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Optimizing Performance and Recovery: Dry Needling of Myofascial Trigger Points in Sports Medicine

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ABSTRACT

Background. Myofascial pain syndromes (MPS) and musculoskeletal disorders are common conditions that can impair athletic performance. Dry needling (DN), an invasive physiotherapeutic technique targeting myofascial trigger points (MTrPs), has gained increasing attention as a therapeutic intervention in sports medicine and rehabilitation.

Aim. This review aims to synthesize current evidence regarding the neurophysiological mechanisms, molecular effects, and clinical applications of DN in the management of musculoskeletal disorders, with particular emphasis on sports-related conditions.

Methods. A comprehensive review of randomized controlled trials, systematic reviews, meta-analyses, and experimental mechanistic studies published primarily within the last 20 years was conducted using electronic databases including PubMed, Scopus.

Results. DN modulates nociception at many levels. Mechanical stimulation of MTrPs triggers a local twitch response, reduces spontaneous electrical activity (SEA) and pro-inflammatory mediators (substance P, CGRP, IL-1β), improves microcirculation, and activates descending inhibitory pathways while normalizing cortical excitability. Clinical studies demonstrate that DN reduces pain intensity, enhances range of motion, optimizes muscle activation patterns, and shortens time to return to sport in conditions like patellofemoral pain syndrome, lateral epicondylalgia, rotator cuff-related shoulder pain, and hamstring strain.

Conclusions. Dry needling is a safe and effective adjunctive intervention in sports medicine and musculoskeletal rehabilitation. When integrated with structured exercise therapy and load management strategies, it enhances functional recovery, reduces injury recurrence, and optimizes athletic performance. Future studies should focus on standardization of needling protocols, identification of patient-specific predictors of response, long-term outcomes, and integration with objective biomarkers of muscle and neural function.

Keywords: dry needling (DN); myofascial trigger points; sports medicine; neuromuscular modulation; rehabilitation

1. Introduction

Myofascial pain syndrome (MPS) is among the most prevalent causes of musculoskeletal pain encountered in sports medicine and rehabilitation. It is characterized by hyperirritable spots within taut bands of skeletal muscle - myofascial trigger points (MTrPs) - which induce local tenderness, referred pain, and impaired motor function [1]. Athletes are specifically vulnerable due to repetitive overload, microtrauma, and insufficient recovery, which promote sustained sarcomere contraction, metabolic disturbances, and localized ischemia. Historically, invasive interventions targeting MTrPs were introduced in the mid-20th century. Travell and Simons established the clinical framework for MTrP identification and highlighted the therapeutic potential of mechanical stimulation using needles [2]. Over the past decades, dry needling (DN), defined as the insertion of a thin filiform needle into muscle tissue without the injection of pharmacological agents, emerged as a distinct physiotherapeutic technique, conceptually different from traditional acupuncture despite similarities in instrumentation [3]. The rising popularity of DN in sports medicine reflects an ongoing shift toward multimodal, function-oriented rehabilitation which emphasizes neuromuscular control, pain modulation, and restoration of optimal movement patterns rather than solely treating structural pathology. Epidemiological studies indicate that up to 85% of individuals experience myofascial pain during their lifetime, and its prevalence among athletes with overuse injuries exceeds 50% [4]. Persistent MTrPs not only contribute to pain but also disrupt motor unit recruitment, decrease strength, impair proprioception, and increase the risk of reinjury. As a consequence of that, interventions targeting MTrPs have implications for both symptom relief and performance optimization. Despite widespread clinical application, controversies remain regarding the exact mechanisms and magnitude of DN effects. Variability in needling technique, dosage parameters, patient characteristics, and outcome measures has contributed to heterogeneous findings across studies. Furthermore, the relative contributions of local mechanical effects, biochemical modulation, central neuromodulation, and contextual/placebo mechanisms remain incompletely understood.

The aim of this narrative review is to synthesize current evidence regarding the neurophysiological mechanisms, molecular effects, and clinical applications of DN in musculoskeletal disorders, with particular emphasis on sports-related conditions. Additionally, limitations, methodological heterogeneity, and future research priorities are critically discussed to provide a balanced and clinically relevant perspective.

