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**Myofascial Trigger Points: Implications for Physical Therapist Practice**

 Human skeletal muscle can account for as much as 50% of total body weight and by that metric, is the largest organ in the body.1 Yet while most organs, organ systems, or important body structures have dedicated specialties (gastroenterology, dentistry, podiatry, dermatology, neurology), no medical or health care specialty claims the muscular system in the same manner as the others. As a result, referred pain from the pathological condition known as a myofascial trigger point (MTrP) within skeletal muscle is often overlooked or incorrectly diagnosed, despite being one of the most common conditions associated with musculoskeletal pain.2 In published Western scientific literature, Dr. Janet Travell is credited with the first use of the term “trigger point” in 1942,3 and is generally considered to be the single most prominent figure in the modern history of medical study on the subject. According to the seminal text by Travell and Simons, the etiological definition of a trigger point is, “A cluster of electrically active loci each of which is associated with a contraction knot and a dysfunctional motor endplate in skeletal muscle.”1 The same book also provides a more clinically descriptive definition as being, “a hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band. The spot is painful on compression and can give rise to characteristic referred pain, referred tenderness, motor dysfunction, and autonomic phenomena.”1 Travell and her research found a national platform during her time as the White House physician during the Kennedy administration, where she pioneered her techniques of injecting saline or local anesthetic into MTrP’s as a treatment for President Kennedy’s chronic pain symptoms due to Addison’s disease which threatened his ability to continue in his political career.3 It was during her time in the White House that Dr. Travell met Dr. David Simons, an aerospace physician who, in 1965, became the director of research for the Department of Veterans Affairs.3 Although Travell and Simons were both medical doctors, their work has had a profound impact on the field of physical therapy and how PT’s are able to understand, diagnose, and treat musculoskeletal pain which comprises such a large percentage of patient complaints in orthopedic PT clinics. Despite this, in depth training in the structure, formation, identification, and treatment of MTrP’s is not a standard part of entry level DPT curricula in the United States. The aim of this paper is to investigate what is known to date about the pathophysiology of MTrP’s, and their detection, diagnosis, and treatment. This is a fast-growing area of research in physical therapy, with wide-ranging and exciting implications for improved treatment of chronic pain and combatting the sharp rise in addiction and deaths associated with pharmaceutical agents often used to treat it.

 An important starting point in understanding MTrP’s is to understand the accumulation of evidence proving their existence through objective, controlled, and quantifiable means. More than twenty years ago, evidence of increased spontaneous electrical activity in the motor endplates of human muscle containing MTrP’s was obtained through needle EMG studies.4 Furthermore, this activity was shown to be highly localized to the focal area of tenderness and hyperirritability within a taut band of muscle indicating a trigger point – as little as 1mm difference in needle placement recorded significant changes.4 Simons is usually credited with coining the term “endplate noise” to describe this phenomenon, and while random EMG activity is common in all skeletal muscle, his research demonstrated that the immediate area surrounding MTrP’s exhibited spikes of activity not explainable by sub-threshold action potentials which occur naturally at the motor endplate.5 It has even been shown that MTrP’s respond to psychological stressors with an increase in electrical activity that far surpasses the stress response in healthy muscle tissue, supporting the understanding of the degree to which emotional well-being and psychological distress feed into the manner and degree to which patients experience pain.6

 More recently, advanced techniques in assaying the results of needle biopsies have provided proof that not only is the area immediately adjacent to MTrP’s chemically distinct from healthy muscle tissue, but that differences can be objectively measured between the biochemical milieus of active versus latent MTrP’s.7 The release of acetylcholine (ACh) into the synaptic cleft at the neuromuscular junction is both quantal and non-quantal, with the spontaneous, slow leakage of ACh even at rest tending to be non-quantal in nature.8 Needle biopsies have shown the chemical milieu of MTrP’s to exhibit low levels of oxygen saturation leading to a localized drop in pH.2 This concentrated acidification secondary to hypoxia downregulates release of acetylcholinesterase (ACh-esterase) meant to break down excess ACh to prevent accumulation, and initiates an inflammatory cascade which concentrates common mediators such as prostaglandins, bradykinin, substance-P, interleukins, and more within the immediate vicinity of an MTrP.7 These inflammatory mediators have dedicated nociceptors which respond to their presence by central nervous system input, and the cascade becomes a positive feedback loop9 resulting in a constant, low level nociceptive input stemming from the site of an MTrP. This provides an explanation for the localized area of exquisite tenderness to palpation that is characteristic to MTrP’s and also has implications for the central sensitization theory of chronic pain which will be discussed later.

