due to fatty infiltration and atrophy of the supraspinatus. The patient sought nonoperative treatment to improve her function and return to regular exercise and recreational sports. She was very motivated and agreed to an intense exercise program to reach these goals. As this was a privately done case study, no institutional review was required. Consent to participate was given by the client and confidentiality was maintained throughout this report.

Procedures

An initial examination was done to collect data thus establishing a baseline to monitor progress. The collect data confirmed the medical diagnosis.

Posture examination

Postural observation was performed in both the sagittal and frontal planes. The sagittal view of the posture was examined as described by Cleland et al.[21] The patient demonstrated no excessive thoracic spine kyphosis or forward head posture. In the frontal plane the cervical or thoracic spine did not deviate to the left or the right.

Range of motion

Right shoulder active range of motion (AROM) was visually assessed and compared to the nonaffected arm as described by Terwee and colleagues.[22] In order to achieve full AROM there was excessive compensation in the scapula-thoracic joint. Passive range of motion (PROM) was full in all planes. Active range of motion measures are presented in Table 1.

Muscle performance

Upper extremity muscular performance was assessed by manual muscle testing and with a modified push-up test. A modified push-up test can be used to objectively measure upper body strength if the client is unable to perform very many repetitions (≤ 6) during the test.[23] The modified push-up test was used as described by Earle and Baechle[23] by having the patient in a hands-knee position prior to lowering the body to the ground. Age and gender normative data tables were used to provide a general population comparison via a percentile ranking for the patient's modified push-up score.[24] The normative data table showed the 50th percentile was considered average, the 30th percentile below average, and the 70th percentile above average.[24] The patient performed one modified push-up, which placed her in the 30th to 40th percentile. Manual muscle testing was performed comparing the non-affected arm to the affected arm as described by Lyle.[25] A grade of strong was given if the manual muscle testing grade was evaluated to be 5/5 on the affected arm (R UE) and a grade of weak was given if a grade of 4/5 or less was achieved in the test. The results are presented in Table 2.

Special tests

Special tests on the right shoulder were performed to confirm the diagnosis and rule out other pathologies. The tests and results are listed in Table 3.[26-31]

Table 1. Active Range of Motion Measures

Movement	Active Range of Motion
Forward Flexion	100°
Abduction	50°
External Rotation	15°
Internal Rotation	1 inch above belt

Table 2. Manual Muscle Testing

Right Upper Extremity Muscle	Strong/Weak
Deltoid	Weak
Biceps	Weak
Shoulder ER	Weak
Shoulder IR	Weak

Patient-rated outcome measure

The Western Ontario RC (WORC) Index is a disease specific quality of life questionnaire designed to assess the level of functional loss and disability for patients with RC disease.[32] The score ranges from 0 – 2100; the highest possible score is 2100 that indicates severe disability, and 0 indicates no disability. The patient's score on the WORC was 980/2100. Most affected were sports/recreation and work, with scores of 350/400 and 325/400 disability respectively.

Program Implementation

It was hypothesized if joint stability can be maintained with exercise, the stress on the remaining cuff tissue would be decreased and shoulder joint kinematics better preserved, allowing for improved function without increased tissue damage. To reach these goals, a program focusing on a modified periodized progressive resistance CC upper extremity exercise program was designed, and the patient was fitted with an external shoulder support to maximize stability. The support was made out of two Nylatex wraps with a smaller wrap attached to the right arm just below the axial and a second wrap stitched to the outside of the arm wrap and anchored around the ribs on the left side with Velcro. This created a compressive force in line with the right infraspinatus muscle. The strap was also tightened from posterior to anterior creating an external rotation force at the glenohumeral joint. External supports can improve shoulder joint reposition sense in unstable shoulders.[19]

The treatment program was implemented up to 6 times weekly, with direct supervision provided 3 times per week. The treatment program lasted for 18 months. On supervised exercise days, the CC exercise program was done. This frequency of force application is supported in the strength and conditioning literature.[23] On the other days the patient was required to do independent exercises to promote proper musculoskeletal adaptation. The duration of treatment was determined by taking into account the age of the patient, patient goals, and the length of time needed for tissue adaptation. Three distinct phases were identified as part of the progressive resistance exercise plan: a tissue adaption phase, a hypertrophy phase, and a strength phase.

A tissue adaptation phase is needed to allow the tendons and muscle to adjust to gradual application of applied stress, and so the tissues can be ready to endure the increased loads associated with resistance training. This phase can last months. Research has shown that tendon adaptation can occur over a period of ≥ 6 months. With the loading of the tendon, the tendons cross sectional area will increase.[33] The cross sectional area of a tendon is correlated to the size of the muscle belly. If the tendon size is not sufficient to anchor the produced muscle force (enough tendon adaptation time is not given), tendon failure is possible.[33] The plan for tissue adaptation consisted of two components.

The first component of the tissue adaptation phase was the initiation of the CC

Table 3. Special Tests and Performance

Test and Performance	Result
Full can test: Evaluates full thickness tear of the supraspinatus muscle. Done by resisting 90⁰ humeral abduction with ER. Inability to resist/hold indicates a positive test.[26]	+
External rotation lag sign: Evaluates Infraspinatus muscle. Arm held at the side, elbow bent 90⁰, passive ER of shoulder to end ROM, and then patient holds position. Positive if unable to hold.[27]	+
Drop Arm Test: Used to rule in a full thickness tear of the supraspinatus muscle. Patient abducts the arm to 90⁰ then lowers it slowly. Difficulty lowering slowly indicates a positive test.[28]	+
Sulcus Test: Used to test multidirectional instability of the shoulder joint. While palpating the sub AC space, An inferior force is applied to the humerus. If a sulcus forms the test is positive.[29]	+
Anterior release test: Evaluates anterior shoulder instability. With the patient lying and the Shoulder and Elbow in the 90/90 position, a posterior force is applied to the shoulder. Positive test with apprehension or pain post release.[30]	–
Spurlings test: Evaluates cervical radiculopathy or spondylosis. The neck is extended, rotated and side bent to the same side. Pressure is applied through the skull. Positive test if nerve symptoms are reproduced.[31]	–

exercises; very low loads were set—30% to 60% of estimated one rep max for 15 to 20 repetitions—for each exercise to avoid excessive stress on the remaining tissue, but still enabling the patient to experience the benefits of resistance training. The desired rep range dictated the applied load. When the patient was able to do more than the 15 to 20 repetitions with a given load over the course of two successive treatment sessions, then the resistance was increased. During this phase, the treatment frequency was two to 3 sessions a week depending on exercise recovery. Exercises in this phase included push-ups, inverted rows, pull-ups, closed shoulder flexion, closed shoulder shrugs, triceps' dips, and closed shoulder horizontal abduction (Figures 1-7). The patient was kept in this phase for the first year of the program based on the research regarding tendon adaptation and due to the severity of the pathology.

The second component of the tissue adaptation phase was initiated due to poor quality of the remaining rotator cuff tissue and after a careful literature review. Tendons are made primarily of collagen, a small amount of elastin, and have limited vascularity. There is evidence that tendons are dynamic--they adapt to mechanical loading by changing their structure;[33] and exercise in general leads to increased collagen turnover and to some degree of net collagen synthesis.[33] There are competing theories on how best to achieve this collagen synthesis. Eccentric exercise specifically has been shown to be an effective treatment for tendon pathologies.[34] It is reasoned that the high loads used in eccentric exercise elicit the positive changes to the mechanical and viscoelastic properties of the tendon.[35] These changes in turn make the tendon more load resistant.[33] However, eccentric loads in rehabilitation programs to improve tendon structure use lower loads that are applied daily, below intensities that cause discomfort, without a recovery day and they seem to also promote net collagen synthesis.[33]

The differing levels of intensity used to effect positive tendon changes when comparing the classic strength and conditioning approach to what is commonly done in rehabilitation protocols seems to create a contradiction. This may mean that load or intensity may not be the only reason for the positive changes seen in the tendon post application of eccentric forces. Other factors must be considered. Both strength training and rehabilitation programs used to affect tendon structure use a slower eccentric phase as compared to its concentric counterpart. Is it this longer time under tension that causes the positive tendon changes associated with eccentric exercise? A recent study supports this theory. The study indicated that when tendons were exposed to low levels of constant force over at least a two-year period, the tendons adapted to this stress by demonstrating increased thickness and strength.[36]

If time under tension is the factor driving positive tendon changes seen in exercise, then isometric exercise may be a better option for tissue adaptation. Isometric muscle contractions can be held for a much longer period of time than eccentric contractions.

Isometric exercise was the second component of the adaptation phase. This was accomplished via the use of daily electrical stimulation at the onset. Russian stimulation mode was used and directed at the infraspinatus muscle with sufficient intensity to cause an isometric muscle contraction held for up to 30 minutes continuously on average 6 days a week. After two months, isometric exercises were introduced using low loads initially set at one pound. Isometric contractions were held for 60 seconds and done 5 times daily per muscle. Once the patient was able to hold all 5 contractions for the determined 60 seconds, loads were increased incrementally. Loads were never set at levels that created any shoulder discomfort. After one year from the start of care, the loaded isometric contractions were stopped, and the next two phases in the progressive resistance exercise plan for this patient were initiated. However, the electrical stimulation to the infraspinatus continued during every treatment session throughout the course of care.

The hypertrophy phase was the next step of the treatment. This involved moderate amounts of resistance that allowed for 8 to 12 repetitions during each exercise. The CC exercises done in this phase were the same

Figure 1. Closed shoulder shrugs.

Figure 2. Closed shoulder horizontal abduction.

Figure 3. Inverted rows.

Figure 4. Push-ups.

Figure 5. Dips.

Figure 6. Closed shoulder flexion.

as in the adaptation phase. The frequency of stimulus application was two times a week. The desired rep range dictated the applied load. When the patient was able to do more than the 8 to 12 repetitions with a given load over the course of two successive treatment sessions, then the resistance was incrementally increased. The purpose of this phase was to increase growth of the muscle to improve force production.

The strength phase, the third phase, commenced after one month. The exercises for the first and second phases continued to be performed. Strength phase was initiated with higher loads than the hypertrophy phase. Loads were increased to allow for 4 to 6 repetitions per exercise. The desired rep range dictated the applied load. When the patient was able to do more than the 4 to 6 repetitions with a given load over the course of two successive treatment sessions, then the resistance was increased. In the strength phase the goal was to improve motor control, which involves neural coordination and recruitment of fast twitch muscle fibers allowing for maximal contractions and force production. The patient was cycled monthly through these last two phases (hypertrophy and strength) for the remaining time of the treatment plan.

A properly designed resistance training program allows for exercise in keeping with the main tenets of progressive resistance exercise. These tenets include overload, specificity, and adaptation. By adjusting load and volume over time, the plan met the criteria of a well-designed resistance training program. However, one problem remained unsolved. Normative data shows that the majority of humans are not capable of manipulating their mass against a CC with the needed exercise volume to cause positive change.[23] A machine was developed to overcome this challenge. It allows CC exercises such as push-ups, one arm push-ups, chin-ups, inverted rows, straight arm shrugs, shoulder flexion, and horizontal shoulder abduction to be performed in a progressive body weight resisted manner. The machine assists in decreasing the load of the body mass, while still allowing compressive forces, during the exercises. The machine is made of an adjustable metal frame with attached strength bands of varying widths, which permits altering the assistance to perform the CC exercises. Pictures of the patented closed chain exercise devise are shown below.

RESULTS

After 18 months, a return to pre retear function was achieved with some modifications to protect the remaining cuff tissue. Objective data supported the functional improvement.

A modified push-up test, the primary measure to monitor gross upper body strength, was chosen to objectively rate the patient according to normative data. After 16 months, the patient was able to do 18 modified push-ups, placing the patient between the 80th and 90th percentile rank for her age group.[23] The patients' external rotation lag sign was negative at the 18-month mark indicating improvement in shoulder external rotator function.

The WORC score decreased from 980/2100 to 612/2100, representing a change of 368 points. This change represents a meaningful clinical improvement, as the minimal clinically important difference has been reported to be 275 points.[37] The index consists of 5 sections, in which two of the sections specifically relate to the patient's stated goals. One of these sections is related to sports and recreation and the other to physical work. In these two sections the patient's self-reported disability score has decreased from 87.5% to 46% and from 81.25% to 46% respectively. In objectifying the patient's symptoms, the first section of the WORC index also demonstrated improvement when measured at discharge. The score changed from 120 points at evaluation to a 98 point score at 18 months. This is an important factor as it relates to the theoretical framework of the treatment approach. If this intensive exercise program were to worsen the patient's degenerative joint disease, her shoulder symptoms would have increased rather than decreased.

After 12 months of care, the patient began participating in tennis with the continued use of the stabilization strap. Having the cuff pathology associated with the patient's right shoulder and given the fact that she is a right-handed tennis player, modifications were made in the patient's serve and stroke.

DISCUSSION

For patients with failed RC repairs

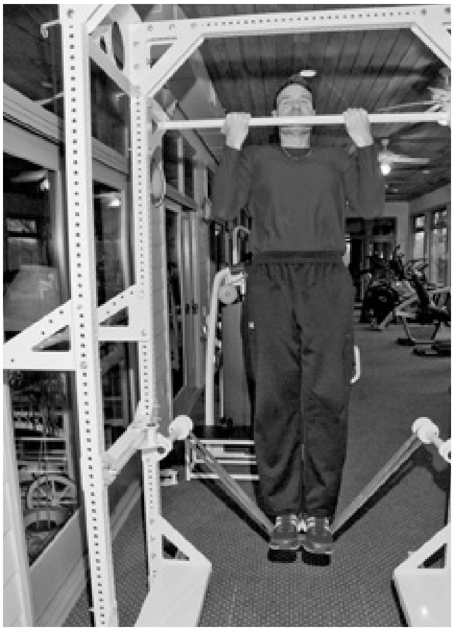

Figure 7. Pull-ups.

and resultant massive tears, the treatment options are limited. The nonoperative management includes activity modification, avoiding excessive shoulder stress, and exercise.[38] Exercise as a part of the nonoperative management of patients with massive RC tears is an option to improve function,[12] but there is no standardized exercise approach for those with massive cuff tears or failed repairs. This case study described a modified periodized CC exercise approach used to treat this patient with failed repairs of a massive RC tear. The developed treatment approach was designed to increase shoulder muscle strength while minimizing the abnormal humeral head arthrokinematics associated with massive RC tears using external joint stabilization and a modified periodized CC exercise model. The patient experienced large improvements in her function and disability levels, as evidenced by the WORC scores, along with improvements in gross upper body strength and symptoms. For the first time in 10 years the patient was able to return to playing tennis, which requires more advanced shoulder motion and force production, without increasing shoulder symptoms. There are no studies reporting significant improvement in the specific sports recreation after using exercise to treat a failed RC repair.

The nonoperative management of patients with chronic symptoms lasting greater than 6 months generally results in inferior functional outcomes.[39] It appears that over time the nonoperatively managed patient will experience a significant progression in the degenerative joint disease process associated with the RC dysfunction.[8] A randomized clinical trial demonstrated improvement in the shoulder use after an exercise program for those with RC tears, but not after repairs.[12] The modified CC exercise program theoretically allowed exercise to take place while lessoning improper shoulder arthrokinematics. This in turn may have prevented the worsening of the degenerative joint disease and decreased the need for other surgical interventions such as a reverse total shoulder arthroplasty. This case study presents evidence that a modified CC exercise program used after a failed repair can lead to improvements in self-reported shoulder function, strength, and symptoms.