2. Neurophysiological and molecular mechanisms of dry needling

2.1 Local mechanical and biochemical effects

Needle insertion into MTrPs often elicits a local twitch response (LTR) - a brief involuntary contraction of the taut muscle band. Electromyographic studies show that LTRs are associated with a reduction in spontaneous electrical activity (SEA), reflecting normalization of dysfunctional motor endplates [5]. Biochemically, active MTrPs demonstrate elevated concentrations of pro-nociceptive mediators (substance P, CGRP, bradykinin, IL-1β, TNF-α) and decreased pH levels, indicative of local ischemia and metabolic stress [6]. Microdialysis studies reveal that DN reduces these mediators while enhancing local blood flow and tissue oxygenation [7]. Mechanically, DN disrupts contracted sarcomeres, restores actin–myosin overlap, and reduces sustained calcium release from the sarcoplasmic reticulum, thereby interrupting the "energy crisis" cycle central to trigger point pathophysiology [8]. Additionally, microtrauma from needle insertion induces controlled inflammation, platelet aggregation, and fibroblast activation, potentially stimulating tissue remodeling and improved muscle elasticity [9].

Table 1: Changes of mediators in dry needling with their functional implications.

Parameter	**Active MTrP**	**After DN**	**Functional Implication**
Substance P	↑ Elevated	↓ Decreased	Reduced nociceptor sensitization
CGRP	↑ Elevated	↓ Decreased	Reduced peripheral sensitization
pH	↓ Acidic	↑ Normalized	Improved metabolic environment

Blood flow	↓ Reduced	↑ Increased	Enhanced tissue oxygenation
Spontaneous electrical activity	↑ Increased	↓ Decreased	Motor endplate normalization
Sarcomere contraction	Sustained	Reduced	Restored muscle function
Fibroblast activity	Baseline	↑ Increased	Collagen remodeling

2.2 Spinal and Supraspinal Modulation

DN also exerts central effects. Activation of A-delta fibers modulates dorsal horn interneurons, reducing nociceptive signal transmission through gate-control mechanisms [10]. Functional MRI studies demonstrate altered activity in pain-related cortical regions - including the anterior cingulate cortex, insula, and primary somatosensory cortex - following needling interventions [11]. These central effects involve descending inhibitory pathways mediated by endogenous opioids, serotonin, and norepinephrine [12]. Moreover, DN may normalize cortical excitability in patients with chronic musculoskeletal pain, potentially reversing maladaptive neuroplastic changes associated with persistent nociception [13]. These findings support the dual local and central modulatory role of DN in both pain control and motor function restoration.

3. Clinical Applications in Sports Medicine

3.1 Patellofemoral Pain Syndrome

Patellofemoral pain syndrome (PFPS) is a condition prevalent among runners, jumpers, and athletes involved in sports requiring frequent knee flexion and extension. MTrPs in the vastus medialis and vastus lateralis can contribute to imbalanced patellar tracking, altered quadriceps activation and anterior knee pain. DN targets these trigger points to restore proper muscle tone and improve neuromuscular recruitment patterns. Randomized controlled trials demonstrate that DN, particularly when combined with structured exercise therapy focusing on quadriceps strengthening and hip stabilization, produces significant reductions in pain (2–3 points on the VAS) and improvements in functional outcome scores, such as the Anterior Knee Pain Scale (AKPS) [14, 15]. As a mechanism, DN interrupts local energy crises within muscle fibers, reduces SEA, and normalizes motor endplate activity, which facilitates improved quadriceps firing and patellar alignment. Additionally, enhanced local blood flow may support recovery of microvascular function within the quadriceps. Studies suggest that combining DN with progressive load management and biomechanical retraining may reduce recurrence rates and improve long-term function, emphasizing its role as an adjunct to a comprehensive rehabilitation program.

