



# Thermal Hydrotherapy in Musculoskeletal Rehabilitation: Clinical Relevance, Mechanisms, and Future Perspectives

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## Opinion

Thermal hydrotherapy represents a long-standing non-pharmacological intervention in the management of musculoskeletal disorders; however, its role in contemporary rehabilitation remains underrecognized and insufficiently integrated into evidence-based clinical pathways. In the context of the growing global burden of chronic musculoskeletal conditions and increasing concerns regarding long-term pharmacological management, there is a pressing need to re-evaluate therapeutic strategies that are both effective and sustainable. Within this framework, hydrotherapy emerges as a clinically relevant, low-risk intervention that aligns with modern principles of integrative and patient-centered care [1,2].

The therapeutic effects of hydrotherapy are inherently multidimensional, involving a complex interplay of thermal, mechanical, and neuroendocrine-immunomodulatory mechanisms. Warm water immersion (34-36°C) induces peripheral vasodilation, enhances tissue perfusion, and reduces neuromuscular excitability, leading to muscle relaxation, decreased pain, and improved tissue compliance. At the same time, the mechanical properties of water—particularly buoyancy, hydrostatic pressure, and viscosity—reduce joint loading, facilitate movement, and support low-impact strengthening, thereby enabling patients to engage in rehabilitation with reduced discomfort and facilitating early mobilization and functional rehabilitation in clinical practice.

In addition, hydrotherapy appears to enhance endogenous analgesic mechanisms and support tissue recovery. Improvements in pain perception and functional capacity are likely mediated through combined peripheral and central mechanisms, including

reduced nociceptive input and improved patient engagement in physical activity. These biological and functional effects create a therapeutic environment conducive to rehabilitation and long-term disease management.

Clinically, these mechanisms translate into meaningful outcomes. Evidence from Cochrane systematic reviews supports the use of balneotherapy and aquatic exercise in musculoskeletal disorders, demonstrating modest but clinically relevant improvements in pain and functional status, particularly in osteoarthritis and chronic low back pain [3,4]. Importantly, the favorable safety profile of hydrotherapy and its ability to facilitate participation in exercise-based rehabilitation strengthen its role as a valuable adjunct within multidisciplinary treatment strategies.

Beyond these clinical effects, hydrotherapy appears to exert systemic neuroendocrine and immunomodulatory influences. Evidence suggests modulation of stress-related pathways, with reductions in physiological stress markers and improvements in overall well-being. At the molecular level, hydrotherapy has been associated with downregulation of pro-inflammatory cytokines, including interleukin (IL)-1 $\beta$ , IL-6, and tumor necrosis factor-alpha (TNF- $\alpha$ ), alongside increased levels of anti-inflammatory mediators such as IL-10 and transforming growth factor-beta (TGF- $\beta$ ) [5]. These changes contribute to attenuation of inflammation and modulation of pain in chronic musculoskeletal conditions.

Despite this evidence, hydrotherapy remains underrepresented in clinical guidelines. This may be attributed to variability in treatment protocols, lack of standardization, and heterogeneity across

studies, which limit direct comparability and broader clinical implementation. Furthermore, uncertainty persists regarding optimal treatment duration and frequency, although available evidence suggests that structured and repeated interventions may yield greater clinical benefit.

These findings are consistent with current literature on non-pharmacological interventions in musculoskeletal rehabilitation.

In conclusion, thermal hydrotherapy appears to exert therapeutic effects through integrated thermal, mechanical, and immunomodulatory pathways, supported by both mechanistic rationale and clinical evidence. Its incorporation into modern rehabilitation programs may enhance patient outcomes and support more holistic, non-pharmacological approaches to musculoskeletal care. Further research is warranted to strengthen the evidence base and optimize treatment protocols.

## Acknowledgment

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## Conflict of Interest

None.

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