The modified periodized CC exercise approach and the long isometric adaptation phase used in the treatment of this patient theoretically increased upper extremity muscle and tendon strength. These are evidenced by the improvements in the modified push up test and the external rotation lag sign. In contrast, other studies have demonstrated tear progression after evaluating the use of conservative care for the treatment of those with irreparable RC tears.[8]

It should be noted that this patient was highly motivated and disciplined and adhered to the treatment plan strictly over the last 18 months. It is impossible to know if lesser motivated subjects would experience the same results. It is also possible that with this strict adherence to any exercise program over this length of time the patient would have seen similar results.

A factor that may contribute to the lack of positive outcomes in patients with shoulder pain is the fear avoidance of arm motion as this may cause pain. A measure of fear avoidance was not performed on this patient, and therefore it is not known if this was an issue with this patient. As the exercise program progressed and the patient's ability to perform the exercises improved, and her function improved, it is likely that the fear associated with 10 years of shoulder pain and dysfunction was reduced. Future studies are needed to examine the efficacy and effectiveness of this model. Moreover, further research is needed to examine the mechanisms associated with successful outcomes of this treatment approach.

REFERENCES

1. Van der Windt DA, Koes BW, De Jong BA, Bouter LM. Shoulder disorders in general practice: incidence, patient characteritics, and management. *Ann Rheum Dis*. 1995; 54(12):959-964.
2. Lee SB, Kim KJ, Odriscoll SW, Morrey BF, An KN. Dynamic glenohumeral stability provided by the RC muscles in the mid and end range of motion: a study in cadavera. *J Bone Joint Surg Am*. 2000;82(6):849-857.
3. Milgrom C, Schaffler M, Gilbert S, Van Holsbeeck M. RC changes in asymptomatic adults. The effect of age, hand dominance and gender. *J Bone Joint Surg Br*. 1995;77(2):296-298.
4. Yamaguchi K, Ditsios K, Middleton WD, Hildebolt CH, Galatz LM, Teefey SA. The demographic and morphological features of RC disease. *J Bone Joint Surg*. 2006;88(8):1699-1704.
5. Tempelhof S, Rupp S, Seil R. Age related prevalence of RC tears in asymptomatic shoulders. *J Shoulder Elbow Surg*. 1999;8:296-299.
6. Baydar M, Akalin E, Ozlem E, et al. The efficacy of conservative treatment in patients with full thickness RC tears. *Rheumatol Int*. 2009;29(6):623-628.
7. Ruckstuhl H, de Bruin ED, Stussi E, Vanwanseele B. Post traumatic glenohumeral cartilage lesions: a systematic review. *BMC Musculoskelet Disord*. 2008;23(9):107.
8. Zing PO, Jost B, Sukthankar A, Buhler M, Pfirrmann CW, Gerber C. Clinical and structural outcomes of nonoperative management of massive RC tears. *J Bone Joint Surg Am*. 2007;89(9):1928-1934.
9. Kyrola K, Niemitukia L, Jaroma H, Vaatainen U. Long term MRI findings in operated RC tear. *Acta Radiol*. 2004;45(5):526-533.
10. Gerber C, Fuchs B, Hodler J. The results of repair of massive tears of the RC. *J Bone Joint Surg Am*. 2000;82(4):505-515.
11. Mellado JM, Calmet J, Olona M, et al. Surgically repaired massive RC tears: MRI of tendon integrity, muscle fatty degeneration, and muscle atrophy correlated with intraoperative and clinical findings. *AJR Am Roentgenol*. 2005;184(5):1456-1463.
12. Ainsworth R, Lewis J, Conboy V. A prospective randomized placebo controlled clinical trial of a rehabilitation programme for patients with a diagnosis of massive RC tears of the shoulder. *Br Shoulder Elbow Soc*. 2009;1:55-60.
13. Ainsworth R, Lewis J. Exercise therapy for the conservative management of full thickness tears of the RC: A systematic review. *Br J Sports Med*. 2007;41:200-210.
14. Dillman CJ, Murray TA, Hintermeister RA. Biomechanical Differences of open and CC exercises with respect to the shoulder. *J Sport Rehabil*. 1994;3:228-238.
15. Uhl TL, Carver TJ, Mattacola CG, Mair SD, Nitz AJ. Shoulder muscle activation during upper extremity weight bearing exercise. *J Orthop Sports Phys Ther*. 2003;33(3):109-117.
16. Lippet S. Glenohumeral stability from concavity compression. quanatative analysis. *J Shoulder Elbow Surg*. 1993;2:27-35.
17. Apreleva M, Parsons IM. Experimental investigation of reaction forces at the glenohumeral joint during active abduction. *J Shoulder Elbow Surg*. 2000;9(5):409-417.
18. Prokopy MP, Ingersoll CD, Nordenschild E, Katch FI, Gaesser GA, Weltman A. Closed

kinetic chain upper body training improves throwing performance of ncaa division 1 softball players. J Strength Cond Res. 2008;22(6):1790-1798.
19. Chu JC, Kane EJ, Arnold BL, Gansneder BM. The effects of a neoprene shoulder stabilizer on active joint reposition sense in subjects with stable and unstable shoulders. *J Athl Train*. 2002;37(2):141-145.
20. Cardoso de Souza M, Trajano JR, Jones A, Lombardi JL, Natour J. Progressive resistance training in patients with shoulder impingement syndrome: literature review. *Reumatismo*. 2009;61(2):84-89.
21. Cleland JA, Childs JD, Fritz JM, Whitman JM. Interrater reliability of the history and physical examination in patients with mechanical neck pain. *Arch Phys Med Rehabil*. 2006;87(10):1388-1395.
22. Terwee CB, de Winter AF, Scholten RJ, et al. Interobserver reproducibility of the visual estimation of range of motion of the shoulder. *Arch Phys Med Rehabil*. 2005;86(7):1356-1361.
23. Earle R, Baechle T. *NSCA's Essentials of Personal Training*. Champaign Ill: Human Kinetics; 2004.
24. Heyward V. *Advanced Fitness Assessment and Exercise Prescription*. 4th ed. Champaign, IL: Human Kinetics; 2002.
25. Lyle MA. Relationship of physical examination findings and self reported symptom severity and physical function in patients with degenerative lumbar conditions. *Phys Ther*. 2005;85(2):120-133.
26. Itoi E, Kido T, Sano A, Urayama M, Sato K. Which is more useful, the full can test or the empty can test in detecting the torn supraspinatus tendon? *Am J Sports Med*. 1999;27(1):65-68.
27. Hertel R, Ballmer FT, Lombert SM, Gerber C. Lag signs in the diagnosis of RC rupture. *J Shoulder Elbow Surg*. 1996;5(4):307-313.
28. Calis M, Akgun K, Birtane M, Karacan I, Calis H, Tuzun F. Diagnostic values of clinical diagnostic tests in subacromial impingement syndrome. *Ann Rheum Dis*. 2000;59(1):44-47.
29. Magee DJ. *Orthopedic Physical Assessment*. Philadelphia, PA: WB Saunders; 1987.
30. Gross ML, Distefano MC. Anterior release test. A new test for occult shoulder instability. *Clin Orthop Relat Res*. 1997;339:105-108.
31. Tong HC, Haig A, Yamakawa K. The Spurling test and cervical radiculopathy. *Spine*. 2002;27(2):156-159.
32. Kirkley A, Alverez C, Griffin S. The development and evaluation of a disease specific quality of life questionnaire for disorders of the RC: The Western ontario RC index. *Clin J Sports Med*. 2003;13(2):84-92.
33. Kjaer M. Role of extracellular matrix in adaptation of tendon and skeletal muscle to mechanical loading. *Physiol Rev*. 2004;84(2):649-698.
34. Woodley BL, Newsham West RJ, Baxter GD. Chronic tendinopathy: effectiveness of eccentric exercise. *Br J Sports Med*. 2007;41(4):188-198.
35. Rees JD, Wolman RL, Wilson A. Eccentric exercises; why do they work, what are the problems and how can we improve them? *Br J Sports Med*. 2009;43(4):242-246.
36. Caspo R, Maganaris CN, Seynnes OR, Narici MV. On muscle, tendon and high heels. *J Exp Biol*. 2010;1(213):2582-2588.
37. Ekeberg OM, Bautz Holter E, Keller A, Tveita EK, Juel NG, Brox JL. WORC index is not more responsive than Spadi and OSS in RC disease. *J Clin Epidemiol*. 2010;63(5):575-584.
38. Neri BR, Chan KW, Kwon YW. Management of massive and irreparable RC tears. *J Shoulder Elbow Surg*. 2009;18(5):808-818.
39. Boker DJ, Hawkins G. Results of non operative management of full thickness tears of the RC. *Clin Orthop Relat Re*. 1993:103-110.

Book Reviews

Michael J. Wooden, PT, MS, OCS
Book Review Editor

Book reviews are coordinated in collaboration with Doody Enterprises, Inc.

Physical Therapy Case Files: Orthopaedics, McGraw-Hill Companies, 2013, $40
ISBN: 9780071763776, 496 pages, Soft Cover

Author: Brumitt, Jason, PT, PhD, SCS, ATC, CSCS

Description: This book presents 34 case scenarios that focus on the evidence-based examination and intervention procedures for a wide spectrum of orthopedic, sports, and musculoskeletal diagnoses. **Purpose:** The purpose is to compile the evidence for a variety of conditions in one place--a need that has gone unaddressed for a many years, as both clinicians and educators find it challenging to remain updated on current best practice and evidence-based practice. The authors and contributors are among the top physical therapy researchers, educators and clinicians in the field and they use their expertise to meet the objectives. **Audience:** The book is useful for a broad audience, including physical therapy students, residents, or fellows, novice practitioners, and educators in musculoskeletal physical therapy. As an educator and a clinician, I find it to be an excellent resource, both for evidence-based case examples for my students, and as a reference in treating my patients. The 36 contributors are clinicians, researchers, and/or educators in the field of orthopedic PT. **Features:** Each of the 34 case scenarios is presented in a well-organized format using language from the World Health Organization's ICF framework and the Guide to Physical Therapist Practice. Each case begins with a patient scenario and a series of open-ended questions. Key definitions, a short explanation of the pathology, and a summary of the role of the physical therapist in the management of the condition follow. Then a targeted and well-organized summary of examination, evaluation, and diagnostic procedures is presented, including special tests and outcome measures. Reliability and validity information are included when available. The next section outlines interventions and plan of care information for the diagnosis. The next section, on evidence-based clinical recommendations, outlines at least three clinical recommendations for diagnostic tools and/or treatment interventions. The quality of these recommendations is improved by using a strength of recommendation taxonomy (SORT) grade, in which the author of the section gives an A, B or C grade based on the evidence and the author's clinical expertise. (This grade is also reviewed by the editors.) Each case concludes with comprehension questions and answers, along with detailed explanations when appropriate. Some cases focus heavily on exam and diagnostic practices, while others focus more on intervention techniques. For example, there are four different cases addressing lumbar spine herniated disc, each highlighting a different treatment approach. There is an alphabetized listing of diagnoses in the back of the book, increasing its usability for the reader. **Assessment:** This is a very useful book that fulfills a very large need in both educational and clinical practice of orthopedic physical therapy. As a clinician, I will use it in making sure that my current practices are evidence based. As an educator, it will greatly assist me in writing practice cases for my students that are comprehensive, evidence-based, and with less personal bias.

Amanda M. Blackmon, PT, DPT, OCS
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Musculoskeletal Assessment: Joint Motion and Muscle Testing, 3rd Edition, Lippincott Williams & Wilkins, 2013, $84.99
ISBN: 9781609138165, 532 pages, Spiral Cover

Author: Clarkson, Hazel M., MA, BPT

Description: This book teaches how to assess joint mobility and strength testing. The previous edition was published in 2000. **Purpose:** This edition maintains the original purpose of teaching the assessment of joint motion and muscle testing to students of physical therapy and occupational therapy while incorporating updated techniques and new mediums of learning. **Audience:** Physical therapy and occupational therapy students are the intended audience. The author was assisted by 13 reviewers in creating this updated edition, all of whom are from the academic setting. **Features:** The first two chapters cover the basic principles for assessing joint mobility and muscle length and strength. The next seven chapters are dedicated to the upper extremities, lower extremities, head, neck, and trunk. Each chapter is organized in a consistent manner, which makes it easy for readers to reference a specific topic. Video clips are available online showing different assessment techniques. There are also practical testing forms that students can use that correspond to "Practice Makes Perfect" icons that appear in the text. The major shortcoming of this book is that it is spiral bound and quickly showed signs of wear and tear. **Assessment:** Overall, this is a well referenced, organized, and welcome update of a book that was last published 13 years ago.

Jeff Yaver, PT
Kaiser Permanente

Cram Session in Goniometry and Manual Muscle Testing: A Handbook for Students and Clinicians, 2nd Edition, Slack Incorporated, 2013, $49.95
ISBN: 9781617116209, 370 pages, Soft Cover

Author: Van Ost, Lynn, MEd, RN, PT, ATC

Description: The first five sections of this user-friendly manual focus on goniometry, while the last two tackle manual muscle testing. **Purpose:** It is intended as a standalone quick reference on goniometry and manual muscle testing. It meets the author's objectives to create a compact summary of musculoskeletal examination. **Audience:** The book is written primarily for physical therapists, athletic trainers, and occupational therapists, and the author states that "it would be at home on the office shelf of any health care provider who performs musculoskeletal examination." However, healthcare providers who have not had previous training in goniometry or manual muscle testing would find it difficult to follow when performing a musculoskeletal examination because it does not cover the theories, validity, or reliability for either. Similarly, students should be aware that it lacks specifics in the manual muscle testing section. The author has written two previous books on each topic. **Features:** The sections on goniometry cover cervical spine, upper extremity, thoracic and lumbar spine, lower extremity and temporomandibular joint, and the sections on manual muscle testing cover the neck and upper extremities and the trunk and lower extremities. The eight appendixes detail general procedures for goniometric and manual muscle testing measurements, commonly used terms, normal range of motion values, anatomical zero, a key to manual muscle testing grading, and factors that may cause measurement error. The black-and-white photos of each of the goniometric measurements and manual muscle testing positions are well done and easy to follow. In the goniometry section, the type of joint, capsular pattern, normal ROM values, patient position, goniometer alignment, stabilization, and substitutions are presented on each page. The manual muscle testing section covers primary and secondary movers, the specific movement to be tested, stabilization, and grading. Each grade of testing (0-5) is presented with a figure, concise directions on testing, and common substitutions for the manual muscle test. An unusual feature of the book is that the muscle tests are arranged by primary movement, not by muscle. For example, elbow flexion lists the prime movers as biceps brachii, brachialis, and brachioradialis, but the manual muscle test covers elbow flexion primarily for biceps brachii without alternate positions available to test specifically for brachioradialis. The book's arrangement makes it difficult to find a specific measurement or MMT without going to the index. The sections are quite large, covering multiple joints in each segment. The book would be easier to follow if each joint were tabbed individually for goniometry and manual muscle testing. While the black-and-white photos are excellent, color photos would be easier to follow. Also, the manual muscle testing section describes only one method to test all of the prime and secondary movers without details for specific testing of each muscle. **Assessment:** Readers looking for a new manual to replace an outdated version or who just need a reference on the shelf, this would make a good and useful addition. However, readers who already own a muscle testing book and a goniometry book, this is a less detailed duplicate of those. I would recommend this book for clinicians, specifically physical and occupational therapists, searching for a general resource to have in the clinic.

