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White paper

An Update on Physical Therapy Adjuncts in Orthopedics

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ABSTRACT

Physical therapy is a necessary part of the recovery process after most orthopedic procedures. Effective treatment, patient satisfaction, and financial reimbursement hinge on the successful implementation of both surgical and nonsurgical interventions. Evidence-based practice and open communication between therapists and orthopedic surgeons continue to form the foundation of patient care. The aim of this paper is to familiarize orthopedic surgeons with the relevant data behind some of the recent advances in rehabilitation adjuncts to better address the needs of our patients. Although each intervention has been found to be relatively safe, high-quality evidence is still sparse. Opportunities exist for improved outcomes with further well-designed studies to investigate the role of these therapy modalities among orthopedic patients.

Introduction

Physical therapy is a necessary part of the recovery process after most orthopedic procedures. Therapy increases range of motion, strengthens surrounding muscles, improves neuromuscular coordination and balance deficits, and develops functional endurance. Communication between the patient, surgeon, and therapist is vital to a successful recovery. Today, with hospital reimbursement being tied to satisfaction, it is important for all parties to have a strong working relationship to ensure adequate rehabilitation and patient-reported outcomes after orthopedic procedures.

Physical therapists are doctoral-educated medical personnel that treat orthopedic patients on a routine basis. They serve as a physician extender during the recovery process and relay abnormal findings to the surgeon before larger problems arise. Encouraging active participation to reach attainable goals with realistic expectations is essential during the rehabilitation process. Therapists must individualize therapeutic routines to meet the needs of the patient. Functional recovery can take weeks to months; therefore, it is important that therapists progressively challenge patients to prevent plateauing or regression.

Physicians must remain cognizant of the level of specialization of their therapists and prescribe specific therapy instructions based on the needs of the patient. In underserved areas, therapeutic resources may not be readily available, thereby limiting the use of novel techniques. In some states, a specific physician order is necessary for the therapist to administer particular treatments such as dry needling (DN).

Problem statement

Evidence-based medicine permeates all aspects of the medical field. Frequently a referral to physical therapy is accompanied with the instructions of "evaluate and treat." It is important for practitioners to make sound judgements based on current research-supported interventions. Continued investigation of old and new techniques is important to provide appropriate care to patients. Insurance carriers have suggested using patient satisfaction scores to adjust surgeon reimbursement; therefore, we must remain cost-conscious and ensure high-quality patient care across all disciplines [1]. This paper will serve to familiarize orthopedic surgeons with the relevant data behind some of the recent advances in rehabilitation adjuncts to better meet the needs of our mutual patients.

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Proposed solutions Ultrasound

Ultrasound (US) as both an imaging and therapeutic modality has been evolving since the 1930s. Diagnostic US is currently not within the scope of practice for physical therapists but is currently reserved for physicians [2]. Therapists have a need for advanced imaging within their practice to help diagnose and treat a variety of musculoskeletal ailments. Diagnostic US can provide feedback to help therapists improve neuromuscular function and deliver personalized rehabilitation for their patients [2].

Therapeutic US is frequently employed by therapists after a joint replacement both in the acute postoperative period to quell postoperative inflammatory response and to increase soft-tissue extensibility during the remodeling phase of tissue healing [3]. Therapeutic US uses high-frequency (0.75 − 3.3 MHz) sound waves to produce thermal effects on deep tissues (>3 cm) [4]. The purported benefits include enhanced blood flow via vessel dilation, increased pliability of collagen leading to improved joint range of motion, improved neuronal velocity for muscle recruitment, and modulation of pain and inflammation [5].

Therapeutic US has been previously used by physical therapists on patients with soft-tissue pathologies including tendinitis, bursitis, muscle spasms, neuromas, and myositis ossificans [3,6]. After a water-based coupling gel is applied to the skin, a hand-held transducer is then used to direct the sound waves into the soft tissues over the area of interest. This treatment is then usually followed by components of a rehabilitation program such as stretching or strength training.

Nonthermal applications of therapeutic US include phonophoresis and bone healing. Phonophoresis uses low-frequency therapeutic US waves to increase the permeability of the *stratum corneum* layer of the epidermis to promote the transdermal delivery of prescribed medications (usually lidocaine or dexamethasone) [6]. Most state laws require the patient to have an accompanying prescription for the medication prior to the use of phonophoresis [5]. Studies have also shown nonthermal therapeutic US can be prescribed to aid bone healing although the effects can vary depending on the location of the fracture and thickness of the soft-tissue envelope [5].

