ORIGINAL RESEARCH PAPER

Primary Care Medicine

THE UNRESOLVED DEBATE: A SYSTEMATIC REVIEW ON WEATHER VARIABILITY AND MUSCULOSKELETAL PAIN

KEY WORDS: pain, musculoskeletal pain, pain perception, weather variability, temperature, cold weather

Joana Reis* USF Caminhos do Cértoma, Portugal. *Corresponding Author

Rita Pinto USF Salvador Lordelo, Portugal.

Laura Sousa USF Tiago de Almeida, Portugal.

ABSTRACT

The relationship between weather changes and musculoskeletal pain has been widely debated, but the evidence remains inconsistent. This systematic review aimed to critically synthesize the available studies, identifying methodological weaknesses and knowledge gaps. A comprehensive search was conducted in PubMed, Scopus, Web of Science, Embase, and Cochrane Library, including observational studies and clinical trials published in the last 15 years. The methodological quality of the studies was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies and the Cochrane Risk of Bias Tool for clinical trials. Data extraction and analysis followed PRISMA guidelines, and a meta-analysis was performed when appropriate. The review revealed significant methodological heterogeneity among studies, making definitive conclusions difficult. A lack of consensus on the effects of temperature and humidity on chronic pain was evident, with some studies demonstrating significant associations, while others found no correlation. Factors such as the psychological impact of weather and the challenge of isolating meteorological variables were often overlooked. Additionally, the absence of robust meta-analyses limited the generalizability of findings. This systematic review highlights the need for studies with more rigorous methodologies, standardized measurement approaches, and analyses that consider multiple interfering factors. A deeper understanding of this relationship may contribute to the development of personalized clinical strategies, improved chronic pain prediction, and evidence-based education for both patients and healthcare professionals.

INTRODUCTION

The relationship between meteorological conditions and musculoskeletal pain has been a subject of scientific interest for decades, yet it remains controversial. Patients with chronic musculoskeletal disorders frequently report symptom fluctuations associated with changes in weather, particularly temperature, humidity, and barometric pressure. However, translating these subjective experiences into consistent empirical evidence has proven challenging.

Recent systematic reviews have attempted to clarify this association. Wang et al. synthesized evidence on osteoarthritis pain and weather parameters, identifying small but statistically significant associations with temperature and barometric pressure, while emphasizing substantial heterogeneity across studies and outcomes [1]. Similarly, Ferreira et al. evaluated case-crossover studies on musculoskeletal pain and weather, concluding that while certain meteorological variables may be associated with pain exacerbation, the overall effects were modest and clinically uncertain [2].

Large-scale observational studies further highlight this inconsistency. This heterogeneity has been reinforced by mechanistic and conceptual analyses proposing that weather-pain relationships are mediated by complex interactions between peripheral nociceptive processes, central sensitization, and psychological factors [3]. Yimer et al. demonstrated that weather sensitivity among patients is more apparent in some subgroups, and even to those sensitive to the weather, the direction of the weather-pain association can differ [4].

Taken together, existing literature suggests that the impact of weather on musculoskeletal pain cannot be explained by a single environmental factor or biological mechanism. Instead, variability in study design, exposure measurement, pain phenotyping, and individual susceptibility continues to limit definitive conclusions. This systematic review aims to critically synthesize current evidence, identify methodological limitations, and highlight key knowledge gaps in the investigation of weather-related musculoskeletal pain.

METHODS

A systematic literature review was conducted following PRISMA guidelines. Searches were performed in PubMed, Scopus, Web of Science, Embase, and the Cochrane Library, targeting studies published within the last 15 years. Eligible studies included observational designs (cross-sectional, cohort, and case-crossover studies) and clinical trials assessing associations between meteorological variables and musculoskeletal pain outcomes.

Methodological quality was assessed using the Newcastle–Ottawa Scale for observational studies and the Cochrane Risk of Bias Tool for clinical trials. Data extraction focused on study population characteristics, weather exposure variables (e.g., temperature, humidity, barometric pressure), pain outcomes, and statistical approaches. Meta-analysis was performed when methodological and outcome homogeneity permitted, as reported in the included systematic reviews and primary studies.

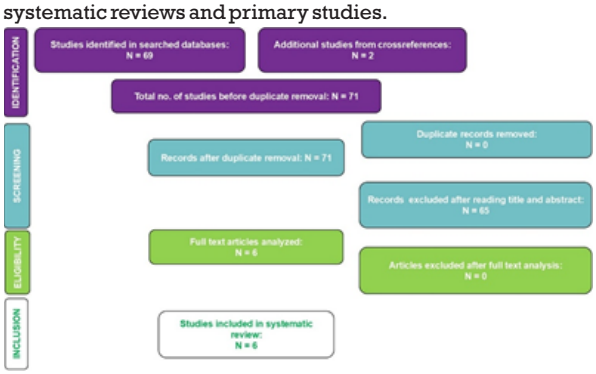

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Figure – 1: PRISMA flow diagram for the article selection process

RESULTS

Across the included literature, substantial heterogeneity was observed in both exposure assessment and outcome measurement. Systematic reviews reported inconsistent associations between temperature and pain intensity, with some studies demonstrating statistically significant effects and others reporting null findings [1,2].