 The most recent advances in MTrP research have finally led to the visual imaging of their structure *in situ* through the use of ultrasonography. In 2009, new research began to appear, exploring the possibility of gray-scale ultrasound imaging to differentiate MTrP’s from surrounding muscle tissue.10 Ultrasonography has proven useful in identifying local twitch responses related to resolution of MTrP’s, particularly in deeper musculature where the involuntary twitch may not be visible or palpable.11 In a literature review published in 2016, Kumbhare et al identified the advances in three ultrasound imaging techniques – gray-scale, elastographic, and Doppler – which are currently being used to visualize MTrP’s in living human muscle.12 While the reviewers conclude that this area of research is still evolving, they note that even just ten years ago it was thought that ultrasound was not a viable method for detecting MTrP’s but that advances in hardware technology and onscreen resolution software have produced promising breakthroughs in this clinically useful method of diagnosis.12 The studies that have demonstrated visualization of MTrP’s using gray-scale ultrasound have described them as hypoechoic, appearing as a dark spot interrupting the continuity of the adjacent muscle fibers on screen.10 As technology advances and the research methodology is refined, ultrasonography has strong potential to become a reliable and noninvasive method for locating and diagnosing MTrP’s for the purpose of targeted intervention.

 Travell and Simons indicate that MTrP’s can form either as a result of acute trauma, or more gradual onset due to repetitive postural abnormalities and overuse.1 Other researchers have built on their work and outlined conditions which lead to MTrP formation with greater specificity. Chaitow showed that abnormal or stress patterns of breathing can lead to a reduction in hemoglobin’s affinity for oxygen which causes a measurable degree of systemic hypoxia, creating the conditions for chronic, low-level muscle fatigue and MTrP formation.13 Hoyle et al explored the relationship between low-load, repetitive tasks such as poor posture due to prolonged computer work and the spontaneous generation of MTrP’s in otherwise healthy and pain-free subjects.14 In addition, Giamberardino outlines how visceral pain always includes a secondary presentation as referred musculoskeletal pain to a distant site, resulting in muscle hyperalgesia due to protective MTrP formation.15 As described previously, the actual loci of MTrP’s are tiny – measuring only millimeters in diameter.1 However, the “taut band” which is discernable through palpation of the muscle belly by strumming in a perpendicular direction to the muscle fibers extends out from the MTrP, often covering much of the muscle length. These taught bands are stiffer and less extensible than the surrounding healthy muscle tissue16 and while they demonstrably alter motor function and motor control patterns, they may be seen as a protective mechanism initiated when the body senses pain or instability – or in other words, an attempt to splint a vulnerable body region.17 Related to this point, and building on Chaitow’s research on breathing patterns, Anderson et al have demonstrated that myofascial release protocols to address chronic pelvic pain are more effective when combined with breathing relaxation training.18 It should be evident from these findings, that issues of acute trauma, repetitive use injuries, poor posture, and a poorly managed overload of psychosocial stressors which escalates with anxiety over unexplained pain symptoms are common to a significant majority of patients in an orthopedic physical therapy setting. A therapist who is mindful of these warning signs when taking a subjective history or in their session-to-session interaction with a patient will be more likely to correctly explore the possible presence of MTrP’s as a cause of or contributor to a patient’s lingering symptoms of pain.