Therapeutic US is unique because of the low risk of adverse side effects, the ability to accurately target deep tissues (3-5 cm), and low cost to purchase and maintain the equipment [5]. US in the vicinity of the spinal cord and gravid uterus, near arthroplasty implants in relatively thin individuals, and adjacent to implanted electronic devices should be approached with caution. Furthermore, reports have demonstrated prolonged use of US can cause dose-dependent adverse effects such as burns, soft-tissue necrosis, and hemorrhage [5,6].

There is limited evidence on the clinical efficacy of therapeutic US because it is difficult to quantify the direct effect of US in isolation. During the management of orthopedic conditions, therapeutic US has been proven useful in combination with additional modalities but has no proven benefits when used independently [5,7]. Specifically, US has been shown to have benefits in patients with knee osteoarthritis (OA) when used in addition to laser light therapy and exercise [8]. A randomized controlled trial by Paolillo et al. showed reduced pain and increased functionality with US and low-level laser therapy (LLLT) in patients with knee OA [8]. However, studies including soft-tissue conditions such as tendinopathies have shown no benefit from independent US usage, indicating a necessity for further research on its utility in the field of orthopedics. In conclusion, therapeutic US has been shown to have a modest level of efficacy and patient benefit with a low level of risk during treatment [5,6].

Blood flow restriction therapy

Blood flow restriction therapy (BFRT) is an emerging modality that has been garnering research interest in the United States since 2015. Most of the clinical applications have been studied in athletic populations, but indications are emerging for arthroplasty patients. Currently, BFRT is used on both the upper and lower extremities for the purpose of enhancing muscular strength and endurance [9]. The process involves inflating a pneumatic cuff placed proximally on the limb to occlude arterial and venous blood flow to distal musculature during low-load resistance training (Fig. 1). Subsequent exercises are then typically performed at levels of 20%-50% of the patient's one-repetition maximum under hypoxic conditions [9].

This induced anaerobic state increases muscle hypertrophy as a result of both mechanical and metabolic stressors although the specific cellular processes are uncertain [10,11]. It is postulated that cellular hypertrophy and hypoxic metabolites lead to increased angiogenesis and protein synthesis in muscle tissues [9]. This proposed mechanism seems to explain the elevated levels of the vascular endothelial growth factor, neuronal nitric oxide synthase, and hypoxia-inducible factor-α that are increased after BFRT [10].

Patients who undergo orthopedic procedures often require subsequent therapy that involves weight-bearing exercises that improve strength, endurance, function, and mobility. A unique advantage of BFRT over other exercise modalities is the incorporation of low-load training [9]. BFRT allows for a decrease in required therapeutic resistance volume, expanding the accessibility of therapy to patients who would initially struggle to maintain a traditional exercise protocol [9].

Clark et al. observed young healthy adults that underwent BFRT and measured no significant difference in ankle-brachial indices, nerve conduction, or prothrombin time when compared with typical high-load resistance exercise [12]. The most common risks of BFRT include pain, skin breakdown, swelling, and temporary paresthesia from neural compression [13]. Despite evidence supporting its safety, providers should be mindful when using BFRT for patients that have specific vascular (eg, peripheral artery disease, hypercoagulability, and so on) or radicular pathologies as the current literature has not assessed the universal safety in patients with these conditions. Thankfully, the incidence of severe effects such as hemorrhage, venous thrombus, pulmonary embolism, and cerebral infarction has been exceedingly rare [9,12]. Nonetheless, it is reasonable to conclude that BFRT is safe for healthy adults and those with isolated orthopedic conditions when used appropriately [12,13]. It is recommended that BFRT commences after the incision

Figure 1. Blood flow restriction cuff applied to the upper thigh for use during exercise therapy.

Figure 2. Dry therapeutic cupping applied to the lateral quadriceps muscle to help improve local blood flow.

is healed and the patient is full weight-bearing to participate in both open- and closed-chain exercises [10,11].

Recent studies have shown distinct clinical benefits from the use of BFRT with regard to orthopedics. Gross strength, muscular hypertrophy, and anaerobic capacity all increase at a greater rate with BFRT compared with typical strength training conditions [10,11,14,15]. Knee arthroscopy patients who completed a BFRT program had greater improvement in strength and function than those who followed traditional therapy routines alone [16]. In addition, increased muscle hypertrophy has been documented following anterior cruciate ligament reconstruction in BFRT [17,18]. Due to its efficacy while using low-load resistance, it may be beneficial in elderly populations with more physical limitations due to OA or generalized muscle atrophy. A recent meta-analysis observing BFRT in patients with knee OA concluded that BRFT is a reasonable intervention for improving muscle strength and volume with low mechanical stress [19]. With promising data from current studies, a clear need for expanded research of BFRT after total knee arthroplasty is indicated [9]. BFRT is part of the professional scope of practice for physical therapists, but certification is strongly encouraged before employing this adjunct in the clinical setting.