Amisha Klawonn, PT, DPT
A. T. Still University

Fundamentals of the Physical Therapy Examination: Patient Interview and Tests and Measures, Jones & Bartlett Learning, 2014, $98.95
ISBN: 9781449652685, 323 pages, Spiral Cover

Author: Fruth, Stacie J., PT, DHSci, OCS

Description: This book covers the fundamental principles of the physical therapy examination, detailing numerous screening techniques across multiple body systems. **Purpose:** The author notes that although there are many books that cover advanced evaluative skills, and others that focus on the evaluation of specific conditions, there are none that enable students and novice physical therapists to get a sound, broad-based foundation for developing examination skills. The author fulfills these objectives, and this book is a very strong reference and learning tool for students in an entry-level program. **Audience:** The author intends the book primarily for students and novice or intermediate physical therapists. However, even more experienced clinicians will find some parts of the book very informative. It can be especially useful as a screening reference for topics or techniques that are less familiar to therapists, due to infrequent encounters in their practice. **Features:** As the title suggests, the book deals primarily with the examination process, not interventions. It covers everything from the very basics of the interview process to tests and measures. Multisystem screening areas are also covered, such as cognitive, cardiopulmonary, integumentary, musculoskeletal, and neuromuscular systems. The book uses figures and color-coordinated charts, graphs, and sectional delineators that greatly enhance the organization of the book. It is well written with clear and concise descriptions and instructions. The case examples at the end of each section, which apply the information to clinical scenarios, are very helpful, especially for students. Each chapter is thoroughly referenced with up-to-date citations. **Assessment:** Overall, this book can be a teaching tool in physical therapy education as well as a reference for more experienced clinicians. Students will find the directness of the fundamentals of practice easy to follow and very educational. More experienced clinicians will find the concise descriptions of a variety of topics very useful. The multisystem screening techniques will be particularly helpful to more experienced therapists, especially those who may not be familiar with some techniques based on their practice setting. Those looking for more advanced examination techniques or for examination techniques for specific conditions should look elsewhere. The book does not take an evidence-based approach; rather it takes a traditional approach to present the material.

Daniel Higgins, DPT, OCS, ATC
Orthopedic & Sports Physical Therapy

Orthopaedic Section, APTA, Inc.

BOARD OF DIRECTORS SUMMER MEETING MINUTES

July 18-20, 2013

Steve McDavitt, President, called a regular meeting of the Board of Directors of the Orthopaedic Section, APTA, Inc. to order at 8:00 AM CT on Thursday, July 18, 2013.

Present:	**Guests:**
Steve McDavitt, President	Joe Donnelly, Practice Chair
Gerard Brennan, Vice President	Tess Vaughn, Education Chair
Steve Clark, Treasurer	Duane Scott Davis, Research Chair
Tom McPoil, Director	Tara Fredrickson, Executive Associate
Pam Duffy, Director	Terri DeFlorian, Executive Director

Absent: Nicole Stout, APTA Board Liaison

Steve McDavitt, President, reviewed the following Ground Rules with the Board -

- Share the air; we want to hear everyone's opinion, even if it is a descending one
- Silence implies agreement
- Agree to disagree without being disagreeable
- Honor confidentiality
- Respect all participants and all differences of opinion
- Listen to the person who is talking
- Work to build consensus

The meeting agenda was approved with additions.

The June 17, 2013 Board of Directors Conference Call Meeting minutes were approved as printed.

The Board of Directors approved the following meeting dates and times –

- August 12 – 8:00 PM EST
- September 9 – 8:00 PM EST
- October 10-12 – Fall Board Meeting in La Crosse, WI

The consent calendar was adopted as printed.

The following motions were adopted unanimously via e-mail – None

Steve Clark, Treasurer, reported the Section has 69.67% of its operating expense in reserves.

Steve McDavitt, President, gave the following House of Delegates update –

- **RC 2-13 The American Council of Academic Physical Therapy (ACAPT) Packet II - PASSED**
  - ✓ Creation of ACAPT as an APTA component whose purpose shall be to take a leadership role in setting direction for physical therapist academic and clinical education
  - ✓ ACAPT will have member institutions
    - o Representing CAPTE accredited physical therapist education programs that are represented to ACAPT by individuals who are APTA members
- **RC 3-13 ACAPT as a Consultant to the House Of Delegates**
  - ✓ Named ACAPT as a consultant to the House of Delegates
- **RC 4A-13 Vote for Section Delegates in the House of Delegates**
  Packet l - WITHDRAWN
  - ✓ Provides a vote for between 2 and 5 delegates for each Section, depending on the size of the Section
  - ✓ Maintains the size of the House at approximately 400
- **RC 4B-13 Vote for Section Delegates in the House of Delegates**
  Packet I – DEFEATED
  - ✓ Provides a vote for one delegate for each Section
  - ✓ Enlarges the House of Delegates to 418, thereby preserving current Chapter representation
- **RC 14 -13 Vision for the Profession of Physical Therapy**
  Packet III – PASSED
  - ✓ The vision of the profession of physical therapy is
    - o Transforming society by optimizing movement to improve the human experience
- **RC 15-13 Guiding Principles of the Vision**
  Packet III – PASSED
  - ✓ Creates principles in the following areas:
    - o Identity
    - o Quality
    - o Collaboration
    - o Value
    - o Innovation
    - o Consumer-centricity
    - o Access/Equity

=MOTION 1= Pam Duffy, Director, moved that the Orthopaedic Section Board of Directors take RC 4A-13 back to the 2015 House of Delegates. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – opposed; Pam Duffy – in favor; Tom McPoil – absent)
Fiscal Implication: None

Steve McDavitt, President, reported on component leadership –

- **Component Leadership**
  APTA consists of 3 suborganizations called components. The 3 components of APTA are chapters, sections, and an assembly (Student Assembly). Most components are separately incorporated nonprofit organizations governed by a Board of Directors. Components have committees and districts or special interest groups within their organizations. Roughly 60 of APTA's 71 components have individuals who are paid to manage the component.
- **Academy Description/Purpose**
  An academy is an APTA membership group focused on the science, advancement, and practice of physical therapy in a clearly defined clinical practice arena. Academies support the vision of the profession and the mission of the association.
  - ✓ **Primary Functions:**
    - o Serve as content experts for the association and advance clinical practice with a specific patient population
    - o Develop the evidence base for the content area
    - o Establish best practices in the content area
    - o Propose, develop and advance specialization/subspecialization activities through new proposals and support for ABPTS and residency and fellowship activities
  - ✓ **Responsibilities:**
    - o Represent the interests of its members to the APTA Board of Directors, House of Delegates, chapters, and other governance entities and in collaboration with APTA to external groups
    - o Provide education and develop educational resources for members
    - o Develop and propose changes to APTA policies and procedures that enhance the position of the profession
  - ✓ **Pros:**
    - o Create distinction and focus for clinical groups
    - o Similar to term used in other medical professions
    - o Consolidation of sections promotes collaboration and clarity, reduces duplication, and maximizes resources
    - o Enable members to access more content groups (dues structure)
    - o Promotes consistency – focusing of the role of academies
    - o Reduce tasks beyond content expertise for academies (reduce tendency to become mini-APTAs)
  - ✓ **Cons:**
    - o May disenfranchise some members
    - o Requires significant change

- **Academic Council Proposed Functions and Operations (Purpose, Objectives, Membership, Annual Meeting and Board of Directors)**
  - ✓ **Purpose**
    The purpose of this Council is to advance the enterprise of academic physical therapy by promoting the highest standards of excellence in academic programs/departments/schools. For the purposes of the Council and its

activities, academic physical therapy includes all aspects of physical therapist education, including clinical education, and post-professional education.

- ✓ **Objectives**

  The objectives of the Council shall be to:
  - o Provide mechanisms for colleagues across institutions to work together to develop, implement and assess new and innovative models for curricula, clinical education, teaching/learning, scholarship/research, mentoring, and leadership.
  - o Define dimensions and metrics of quality and excellence within academic physical therapy to enhance academic programs/departments/schools.
  - o Provide mechanisms for active and ongoing involvement of physical therapy educators and researchers to impel relevant decision-making at the institutional and national levels regarding academic policy and practice, accreditation, educational quality, professional licensure and other similar issues.
  - o Establish and influence policy and legislation related to academic physical therapy through collaboration with organizations and institutions that represent health professional education.
  - o Provide resources, mentorship and leadership to those seeking change and improvement in academic programs/departments/schools.

Steve McDavitt, President, supplied the following information on the APTA annual planning calendar-

- **Strategic Plan: Annual Planning Calendar**
  - ✓ Annual planning calendar begins with House of Delegates each year
  - ✓ House decisions on policies for the profession help inform the work of the association for the coming year(s)… including the regular review of the strategic plan
  - ✓ Board reviews the strategic plan at Board meeting in late summer… the decisions of the Board drive the creation of the annual budget
  - ✓ Board approves the budget and the final strategic plan at November/December Board meeting
  - ✓ Result? A more focused and more prioritized strategic plan… that drives the work of the association, including the annual budget, and reflects the decisions of the House of Delegates
- **Strategic Plan: Elements**
  - ✓ Four goals
    - o Effectiveness of Care to Improve Quality of Life
    - o Patient and Client Centered Care Across the Lifespan
    - o Professional Growth and Development
    - o Value and Accountability
    - o Objectives under each goal
  - ✓ Metrics tied to each objective
  - ✓ Strategies to achieve each objective

Steve McDavitt, President, informed the Board that John Barnes, APTA CEO, will end his term in July 2013. Bonnie Polvinale, CMP, APTA Vice President, Member Relations, will be the Interim CEO effective June 17, 2013. Interviews will take place in September 2013 with selection of the new CEO in early 2014. Following outlines the CEO search process.

- **CEO Search Process**
  - ✓ **Step One: Identify CEO Search Board Work Group**
    - o Executive Committee of the Board
      - ◆ Paul Rockar, Sharon Dunn, Laurie Hack, Elmer Platz, fifth member, currently Roger Herr
    - o Members representing various constituencies of the association, including chapters, sections, new professionals, and those with long-term association experience
      - ◆ Susan Appling, Steve Anderson, Daniel Dale, David Emerick, Sr., Colleen Kigin, Craig Moore
    - o Chaired by Sharon Dunn and Laurie Hack
    - o Will begin meeting in mid-July
  - ✓ **Step Two CEO Search Process: Identify Search Firm**
    - o RFP received from 5 firms
    - o Isaacson, Miller chosen
    - o Meetings with search firm have been initiated
    - o To assist the CEOSWG in 5 phases
      - ◆ Identification of desired characteristics of the CEO
      - ◆ Networking and screening to identify potential candidates
      - ◆ Narrowing to the semi-finalists
      - ◆ Assisting in assessing final candidates, including reference check
      - ◆ Assisting with final negotiation
  - ✓ **Step Three: Name Interim CEO**
    - o Bonnie Polvinale, CMP, will serve as interim chief executive officer, effective June 17, 2013.
      - ◆ 34 years' experience at APTA
      - ◆ Currently APTA's Vice President of Member Relations
      - ◆ Will continue to serve in this capacity during her tenure as interim CEO
      - ◆ Numerous other leadership roles at APTA
  - ✓ **Time Line**
    - o Identify Search Work Group, Search Firm, and Interim CEO by June, 2013 (DONE)
    - o Identify desired characteristics of candidates, advertise/recruit, and have preliminary interviews by September 2013
    - o Interview final candidates by October 2013
    - o Make a selection by late 2013
    - o Have a new CEO in place by early 2014

Steve McDavitt, President, informed the Board that APTA is looking into restructuring the career starter dues as a way to retain members longer after graduation.

It was mentioned that Paul Rockar, APTA President, has done an outstanding job in his first year and has stood up for the right initiatives. Pam Duffy, Director, agreed to draft a motion recognizing this for the Board to review and write a letter to Paul letting him know this. Paul is an Orthopaedic Section member.

Steve McDavitt, President, updated the Board on the PTA Advanced Proficiency Pathways. Steve is in the process of filling the remaining committee slots before handing it over to James Irrgang, Chair. Barbara Tschoepe, APTA Academic Council, has agreed to be a consultant to this group.

Steve McDavitt, President, reported that Laurie Hack is part of the research team for the Physical Therapy Education for the Twenty-first Century (PTE-21). The primary function of the PTE-21 project is to conduct a national investigation of physical therapist education to fully investigate the elements of excellence in academic and clinical education. This study is an extension of the ground breaking Carnegie studies, which are already bringing about change in professional education in those targeted professions. Laurie feels this is an extremely important study for the future of physical therapist education, and thus for physical therapist practice. The last critical look at physical therapist education was the Worthingham study done in the 1960s. Steve will bring this back to the Board when he has more information on the level of monetary support they are looking for.

Steve McDavitt, President, commented on the response from James Irrgang regarding the request from OrthoEvidence presenting an agreement allowing free access to their web site through December 2013 and after that continuing to offer our members by supplementing their fees. It was agreed that Terri DeFlorian would contact James Irrgang to see if he would be willing to communicate the Section's disappointment with wanting to charge a fee since this was not brought up in their initial discussions.

Sharon Klinski, OPTP Managing Editor, presented an overview of her responsibilities that included discussion of SIG submissions to OPTP and the need for more frequent contact between Board Liaisons and SIGs. SIG compliance with the policies will continue to be tracked over the next year and discussed at the CSM SIG EIG meeting as well as face to face during the 2014 strategic planning meeting. The following were suggestions the Board made regarding OPTP –

- Not enough clinical articles
- Encourage SIGs to submit clinical pearls for publication
- Encourage SIGs to let the Practice Committee Chair know of any advocacy issues they are aware of
- Member feedback was received at CSM on allowing others an opportunity to serve as editor

=MOTION 2= Pam Duffy, Director, moved that the Orthopaedic Section Executive Committee work with staff to bring a proposal forward to the Board on a transition plan for the editor of OPTP and editor of ISCs by the Fall Board of Directors Meeting 2013. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: None

Kathy Olson, ISC Managing Editor, presented an overview of her responsibilities that included a discussion of state approval of the courses for continuing education credit. There was consensus by the Board to continue to seek approval for all ISCs for the first 5 years after initial publication.

Tara Fredrickson, Executive Associate, reported that the Section's web site is due to be redesigned. It was agreed this would be included under the technology initiative when selecting a company for our educational platform.

Tara Fredrickson, Executive Associate, reported the following on the 2013 Annual Orthopaedic Section Meeting–

- Financially the Section ended up in the red approximately $27,000.
- Interest in collaborating with the Section on this meeting has been expressed by the Canadian Physiotherapy Association as well as AAOMPT. The Board agreed to wait until we have had 3-5 annual meetings on our own before considering doing a joint meeting with outside organizations.

- A suggestion was made to consider offering posters at this meeting. The Education Committee will investigate this possibility.
- It was agreed to fund the Board of Directors to future Annual Meetings and the expense to be budgeted under Governance.

Tara Fredrickson, Executive Associate, requested the Board's feedback on offering links to research surveys in Osteo-BLAST as we are receiving more and more requests for this each month. One suggestion was to create a separate page on the web site where members could go to access the surveys. Another suggestion was to consider charging a fee for members and nonmembers who want to post their survey.

=MOTION 3= Steve Clark, Treasurer, moved that the Orthopaedic Section Board of Directors charge the Research Committee to develop a policy for reviewing all research survey requests along with a recommendation on payment structure for review by the Finance Committee at their 2013 August meeting. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: None.