Studies focusing on chronic pain populations revealed pronounced interindividual variability.

Studies focusing on chronic pain populations revealed pronounced interindividual variability. Bayesian and subgroup analyses further supported this heterogeneity, emphasizing that weather-pain associations are not uniform across chronic pain populations [4].

Evidence from specific conditions also varied. Fibromyalgia studies showed weak and inconsistent correlations between pain severity and meteorological variables [6], while population-based research in Finland reported a high prevalence of cold-related musculoskeletal pain, suggesting a potential role of climatic exposure in symptom perception [5].

In contrast, studies on acute low back pain consistently found no meaningful association between weather conditions and pain onset or daily pain intensity [7–9]. These findings were robust across case-crossover and prospective cohort designs, indicating that acute musculoskeletal pain may be less influenced by meteorological factors than chronic conditions.

Table – 1: Results Of The Articles Selected

Author (Year)	Design	Population	Condition	Weather factors	Main findings
Pienimäki (2014)[5]	Cross-sectional survey (n=6.591)	Finnish adults	Cold-related MSK pain	Threshold temperature	High prevalence of cold-induced pain
Steffens (2014)[7]	Case-crossover (n=993)	Patients with acute LBP	Acute LBP	Temp, humidity, pressure, wind	No association; small effect of wind (not clinical)
Duong (2016) [8]	Prospective cohort (n=1.604)	Patients with acute LBP	Acute LBP	Temp, humidity, pressure, precipitation	No associations with pain intensity
Beilken (2017)[9]	Case-crossover (n=981)	Patients with acute LBP	Acute LBP	Temp, humidity, pressure	No significant associations
Fagerlund (2019)[6]	Observational (n=48)	Fibromyalgia patients	Fibromyalgia	Temp, humidity, pressure	Lower pressure & higher humidity associated with more pain
Yimer (2022)[4]	Longitudinal smartphone-based study (n~ 13.000)	Patients with chronic pain	Chronic pain	Temp, relative humidity, pressure, wind speed	Inconsistent associations

Legend: LBP - low back pain; MSK - musculoskeletal; N - number, Temp - temperature

DISCUSSION

The findings of this review highlight the complexity of the relationship between weather conditions and musculoskeletal pain, which cannot be explained by simple meteorological exposure models. Although some studies report statistically significant associations, particularly in chronic pain and osteoarthritis populations, the magnitude of these effects is generally small and highly variable, limiting their clinical relevance for most patients [1,2,4].

Methodological heterogeneity remains a central limitation across the literature. Variability in weather exposure definitions, pain outcome measures, and analytical strategies restrict comparability and weaken causal inference [1,2]. Short observation periods and insufficient adjustment for psychological and behavioral confounders further complicate interpretation, potentially amplifying perceived associations [2,6].

Studies in chronic pain populations consistently demonstrate marked interindividual heterogeneity, with only a subset of patients exhibiting reproducible sensitivity to weather variability [4]. Population-based data from colder climates support the high prevalence of weather-related pain complaints but do not establish causality [5]. These findings align with mechanistic frameworks proposing that weather acts as a contextual modifier of pain perception, influenced by central pain modulation and cognitive-emotional factors rather than as a direct nociceptive trigger [3].

In contrast, evidence from acute low back pain is consistent and robust. Case-crossover and prospective cohort studies show no meaningful influence of weather on pain onset or daily pain intensity [7–9]. These findings challenge common patient beliefs and underscore the importance of evidence-based education to prevent reinforcement of maladaptive pain interpretations. Future research should focus on standardized exposure assessment and analytical approaches that integrate psychological and contextual factors, enabling a more nuanced and individualized understanding of weather–pain interactions and reducing reliance on unsupported explanatory models.

CONCLUSIONS

Current evidence does not support a universal or clinically meaningful association between weather conditions and musculoskeletal pain. While certain individuals with chronic pain may exhibit sensitivity to meteorological changes, large-scale and methodologically robust studies, particularly in acute pain, demonstrate minimal or no effect. Case-crossover and prospective cohort studies consistently show that weather does not influence the onset or severity of acute low back pain.

Similarly, research in fibromyalgia and general populations reveals weak and heterogeneous associations, reinforcing the importance of individual-level analyses. Future research should prioritize standardized exposure measurements, longitudinal designs, and analytical approaches that account for psychological and contextual factors. A more nuanced understanding of weather–pain interactions may support personalized clinical strategies, improve patient education, and reduce reliance on unsupported explanatory models.

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