Myofascial cupping

Therapeutic cupping involves applying cutaneous suction to different regions of the body to induce changes in soft-tissue restrictions that can develop after injury or surgery (Fig. 2). Two common cupping techniques may be used: “Dry” cupping involves applying the therapeutic cup over intact skin, whereas “wet” cupping involves creating small superficial skin perforations to induce bleeding before/after cup application [20]. The suction-induced negative pressure during treatment causes adjacent vasodilation, which is postulated to reduce inflammation and influence local cell mechanics that ultimately alter pain thresholds, inflammatory gene expression, and immune signaling [21-25]. However, these potential mechanisms of action are still speculative, and further research is necessary. Potential side effects of cupping include local pain and ecchymosis due to the duration and suction strength applied to the skin microvasculature [26]. Although infection risk is small, wet cupping should be approached with caution around joint replacements.

Therapeutic cupping began over 2000 years ago, but there is a paucity of quality data supporting it as a reliable treatment option for musculoskeletal conditions. In therapy literature, cupping has been used in postexercise recovery and additionally in pathologies such as chronic low-back pain, shoulder pain, headaches, knee OA, rheumatoid arthritis, carpal tunnel syndrome, and cervicalgia [25-29]. There appears to be a strong association between therapeutic cupping and other modalities as coping strategies for chronic musculoskeletal pain. For example, those with fibromyalgia subjected to cupping therapy showed reductions in pain intensity and improvements in subjective quality of life compared with those who followed normal exercise routines [26]. Furthermore, an analysis from the study by Moura et al. demonstrated cupping therapy was effective in reducing pain compared with control groups in multiple studies involving chronic low-back pain [28].

Therapists employ cupping techniques to modulate blood flow and help facilitate blood flow and manage myofascial restrictions to improve rehabilitation efforts. One study investigating cupping and hamstring flexibility suggests cupping has an adjunct role when combined with other therapeutic techniques to improve muscle function, but the results were transient [30]. After the incision is adequately healed, cupping can be used to facilitate muscular recruitment, mobilize patellar adhesions, improve lymphatic drainage, and enhance scar healing, all of which serve to improve range of motion after knee replacement [20,31,32].

Recently, two reviews evaluating the efficacy of therapeutic cupping for patients with knee OA concluded there was weak evidence that cupping interventions alone were of benefit in reducing pain and improving function [33,34]. Therefore, coupling therapeutic cupping with other available treatment modalities seems to provide more realistic benefit. Although the current data are not overwhelming, therapists continue to incorporate therapeutic cupping as part of their musculoskeletal rehabilitation programs, making this modality an intriguing area of future study. Cupping techniques have practical advantages considering they are less expensive than other physical therapy modalities such as DN or US [34-36]. Therapists are encouraged to obtain certification prior to utilizing cupping in practice although it is not a perquisite. Cupping interventions are contraindicated over open wounds, in the vicinity of fractures, and in the setting of deep vein thrombosis [20].

Laser therapy

LLLT (also known as photobiomodulation) represents an interesting therapy modality utilizing low-power focused beam of light between wavelengths ranging from 600 to 1000 nm for musculoskeletal use [37]. The photochemical effects of LLLT have demonstrated alterations at the cellular level including modification of enzyme activity, increased cellular metabolism, and upregulation of gene expression [38]. These effects have been postulated to have downstream effects on regional pain and inflammation [38,39]. At this time, the United States Food and Drug Administration only recognizes LLLT as a pain relief treatment [40]. Ongoing studies seek to investigate the long-term impact of laser therapy on tissue healing.

A systematic review by Da Silva et al. highlighted the promise of laser therapy on inducing differentiation and proliferation of adipose-derived stem cells in the treatment of osteoporosis [41]. Likewise, Yang et al. noted the potential benefit of laser irradiation on mice cardiac myocytes after myocardial infarction, resulting in beneficial alterations in cytokine levels such as granulocyte-macrophage colony-stimulating factor and fractalkine [42]. These studies shed potential light on one possible future of LTTT and its effects on inflammatory markers and cytokines.