3.2 Lateral Epicondylalgia

Lateral epicondylalgia, or “tennis elbow,” involves pain and functional limitation in the extensor carpi radialis brevis (ECRB) and adjacent forearm musculature. Chronic repetitive loading leads to the formation of MTrPs, which can exacerbate nociceptive signaling and impair grip strength. Dry needling applied to the ECRB effectively reduces pain intensity and improves functional outcomes. Meta-analyses indicate moderate effect sizes for short- and medium-term improvements in pain and grip strength compared with sham interventions [16]. DN may restore normal motor unit recruitment by reducing SEA at dysfunctional endplates, while local mechanical stimulation and LTRs facilitate improved muscle flexibility and reduced protective guarding. When integrated with eccentric strengthening programs for the wrist extensors and ergonomic modifications for sport or occupational tasks, DN may enhance both symptomatic relief and functional recovery, accelerating return to sport or activity without exacerbating tendon load.

3.3 Rotator Cuff–Related Shoulder Pain

Shoulder pain related to rotator cuff dysfunction is common among overhead athletes (for example volleyball, baseball, swimming). Trigger points in the infraspinatus, supraspinatus, and posterior deltoid can contribute to scapular dyskinesis, restricted range of motion (ROM), and nocturnal pain. Clinical trials show that DN of these muscles improves shoulder ROM, reduces pain intensity, and enhances activation patterns in the rotator cuff and scapular stabilizers [18, 19]. By normalizing SEA and restoring sarcomere function, DN facilitates recruitment of previously inhibited motor units. This improves dynamic stability of the glenohumeral joint and enhances proprioceptive feedback, which is critical for injury prevention in overhead athletes. Dry needling reaches its peak effectiveness when applied as a part of extensive rehabilitation protocol that includes scapular stabilization, rotator cuff strengthening, and kinetic chain retraining. Early integration of DN may accelerate time to return to sport and optimize shoulder mechanics, potentially reducing the risk of recurrent injuries.

3.4 Hamstring Strain and Return to Sport

Hamstring injuries are widespread in sports requiring sprinting, sudden acceleration, and deceleration, with recurrence rates reported between 12–31%. MTrPs in the hamstring group contribute to pain, altered muscle firing patterns, and protective inhibition. DN performed during the subacute phase of rehabilitation improves flexibility, reduces protective muscle guarding, and enhances eccentric strength recovery. Preliminary studies indicate that athletes receiving DN may return to sport more quickly than those receiving conventional rehabilitation alone [20, 21]. In hamstring injuries, needle stimulation improves local perfusion, decreases SEA, and promotes neuromuscular normalization, supporting optimal muscle function during high-speed contractions. When combined with eccentric strengthening, neuromuscular re-education, and sport-specific drills, it can be a valuable adjunct to reduce reinjury risk and restore full athletic performance. Emerging evidence also suggests that DN may modulate central pain processing, which could decrease fear-avoidance behaviors and facilitate earlier engagement in high-intensity rehabilitation exercises.

3.5 Other Sports-Related Applications

In addition to the commonly studied conditions above, DN has shown utility in managing iliotibial band syndrome, Achilles tendinopathy, plantar fasciitis, and cervical-thoracic overuse syndromes in athletes. For example:

- **Iliotibial band syndrome:** DN targeting gluteus medius and tensor fasciae latae MTrPs can reduce lateral knee pain and improve hip mechanics.

- **Achilles tendinopathy:** DN of gastrocnemius and soleus trigger points can enhance calf flexibility, reduce pain, and support progressive loading.

- **Plantar fasciitis:** DN of intrinsic foot and gastrocnemius-soleus MTrPs can decrease heel pain and restore normal gait patterns.

- **Cervical-thoracic overuse syndromes:** DN of upper trapezius, levator scapulae, and rhomboid MTrPs can alleviate tension, improve posture, and optimize scapulothoracic motion in overhead athletes.

Across all applications, multimodal integration with manual therapy, therapeutic exercise, and progressive load management enhances both short - and long-term outcomes, emphasizing that DN is most effective as part of a structured rehabilitation strategy rather than a standalone intervention.