 Patients suffering from chronic pain have historically been considered a complicated and difficult population with which to work in clinical practice. The influence of multiple body systems, as well as a heavy prevalence of psychosocial involvement often necessitate an interdisciplinary team for successful outcomes in the setting of a clinical practice that specializes in chronic pain.19 However, recent research and currently developing models of the physiological and neurological mechanisms that underlie chronic pain can allow physical therapists to play a significant role in helping to alleviate their patients’ suffering, particularly as it relates to addressing MTrP’s in skeletal muscle which is directly within the scope of PT practice.20 Pain constitutes an astronomical cost when healthcare expenses are calculated in the United States. It is estimated that $77 billion in direct medical care expenses are linked to musculoskeletal issues, and a $100 billion price tag is attached to low back pain alone when costs of lost productivity at work or unemployment due to disability are factored in.21 In a systematic analysis of the 2010 Global Burden of Disease Study, Vos and colleagues show that musculoskeletal disorders ranked second in the world – only behind behavioral and mental health disorders – as a primary cause of years of life lost to disability.22 Of the years lost due to musculoskeletal disorders, 70% were related to low back pain, and years lost due to lumbar spine involvement outnumbered years lost due to cervical spine involvement at a rate of two to five times the number of occurrences.22 In light of these numbers, the conversion of physical therapy to a doctoral-level profession and the increased role and responsibility being assumed by the physical therapy community as it ascends within the medical model could not be timelier. While it remains true that no profession claims skeletal muscle as its own in the way that dentistry claims the mouth and teeth, no profession has a wider array of treatment tools at its disposal while enjoying the legitimacy afforded by the pursuit of evidence based treatment than does physical therapy for treating muscle-based causes of musculoskeletal pain.

 In addition to evidence-informed physical therapy being an effective treatment for musculoskeletal pain, it is also critical to discuss the comparatively lower risk of physical therapy intervention when considering other available treatments for the same symptoms. A recent systematic review failed to show any significant difference in outcomes for patients with intractable discogenic low back pain who received a lumbar fusion surgery versus non-operative treatment (which included physical therapy and patient education) and concluded that both treatment avenues were viable options.23 Absent from the analysis, however, was a discussion of the risks inherent in all surgical procedures such as infection and hospital-acquired sequelae. It is incumbent upon physical therapists when asked for counsel regarding two courses of treatment with ostensibly equivalent outcomes, to be able to explain to their patients that the risks and side effects inherent in the process of a particular treatment itself may be important factors in making the wisest decision. This is true of another prominent issue in the United States: prescription opioid use, abuse, and addiction. In 2010, American providers wrote more than 300 million prescriptions for pain-relieving medications alone, with fully 128 million of those prescriptions containing hydrocodone, which is only one type of opiate.24 Between 1999 and 2007, there was a 124% increase in accidental death by prescription opioid overdose in the United States.25 This statistic does not reflect overdose deaths attributable to patients who became addicted to prescription opioids and then turned to illegal drugs with no quality control standards such as heroin when they were unable to afford or obtain a refill. A 2009 review commissioned by the American Pain Society and the American Academy of Pain Medicine attempted to establish clinical guidelines based on limited evidence pertaining to opioid therapy for chronic non-cancer pain.26 While the authors concluded that judicious use of opioids for pain management was still a medically valid intervention,26 it is still a fact that this class of pharmaceuticals influence only the way in which the central nervous system senses and processes pain, and do nothing to address the aforementioned process of MTrP formation or the altered movement patterns that either precede or follow it. In this way physical therapy can be seen as affecting the root cause of pain in this patient population rather than merely the perception of symptoms, which indicates a superior treatment for chronic musculoskeletal pain over opioid analgesics, even if opioids did not carry the steep physical and psychological risks inherent in all narcotics.

 As discussed previously, recent advances in ultrasonography show promise in the future ability of even small clinics to have a non-invasive means of positively diagnosing MTrP’s in patients.12 However, ultrasound imaging is not currently taught in entry level DPT curriculum and the evidence for its validity and reliability is incomplete at present. More research must be done before a more sizeable percentage of physical therapists can confidently invest in the equipment and post-professional training needed for this technique. In a 2009 systematic review, Lucas et al highlighted the poor methodological quality of the existing literature on the validity and reliability of using palpation to identify MTrP’s in patients.27 As with any of the previously mentioned detection methods, no consensus agreement exists regarding a gold standard diagnostic test that is both valid and reliable, and further research will be hampered until this consensus is achieved.11,27 Point tenderness and pain reproduction achieve the benchmark for good interrater reliability, however those two symptoms alone are not unique to MTrP’s and cannot be considered a definitive diagnostic test.27 Nonetheless, it is often the case in clinical practice that one must operate according to the best available evidence rather than the high quality research a therapist may wish were available for all possible interventions. Indeed, these gaps in the research are common enough that entry level DPT students are taught that much can still be accomplished by simply treating the symptoms and the impairment when a definitive diagnosis is impossible or prohibitively difficult to obtain. A patient with chronic shoulder pain likely does not care about statistical significance or the lack of interrater reliability in the palpation of a trigger point if the clinician they are seeing effectively utilizes evidence informed treatment techniques based on the existing knowledge of MTrP’s and pain referral patterns to relieve that individual’s pain.