Over the past decade, studies have shown various effects on soft-tissue and skin pathologies, but there has been limited measurable benefit of laser therapy treatment for orthopedic pathologies. Case reports have suggested laser therapy has possible benefit for relatively superficial musculoskeletal and nervous system ailments including temporomandibular dysfunction, lateral epicondylitis, plantar fasciitis, and carpal tunnel syndrome when used as an adjuvant with other therapeutic modalities (Fig. 3) [37,39,40,43,44]. A meta-analysis by Huang et al. suggested a lack of significant benefit when LTTT was used as an isolated therapeutic modality in patients with knee OA [45]. In contrast, Paolillo et al. affirmed laser therapy improves functionality in patients with knee OA but only when used in conjunction with therapeutic exercise or US [8]. Efforts are ongoing to further assess the efficacy of LLLT as a treatment for patients with knee OA [46].

With more questions than answers, it is still early to discredit LTTT as a treatment option that can theoretically benefit the patient especially with a low operating cost and minimal risk of adverse side effects. Consistent wavelength parameters, mode of laser application (pulsed vs continuous), and duration of treatment(s) still need to be defined. Since the depth of penetration of LLLT is inversely related to the thickness of the soft-tissue envelope (less than 5 cm), future applications may be limited to the distal aspects of the upper and lower extremities [47]. To this effect, the American Academy of Orthopaedic Surgeons recently offered little guidance on the safety and efficacy of LTTT for orthopedic conditions [48].

Overall, the efficacy of LLLT in management of musculoskeletal conditions appears to be limited at this time and will require placebo-controlled trials to further specify its utility as a physical therapy modality [49].

Kinesiology taping

Kinesiology taping (KT) is a therapeutic adjunct that has gained popularity among professional athletes where it has been used for the treatment of musculoskeletal and myofascial disorders among other conditions. KT uses elastic tape that is carefully stretched and strategically applied to the skin over targeted soft tissues and allowed to recoil for therapeutic effects (Fig. 4). The shape and direction of tape application serve to define specific treatment principles. Athletic taping is intended to immobilize, support, and protect a particular joint, whereas KT facilitates muscular function during activity [50]. Athletic tape has been demonstrated to lose effectiveness within 10 to 15 minutes after application while KT can remain in place for 3 to 5 days before removal [50].

Kase et al. have asserted that KT increases lymphatic drainage and blood flow which results in pain relief, reduced tissue swelling and inflammation, and improved tissue healing [51]. However, there is a lack of substantial evidence in the current literature to support these causal relationships. Currently, KT is used by

Figure 3. Low level laser therapy applied to the quadriceps tendon as part of a therapeutic exercise prescription.

Figure 4. Kinesiology tape applied to the knee to help support a patient with patellar tendonitis.

therapists to address generalized pain within the cervical and lumbar spine, shoulder, knee, and ankle joints [51]. KT as a therapeutic modality has proven to be an affordable noninvasive adjunct for rehabilitation but has mixed results according to recent studies investigating clinical significance.

Many studies have assessed KT as a therapeutic modality for patients with orthopedic conditions. A literature review of the effects of KT on knee OA from Abolhasani et al. showed improvement in pain, increased joint range of motion, and mixed results in regard to proprioceptive feedback during exercise [52]. Conversely, a meta-analysis assessing the effect of KT on pain for shoulder pathology demonstrated no significant change in pain levels [53]. However, this meta-analysis verified a small benefit in shoulder range of motion and neck kinematics, citing the proprioceptive feedback provided by the tape can help facilitate muscular firing patterns during therapeutic exercise [50]. It appears that the majority of clinical benefits from KT appear to be short-lived. A randomized control trial performed on shoulder joints with KT demonstrated short-term improvements in range of motion but no significant long-term effects when compared with a control group [54].

Altogether, KT is a low-risk and readily available adjunct for therapists in the management of certain orthopedic conditions. While KT has limited evidence for its long-term benefits, it poses no significant risks and has clinical benefits on short-term outcomes such as pain and functional range of motion when used appropriately [54]. The most common side effect reported is skin irritation from the tape adhesive. The use of KT is contraindicated around open wounds, active infection, and deep vein thrombosis [51].

Dry needling

The American Physical Therapy Association defines DN as an invasive therapeutic technique where filamentous “dry” needles (without medication or injection) are inserted through the skin into areas of skeletal muscle and connective tissue to treat pain and improve function [55]. DN differs from traditional Chinese acupuncture which employs various cutaneous needles that target meridian lines to alter the body's "life energy" [56]. Currently, only six states (California, Hawaii, New York, New Jersey, Oregon, and Washington) have laws that prohibit DN by a physical therapist despite advanced certification requirements [57].