Terri DeFlorian, Executive Director, gave the following office update –

- One of our tenants, Galileo Engineering Consultants, requested their carpet be replaced due to wear and tear. During the discussion the idea of doing a first floor remodel came up since Galileo has asked us several times in the past couple of years if we had additional space for them.
  =MOTION 4= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors approve appointing Terri DeFlorian, Executive Director, to approach Chris Olson, Galileo, asking him to draw up preliminary plans and obtain a cost of implementing a remodel of the first floor Galileo and RSVP tenant spaces with a committee to oversee the investigation and report back to the 2013 Fall Board of Directors Meeting.
  Fiscal Implication: Not to exceed $5,000
- The parking lot has potholes that need to be repaired, and it needs to be resurfaced and restriped. The Board reviewed the couple of bids that were received and asked for more detail on what was included in the cost. The Board will make a decision at their August meeting.
- Weekly conference calls are being conducted with the OPTP Editor and Managing Editor and the ISC Editor and Managing Editor. Feedback from all involved has been positive.
- Weekly meetings between the Executive Director and Executive Associate are being held which have been very positive.
- Annual employee reviews were completed.

Steve Clark, Treasurer, presented information received from our health insurance agent regarding the employee health insurance plan and a presentation was given by the Section's health insurance agent. The Executive Committee will meet to decide what action to take.

Tess Vaughn, Education Chair, reported there will be no residency program at CSM 2014 and asked if the Board wanted to continue to offer this programming at future CSMs. Since residencies now fall under the Practice Committee, Joe Donnelly will contact ABPTSRFE as well as Bob Rowe, AAOMPT President to gather information and report back to the Board at the 2013 Fall Meeting.

The Board discussed plans for the Section's 40th anniversary. Any costs associated with the event will be included in the 2014 budget.

The 2014 CSM Board meeting schedule was discussed and changes were approved.

Tess Vaughn, Education Chair, presented a request from Jim Elliott, 2014 Annual Meeting speaker, to sponsor a portion of the 2nd International Whiplash Conference to be held in Chicago in 2015.

=MOTION 6= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors have Tess Vaughn, Education Chair, call Jim Elliott and relay the message that the Section cannot support sponsoring a portion of the 2nd International Whiplash Conference. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: None

=MOTION 7= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors charge the Practice Committee to create an operational definition, parameters, and criteria that meet Strategic Plan Outcome 3. Public Identity and Promotion of Physical Therapy; Objective B, Develop an alliance with a minimum of 5 professional organizations to work towards the mutual goal of promoting musculoskeletal care by 2015, with a report back to the Board at the 2013 Fall Board Meeting. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: None

Tara Fredrickson, Executive Associate, gave the following Annual Orthopaedic Section Meeting update –

- Exhibitors will be invited to participate in the 2014 meeting.
  =MOTION 8= Steve Clark, Treasurer, moved that the Orthopaedic Section Board of Directors charge an exhibitor fee of $250 for the 2014 Annual Orthopaedic Section Meeting. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)
  Fiscal Implication: None
- The meeting brochure will be mailed in January 2014.
- Video conferencing will be put on hold for the 2014 meeting and instead possibly offering a webinar will be considered.
- **=MOTION 9=** Steve Clark, Treasurer, moved that the Orthopaedic Section Board of Directors eliminate their May 2014 conference call and have a 2-3 hour face to face dinner meeting on Friday evening at the Annual Orthopaedic Section Meeting. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)
  Fiscal Implication: None
- A registration rate of $595 was discussed for the 2014 meeting.
- The site visit for the 2015 meeting will be held in January 2014.

Scott Davis, Research Chair, reported that the Research Committee agreed upon the following area of study in response to the request from the Foundation for Physical Therapy's 2014 Orthopaedic Section Foundation Grant-

> ***Area of Study:*** *One grant will be funded for research that examines clinical outcomes of physical therapy practice for patients with musculoskeletal conditions. The project may investigate mechanisms, comparative effectiveness or optimal management of musculoskeletal conditions, including screening, differential diagnosis, prediction, and testing of theories related to treatment dosage, efficacy, and effectiveness.*

=MOTION 10= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors support the following area of study for the 2014 Orthopaedic Section Foundation Grant–

> ***Area of Study:*** *One grant will be funded for research that examines clinical outcomes of physical therapy practice for patients with musculoskeletal conditions. The project may investigate mechanisms, comparative effectiveness or optimal management of musculoskeletal conditions, including screening, differential diagnosis, prediction, and testing of theories related to treatment dosage, efficacy, and effectiveness.*

ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: None

Joe Donnelly, Practice Chair, requested that the practice area on the web site be updated to include reports from various meetings throughout the year.

Terri DeFlorian, Executive Director, gave the following Membership Committee report –

- Based on the Membership Chair report the Board agreed to fund the Mentor/Mentee program again in 2014. This includes giving one free 3- or 6-monograph ISC to each of the 6 mentors.
- It was decided that the Membership Vice Chair would not be funded to CSM until the year before they assumed the chair position.
- It was agreed that the Outstanding PT Student Award winner would be invited to be a member of the Membership Committee. The Membership Chair will need to structure the committee to accommodate this extra member.
- The Board agreed to fund the Membership Vice Chair to attend Student Conclave each year to man the booth.
  =MOTION 11= Steve Clark, Treasurer, moved that the Orthopaedic Section Board of Directors approve the expense to fund the Membership Chair to attend the Membership Chair Conference each year. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)
  Fiscal Implication: $215 in 2014

=MOTION 12= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors collaborate with the Section on Geriatrics to create clinical practice guidelines on Hip Fractures, (1) coordinated by the Orthopaedic Section ICF-based Clinical Practice Guidelines Coordinator and Advisory Panel, (2) to be published in JOSPT, (3) using the following listing in the title: Clinical Practice Guidelines linked to the International Classification of Functioning, Disability, and Health from the Section on Geriatrics and Orthopaedic Section of the American Physical Therapy Association, (4) utilizing the following copyright and permission statements: ©201_ Orthopaedic Section American Physical Therapy Association (APTA), Inc., and the Section on Geriatrics, APTA, Inc., and the *Journal of Orthopaedic & Sports Physical Therapy* consent to the reproducing and distributing this guideline for educational purposes, and (5) submit to have the guideline on www.guidelines.gov. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: None

=MOTION 13= Steve Clark, Treasurer, moved that the Orthopaedic Section Board of Directors accept the 2014 ICF budget as presented in the amount of $45,670. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: $45,670

Steve McDavitt, President, reported that the ARSIG may need expert assistance in creating a "new" practice analysis survey to address the current status of animal rehabilitation in the United States. In addition, any support from the Orthopaedic Section to analyze current data from the original survey that was completed several years ago would be greatly appreciated. Kirk Peck, ARSIG President, just recently obtained a copy of the raw data but no analysis has been completed to date.

=MOTION 14= Steve McDavitt, President/ARSIG Liaison, on behalf of Kirk Peck, ARSIG President, moved that the Orthopaedic Section Board of Directors approve allowing the ARSIG to co-sponsor the 8th International Symposium on Veterinary Rehabilitation/Physical Therapy and Sports Medicine. The symposium will be held in Corvallis, OR, August 4-8, 2014. *(International Association for Rehabilitation Veterinarians and Physical Therapy)* (http://www.iavrpt.org/).

Fiscal Implication: $1,000 - $2,500

=AMENDMENT TO MOTION 14= Steve Clark, Treasurer, moved that the Orthopaedic Section Board of Directors approve to amend Motion 14 by adding the following after, approve allowing, "*up to $2,500 for*". ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil - absent)

=MOTION 14 AS AMENDED= Steve McDavitt, President/ARSIG Liaison, on behalf of Kirk Peck, ARSIG President, moved that the Orthopaedic Section Board of Directors approve allowing up to $2,500 for the ARSIG to co-sponsor the 8th International Symposium on Veterinary Rehabilitation/Physical Therapy and Sports Medicine. The symposium will be held in Corvallis, OR, August 4-8, 2014. *(International Association for Rehabilitation Veterinarians and Physical Therapy)* (http://www.iavrpt.org/). ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

=MOTION 15= Steve McDavitt, President/ARSIG Liaison, on behalf of Kirk Peck, ARSIG President, moved that the Orthopaedic Section Board of Directors approve funding of the ARSIG President and Vice President to help organize and attend the 8th International Symposium on Veterinary Rehabilitation/Physical Therapy and Sports Medicine that will be held in Corvallis, OR, August 4-8, 2014 (International Association for Rehabilitation Veterinarians and Physical Therapy) in addition to supporting a public relations booth for the 5-day event. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: Estimate: $1,500 x 2 people = $3,000 (2 days lodging/meals). Funds to come out of the SIG's encumbered funds.

=MOTION 16= Steve McDavitt, President/ARSIG Liaison, on behalf of Kirk Peck, ARSIG President, moved that the Orthopaedic Section Board of Directors approve Dr. Peck and Dr. Carrie Adrian to attend the California Veterinary Medical Board public hearing tentatively scheduled for January 2014.

Fiscal Implication: ($470 x 2 = $940) (2 days x 2 people x $280/day = $1,120)

=AMENDMENT TO MOTION 16= Steve Clark, Treasurer, moved that the Orthopaedic Section Board of Directors approve to amend Motion 16 by adding the following after, approve, "$2,060". ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil - absent)

=MOTION 16 AS AMENDED= Steve McDavitt, President/ARSIG Liaison, on behalf of Kirk Peck, ARSIG President, moved that the Orthopaedic Section Board of Directors approve $2,060 for the ARSIG to co-sponsor the 8th International Symposium on Veterinary Rehabilitation/Physical Therapy and Sports Medicine. The symposium will be held in Corvallis, OR, August 4-8, 2014. *(International Association for Rehabilitation Veterinarians and Physical Therapy)* (http://www.iavrpt.org/). ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Steve McDavitt, President, presented the issue of licensing as it relates to therapists who are touring with Broadway shows and going from state to state as requested by the PASIG. The FSBPT Model Practice Act (2011) contains language for state licensure boards to adopt that provides an exemption for physical therapists working and traveling with performing arts companies. The APTA has a position on this as well. This will be communicated to the PASIG.

Pam Duffy, Director, reported that the OHSIG is deciding whether or not to repetition the ABPTS for specialization. Pam will get an update from the SIG and update the Board at their fall meeting in October 2013. There was also discussion on getting the SIG to work with the Practice Committee on publishing an advocacy article in OPTP. The Board agreed that a mechanism should be developed for each SIG on informing the Practice Committee of their advocacy activities.

Pam Duffy, Director, reported that the FASIG requested Board input regarding an initial document that was created identifying minimum standards of knowledge for the graduating physical therapist. The FASIG is particularly interested in (1) seeing the document become a final and thorough research-based template for instruction, and (2) becoming implemented in entry-level programs because of its comprehensiveness and ease of use. The Board recommended getting the document to the point of being able to share with the Academic Council. Pam will communicate this to Barbara Tschoepe who is the Orthopaedic Section Liaison to the Academic Council.

Gerard Brennan, Vice President, gave the following technology update –

- The ISC work teams are in place and have their ISCs to review and make recommendations on how they could be offered in smaller chunks to increase their marketability.
- Jason Bellamy, APTA Director in Communications and Marketing Department, will be contacted to possibly arrange a meeting at CSM 2014 to discuss social media.
- A company needs to be chosen to develop an RFP to send to potential educational platform companies.
- A company needs to be selected for translating 2 ISCs into a format that allows for flexibility in media options.

Steve McDavitt, President, lead a discussion on the purpose of EIGs and their responsibility at CSM. The Board agreed to review the EIG policies and see if any changes need to be made before discussing further.

Steve McDavitt, President, gave a report on the National Orthopaedic Physical Therapy Outcomes Database project from James Irrgang, Chair. The goal is to create a web-based platform to capture data for neck pain outcomes that could cost up to $25,000 and to develop a paper-based system for a pilot program for low back pain and possibly knee and shoulder. Factors that need to be taken into account are (1) what APTA decides on developing a National Physical Therapy Outcomes Registry and if that moves forward should the Orthopaedic Section attempt to piggy back on what they are doing, (2) the results of the survey to get feedback from those that participated in the Neck Pain Pilot Project, and (3) the outcome of the Outcomes Task Force that will occur sometime this fall.

=MOTION 17= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors hold on budgeting $25,000 in 2014 to create a web-based platform to capture data for neck pain outcomes pending obtaining further information from APTA on their outcomes registry, results from the neck pain pilot project survey, and recommendations from the outcomes task force. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: None

=MOTION 18= Gerard Brennan, Vice President, moved that the Orthopaedic Section Board of Directors fund the Section President to Annual Conference and the House of Delegates annually not to exceed 7 days lodging and meals. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: $280 x 7 days = $1,960

Steve Clark, Treasurer, presented information from the 2013 CSM Task Force Meeting on Volunteer Paid Positions. The Task Force reviewed and presented information to the Board and the Board determined no action was necessary.

=MOTION 19= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors approve the Board of Director policy cover page as printed. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)

Fiscal Implication: None

=MOTION 20= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors approve the Board of Director Policies with the following changes –

- I. Administrative, C. Advertising in JOSPT, i. Complementary Advertising

Space -
Delete the sentence indicated; JOSPT agrees to provide the SECTIONS with complimentary 4-color advertising space, not to exceed one page, which meets the JOSPT materials specifications included in the JOSPT Advertising Rate Card, in each monthly issue of the Journal.

- I. Administrative, D. APTA Nominations -
  Add, Recommendations for, at the beginning of the following sentence - Nominations for National office will be brought forth to the Board of Directors and upon approval, the President will complete an NC-1 form for nomination.

ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)
Fiscal Implication: None

=MOTION 21= Steve McDavitt, President, moved that the Orthopaedic Section Board of Directors approve the Board/Committee/SIG Policies with the following changes –

- I. Administrative, N. Member Electronic Mail Addresses Policy, ii. –
  Delete this subsection.
- I. Administrative, P. Logo Policy, i. –
- Orthopaedic Section members may imprint or affix the Section's full name and/or insignia including but not limited to electronic media, stationery, publications, documents, advertisements of their professional services, materials promoting the physical therapy profession and other materials produced by the members, provided that:

ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)
Fiscal Implication: None

Steve McDavitt, President, brought up the PASIG's practice analysis and how they were planning on using the final document. Tom McPoil, Director, will follow up with the PASIG.

Terri DeFlorian, Executive Director, presented information on several webinar companies. The Board decided to hold off on subscribing to one until we see if this could be incorporated into our new education platform.

Terri DeFlorian, Executive Director, requested that the travel reimbursement be increased from $470 to $600 to reflect actual cost of airfare. The Board asked for the data to be presented to the Finance Committee at their August meeting before making a decision.

=MOTION 22= Gerard Brennan, Vice President, moved that the Orthopaedic Section Board of Directors establish a work group to include Steve Clark, Chris Hughes, Tom McPoil, Gerard Brennan, and Terri DeFlorian, for the purpose of redesigning the honorarium plan for ISCs and report back to the Board at their 2013 fall meeting. ADOPTED (unanimous)
Fiscal Implication: None

=MOTION 23= Tom McPoil, Director, moved that the Orthopaedic Section Board of Directors charge the OPTP Editor to go through a search process to recruit 2 associate editors and make a recommendation to the Board on who to appoint at the 2013 Fall Board Meeting. ADOPTED (unanimous)
Fiscal Implication: None

=MOTION 24= Pam Duffy, Director, moved that the Orthopaedic Section Board of Directors submit an NC-1 form nominating Steve Clark for APTA Treasurer. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)
Fiscal Implication: None

The Board discussed a comment they received regarding a situation with the Nominating Committee not contacting an incumbent to ask them if they were considering running for re-election. As the Liaison to the Nominating Committee, Tara Fredrickson, Executive Associate, was asked to express the Board's disappointment to the committee.