Table 2: Clinical applications of DN in sports medicine - summary.

Condition	**Target Muscles / Tissues**	**Main Clinical Outcomes**	**Evidence Level**
Patellofemoral Pain Syndrome (PFPS)	Vastus medialis, Vastus lateralis	↓ Pain (VAS 2–3 pts), ↑ Function (AKPS), ↑ Quadriceps activation, Improved patellar tracking	RCTs, moderate-high
Lateral Epicondylalgia / “tennis elbow”	Extensor carpi radialis brevis (ECRB)	↓ Pain, ↑ Grip strength, ↓ SEA at motor endplates	Meta-analyses, moderate
Rotator Cuff–Related Shoulder Pain	Infraspinatus, Supraspinatus, Posterior deltoid	↑ ROM, ↓ Nocturnal pain, ↑ Muscle activation, ↓ Scapular dyskinesis	RCTs, moderate

Hamstring Strain	Biceps femoris, Semitendinosus, Semimembranosus	↑ Flexibility, ↓ Muscle guarding, ↑ Eccentric strength, ↓ Return-to-sport time	Pilot studies, low-moderate
Iliotibial Band Syndrome	Gluteus medius, Tensor fasciae latae	↓ Lateral knee pain, ↑ Hip mechanics, ↓ Abnormal gait patterns	Case series / pilot studies, low
Achilles Tendinopathy	Gastrocnemius, Soleus	↓ Pain, ↑ Calf flexibility, ↑ Tolerance to progressive loading	RCTs and case series, low-moderate
Plantar Fasciitis	Intrinsic foot muscles, Gastrocnemius-soleus	↓ Heel pain, ↑ Plantar fascia elasticity, ↑ Gait normalization	Pilot studies, low
Cervical-Thoracic Overuse Syndromes	Upper trapezius, Levator scapulae, Rhomboids	↓ Neck/shoulder pain, ↑ Posture, ↑ Scapulothoracic motion	Case studies / RCTs, low-moderate

4. Safety considerations of dry needling

4.1. Adverse effects

Dry needling is generally considered a safe intervention when performed by adequately trained clinicians following established guidelines. Minor adverse events are common and typically self-limiting, including: post-needling soreness lasting 24–72 hours, bruising at the insertion site due to capillary disruption and mild bleeding and transient local discomfort.

4.2. Complications

Serious complications are rare but can occur, particularly in regions with high-risk anatomy. These include pneumothorax when needling the upper thoracic or shoulder regions, nerve injury due to improper anatomical placement, infection (rare when sterile technique is adhered to).

4.3. Contradictions

Contraindications for DN include local or systemic infection at or near the needle site, bleeding disorders or anticoagulant therapy (relative contraindication), severe needle phobia or inability to tolerate invasive interventions.

Adherence to precise anatomical knowledge, sterile technique, and professional competency is essential to minimize risks [17, 22]. Clinicians should perform a thorough pre-treatment assessment, including patient history, previous musculoskeletal injuries, and potential comorbidities, to ensure safe practice.

5. Integration with exercise-based rehabilitation

While DN can provide rapid analgesia and local tissue modulation, long-term functional improvements depend on active rehabilitation and neuromuscular retraining. Evidence consistently demonstrates that DN is most effective when combined with exercise therapy, manual therapy, and load management strategies. Crucial considerations include:

- **Neuromuscular retraining:** DN reduces SEA and muscle guarding, allowing for optimal recruitment patterns during corrective exercise.

- **Progressive loading:** Restored tissue flexibility and local perfusion facilitate safe introduction of sport-specific loads and resistance training.

- **Biomechanical correction:** DN prepares muscles for improved alignment, posture, and joint kinematics, particularly in the shoulder, knee, and hip regions.

- **Patient engagement:** Rapid pain reduction via DN can enhance adherence to exercise programs and reduce fear-avoidance behaviors.

