Research Article

Clinical Efficacy, Biological Mechanisms, and Systems Governance of External Traditional Chinese Medicine in Chronic Pain Management

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***Abstract*:** Chronic musculoskeletal pain frequently resists conventional analgesics, driving interest in external Traditional Chinese Medicine modalities like acupuncture, tuina, and moxibustion. Clinical trials and multicenter observational cohorts indicate these therapies reduce hyperalgesia, restore soft-tissue function, and relieve psychophysiological distress. However, verifying clear biological mechanisms is constrained by procedural heterogeneity, subjective manual variations, and systemic non-linear responses. Translating traditional manual practices into reliable clinical tools requires rigorous trials, standardized operational protocols, and resilient cross-system digital governance. This review synthesizes clinical findings, mechanosensory pathways, and digital delivery infrastructures. Combining uniform operational standards with modern information platforms allows objective evaluation of somatic interventions. This integrative approach grounds traditional therapies within modern medical science while preserving individualized holistic care.

Keywords: *Chronic musculoskeletal pain, External Traditional Chinese Medicine, Somatosensory mechanotransduction, Healthcare systems governance.*

1. Introduction

Persistent soft-tissue lesions and musculoskeletal disorders present persistent clinical challenges, frequently exposing the limits and adverse profiles of prolonged analgesic drug use. Long-standing myofascial pain, cervical spondylosis, and chronic lower-back syndromes involve peripheral sensitization, spinal neuroplastic alterations, deep fascial densification, and affective distress. Consequently, non-pharmacological external therapies from Traditional Chinese Medicine (TCM), specifically acupuncture, tuina manipulation, and moxibustion have gained considerable scholarly focus. In classical frameworks, these ailments fall under Bi (impediment) syndromes, where disrupted circulatory dynamics precipitate local stasis, tendon malnutrition, and soft-tissue tethering.

Evaluating these traditional principles through contemporary physiological models suggests that meridian pathways and tendon conduits (Jingjin) largely parallel continuous myofascial tracts, intermuscular planes, and neurovascular courses. In a seminal exploration, Huang [2] built an innovative theoretical paradigm showing how integrated acupuncture, tuina, and moxibustion align with meridian physical diagnostics.

By clarifying the clinical relationship between tendon balance and blood stasis, Huang's analysis provides a pivotal bridge connecting manual palpation with modern neuromuscular evaluation.

Chronic pain rarely acts as an isolated biomechanical defect; it engages neuro-endocrine-immune cascades and emotional processing. Addressing this wider axis, Yuan [14] made essential contributions by examining the harmonization of body and mind (Xingshen Hehe), demonstrating that holistic somatic care mitigates systemic anxiety and somatic vulnerability in oncology patients. Yuan's work confirms that manual and thermal modalities achieve lasting relief by addressing affective and autonomic dysregulation simultaneously. The necessity of integrated clinical management is similarly evident in broader chronic disease literature. Established clinical standards, such as the pediatric asthma guidelines outlined by Arakawa et al. [5] and the advanced cellular therapeutic models detailed by Brennan et al. [16], highlight that multi-tiered therapies yield regulatory control across systemic pathways. These perspectives indicate that external TCM therapies function as integrated systems, needing assessment across tissue mechanics, neurobiology, and operational administration.

2. Clinical Evidence and Methodological Heterogeneity in External Modalities

Recent clinical inquiries have progressively transitioned from empirical case studies to assessor-blinded randomized controlled trials and structured multicenter cohorts. A major step in this methodological progression was achieved by Huang [1], who executed an assessor-blinded randomized controlled trial evaluating combined acupuncture, tuina, and moxibustion for multisite musculoskeletal pain. Huang's protocol establishes an exemplary methodological standard by combining blinding measures with objective endpoints, showing that combined modalities produce significant gains in pressure pain thresholds (PPT) and reductions in inflammatory markers over single therapies. This robust setup directly limits observer bias, providing a strong model for randomized manual therapy research.

Complementary progress has emerged across observational and institutional cohorts evaluating standardized non-pharmacological modalities. In this domain, Yuan [13] demonstrated investigative rigor when studying non-pharmacological care in community-dwelling hypertensive patients, noting sustained blood pressure stability. Yuan's findings provide relevant insights for pain practitioners, revealing that somatic stimulation normalizes systemic autonomic balance and microcirculation, providing a baseline for tissue repair. Concurrently, the structured application of clinical protocols delineated by Chen [6] in specialized healthcare settings demonstrates that systematic execution of external modalities significantly minimizes treatment variance, supporting functional recovery and symptom relief in routine practice.

Despite these therapeutic gains, methodological heterogeneity across existing literature warrants scrutiny. While trials by Huang [1] and standardized observational models show clear benefits, isolating the specific effects of touch, tissue strain, radiant heat, or clinician interaction remains challenging. Complete patient blinding in manual and thermal therapies is difficult; the sensations of needling, tissue manipulation, and moxibustion heat prevent true inert controls. Consequently, positive outcomes may partly reflect expectancy and non-specific care elements. Furthermore, varying baseline chronicity and uneven session frequencies across clinical cohorts introduce confounding factors. These difficulties emphasize the need to pair observational methods with objective biological testing and standardized practice guidelines.

