Climate Change and Musculoskeletal Health: Implications for Rehabilitation Medicine

Ahmad J. Abdulsalam[1], *Farooq Azam Rathore[2], Levent Özçakar[3]

Abstract

The relationship between climate change and human health has become increasingly clear as global temperatures rises. The cardiovascular and pulmonary consequences of extreme weather events have been well researched and documented in the literature. However, the effects of climate change on MSK health are not well understood. This mini- review explores the complex relationship between MSK health and climate change particularly global warming. It highlights the emerging challenges for rehabilitation medicine due to the climate change and suggests adaptive approaches to clinical practice. The mechanisms linking environmental factors and MSK health are multifactorial and intricate. Temperature extremes can disrupt tissue physiology, while severe weather events may result in trauma and limit access to healthcare services. In addition, exposure to poor air quality has been associated with the exacerbation of inflammatory MSK conditions.

Vulnerable populations including elderly adults, outdoor workers, and those with pre-existing MSK disorders face increased risks from climate changes. Climate-resilient rehabilitation services using telemedicine, mobile units, and environmental monitoring can be important considerations. Further research is suggested to establish evidence-based guidelines for climate-adaptive rehabilitation protocols.

Keywords: Environmental health, extreme weather, heat stress, rehabilitation protocols, telerehabilitation, inflammatory arthritis

DOI: https://doi.org/10.47391/JPMA.26-41

Introduction

Due to the rapid and unprecedented climate changes in the planet in the last few decades, the human body is being increasingly exposed to new environmental hazards. The World Health Organization estimates that climate change will result in an additional 250,000 fatalities annually between 2030 and 2050.[1] However, the specific impact of climate change on musculoskeletal (MSK) health is not well documented in medical literature. As rehabilitation professionals, we must recognize and address the environmental factors that directly impact and functional outcomes and particularly MSK health in our patients.

The interconnection between climate and MSK health can be understood through four primary pathways:

1. Direct thermal effects that can alter tissue physiology.
2. Indirect consequences of extreme weather on incidence of trauma and damage to rehabilitation infrastructure.
3. Socioeconomic disruptions that affect access to essential rehabilitation care.
4. Environmental stressors that influence and amplify chronic pain conditions.

Recognizing these mechanisms is important for developing effective intervention strategies and proactively preparing healthcare systems for anticipated clinical and infrastructural challenges.

Temperature Extremes and MSK Tissues

Temperature extremes are becoming more frequent due to global warming and significantly impact MSK tissues. Elevated temperatures can alter muscle contractility, joint viscosity, and connective tissue characteristics. It potentially increases the risk of injury.[2] Exercise tolerance is a key component of MSK rehabilitation and can be compromised by heat. Dehydration from extreme heat waves impairs tissue healing and recovery processes.

In contrast, the rise in extreme cold events in certain regions presents additional challenges. Exposure to cold increases incidence of soft tissue injuries, decreases joint range of motion, and increases muscle stiffness.[2,3] Temperature variations exacerbate symptoms in patients with chronic conditions such as rheumatoid arthritis and fibromyalgia, complicating treatment plans and functional assessments.[2,3]

[1]Department of Physical Medicine and Rehabilitation, Mubarak Alkabeer Hospital, Kuwait; [2]Department of Rehabilitation Medicine, Quetta Institute of Medical Sciences, Quetta, Pakistan; [3]Department of Physical and Rehabilitation Medicine, Hacettepe University Medical School, Ankara, Turkey.

Correspondence: Farooq Azam Rathore. e-mail: farooqrathore@gmail.com
ORCID ID: 0000-0002-4759-0453

Extreme Weather Events and Access to Rehabilitation Services

The rising frequency and severity of extreme weather events, including floods, wildfires, and hurricanes, cause both acute and chronic MSK health problems. Beyond direct trauma-related injuries, natural disasters can have significant long-term effects on MSK health by destroying infrastructure, straining healthcare systems, and displacing populations.[4]

Rehabilitation facilities in post-disaster settings often face disruptions that cause long-term disability and functional deterioration. Overuse injuries and MSK pain syndromes increase during disaster recovery efforts, particularly among individuals unprepared for such physical exertion. Psychological strain from climate-related catastrophes may amplify pain perception and hinder adherence to treatment.[5]