=MOTION 25= Joe Donnelly, Practice Chair, moved that the Orthopaedic Section Board of Directors approve creating a Section nomination form to be used in the 2015 election. ADOPTED (Steve McDavitt – in favor; Gerard Brennan – in favor; Steve Clark – in favor; Pam Duffy – in favor; Tom McPoil – absent)
Fiscal Implication: None

The Board reviewed the current strategic plan in preparation for the 2014 strategic planning meeting.

ADJOURNMENT 9:50 PM CT, July 20, 2013
Submitted by Terri DeFlorian, Executive Director

OCCUPATIONAL HEALTH

SPECIAL INTEREST GROUP

President's Message

Lorena Pettet Payne, PT, OCS

NOT JUST FOR OCCUPATIONAL HEALTH PHYSICAL THERAPISTS

Several years ago, I witnessed the debate at our state legislature regarding changes to labor and worker compensation statute. The ultimate goal was to produce a decrease in worker compensation insurance rates. With an eye on keeping the injured employee on the job and for early return following injury, legislation was passed. Treatment guidelines were adopted largely from American College of Occupational and Environmental Medicine (ACOEM). Two years later, the Department of Labor is glowing over the decline in claims. On August 19, the *Bozeman Daily Chronicle* cites a recent workers compensation report indicating that the number of claims decreased about 4% from the past year. "Representative Reichner expects that safety training and new medical guidelines going into place will further decrease rates. The Labor Department also said it continues to invest in training for safer workplaces and campaigns designed to get workers back to work more quickly. Before a slate of 2011 reforms, Montana was the most expensive state in the nation to buy such insurance. In rankings released late last year, Montana moved up 7 slots."

More recently, as a representative of the OHSIG, I have had discussions with representatives of two different states requesting resources and assistance in educating our membership in documentation and inclusion of return to work/stay at work initiatives in the plan of care and goals. The OHSIG continues to provide information through articles published here, e-blasts, an upcoming home study course, and programming at Combined Sections Meetings. The information is meant for any therapist that may treat an injured worker. Stay tuned in; it is always wise to be proactive and avoid the necessity of more legislative reforms.

Limitless Opportunities for the Physical Therapy Professional in the Occupational Health & Workers' Compensation Industry

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AN EXCITING PARADIGM SHIFT FOR OUR PROFESSION

The role of the Physical Therapist in occupational health has been an exciting paradigm shift for our profession. It can be a means of providing value to industry by serving employers and employees alike with injury prevention and management programs. These programs can reduce ergonomic risk factors, provide post-offer/pre-employment assessments and develop return-to-work programs that can facilitate a prompt and safe return to work following a work-related injury. Physical therapists are well prepared to determine work-related injury diagnosis, prognosis, and intervention. As physical therapists, our core competencies are in anatomy and the pathomechanics of injury. We understand how injuries happen in the workplace. As experts in movement science and treatment intervention, we know how to address work-related injuries and prevent them from happening again. Our understanding of biomechanics and work physiology allows us to step into the setting of the workplace, assisting with workplace design, ergonomic adaptations, and employee education programs. Additionally, venturing out into the workers' compensation industry can provide a physical therapist with new personal and professional experiences. Occupational health physical therapists visit various work environments, put on steel toed boots, hard hats, and get a little dirty! It allows us to experience what the workers experience, from the factory line conveyor belts, to driving forklifts, to engineering design, to attending union meetings. The work takes us out of the traditional clinical setting to ride in a semitrailer, watch glass bottles being made in an orange juice factory, see how firefighters train to do their job, and measure fingertip pressure of an employee typing on a keyboard. We get to test our creative problem solving skills by thinking of new ergonomic adaptations and solutions. We get to walk in the shoes of the employee, case manager, adjuster, engineer, and line manager, if even for a minute, to see how their goals can align with the therapy goals. If you are new to occupational health or want to kick the tires, so to speak, then read on! This article provides an overview of the workers' compensation industry and describes some of the limitless opportunities you have as a physical therapy professional, to learn, grow, and serve in the realm of occupational health.

HISTORY OF WORKERS' COMPENSATION IN THE UNITED STATES

A great starting point is understanding a little about workers' compensation, what it is, how it began, why it is in place, and the benefits it provides to both employers and their employees. Workers' compensation is a form of insurance that provides wage replacement and medical benefits to employees who are injured in the course of employment, in exchange for the mandatory relinquishment of the employee's right to sue her employer for the tort of negligence.

The first form of workers' compensation in the United States officially began in 1855, when the states of Georgia and Alabama passed an "Employer Liability Act." This Act permitted employees to sue their employers when they were injured or got sick at work, but the employees also had to prove fault. Under this Act the employee, if injured, had no medical coverage or wage replacement. Additionally, the employer, if sued, was exposed to big settlements, high costs, and unpredictable outcomes. In the years following the drafting of the Employer Liability Act, there was a drastic increase in occupational claims and costs, forcing the states to develop an alternative solution.

Over the next few decades, each state one by one created their own form of workers' compensation legislation. This resulted in a fairly standardized workers' protection and compensation system nationwide, but workers' compensation claims were still administered at the state level. The goal of the system was to provide a worker with rights to medical treatment and compensation due to a partial or permanent disability that was incurred due to a work-related incident. Additionally, the new system was considered a "no fault" system. This "no fault" system eliminated the need for the employee to prove fault of the employer in order to receive benefits. Therefore, this new system eliminated the high costs to employers from the claims involving employer negligence.

Presently, the workers' compensation laws in the United States vary from state to state, including their corresponding fee schedules, payment policies, and treatment guidelines. Most states allow private insurance companies to administer their claims, whereas 12 states operate individual state funds and a few states have a state-owned monopoly. Lastly, there is also a Federal Workers' Compensation Program, called the Federal Employees Compensation Act (FECA) that was adopted in 1908. The FECA is administered by the federal government and applies only to federal employees.

BENEFITS OF WORKERS' COMPENSATION

The following are benefits of workers' compensation insurance for both the employer and their employees.

- **For the Employer:** it provides protection and substantial cost savings from potential negligence. For example, prior to workers' compensation laws, the injured or sick employee could sue their employer and receive large claims from employer negligence. Under the current system, the employee gives up their right to sue for negligence in return for medical treatment and wage replacement.
- **For the Employee:** it provides wage replacement and medical benefits to injured employees in return for mandatory relinquishment of their right to sue their employer for negligence. Workers' compensation does not cover pain and suffering, punitive damages, or employer negligence. Workers' also receive protection of their job, as the employer cannot terminate or refuse to hire an employee after reporting or filing of a workers' compensation claim. The specific benefits are:
  - Medical Care
  - Temporary Disability Benefit
  - Permanent Disability Benefit
  - Vocational Rehabilitation Services
  - Death Benefits

It is important for the physical therapy professional practicing occupational health to be aware of the intent and benefits of workers' compensation insurance, as they can affect our treatment plans, our remuneration for services provided, and also the motivation of our patients, who are injured workers.

OUR WORKFORCE IS CHANGING, BRINGING NEW OPPORTUNITIES FOR THE PHYSICAL THERAPY PROFESSIONAL

It is well documented that our workforce is changing. Workers are getting older and heavier, and both of these characteristics provide new opportunities for the therapist in occupational health to ensure this changing workforce stays healthy, fit, and productive.

Aging Workforce

The aging workforce is traditionally defined as those individuals aged 55 and higher. This part of our workforce is growing, reflecting 19% of the workforce in 2009, up from 12% of the overall workforce in 2003.[1] Many individuals continue to work past the traditional retirement age due to both financial and personal reasons. When we look at financial impacts, we see that the economic recession, the invention of a 30-year mortgage, and higher overall living costs have all been linked to the growth of the aging workforce. Additionally, people are living longer and they desire a more active lifestyle, a lifestyle that continues to challenge them both physically and mentally. This fact is also shown to be correlated to the increase in the percentage of people foregoing retirement until later years.

When we examine work-related absences following a work-related injury, we see that the duration of work absences steadily increases and the median number of lost work days after injury increases with age.[2] When we examine various injury trends of this 55+ demographic of our workforce, we find some interesting facts that can help us to develop more focused treatment and injury prevention plans. Falls are the most common means of injury in this group. Overexertion and contact with an object are the next most common ways these workers are getting injured. The conditions and types of issues that appear most commonly are strains, sprains, or soft tissue injuries. Additionally, a higher incidence of fracture rates in this population may correlate to the higher incidence of falls noted above. We also tend to find more patients with multiple injuries and more co-morbidities. This means clinical complications and even the side effects of certain medicines to treat these medical complications can delay the healing process, or the pace in which we can progress these patients through the therapy process. All of these factors may in effect contribute to a delay in the healing process, longer recovery times, extended episodes of therapy, and longer absences from work.[3]

As physical therapy professionals practicing in occupational health, we have an opportunity to assist in the general wellness, education, and injury prevention for the aging workforce. Points of focus may include educating and encouraging our older patients to participate in wellness programs. When preventing injuries in the workplace for this aging population, reducing fall risk is a priority. Programs that include pre-employment screening and matching the abilities of the aging worker to the physical demands of the work tasks can help to ensure safety and minimize the risk for injury. Upon injury, physical therapy may include a specific focus on increasing balance and muscle power. A recent article demonstrates the benefits of an eccentric focused exercise program for the older population. This article produced data that supports an eccentric-based exercise program, demonstrating superior gains in muscle strength tolerance by the individuals.[4] If, after formal therapy, the injured worker is still not tolerating full duty, then a formal return-to-work program may be appropriate to help the worker safely transition back to full work duties. Lastly, ergonomics programs at the worksite can help ensure workplace safety by analyzing body mechanics and changes in posture due to the aging body. These programs can offer ergonomic adjustments to workstations and identify alternate equipment solutions that will reduce joint stress or modify work cycles for this population.

Obesity in our Workforce

An additional trend we see in our workforce demographics is the shift in the body weight of the worker. There continues to be an increase of workers classified as obese or morbidly obese, and generally less active than the previous decades. The research is abundant in pointing out that the workforce that is sedentary is at a higher risk for diabetes and heart disease, has decreases in endurance and muscle strength, and has a much higher risk for disability. In general, as body mass increases, so does physical strength, up to the body mass index of about 38. Once a patient is over a BMI of 38, near the index for severe obesity, the physical strength cannot keep up with the body's mass and the risk for injury, health issues, and lower performance increase dramatically. Additionally, both the medical costs and disability costs increase substantially. One of the best studies that quantified this point is the Duke Study.[5] The researchers noted the following:

- Moderately Overweight, BMI 25-29.9:
  - 7% more workers' compensation claims
  - Missed 3.5 times more work days
  - Medical costs 1.5 times higher
  - Indemnity costs 2 times greater
- Morbidly Obese, BMI 40+:
  - 45% more workers' compensation claims
  - Missed 8 times more work days
  - Medical costs 5 times higher than normal weight workers
  - Indemnity costs 8 times greater

As you can see by the data, the frequency and cost of the workers' compensation claims for the moderately obese and morbidly obese is significantly higher than normal weight workers. Another recent article presented the data that supports a clinically significant increase in body weight following an occupational back injury, making return to work harder to achieve.[6]

These changes in the workforce demographics and the fact that physical therapists are experts in improving health, function, and mobility provide a unique opportunity for physical therapy professionals to make a difference in keeping our workforce healthy, productively employed, and fit. In occupational health we can help address this obesity in the workforce epidemic with fitness programs, pre-employment screening programs to ensure the worker has the physical capacity to perform the essential work duties, and also provide therapy focused on strengthening and educating the individual.

OPPORTUNITIES FOR PHYSICAL THERAPISTS IN OCCUPATIONAL HEALTH

This section will describe some of the opportunities that the occupational setting opens up for the physical therapy professional. Some of these may include: performing ergonomic assessments, injury prevention services, providing functional assessments, and return-to-work programs. Let's look at the specific skill sets and programs and services the physical therapy professional can engage in when practicing occupational health.

Ergonomic programs and services: Ergonomics means the study of work. The term is derived from the Latin root words "ergos" meaning "work" and "nomos" meaning "the laws of" or "the study of." When therapists perform ergonomic services, we are attempting to better fit the work to the worker or injured worker. Ergonomic opportunities for the physical therapy professional in occupational health include:

- evaluating the essential functions of the job;
- evaluating range of motion, movement quality, strength, and work postures used to perform work tasks or activities;
- assessment of risk factors for work-related injury development; and
- identification of ergonomic adjustments and adaptive equipment to address ergonomic risk factors that may be causing or contributing to work-related injuries.

Injury Prevention: Physical therapy professionals practicing in occupational health may also be involved in injury prevention, wellness, and performance screening services. These programs and services help to decrease work-related costs, achieve and restore optimal functional capacity, minimize impairments, maintain health, and prevent further condition deterioration and future injury. Therapists may conduct physical screening assessments to determine the need for injury prevention services, and appropriateness of specific components of the program. Additionally, the economic value that employee focused health promotion and wellness programs in the workplace can provide in terms of reduce workers' compensation, medical, pharmacy related and indemnity costs can be significant.[7] Truly a niche, physical therapists can serve the workers' compensation industry. Examples of prevention activities and wellness programs in the occupational health setting include:

- identification of ergonomic risk factors for musculoskeletal injuries in the workplace;
- performance testing of employees for post offer, pre-employment evaluations;
- employee education programs such as back to school programs, strengthening, stretching, and exercise program instruction; and
- workplace redesign, postural training to prevent job related disabilities, including direct trauma and cumulative trauma injuries.

Functional Assessment: Physical therapy professionals in occupational health have opportunities to provide services evaluating functional abilities. Activities that may be provided in the occupational health setting include:

- functional capacity evaluations,
- assessment of work performance and physical limitations during work activities, and
- development of functional job descriptions.

Return to Work: Physical therapy professionals in the occupational health setting may be involved in determining return-to-work interventions and programs. Return-to-work determination has evolved with the increasing use of functional capacity evaluations. However, in most cases after an injured worker completes a course of formal skilled therapy, concerns regarding return-to-work eligibility and safety remain. Physical therapists who are experts in movement science and injury treatment make important contributions with return-to-work determinations. Activities for therapists to facilitate return-to-work outcomes include:

- assessment and implementation of work conditioning programs, including identification of needs in regards to physical conditioning; and
- assessment and implementation of work hardening programs, including identification of needs related to physical, functional, behavioral, and vocational status.

CONCLUSION

Over time, the role of the physical therapist professional has evolved into different clinical settings and specialties. The role of the physical therapist in occupational health has been an exciting paradigm shift away from the traditional setting in clinics and hospitals into the occupational setting. It has resulted in a great contribution to industry. There is no greater time for the physical therapy professional to spread their wings and fly high than in the practice of occupational health and serving the workers' compensation industry!