Contemporary sports medicine guidelines emphasize multimodal management, integrating DN as a catalyst rather than a stand-alone treatment. For example, in patellofemoral pain syndrome, DN is applied to quadriceps MTrPs before targeted strengthening of the vastus medialis obliquus to optimize muscle activation and patellar tracking. Similarly, for rotator cuff injuries, DN precedes scapular stabilization exercises to enhance proprioception and neuromuscular control.

6. Discussion

The available evidence suggests that DN exerts multifactorial effects at peripheral, spinal, and supraspinal levels. At the local level, needling appears to reduce spontaneous electrical activity, influence biochemical mediators associated with nociception, and enhance microcirculation. These changes may partially explain short-term reductions in pain and improvements in range of motion observed in several randomized trials.

At the central level, activation of A-delta afferents and engagement of descending inhibitory pathways provide a plausible neurophysiological framework for DN-induced analgesia. Functional imaging studies indicate modulation of pain-related cortical regions; however, these findings are preliminary and derived from small samples. The extent to which such changes translate into meaningful long-term functional improvements remains uncertain.

Importantly, contextual and nonspecific treatment effects—including patient expectations, therapeutic alliance, and ritual aspects of needling—may also contribute to observed outcomes. Sham-controlled trials demonstrate that while DN often outperforms control conditions, effect sizes are sometimes modest, particularly in chronic pain populations. Therefore, DN should not be interpreted as a standalone corrective intervention but rather as one component within a multimodal rehabilitation strategy.

Across sports-related conditions, the strongest evidence currently supports adjunctive use in patellofemoral pain syndrome, lateral epicondylalgia, rotator cuff-related shoulder pain, and selected muscle strain presentations. Nevertheless, heterogeneity in needle depth, manipulation technique, frequency of sessions, and co-interventions limits direct comparison across studies. Standardization of protocols remains an important research priority.

7. Limitations and Knowledge Gaps:

Several limitations warrant consideration. First, variability in diagnostic criteria for MTrPs introduces potential inconsistency across studies. What is more, standardized protocols regarding needle depth, manipulation technique, frequency, and number of sessions remain underdeveloped. Patient-specific predictors of response, including age, sex, chronicity, and neuromuscular profile, remain not well-characterized. Integration of objective biomarkers, such as electromyography, ultrasound, or molecular assays, could enhance mechanistic understanding and individualized treatment planning. Another problem is that trials demonstrate short to medium-term follow-up only, limiting conclusions regarding sustained performance enhancement or reinjury prevention. Long-term outcomes and reinjury prevention effects require robust, multicenter RCTs. Also, the majority of mechanistic evidence derives from experimental or small-sample studies, underscoring the need for large-scale, multicenter investigations.

Overall, DN should be conceptualized as an adjunctive, neurophysiologically informed intervention that prepares tissues for effective rehabilitation rather than a stand-alone analgesic procedure. Its greatest potential lies in synergistic application with multimodal exercise-based programs, enhancing functional recovery, performance, and long-term musculoskeletal health in athletes

8. Conclusions and Future Directions

Dry needling represents a safe and evidence-supported adjunct in the management of sports-related musculoskeletal disorders. It exerts peripheral and central modulatory effects including biochemical normalization, neuromuscular optimization and activation of descending inhibitory pathways. Integration with structured rehabilitation programs enhances functional outcomes, accelerates return to sport and may reduce recurrence of injury. The strongest evidence amongst sport-related injuries supports its use in patellofemoral pain syndrome, lateral epicondylalgia, rotator cuff-related pain and hamstring strains. Other proposed applications such as iliotibial band syndrome, Achilles tendinopathy, plantar fasciitis and cervical-thoracic overuse syndromes show promise but require further high-quality studies. Future research should focus on standardization of protocols including needle depth manipulation, frequency and session number identification, patient-specific predictors of response, long-term outcomes related to reinjury prevention and sustained performance. The use of objective biomarkers to guide individualized treatment and optimization of multimodal strategies combining dry needling with exercise therapy and load management is crucial. When applied judiciously within individualized rehabilitation programs, dry needling has the potential to enhance pain resolution, restore muscle performance and support safe and efficient return to sport ultimately promoting both short-term recovery and long-term musculoskeletal health.

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