Healthcare systems must plan to develop climate-resilient rehabilitation services, including mobile units, telemedicine, and disaster-responsive treatment protocols. Telerehabilitation using digital health has demonstrated significant promise. It can reduce chronic MSK pain and improve quality of life while potentially mitigating climate-related access barriers.[6] The conventional facility-based rehabilitation model may be inadequate in an era of rapid climate change and infrastructure risk.[7]

Air Quality and Inflammatory Pathways

Air pollution from wildfires, dust storms, and elevated ground-level ozone concentrations worsens the ongoing climate change challenge. Research demonstrates that air pollution triggers systemic inflammatory pathways affecting MSK health.[8] Exposure to airborne particulate matter correlates with elevated systemic inflammation markers and can MSK conditions including fibromyalgia and rheumatoid arthritis.[8]

Poor air quality also poses practical challenges for rehabilitation professionals who recommend outdoor exercise regimens routinely for multiple therapeutic reasons. Air quality concerns must be balanced against traditional rehabilitation advice to engage in regular physical activity, requiring alternative treatment planning that incorporates environmental considerations.

Impact of Climate Change on Vulnerable Populations

Climate change poses significant risks to specific populations. Elderly adults are already vulnerable to heat-related complications and may experience rapid functional decline during extreme weather.[9] Children and adolescents participating in outdoor sports face increased injury risks due to heat stress and altered playing conditions.

Occupational groups with high MSK injury incidence, such as construction workers, agricultural labourers, and outdoor workers, face climate related hazards as extreme heat exposure rises. These populations require tailored preventative programmes and adjusted work practices to preserve MSK health.[10]

Individuals with pre-existing MSK disorders are particularly vulnerable to climate change. People with limited mobility face additional hardships during extreme weather, while those with chronic pain may experience symptom exacerbations related to temperature and air pressure variations.

Adaptive Strategies for Rehabilitation Practice

Addressing the relationship between climate change and MSK health requires innovative clinical approaches. Treatment plans must incorporate environmental factors, with interventions modified based on weather changes and air quality. Rehabilitation centres should invest in climate-controlled spaces to optimize therapeutic outcomes and ensure patient safety during severe weather events

Technology enhanced rehabilitation, including virtual reality systems and remote monitoring equipment, can maintain treatment continuity when traditional in-person care becomes difficult.[11] Telemedicine platforms designed for MSK assessment and treatment guidance can address care shortages during climate-related events.

Climate adaptation methods must be integrated into standard injury prevention guidelines. This includes educating patients about heat-related illness prevention, proper hydration during outdoor activities, indoor exercise alternatives, and early warning signs of temperature-related MSK problems.

Addressing Disparity: Climate Change and Rehabilitation in Low Resourced Areas

Pakistan and other many other Low- and Middle-Income Countries (LMICs) face disproportionately severe impact of climate change due to geographic vulnerability, underdeveloped healthcare infrastructure, and existing socioeconomic constraints.

- **Acute Crisis Impact:** Severe monsoon rains, intensified by climate change, have led to catastrophic flooding across Pakistan.[14] These events have killed hundreds of people, displaced millions, and resulted in damages exceeding $30 billion. In addition, prolonged heat waves, and recurrent poor air quality crises[15] can directly compromise MSK health outcomes and disrupt ongoing rehabilitation. The infrastructural damage because of these climate change disasters can create access barriers

for those requiring mobility and rehabilitation services.

- **Cost-Effective Solutions:** In the LMIC settings, the implementation of large scale, climate resilient rehabilitation services can be particularly challenging. However, telerehabilitation and mobile health solutions can offer a cost-effective, decentralized alternatives to traditional facility-based rehabilitation care. The establishment of Community-Based Rehabilitation programmes, which incorporate climate adaptation and disaster-responsive strategies, can be an option to improve access to rehabilitation services while building local capacity and resilience.
- **Rehabilitation Medicine Leadership:** Rehabilitation professionals in Pakistan and similar LMIC should incorporate specialized training in climate-adaptive rehabilitation protocols during training. They should develop context-appropriate treatment guidelines, and advocate for policies supporting resilient healthcare infrastructure. International collaboration and cross border knowledge sharing are necessary to develop evidence-based approaches that are tailored to the unique complexities and challenges of LMIC contexts

Conclusion and The Way Forward

The connection between MSK health and global warming is not a future projection, but an urgent issue that requires immediate attention from the rehabilitation community. To preserve and optimize human function and mobility, the rehabilitation professionals community must proactively integrate climate adaptation strategies into established clinical protocols to mitigate the adverse effects of environmental change on MSK health. There is a need for further research to accurately quantify the climate-related MSK illness burden globally and within LMIC settings. It is necessary to develop evidence based environmental criteria for safe therapeutic physical activity (e.g., specific heat/air quality indices that mandate exercise modification). We need to validate and establish the efficacy of novel climate adaptive rehabilitation interventions such as Virtual reality-enhanced home programmes and condition-specific telerehabilitation protocols.