Research confirms DN facilitates relaxation and improves muscular contractions that can aid rehabilitation efforts [56]. DN has been used in the postoperative period to facilitate return of coordinated muscular activity by stimulating the motor end plate at various neuromuscular interfaces [58]. Treatments can help stimulate branches of the femoral nerve to disrupt the quadriceps inhibition reflex that can develop after knee replacement [58]. Preliminary evidence suggests that DN can also help address incision-related pain and aid wound healing under certain circumstances [59].

DN has shown clinical benefit in orthopedic conditions including low-back pain, carpal tunnel syndrome, plantar fasciitis, shoulder pain, and cervicalgia [55,56,60,61]. A recent randomized controlled clinical trial compared DN and sham treatments directed at myofascial trigger points of the iliopsoas, tensor fascia latae, rectus femoris, and gluteus minimus muscles in patients with unilateral hip OA [62]. The study revealed significant reduction in hip pain with improvement in physical function and hip muscle strength in the DN group compared with the sham and control groups [62]. A similar study concluded DN of quadriceps and hamstring muscles was beneficial for moderate knee OA; however, the improvements in functional activity, pain, and balance were only found to be temporary [63].

A recent systematic review and meta-analysis investigating the effectiveness of DN techniques in patients with knee OA concluded moderate evidence and short-term effects of DN may be beneficial for knee OA, but frequency and duration of treatment along with long-term follow-up are still lacking [64]. Interestingly, this review included studies on periosteal stimulation in which an electrical current is applied through cutaneous needles to stimulate the nerves of the periosteum. This aggressive treatment is currently outside the scope of practicing physical therapists [64]. An important discussion on infection risk should be arranged with each patient because needle-based therapies in the vicinity of a joint replacement may convey more risk than previously thought. Several case reports have linked DN therapy to an acute periprosthetic joint infection [65]. Further research on the safety of DN is currently ongoing.

Several promising studies are ongoing to demonstrate decreased opioid dependence when using DN for various musculoskeletal ailments [66]. There are currently no recommendations or substantial data for the optimal mode, frequency, or duration of DN in orthopedics. A recent consensus statement from the American Academy of Orthopaedic Surgeons denotes the current utility and efficacy of DN remain unclear due to insufficient evidence [48]. The need for more high-quality studies is critical for defining a future role for DN.

Future directions and recommendations

Physical therapists have a variety of options in the realm of exercise prescription for the management of various orthopedic conditions. Each program is tailored to meet the individual needs of the patient because the response to therapeutic intervention is variable. The abovementioned adjuncts are relatively safe, but high-quality evidence-based studies are sparse. Opportunities for improved patient outcomes arise when the therapist and physician understand the current science and evidence behind an intervention.

Cost-conscious care is key in the delivery of value-based medicine. Just as inpatient rehabilitation has become antiquated, current research suggests formal therapy beyond 8 weeks after knee replacement may not be necessary for a successful outcome [67]. Likewise, a recent randomized controlled trial demonstrated no clinical difference in outcomes between formal therapy and a home-based exercise program after total hip replacement [68]. These studies highlight an area with potential for change in current rehabilitation practice.

Extended therapy incentivizes therapists but places undue financial and temporal strains on our health-care system without significant functional gains or improved outcomes [69]. In addition, a prolonged rehabilitation track limits access for patients with greater needs beyond primary hip and knee replacement. A challenge that therapists now face is meeting specific functional goals and delivering their services within a defined timeframe in an effort to conserve resources. Therefore, novel therapeutic techniques and modalities should be selectively employed by therapists and be predicated on evidenced-based outcomes so as not to inflate the cost of services. As surgeons, we must help steward therapy resource utilization.

Thanks to the COVID-19 pandemic, telehealth services have enabled a host of new options for patient-provider interactions. A new potential role for therapists may encompass remote monitoring of functional progression after total joint replacement where interactive feedback can be provided remotely [70]. Legislation and reimbursement for these types of services are being debated.

Open communication between therapists and orthopedic surgeons continues to form the foundation of care for our mutual patients. It takes time to systematically investigate the outcomes of various treatment modalities to determine if they are appropriate, how they should be employed, and who is most likely to benefit from their use. Prospective randomized studies to further evaluate the value of these new modalities in isolation and in conjunction with other therapeutic techniques are necessary.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: M.B. serves on the editorial board for *Arthroplasty Today*. He was not involved in the peer review process.

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Informed patient consent

Informed consent was obtained for the photographs used in this article.

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