 MTrP’s are thought to play a role in “maladaptive neuroplasticity”28 or what is becoming more widely known as central sensitization, in which the dorsal horn of the spinal cord becomes hyperreactive to afferent signals from peripheral nociceptors.29 Lim et al describe it as an “an amplification of nociceptive signal by the hyperexcitable spinal neurons” and propose as a measurement of central sensitization, the nociceptive flexion reflex which involves the threshold reached by the lowest possible level of stimulus needed to activate the reflex without also stimulating peripheral nociceptors.30 In any case, it is known that MTrP’s are a source of constant, low-level nociceptive input to the central nervous system8 and it has been indicated that interventions consisting solely of static stretching are ineffective in the long term at resolution of MTrP’s or their resulting effects on muscle extensibility.31 One of the techniques rapidly gaining in both popularity of usage as well as peer-reviewed evidential backing is trigger point dry needling. Also called simply “dry needling” or “needling” for short, the APTA defines trigger point dry needling as a skilled intervention which involves using a solid, monofilament needle inserted intramuscularly at the site of a known or suspected MTrP through the overlying dermal, adipose, and healthy muscle tissue, as a treatment for nueromusculoskeletal pain or movement impairment.32 Even during Dr. Travell’s early research on injecting local anesthetics into MTrP’s (or “wet” needling), she suspected that the mechanical stimulation of the needle itself played a role in positive outcomes when she discovered that some patients reported an improvement following the insertion of the hypodermic needle alone, prior to any injection of fluid.2 This has led to a proliferation of research on dry needling which replaces the hypodermic syringe with a thinner, solid needle, such as the type used in some acupuncture treatments. Producing high quality evidence in support of dry needling is complicated by a number of factors including the previously mentioned lack of consensus on an official method of MTrP diagnosis,27,33 as well as the nature of the intervention which defies the same level of blinding as is possible when testing a novel pharmaceutical treatment. Nonetheless, Mayoral et al managed to conduct a successful, placebo-controlled, double-blind RCT in which patients received a single dry needling treatment under anesthesia immediately prior to undergoing a total knee arthroplasty.34 The patients who received the needling objectively required overall less analgesic intervention following surgery and presented with similar pain outcomes at one month post-operatively as what the control group required six months to achieve with conventional pain control methods.34 A 2015 systematic review found that dry needling was significantly effective at reducing musculoskeletal pain secondary to MTrP’s regardless of body region affected.35 Dry needling that elicits a local twitch response in the underlying skeletal muscle has been shown to result in an immediate reduction of excess spontaneous electrical activity or endplate noise in the area of an MTrP36 as well as an immediate reduction in the level of nociceptor-stimulating chemical inflammatory mediators that become concentrated within the immediate vicinity.7 While the precise mechanisms of these proven results are still the subject of ongoing research, the overall safety of dry needling as an intervention, combined with its favorable outcome rate, make it a promising tool within PT practice for treating a patient population known for a high prevalence of unsuccessful outcomes even with interdisciplinary care.28

 This paper has described the clinical significance of MTrP’s, the ways in which they can be detected, their role in chronic pain, the enormous multifaceted burden that musculoskeletal pain and dysfunction inflicts on a national and global scale, as well as the role of physical therapy in being a part of the solution to this problem. Physical therapy is a profession in transition, assuming a greater role, responsibility, and accountability within the American healthcare model than ever before in its history. PT clinicians and researchers must continue to drive the production of high quality research, both independently and in collaboration with other disciplines, to firmly establish a set of best practices in the management and resolution of chronic musculoskeletal pain. Future research must focus on developing gold standard clinical tests for the diagnosis of MTrP’s, improving current conceptual models of the mechanisms of chronic pain and related neuroplasticity, and continuing to explore the efficacy of novel treatments such as dry needling and their limits. Continued breakthroughs in these areas are likely to radically improve the outlook of healthcare in the United States through the successful conservative management of chronic pain while avoiding untold costs related to surgeries and pharmaceutical complications.

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