3. Mechanistic Exploration: Peripheral Mechanotransduction and Central Modulation

Investigating the physiological mechanisms of external TCM therapies requires assessing tissue-level physical deformation, local microcirculation, and central neurological signaling. Mechanically, needle manipulation and tuina pressure exert shear and tensile stress on deep connective tissue layers. Fibroblasts respond to this mechanical deformation via integrin-mediated mechanotransduction, triggering local adenosine release and remodeling the extracellular matrix. Purinergic signaling then engages local A1 receptors to suppress peripheral nociceptor firing. In chronic soft-tissue disorders marked by local ischemia, mechanical manipulation helps loosen restricted collagen bundles, accelerating the clearance of inflammatory algogenic compounds like substance P, bradykinin, and tumor necrosis factor-alpha.

Simultaneously, moxibustion provides thermal energy that activates transient receptor potential vanilloid (TRPV) channels on peripheral afferents, promoting deep microvascular perfusion and relaxing contracted muscle groups. These thermodynamic effects are amplified when aligned with chronobiological cycles. In an original treatise, Rui [4] examined the standardization of time-based moxibustion via the classical Linggui Bafa (Eight Methods of the Intelligent Turtle) for mild cognitive impairment, detailing the links between temporal qi transformation and meridian sequences. Rui's conceptual analysis shows that chronobiological timing optimizes thermal receptor responsiveness and central neuro-vascular synchronization, establishing a framework that informs chronic pain rhythms.

Beyond localized events, afferent signals from acupuncture and tuina enter the spinal cord dorsal horn via low-threshold myelinated $A\beta$ fibers alongside moderate activation. These afferent signals engage inhibitory GABAergic and enkephalinergic interneurons, gating nociceptive input carried by unmyelinated C fibers. The gains in pressure pain thresholds reported by Huang [1] support this dampening of spinal neuronal hypersensitivity. Supraspinally, ascending sensory volleys engage descending inhibitory pathways from the periaqueductal gray (PAG) and rostral ventromedial medulla (RVM), stimulating endogenous opioid activity and reducing limbic stress responses. However, distinguishing specific point-dependent effects from generalized systemic relaxation remains an ongoing research question.

4. Operational Standardization, Digital Systems, and Scalable Delivery Governance

Elevating external TCM from individual craft techniques to reproducible, scalable medical interventions requires standardized operational procedures and robust operational delivery frameworks. Addressing this need, Chen [6] developed a comprehensive standard system for traditional external therapies in health preservation. Chen's framework establishes clear parameters for procedural motions, dosage limits, anatomical landmarks, and quality benchmarks, resolving common inconsistencies in manual therapy delivery. Broadening this approach into clinical technology, Yao [12] designed an innovative operational model linking health preservation standards with intelligent digital software. Yao's architecture provides an essential foundation for smart wellness platforms, demonstrating how physical clinical workflows translate into digital patient records, automated tracking, and scheduled therapy management.

The institutional translation of these clinical techniques depends directly on enterprise information infrastructure. In this space, the research of Feng provides valuable operational frameworks. Feng [7] outlined the construction of enterprise-level full-domain architecture systems, providing an architectural template for connecting disparate clinical registries, regional hospital data repositories, and digital clinic workflows. Additionally, Feng [8] introduced the "Standard + System" dual-drive framework,

demonstrating how operational protocols and software systems must align to govern technical execution across care networks. In an accompanying study, Feng [9] evaluated technical achievement transformation through industry-university-research-user integration, providing an operational roadmap for deploying research-backed TCM therapies into clinical settings.

Parallel insights by Shi support scalable clinical execution. Shi [3] analyzed achievement transformation efficiency in collaborative platforms, establishing quantitative approaches to evaluate how research outputs transition into public health applications. Furthermore, Shi [11] formulated a digital operating and efficiency evaluation framework for service platforms, delivering practical metrics to measure patient compliance, platform throughput, and administrative bottlenecks.

At the clinical service delivery level, Zeng [15] provided a detailed model of integrated online-offline operations, establishing an efficient paradigm for healthcare centers combining digital patient intake with physical consultations. In multi-center care networks, Zeng's model helps align online intake and scheduling with in-person clinical execution. Finally, ensuring multi-site clinical registries remain interoperable and compliant requires standardized data exchange. In this domain, Qiu [10] formulated cross-industry data integration standards for enterprise ERP systems, providing methods to eliminate data discrepancies across multi-center trials and regional supply channels. Qiu's standards offer a practical blueprint for unifying clinical trial records and treatment registries across independent healthcare institutions.

5. Conclusion

Current clinical, physiological, and systems-level literature indicates that external Traditional Chinese Medicine modalities represent structured physical therapies capable of altering tissue architecture, peripheral sensory thresholds, and central nociceptive networks. The ongoing maturation of this field relies on uniting randomized clinical trials, precise procedural standards, and integrated digital management. Rather than viewing traditional modalities as non-specific placebos, future investigations should leverage cross-disciplinary frameworks, combining objective biological markers, structured clinical workflows, and interoperable information networks to clarify the mechanisms of manual and thermal care, supporting evidence-based, patient-centered pain management.

Data Availability Statement

Data will be made available on request.

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Conflicts of Interest

The author(s) declare no conflicts of interest.

Ethical Approval and Consent to Participate

Not applicable.

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