Although, some recent systematic reviews have found mixed results regarding the direct link between general weather patterns and chronic MSK pain,[12,13] the catastrophic impacts of extreme weather events and chronic air quality degradation are undeniable stressors on both tissue physiology and care infrastructure.

The path forward requires interdisciplinary cooperation, innovative therapeutic strategies, and a commitment to understanding how our evolving planet impacts patient care. By recognizing and proactively addressing these challenges, we can preserve the effectiveness and quality of MSK care during unprecedented environmental change. The time to act is now, adapting rehabilitation treatment to the reality of a warming planet is important to ensuring our patients' long term wellbeing.

References

1. World Health Organization. Climate change and health. Geneva: WHO Press; 2021.
2. Périard JD, Racinais S, Sawka MN. Adaptations and mechanisms of human heat acclimation: applications for competitive athletes and sports. Scand J Med Sci Sports. 2015;25:20-38.
3. Castellani JW, Young AJ. Human physiological responses to cold exposure: acute thermal stress responses and acclimatization to prolonged exposure. Autonomic Neuroscience. 2016;6:a025742.
4. Goldmann E, Galea S. Mental health consequences of disasters. Annu Rev Public Health. 2014;35:169-183.
5. Fernandez A, Black J, Jones M, Wilson L, Salvador-Carulla L, Astell-Burt T, Black D. Flooding and mental health: a systematic mapping review. PLoS One. 2015;10:e0119929.
6. Jang S, Lee B, Lee E, Kim J, Lee JI, Lim JY, Hwang JH, Jang S. A Systematic Review and Meta-Analysis of the Effects of Rehabilitation Using Digital Healthcare on MSK Pain and Quality of Life. J Pain Res. 2023;16:1877-1894.
7. Patel DJ, Cowen-Bradbeer R, Greig CA, McEachin S, Nadeau K, Kakkad K, Kizer KW. Climate change and health through the lens of physical medicine and rehabilitation: A scoping review. PM R. 2024;16:675-690.
8. Chuang KJ, Chan CC, Su TC, Lee CT, Tang CS. The effect of urban air pollution on inflammation, oxidative stress, coagulation, and autonomic dysfunction in young adults. Am J Respir Crit Care Med. 2007;176:370-376.
9. Gronlund CJ, Zanobetti A, Schwartz JD, Wellenius GA, O'Neill MS. Heat, heat waves, and hospital admissions among the elderly in the United States, 1992-2006. Environ Health Perspect. 2014;122:1187-1192.
10. Jacklitsch B, Williams WJ, Musolin K, et al. NIOSH criteria for a recommended standard: occupational exposure to heat and hot environments. Cincinnati: National Institute for Occupational Safety and Health; 2016.
11. Laver KE, Lange B, George S, Deutsch JE, Saposnik G, Crotty M. Virtual reality for stroke rehabilitation. Cochrane Database Syst Rev. 2017;11:CD008349.
12. Ferreira ML, Hunter DJ, Fu A, Raihana S, Urquhart D, Ferreira PH. Come rain or shine: Is weather a risk factor for MSK pain? A systematic review with meta-analysis of case-crossover studies. Semin Arthritis Rheum. 2024;65:152392.
13. Beukenhorst AL, Schultz DM, McBeth J, Sergeant JC, Dixon WG. Are weather conditions associated with chronic MSK pain? Review of results and methodologies. Pain. 2020;161:668-683.
14. World Weather Attribution. Climate change likely intensified heavy monsoon rain in Pakistan. 2025. Available from: https://www.worldweatherattribution.org/climate-change-likely-intensified-heavy-monsoon-rain-in-pakistan-exacerbating-urban-floods-that-impacted-highly-exposed-communities/ Accessed 18th Oct 2025
15. Iram S, Qaisar I, Shabbir R, Pomee MS, Schmidt M, Hertig E. Impact of air pollution and smog on human health in Pakistan: a systematic review. Environments. 2025;12:46. doi:10.3390/environments12020046.