REFERENCES

1. Nonfatal Occupational Injuries and Illnesses Requiring Days Away From Work 2011; Bureau of Labor Statistics, November 8, 2012.
2. Nonfatal Occupational Injuries and Illnesses Among Older Workers--United States, 2009; Centers of Disease Control, http://cdc.gov/mmwr/preview/mmwrhtml/mm6016a3.htm. April 29, 2011/ 60(16);503-508/.
3. National Institute Health MedLine Plus: 8 Areas of Age-Related Change. 2007;2(1):10–13.
4. Jacobs J. The power of eccentrics for the aging. *Impact Magazine*, Private Practice Section, APTA. January 2013:34-37.
5. Ostbye T, Dement JM, Krause KM. Obesity and workers' compensation, results from the Duke University Safety and Surveillance System. *Arch Int Med*. 2007;167:766-773.
6. Keeney BJ, Fulton-Kehoe D, Wickizer TM, Turner JA, Chan KC, Franklin GM. Clinically significant weight gain 1 year after occupational back injury. *J Occup Environ Med*. 2013;55(3):318-324.
7. Lerner D, Rodday AM, Cohen JT, Rogers WH. A systematic review of the evidence concerning the economic impact of employee-focused health promotion and wellness programs. *J Occup Environ Med*. 2013;55(2):209-222.

FOOT & ANKLE

SPECIAL INTEREST GROUP

CSM 2014: FASIG GOES INTERACTIVE!

CSM Attendees (YOU) Will Help Design Future Curriculum!

If you have ever wanted to provide input on the curriculum of entry-level physical therapy students, the Foot and Ankle Special Interest Group (FASIG) needs you at CSM in Las Vegas, 2014!

Programming at CSM will be better than ever and the FASIG promises to provide students, educators, and clinicians the opportunity to actively contribute to, and modify as needed, a developing curriculum guide for physical therapy students. As you may know, the Orthopaedic Section and the FASIG have been partnering for the past 3 years in the development of a mechanism by which SIGs can offer meaningful assistance to physical therapy educators. Following the gathering of a 15-member task force in November 2012, the result is a comprehensive review of Foot and Ankle literature, including assessment, intervention, and biomechanics. This review is now in the form of a document that will be the focus of a 2-hour interactive programming session at CSM.

Our CSM session will include a thorough review of Foot and Ankle evaluation, diagnosis, and interventions. In order for the content of this document to be implemented in any entry-level physical therapy curriculum, we need to ensure that it is complete, thorough, and is user friendly for the instructors of orthopaedic instruction for whom this information has been generated. This step in the process is where YOU fit in. Collectively, the national audience that CSM attracts will act as an upper level of document review; CSM attendees will help clarify and condense information, besides suggesting content modifications, additions, and alternate approaches.

So, come to Vegas! Come to FASIG programming and play a part in the process of preparing physical therapy students for practice!

PERFORMING ARTS

SPECIAL INTEREST GROUP

President's Message

The PASIG is excited to announce our CSM 2014 programming in Las Vegas surrounding the topic of "A multidisciplinary approach in caring for the acrobatic athlete in the performing arts." We are excited to have experts from Cirque du Soleil in Las Vegas including Kerry Gordon, MS, ATC, CMT, CSCS, PES, who is the assistant director of performance medicine as a keynote speaker. She will speak with her colleagues Steve McCauley, ATC, CSCS, Chad Hason, MD, Tiffney Touton, PT, DPT, LAT, ATC, CSCS, and Frank Perez, ATC, on behind the scenes care of performers, epidemiology of injuries, assessments of hypermobile performers and management of hip and shoulder pathologies. They will be presenting on Wednesday, February 5th.

We are seeking authors for content related to the performing arts specialties such as dance, music, gymnastics, and figure skating. Please review the current content at our resource center link located on the PASIG web page at www.orthopt.org. Please contact me if you are interested in assisting with creating content.

Our Research Committee prepares a citation blast each month that consists of an annotated bibliography on a specific topic area related to the performing arts. We are always seeking authors to assist us with this process. If you are interested in contributing, please contact our Research Committee Chairperson, Annette Karim at akarim@evergreenpt.net. Please check out our current listing and summaries of these annotated bibliographies at http://www.orthopt.org/content/special_interest_groups/performing_arts/citations_endnotes.

To all students who have been accepted to present at CSM 2014, please apply for a $400 scholarship to help defray the travel costs of your trip. If you are interested in applying for this scholarship, please contact our Student Scholarship Committee Chair, Amy Humphrey at amy@lancasterpt.com. We look forward to receiving your applications and reviewing the submissions to select a winner.

We have upcoming elections for the position of President and Nominating Committee member. Ballots will be available in November. Please vote to elect your new PASIG board members. I will be completing my term as President and Amanda Blackmon will be completing her term as the Nominating Committee Chair.

Sincerely,
Julie O'Connell, PT, DPT, OCS, ATC
PASIG President

Intrarater Reliability And Predictive Validity of the Annual Post-Hire Health Screen for Professional Dancers: A Methodological Proposal

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***Author's note:** This proposal is an example of potential performing arts rehabilitation research. A more detailed version of this paper is available upon request, written as part of a PhD program. The author is available for consult should anyone wish to conduct this study.*

INTRODUCTION

Injuries while dancing are widely recognized as an inevitable occupational hazard among dancers, their families, friends, and health care providers. While the incidence of dance injury among pre-professional dancers is reported as 32% to 51%,[1] it is much higher in professional dancers, with annual occurrence of dance-related injury between 67% and 95%.[2] Of the reported injuries in professional dance companies, 60% to 76% are overuse injuries.[3] Tracking these injuries is a challenge. In a systematic review of current literature, Hincapie[4] found 32 scientifically acceptable studies out of 1865 studies on dancer injury between 1996-2004, and in a meta-analysis between 2004-2008, Jacobs et al[5] found 19 studies as scientifically acceptable. In both studies, there were concerns regarding the lack of high quality research in tracking dancer injuries. One of the initiatives of the Dance USA Task Force on Dancer Health is to provide an annual musculoskeletal health screen for professional dancers.[6,7] Another Task Force aim is to track injuries with the hope of demonstrating correlation between deficits found on the annual screen and injuries incurred over time.

Statement of the Problem: While the Task Force has extensively revised the Annual Post-Hire Health Screen for Professional Dancers (AP-HHSPD) for content validity, there are no studies on the predictive validity of this screening tool on injury occurrence to date. Additionally, there are no studies on criterion or concurrent validity of the AP-HHSPD known by the author of this paper.[8] Validity requires reliability, and while there is one study demonstrating substantial levels of interrater agreement (k > 60%) using the AP-HHSPD,[9] percent agreement is limited by not correcting for chance, the study was limited by prevalence, and it did not look at intrarater reliability. The problems to address in this methodological proposal are two-fold: to examine the intrarater reliability and predictive validity of the AP-HHSPD.

Clinical Relevance: While the AP-HHSPD is used by health care teams in large companies, it is often used by the lone practitioner in many small professional dance companies.

It would be of benefit to both the clinician and the dancer to know that this screen can be reliably used by the single tester, regardless of time, environment, company size, history, bias, or clinician fatigue. A study of intrarater reliability would add to the psychometric properties of the AP-HHSPD for the lone tester. In the author's clinical practice, dancers from companies screened by the author periodically require rehabilitation for injuries. Anecdotally, often the author has identified weak areas or missing links, such as weak hip external rotators or poor scapular movement, during the screening process, only to find the same issues along with an injury later in the dance season. While a correlation does not support causation; the relationship between measurement and outcomes is valuable; therefore, a study on the predictive validity of this screening tool would seem to be the next step. As well, the tool needs to have concurrent validity with a criterion reference. In the absence of a criterion reference, concurrent validation against a similar but validated tool is necessary. Validation of this screen against the Functional Movement Screen (FMS) (Perform Better, Cranston, RI),[10] a popular and validated screen used in the athletic population, would benefit the clinicians screening and treating professional dancers. Validation of the AP-HHSPD would benefit clinicians attempting to provide wellness screening to professional dance companies, but in the process are compiling random screening tools, unsure of what tools are best. Concurrent validation of the screen specifically for use in the population of professional dancers is a necessary step toward determining predictive validity. With predictive validity, the clinician is able to recommend interventions to prevent future injury at the wellness screening and follow-up in the clinic.

Review of Literature: In the systematic review by Hincapie et al,[4] there was mention of one cross-sectional study design using one self-report outcome measure, the Self Estimated Functional Inability because of Pain (SEFIP) Perception of Injury Questionnaire. Ramel et al[11] found the SEFIP a valid measurement tool for dancers, with a sensitivity of 78% and a specificity of 89%. The use of the SEFIP has subsequently been tested by Cassidy et al[12] on 294 dancers from professional dance companies of various styles worldwide, but the results of the study have not been published. The SEFIP is important as professional dancers may under-report pain and dysfunction in order to keep their role in a performance, in contrast to a study on injury reporting in pre-professional contemporary dance students, of which 89% reported one or more injuries.[13] While the results of the Cassidy study has import for professional dancers in terms of perception of injury and under-reporting, the focus of this study is the examination of a physical performance tool for use at the start of the professional season, long before the dancer would present in a clinic with pain. The AP-HHSPD is intended to serve as a global musculoskeletal screen, allowing the tester to provide recommendations for improved wellness and prevention of injury. In a study done by Bronner and Ojofeitimi[14,15] on modern professional dancers, primary intervention was given in the form of dancer screening, technique change, additional wellness training, and treatment of minor issues that do not prevent participation, and secondary intervention was provided, consisting of referral and treatment for injury. In 3 years, the addition of intervention, which included screening and subsequent action, demonstrated a reduction in worker's compensation claims from 81% to 17%. The authors attribute the change to addressing minor complaints prior to the development of minor injuries, which comprised most of the worker's compensation claims. The use of a validated, reliable, dancer-specific screen would only increase the generalizability of interventions similar to what was done by Bronner and Ojofeitimi.

The FMS[10] is used by athletes of all levels, firefighters, and military candidates and service members.[16] In a study by Smith et al,[17] good interrater reliability was found between novice and expert raters, and good intrarater reliability was found in healthy adults. In a study using novice raters, Teyhen et al[16] found good intrarater reliability, good interrater reliability, and moderate to excellent interrater agreement, using a test-retest reliability design. Instead of video analysis, these studies were performed in real-time, similar to how the Dance USA screenings are conducted.[16,18] Predictive validity of the FMS was studied in officer candidates, and was found to have a sensitivity of 0.45 and specificity of 0.71 to predict any injury, and a sensitivity of 0.12 and specificity of 0.94 to predict serious injury for those with a FMS score of ≤ 14 in one study.[19] In a similar study, the combination of a slow 3-mile run time and FMS ≤ 14 predicted a 4.2 times increased risk of injury.[20] Because the FMS has demonstrated good inter- and intrarater reliability, and predictive validity in participants of physically demanding occupations, it serves as a good reference standard for the AP-HHSPD.

Overview of the Study: This prospective methodological study will have two components: reliability and validity. The first component will be an analysis of the intrarater test-retest reliability ($ICC_{3,1}$) using the AP-HHSPD on professional dancers over the age of 18. The second component will examine the predictive validity of the AP-HHSPD using the FMS as a reference standard for a physical performance measure in dancer athletes.

SPECIFIC PURPOSES AND HYPOTHESES

The purposes of this study are the following: (1) to examine the intrarater (test-retest) reliability of the AP-HHSPD in screening professional dancers, and (2) to examine the predictive validity of the AP-HHSPD in screening professional dancers, with the FMS as a reference standard. The scientific hypotheses are as follows: (1) The AP-HHSPD would have good intrarater reliability ($ICC_{3,1} \geq 0.75$), excellent intrarater agreement ($k \geq 80\%$), good response stability r > 0.75, and small MDC_{95}. There will be a significant relationship between intrarater measurements. (2) The AP-HHSPD will have good predictive validity. X^2 for dichotomous variables will be significant, $_{(.05)} X^2_{(1)} \geq 3.84$, 95% confidence interval will be small, ROC curve >0.75, with + LR > 0.5. There will be a significant relationship between measurements of the AP = HHSPD and the FMS.

METHODS

Participants: Inclusion criteria for participants are age ≥18 years, female, currently contracted with a professional dance company. Exclusion criteria are recent fracture, surgery, and current pregnancy. Because there is no other study data using the AP-HHSPD considering sample size, 385 participants will be screened as calculated through the National Statistical Service and Sample Size Calculator,[21] working with a 95% confidence interval. Professional dance company members across the United States will be randomly selected to participate during their annual screening.[4] Dance Medicine Fellows will be randomly allocated as testers. Randomization will be conducted through Excel random number generator. Testers will each practice on 8 professional dancers not participating in the study, the AP-HHSPD screen by following the Dance USA video tutorial,[22] the FMS with written instructions prior to testing the professional companies. Participants will sign consent forms, and receive an explanation of procedures prior to screening, as approved by the Institutional Review Board at Texas Woman's University, Houston, TX, and the Committee for Clinical Investigation at Boston Children's Hospital, Boston, MA, the host site for the Dance USA Taskforce. All data and forms will be kept in a secure location.

Instrumentation

The AP-HHSPD is comprised of a general medical history, orthopaedic history, women's health questionnaire, and a physical screening exam.[6] The physical screening exam contains measurements of height, weight, blood pressure, resting heart rate, a 3-minute step test, and 7 orthopaedic measures, which are the measures of interest in this study: Posture, the Beighton 9-Point Hypermobility Test, Passive Range of Motion, Strength/Functional Tests, Functional Shoulder Assessment, Balance in Unilateral Stance, and a Functional Movement Analysis. In total, there are 56 measures on each side of the body, and one assessment of lower abdominal strength. The scoring of variables is mixed, from nominative data, such as varus, valgus, or within normal limits, to ordinal measurements like manual muscle tests, to interval/ratio data such as degrees of passive range, with no cumulative score suggested by the current screen.

The FMS has 9 screen components: deep squat, hurdle step, inline lunge, shoulder mobility, active scapular stability, active straight leg raise, trunk stability pushup, spinal extension clearing, rotary stability, spinal flexion clearing. Scoring is ordinal, from 0-3 for each of the 7 tests, a total of 21 points for each side of the body. As discussed in the literature review section of this paper, the FMS has good interrater, intrarater, and test-retest reliability, and good predictive validity of future injury with cumulative scores ≤ 14, or ≤ 67% of the total possible score for each side of the body.[16-20,23]

Procedures: The randomly allocated tester will independently administer the AP-HHSPD to the selected participants, and will retest the selected dancers between 1 to 3 days later with the AP-HHSPD. After the second AP-HHSPD, the tester will also administer the FMS, with item order randomized by drawing out of a hat. Testing by random allocation of the 4 fellows will occur at the beginning of each company's season, and continue until data is collected for 385 participants. Testing for both the first and second sessions will follow in sequential order as printed in the annual post-hire health screen for professional dancers guidelines 2013-2014.[7] Video demonstration of each test can be found via the Dancer Wellness web site.[22] The tester will have printed instructions and photos in hand along with the AP-HHSPD guidelines,[16,23] FMS testing will follow in random order using Excel RAND.[24] The testers (fellows) will then track all dancer injuries through the Dancer Wellness Project database, a password protected web-based storage site.[25] The fellows will not provide treatment to the participants during each participant's testing period.

Data Analysis: Frequency and histograms will be analyzed for baseline subject characteristics. Intrarater agreement will be calculated for component tests on the AP-HHSPD through weighted Kappa analysis, correcting for chance. Intrarater test-retest reliability of composite scores will be analyzed through $ICC_{3,1}$. Response stability will be calculated for the intrarater reliability using the SEM at a 95% confidence interval (CI), and MDC will be found for error boundaries at the 95% CI. Statistical analyses will be conducted through PASW Statistic 18.0 for Mac. For the validity analysis of the AP-HHSPD, a count of the number of times the rating is within normal limits (WNL) for the all items for each side of the body will be performed, out of 57 total points for each side. FMS scores of ≤ 14 predict injury; this is 67% of the total possible score (21) for each side. For the AP-HHSPD, 67% of the total score of 57 for each side is 38 points. Therefore, this study will examine the predictive validity of the AP-HHSPD in terms of scores ≤ 38 and >38. Within normal limits will be defined as equivalent to (S)ymmetric, (W)NL, (N)eg, 5/5 Manual Muscle Test, (N)A, and no marks in Functional Movement Analysis. X^2 for dichotomous variables will be calculated, with significant findings as $_{(.05)}X^2_{(1)} \geq 3.84$, predictive of injury risk in dancers, confirmed by the occurrence of injury that prohibits full dance participation. The ROC curves will be made for FMS and AP-HHSPD, 95% confidence interval, sensitivity and specificity, likelihood ratios calculated for the FMS (≤14 and >14), and AP-HHSPD (≤38 and >38).

INTERPRETATION

The prevalence of dancers with injuries the 9 months after initial screening with scores ≤ 14 on the FMS and ≤38 on the AP-HHSPD will contribute to the predictive validity of this measure. Standard ICC reliability interpretations will be used and threats to validity will be discussed.

REFERENCES

1. Gamboa JM, Roberts LA, Maring J, Fergus A. Injury patterns in elite preprofessional ballet dancers and the utility of screening programs to identify risk characteristics. *J Orthop Sports Phys Ther.* 2008;38(3):126-136.
2. Ojofeitimi S, Bronner S. Injuries in a modern dance company effect of comprehensive management on injury incidence and cost. *J Dance Med Sci.* 2011;15(3):116-122.
3. Bronner S, Ojofeitimi S, Spriggs J. Occupational musculoskeletal disorders in dancers. *Phys Ther Rev.* 2003;8:57-68.
4. Hincapié CA, Morton EJ, Cassidy JD. Musculoskeletal injuries and pain in dancers: a systematic review. *Arch Phys Med Rehabil.* 2008;89(9):1819-1829.
5. Jacobs CL, Hincapié CA, Cassidy JD. Musculoskeletal injuries and pain in dancers: a systematic review update [abstract]. *J Dance Med Sci.* 2012;16(2):74-84.
6. Gibbs R, Bronner S, Cassella M, Liederbach MJ, Osterberg S, Southwick H. Annual post-hire health screen for professional dancers. Task Force on Dancer Health, Dance/USA. 2013-2014.
7. Gibbs R, Bronner S, Cassella M, Liederbach MJ, Osterberg S, Southwick H. Annual post-hire health screen for professional dancers guidelines 2013-2014. Task Force on Dancer Health, Dance/USA. 2013-2014.
8. Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Practice*. 3rd ed. New Jersey: Prentice-Hall; 2000:104-106.
9. Karim A, Millet V, Massie K, Olson S, Morganthaler A. Inter-rater reliability of a musculoskeletal screen as administered to female professional contemporary dancers. *Work*. 2011;40(3):281-288.
10. Cook G. Verbal Instructions for the Functional Movement Screen. Excerpted from the book, Movement: Functional Movement Systems—Screening, Assessment, Corrective Strategies. 2010.

http://www.functionalmovement.com/files/articles/139a_fms%20verbal%20instructions.pdf. Accessed July 16, 2013.

11. Ramel EM, Moritz U, Jarnlo G-B. Validation of a Pain Questionnaire (SEFIP) for Dancers with a Specially Created Test Battery [abstract]. *Med Probl Perform Art*. 1999;14(4):196-203.
12. Cassidy JD, Jacobs CL. Perception of Musculoskeletal Injury in Professional Dancers. Clinical Trials.gov. http://clinicaltrials.gov/ct2/show/NCT00554957 Completed June 2008. Accessed July 8, 2013.
13. Baker J, Scott D, Watkins K, Keegan-Turcotte S, Wyon M. Self-reported and reported injury patterns in contemporary dance students [abstract]. *Med Probl Perform Art*. 2010;25(1):10-15.
14. Bronner S, Ojofeitimi S, Rose D. Injuries in a modern dance company: effect of comprehensive management on injury incidence and time loss. *Am J Sports Med*. 2003;31(3):365-373.
15. Ojofeitimi S, Bronner S. Injuries in a modern dance company effect of comprehensive management on injury incidence and cost. *J Dance Med Sci*. 2011;15(3):116-122.
16. Teyhen DS, Shaffer SW, Lorenson CL, et al. The Functional Movement Screen: a reliability study. *J Orthop Sports Phys Ther*. 2012;42(6):530-540.
17. Smith CA, Chimera NJ, Wright NJ, Warren M. Interrater and intrarater reliability of the functional movement screen. *J Strength Cond Res*. 2013;27(4):982-987.
18. Gribble PA, Brigle J, Pietrosimone BG, Pfile KR, Webster KA. Intrarater reliability of the functional movement screen. *J Strength Cond Res*. 2013;27(4):978-981.
19. O'Connor FG, Deuster PA, Davis J, Pappas CG, Knapik JJ. Functional movement screening: predicting injuries in officer candidates. *Med Sci Sports Exerc*. 2011;43(12):2224-2230.
20. Lisman P, O'Connor FG, Deuster PA, Knapik JJ. Functional movement screen and aerobic fitness predict injuries in military training. *Med Sci Sports Exerc*. 2013;45(4):636-643.
21. Sample Size Calculator. National Statistical Service. http://www.nss.gov.au/nss/home.nsf/pages/Sample+ size+calculator. Accessed July 14, 2013.
22. http://www.dancerwellnessproject.com/Resources/Tutorial.aspx?Name=DanceUSAScreenTutorial. Access available upon request. Requires author password.
23. Cook G, Burton L. The Functional Movement Screen.® The system for a simple and quantifiable method of evaluating basic movement abilities. www.performbetter.com.
24. Microsoft® Excel® 2008 for Mac Version 12.3.6 (130206). Latest Installed Update: 12.3.6. © 2007 Microsoft Corporation.
25. Dancer Wellness Project. http://www.dancerwellnessproject.com/. Accessed July 14, 2013.

PAIN MANAGEMENT

SPECIAL INTEREST GROUP

President's Message

John E. Garzione, PT, DPT, DAAPM

This upcoming year will be another transition for the PMSIG. Nominations are open for President and one member of the Nominating Committee. Members who are interested in serving are urged to contact either Neena or Laura to be placed on the ballot. I hope everyone had a great summer.

John

When More is Not Better: An Approach to the Treatment of Arthrofibrosis

John E. Garzione, PT, DPT, DAAPM

For those of us who treat chronic pain conditions, patients who present with acute orthopaedic postsurgical conditions readily respond to rehabilitation unless they develop arthrofibrosis. The person with arthrofibrosis becomes more difficult because the more aggressive physical therapy becomes, the more pain and motion limitations they develop.

I have observed, over the past 40 years, that there are a few characteristics that differentiate between patients who will be susceptible to this condition. Many have diabetes (either type 1 or type 2), have past histories of excessive adhesions after previous surgeries, or are women who have endometriosis. These characteristics lead me to believe that there is a metabolic process that contributes to arthrofibrosis. Patients with one or more of these characteristics who develop arthrofibrosis show decreased range of motion, increased swelling, and a higher level of pain within the first 3 weeks after surgery.

Surgical wounds heal in 4 stages. The first stage is when bleeding in the joint stops and clots form to stop the flow of more blood in the joint. Soon after the bleeding stops, inflammation starts which causes a proliferation of white blood cells and exudates to the area initiating complex reactions that help lead to growth of cellular structures. The third stage is the building of new tissue to replace tissue and cells that were involved during surgery. The fourth stage involves remodeling with collagen.[1]

I suspect early arthrofibrosis when a person returns to physical therapy with more pain, swelling, and warmth in the joint after a usual treatment of strength training, range of motion exercises, and joint mobilization. These symptoms represent an acute inflammation and result in a stiff joint (stage 4 of healing) and will progress to further stiffness if this cycle is not interrupted. Antiinflammatory modalities such as iontophoresis with dexamethasone,[2] ice, laser, high voltage pulsed electrical stimulation, and gentle range of motion is recommended for the next few treatments. If the inflammation does not subside in 2 to 3 treatments of physical therapy, a 10-day course of oral steroids may be helpful to decrease the acute inflammation. However, if the person has type 1 diabetes, the use of oral steroids may be contraindicated. As the joint becomes less inflamed, treatment using iontophoresis with iodine[3-5] is helpful to soften the fibrosis so more aggressive stretching can be performed without re-inflaming the joint.

Using this approach has reduced the likelihood of many of my patients having to undergo manipulation under anesthesia to restore joint motion and function.

REFERENCES

1. Stages of Wound Healing. http://www.scarformula.com/wound-healing.php. Accessed August 23, 2013.
2. Gurney BA, Wascher DC. Absorption of dexamethasone sodium phosphate in human connective tissue using iontophoresis. *Am J Sports Med*. 2008;36(4):753-759.
3. Driscoll JB, Plunkett K, Tamari A. The effect of potassium iodide iontophoresis on range of motion and scar maturation following burn injury. *Phys Ther Case Report*. 1999;2:13-18.
4. Langley PL. Iontophoresis to aid in releasing tendon adhesions: suggestions from the field. *Phys Ther*. 1984;64(9):1395.
5. Tannenbaum M. Iodine iontophoresis in reducing scar tissue. *Phys Ther*. 1980;60(6):792.

IMAGING

SPECIAL INTEREST GROUP

Call for Imaging Submissions

The Imaging SIG is soliciting submissions for publication in this space. Types of submissions can include:

- Case Report: A detailed description of the management of a unique, interesting, or teaching patient case involving imaging. Case reports should include: Background, Case Description including Imaging, Outcomes, and Discussion.
- Resident's Case Problem: A report on the progress and logic associated with the use of imaging in differential diagnosis and/or patient management. Resident's Case Problem should include: Background section, Diagnosis section which details the examination and evaluation process leading to the diagnosis and the rationale for that diagnosis, including a presentation of imaging studies. Interventions section used to treat the patient's condition and the outcome of treatment; however, the focus of the resident's case problem should be on the use of Imaging in the diagnostic process and patient management. The Discussion section offers a critical analysis of how the Imaging guided the management of the patient.
- Clinical Pearl: Clinical pearls are short papers of free standing, clinically relevant information based on experience or observation. They are helpful in dealing with clinical problems for which controlled data do not exist. Clinical Pearls should describe information pertaining to Imaging which help inform clinical practice.

Submissions should be sent to: John C. Gray, DPT, FAAOMPT, Publications Editor at jcgray@san.rr.com

Imaging Pearl

John C Gray, DPT, FAAOMPT

THE VACUUM DISK PHENOMENON

In viewing images of the lumbar spine, it is not uncommon to see a vacuum disk phenomenon. On plain radiographs and CT images, the vacuum disk shows up as radiolucent (similar to air filled lungs) intradiskal gas made up of mostly nitrogen that has been released from adjacent extracellular fluid (see Figures 1 and 2).[1,2]

An intervertebral disk without the vacuum phenomenon will look gray (see arrow pointing to L3-4 in Figure 2); whereas the disks with the vacuum phenomenon will have an area that is black (see arrows pointing to L4-5 and L5-S1 in Figure 2). On MR imaging, the disk in general will have a decreased signal intensity due to dehydration (degenerative disk disease) with a signal void at the vacuum site.[2] An MR signal void is an area with no radiofrequency signal because there are no protons within the gaseous vacuum.

Vacuum disk phenomenon is a sign of degenerative disk disease that occurs in approximately 2% to 3% of the population.[2] Lumbar vacuum disks are generally considered a benign asymptomatic indicator of degenerative disk disease. However, there are case reports of radicular symptoms secondary to gas-filled disk herniations and epidural gas cysts associated with vacuum disks.[3-7]

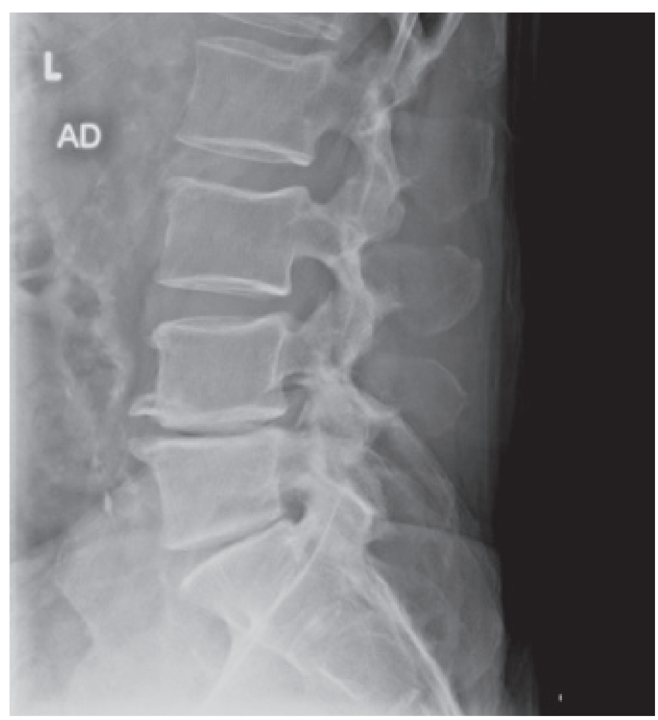

Figure 1. Plain radiograph, lateral view of lumbar spine, of 72-year-old male with severe degenerative disk disease at L4-5 and L5-S1.

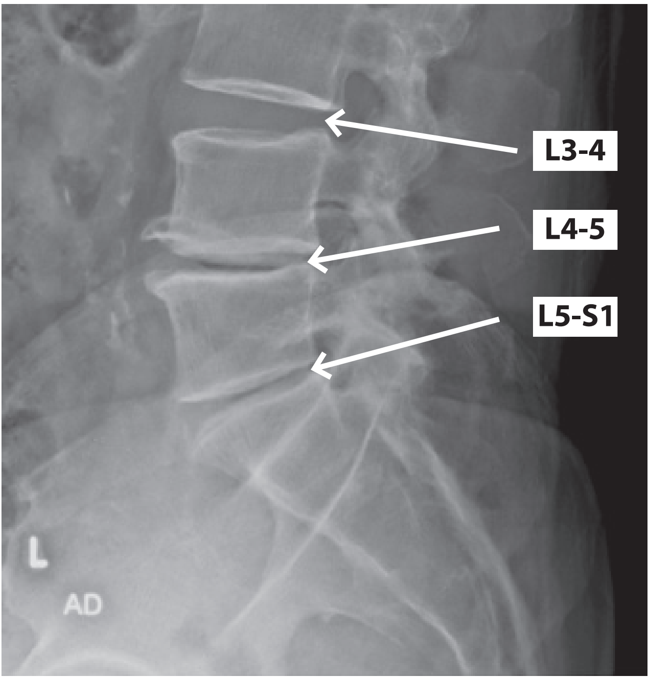

Figure 2. Close-up of image in Figure 1. Vacuum disks are noted at L4-5 and L5-S1. There is no vacuum disk phenomenon at level L3-4.

REFERENCES

1. Ford LT, Gilula LA, Murphy WA, Gado M. Analysis of gas in vacuum lumbar disc. *Am J Roentgenol*. 1977;128(6):1056-1057.
2. Rowe LJ, Yochum TR. Arthritic Disorders. In: Yochum TR, Rowe LJ. *Essentials of Skeletal Radiology*. 2nd ed. Baltimore, MD: Williams & Wilkins; 1996:795.
3. Gulati AN, Weinstein ZR. Gas in the spinal canal in association with the lumbosacral vacuum phenomenon: CT findings. *Neuroradiology*. 1980;20(4):191-192.
4. Kakitsubata Y, Theodorou SJ, Theodorou DJ, et al. Symptomatic epidural gas cyst associated with discal vacuum phenomenon. *Spine*. 2009;34(21):E784-789.
5. Mortensen WW, Thorne RP, Donaldson WF. Symptomatic gas-containing disc herniation. Report of four cases. *Spine*. 1991;16(2):190-192.
6. Pak KI, Hoffman DC, Herzog RJ, et al. Percutaneous intradiscal aspiration of a lumbar vacuum disc herniation: a case report. *Hospital Special Surgery J*. 2011;7(1):89-93.
7. Yasuoka H, Nemoto O, Kawaguti M, et al. An unusual case of nerve root compression by intradiscal gas pseudocyst of the lumbar spine. *J R Army Med Corps*. 2010;156(1):47-48.

ANIMAL REHABILITATION

SPECIAL INTEREST GROUP

Letter from the President

Kirk Peck, PT, PhD, CSCS, CCRT

APTA REVISED VISION STATEMENT & THE ARSIG

During the 2013 House of Delegates members voted unanimously to adopt a new APTA Vision for the profession of Physical Therapy. The new Vision reads, *"Transforming society by optimizing movement to improve the human experience."* Interesting side note, several delegates spoke during the House debate expressing concern that the practice of animal rehabilitation might be overlooked in the new Vision. The APTA legal counsel was consulted and the response was simply "no," the new Vision Statement does not alter any APTA position on practitioners who desire to treat animals. So on behalf of the ARSIG, I wish to express a sincere note of thanks to Stephen McDavitt, PT, DPT, MS, FAAOMPT, President of the APTA Orthopaedic Section, for vocalizing his concerns about animal rehabilitation on behalf of the ARSIG. His support of our cause during the debate was greatly appreciated. I can say this from personal experience since I was present at the House serving as Chapter Delegate from Nebraska.

WHERE ARE THE NEWBIES?

No, I did not say 'babies,' I said 'newbies,' meaning where are the new recruits to the ARSIG? A primary responsibility of members involved in any formal organization is recruitment of new members…the ARSIG is not immune. There are many ways we all can take part in this endeavor including sending a positive message to PTs and PTAs who may just be thinking about treating animals some day. Let them know the benefits of animal rehab and how it does not necessarily mean giving up human practice. Second, organize speeches for other therapists and students in PT and PTA schools, and at state chapter meetings if you can get your foot in the door. Or maybe allow a student or a therapist to shadow you in practice. These are only a few examples of how you might consider getting others excited about a growing area of practice within the profession.

Yes, I completely realize that not every PT or PTA in this country is philosophically on board with therapists supposedly *jumping ship* to treat animals. There seems to be a mythological perception that we are neglecting our human traits as a profession, but *au contraire*. Anyone involved in animal rehab knows for a fact that we as practitioners interact with humans every bit as much as we do when treating humans directly, even more so in some cases. Educating animal owners is certainly one of the biggest aspects of being successful in animal rehab, and let us not forget the countless number of clients who all too often jump at the chance to ask a PT a question about their own injury while treating 'Fluffy.' Yes, we all could tell stories. So my response to the nay-sayers is that animal therapists are pretty darn good at dealing with the psychosocial aspects of human care to comfort emotional distress and to also maximize personal ability to care for…yes, I am going to say it again, animals. In effect I would argue that animal therapists treat both animals and humans simultaneously.

PRACTICE ANALYSIS SURVEY & CSM

The ARSIG would like to move forward with some exciting initiatives but cannot do so until raw data from a practice analysis survey conducted in 2007 are analyzed. Yes the survey is somewhat dated, but elements of it are salvageable and may prove useful in the creation of a new survey that needs to be conducted in the next year or two. The ARSIG officers cannot make arbitrary decisions for action without valid data to support new and innovative proposals. Therefore the practice analysis survey will become a primary focus of attention over the next few months and will be discussed during the APTA Combined Sections Business Meeting, 2014.

Speaking of Combined Sections, I am very excited to announce that the ARSIG had another continuing education program accepted for the conference in Las Vegas, NV. The topic will be on manual therapy of the canine thoracic spine and will be taught by Laurie Edge-Hughes BScPT, MAnimSt (Animal Physio), CAFCI, CCRT. I sincerely hope you will be able to join us at CSM next February for a fun and exciting continuing education course and business meeting.

PHILOSOPHICAL NOTE ON THE TOPIC OF RESEARCH

Finally, I want to address a very important topic, especially for the ARSIG as it continues to gain greater reputability. Simply put, we need more research in the field of animal rehab. The area of focus is wide open considering how little has been validated by way of evaluation tools, movement disorders, evidence-based interventions, and quality outcomes. Research may encompass several methodological designs including case studies, literature reviews, and randomized controlled trials. Another option is for SIG members to consider the idea of looking at multi-site studies to pool large amounts of data on a specific phenomenon of interest. As a brief side-note, it is important to recognize that consistently observed anecdotal evidence certainly influences clinical decision making, but findings should still be validated by quality research before any claims of true efficacy can be made.

I am not sure how else to say this fellow colleagues, but research is what ultimately will define how we practice in the future. There is no escaping this simple fact. Health care today is all about evidence-based practice, so we need to encourage more PTs and PTAs to take the lead on research initiatives and I am referring specifically to topics on animal-based rehabilitation.

Engagement in the process of research is a natural sequence of growth for any new profession or area of practice within a profession. When the early pioneers of physical therapy organized our profession in the 1920s, they were not conducting large amounts of research to validate practice. But look where we are today! The voluminous amount of research published by PTs and PTAs alike is phenomenal, and so too this must happen in our niche market of animal rehab. If we want credibility as practitioners in the future, there is only one path to travel, and that road includes scholarly endeavors. So someday when you are asked, "How do you know that particular procedure is the best option in this case?" What will you hang your hat on?

Kirk Peck, President ARSIG
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Costovertebral Joint Dysfunction in an Obedience Trained Golden Retriever: A Case-Study

Kirk Peck PT, PhD, CSCS, CCRT; Michelle Beck, DVM, CCRT

PAST MEDICAL HISTORY

Buoy is a 7-year-old intact male Golden Retriever, and 2010 AKC National Obedience Champion. Buoy had been treated previously in rehabilitation for a partial tear and avulsion of the left biceps brachii tendon in April 2010, and for a nonpainful gait dysfunction related to compensatory actions of his left forelimb. Both conditions were successfully rehabilitated and allowed Buoy to return to competition. In January 2013, Buoy returned to rehab for evaluation of a 'roached' thoracic spine causing a malaligned sitting posture. The client was concerned the poor sitting conformation would impact Buoy's performance during competition so a professional evaluation was pursued. Figure 1 displays a radiographic view of a roached spine.

SIGNIFCANT PAST HISTORY

During the initial evaluation, the client revealed that when Buoy was young he 'wrapped' himself around a tree while playing and may have injured his spine at that time. The incident did not require formal rehabilitation, and no additional injuries to the spine were reported.

INITIAL PHYSICAL EXAMINATION

In early January 2013, Buoy was examined by a certified rehab veterinarian. Physical evaluation revealed no palpable difference in supraspinatus, pectoralis, or deltoid muscle mass. Tendinous resistance to left elbow extension was noted, but full painfree range of motion was present bilaterally. Vertebral mobility testing using dorsoventral joint glides revealed no signs of pain or discomfort. No change in lameness or gait abnormality was observed during initial assessment. Buoy was cleared of all other medical conditions. Buoy's owner was therefore instructed to resume regular obedience training as tolerated along with weekly sessions of aquatic therapy for conditioning. Following one month of therapy, Buoy's roached back posture remained and a consultation was arranged with a physical therapist certified in canine rehabilitation.

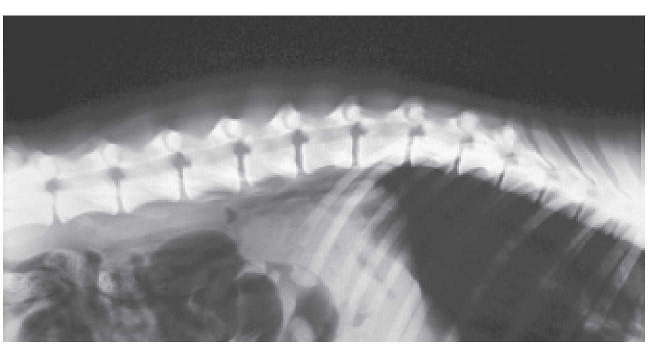

Figure 1. Radiograph image displaying increased kyphosis, eg, roach spine posture.

PT PHYSICAL EVALUATION

On February 14, 2013, an evaluation was performed by the physical therapist that resulted in no abnormal findings or elicitation of pain with the following assessments: (1) passive range of motion to all 4 extremities (including isolated stretching of a variety of thoracic and pelvic limb muscles); (2) dorsoventral mobilizations of the cervical, thoracic, and lumbar spinal segments using pressure over the spinous processes; and (3) all special tests evaluating ligamentous integrity at the shoulders, elbows, hips, and knee joints. Isolated costovertebral joints were then assessed for signs of pain or dysfunction. Grade 3 dorsoventral glides were performed on all thoracic costovertebral joints. A significant and immediate painful response from Buoy was elicited with pressure directly over the right T10 and T11 segments. No signs of pain or dysfunction were found with similar grades of joint movement on the left T10 and T11 segments. No other significant findings were found upon physical examination.

INTERVENTION

Joint mobilization was applied to the right costovertebral segments at T10 and T11 secondary to hypomobility and pain. Grades 3 and 4 joint mobilizations were performed as tolerated in a dorsoventral and slightly oblique plane along with direct mobilization over the corresponding ribs just lateral to the costovertebral joints. Buoy exhibited a decreased roached sitting posture immediately following treatment. The client was instructed to perform deep tissue massage of the epaxial muscles and gentle rib springing over the affected thoracic area as a home program.

FOLLOW-UP VISITS

Buoy returned to rehab on February 18 for deep tissue massage, treatment of involved ribs with costovertebral joint mobilization, lateral rib springing, and laser therapy to the right T8- T12 costovertebral joints. During assessment Buoy continued to exhibit a slight roached back in a sit position although markedly improved in 5 days. He also exhibited significantly less discomfort upon palpation and joint mobilization over the T10 and T11 segments.

Buoy did not return to rehab until March 7, 2013. During follow-up, he exhibited only a mild twinge of discomfort with joint mobilization on the right T11 costovertebral segment, but range of motion of the same segment was unrestricted in comparison to adjacent costovertebral joints. The T10 segment had full painfree joint play. Buoy exhibited only a mildly observable roached spine posture in sitting. The client was so pleased with Buoy's progress she entered him in full Obedience competition.

On March 16-17, 2013, Buoy competed at the AKC

National Obedience Competition in Tulsa, Oklahoma and won the National Championship for the second time in his career (Figure 2). The client reported that he was training well and looked like a "million bucks" during competition.

CLINICAL SIGNIFICANCE

In general, a roached spine is defined as an abnormal convex curvature located in the cervical, thoracic, or lumbar regions. Visual inspection reveals an arch in the spine that may or may not be painful upon palpation. If the arch remains present during standing, sitting, or active movement, it is considered to be roached and may be the source of movement or postural dysfunction. Differential diagnoses of a roached spine includes, but is not limited to, the following: intervertebral disk disease, tumor, kidney disease/infection, abdominal masses, liver disease, gastrointestinal upset, abnormal bone growth, excessive muscle development, congenital abnormality, joint dysfunction, or a benign clinical finding.

The costovertebral joints are classified as 'planar' synovial joints reinforced by several ligamentous structures and muscle attachments.[1-3] Costovertebral joints are located lateral to the zygapophyseal (facet) joints as seen in Figure 3.

Costovertebral joints possess only a few degrees of range of motion at each segment allowing for normal painfree body movements. The limited amount of segmental mobility however serves to also prevent excessive rib displacement during flexion, extension, and side bending of the thoracic spine.[1] Costovertebral segments consist of a synovial joint capsule, mechanoreceptors, and pain nerve fibers. Therefore these joints are a potential source of pain in the presence of movement dysfunction, dislocation, or fracture.[4]

Mechanical disorders of the costovertebral joints may include states of hyper- or hypomobility secondary to ligamentous sprains, muscle strains, bony pathology, or prior fractures. Rehabilitation will vary depending on the cause of injury, involved structures, and state of tissue healing. Therapeutic interventions for rehabilitation may include soft tissue and joint mobilization to restore normal mobility, splinting for protection during periods of controlled healing, physical agents such as laser, ultrasound, or electrical stimulation to reduce pain, swelling, and muscle spasm, and therapeutic exercise for balance/coordination and core stabilization.

CONCLUSION

The importance of this case study is to emphasize the need to evaluate costovertebral segments, in addition to zygapophyseal joints, as part of an initial evaluation on a dog exhibiting a roached thoracic spine, or any painful condition of the spine with suspected mechanical joint dysfunction. It is clinically possible for costovertebral segments to be a primary source of pain and dysfunction even when adjacent zygapophyseals joints exhibit normal painfree motion. Costovertebral joints are a potential trigger for pain and dysfunction but with proper intervention can be restored to normal mobility allowing the canine patient a return to desired activities and sport participation.

REFERENCES

1. Evans H, Christensen G. *Miller's Anatomy of the Dog*. 2nd ed. Philadelphia, PA; Saunders Co; 1979.
2. McGowan C, Goff L, Stubbs N. *Animal Physiotherapy: Assessment, Treatment and Rehabilitation of Animals*. Oxford, UK; Blackwell Publishing; 2007.
3. Riegger-Krugh C, Mills D. *Basic Science for Animal Physical Therapy Canine. Anatomy and Biomechanics: Spine*. 2nd ed. Orthopaedic Section, APTA, Inc; 2007.
4. Erwin W, Jackson P, Homonko D. Innervation of the human costovertebral joint: implications for clinical back pain syndromes. *J Manip Physiol Ther*. 2000;23(6):395-403.

Figure 2. Buoy, National Obedience Champion. March 17, 2013, Tulsa, OK.

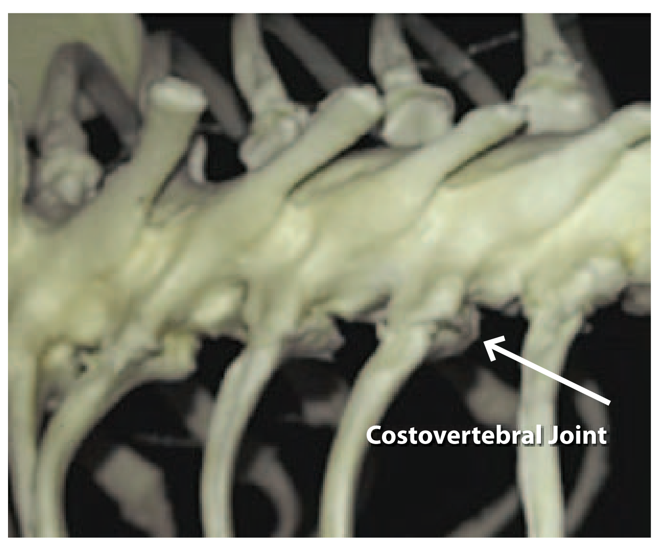

Figure 3. Thoracic spinous process displayed pointing upward with costovertebral joints articulating with vertebral bodies just lateral to the zygapophyseal joints.

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