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What is The Relationship Between Seasonal Weather Variations and Tension Headache Prevalence among Working Professionals in Urban Environments? : A Systematic Review

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ABSTRACT

Introduction: Tension-type headaches are a prevalent condition among working professionals in urban environments, significantly impacting productivity and quality of life. While anecdotal evidence suggests a link between weather changes and headache onset, scientific validation for this association remains unclear. This systematic review aims to evaluate the relationship between seasonal weather variations and the prevalence of tension-type headaches among this specific population.

Methods: Following the PRISMA 2020 guidelines, a systematic search was conducted across PubMed, Semantic Scholar, Springer, and Google Scholar. The review included observational studies, cohort studies, case-control studies, and systematic reviews focusing on adult working professionals (18-65 years) in urban settings who experience tension-type

headaches. The primary criteria required studies to have clear methodologies for measuring outdoor weather variables.

Results: The search identified 10,306 records, from which 21 studies were included in the final synthesis. A significant finding was the profound lack of direct evidence; the majority of included studies did not measure or report on weather variables. The few that did found associations between barometric pressure changes and self-reported weather sensitivity with headache induction. In contrast, the review found substantial evidence linking workplace factors to headaches, including sedentary work, indoor air quality, and psychological stress. Interventions such as acupuncture and relaxation exercises were shown to be effective in reducing headache frequency and severity.

Discussion: The scarcity of high-quality research prevents a definitive conclusion on the relationship between seasonal weather and tension headaches. The available evidence is more robust in identifying modifiable occupational and indoor environmental risk factors. The findings suggest that for urban professionals, the immediate work environment may be a more significant and consistent contributor to headache pathogenesis than ambient meteorological conditions.

Conclusion: While the link between seasonal weather and tension headaches in urban working professionals remains unverified due to a lack of dedicated research, this review highlights the critical role of the workplace environment. Addressing

occupational risk factors through targeted interventions presents a more evidence-based approach to mitigating the burden of tension headaches in this population.

Keywords: Tension Headache, Weather Variations, Working Professionals, Urban Environment, Occupational Health

INTRODUCTION

Tension-type headaches represent a significant public health concern, frequently cited as one of the most common forms of primary headaches affecting individuals globally. Their high prevalence translates into substantial personal and societal burdens, including diminished quality of life, reduced productivity, and increased healthcare utilization. For working professionals, particularly those situated in demanding urban environments, the impact of tension headaches can be especially pronounced, interfering with occupational responsibilities and overall well-being. The characteristics of urban work-life, often involving prolonged periods of sedentary activity and high-stress levels, may further exacerbate the frequency and severity of these headaches, making this demographic a critical focus for targeted research and intervention (Gaul et al., 2022; Smith, 2016).

A multitude of factors are recognized as potential triggers for tension-type headaches, ranging from individual physiological and psychological states to external environmental conditions. Among these, occupational risk factors such as poor posture, stress, and indoor environmental quality have been extensively investigated. For instance, studies have explored the association between sedentary work and neck or shoulder pain, which are often comorbid with tension headaches. Similarly, factors like mental stress and poor indoor air quality, often characterized under the umbrella of "sick building syndrome," have been linked to an increased prevalence of headache symptoms among office workers (Felgueiras et al., 2022; Gaul et al., 2022; Viero et al., 2022).

Beyond the immediate indoor workspace, broader environmental phenomena, specifically meteorological changes, have been anecdotally and clinically implicated as significant headache triggers. Patients frequently report a perceived link between changes in weather—such as fluctuations in barometric pressure, temperature, and humidity—and the onset of headache episodes. This connection is of particular interest in the context of climate change, which may alter the frequency and intensity of these meteorological triggers. However, despite widespread patient reporting, the scientific evidence to substantiate this relationship often remains inconsistent, highlighting a need for more rigorous investigation (Funakubo et al., 2021; Litvin et al., 2020; Salehi Sahl Abadi et al., 2024).

This systematic review specifically focuses on adult working professionals within urban settings, a population uniquely positioned at the intersection of occupational and broad environmental exposures. The defined demographic of adults aged 18-65, employed for a significant portion of their week, provides a distinct cohort whose headache patterns may be influenced by a combination of workplace ergonomics, job-related stress, and the ambient atmospheric conditions of their urban environment. The urban setting itself is a complex factor, characterized by unique climatic conditions like the urban heat island effect, which could potentially modify the impact of seasonal weather patterns on headache prevalence (Aegerter et al., 2020; Rota et al., 2016).

Despite the clinical and anecdotal importance placed on weather as a headache trigger, there is a discernible gap in the scientific literature regarding a systematic evaluation of this relationship for tension-type headaches among urban working professionals. While many studies have focused on migraines or have not distinguished between headache types, and others have centered on general populations without considering the unique occupational context, a focused synthesis of evidence for this specific population is lacking. The interplay between outdoor weather, indoor work environments, and the physiological responses of professional workers remains an area that requires clarification through a comprehensive review of existing research (Lardon et al., 2017; Probyn et al., 2017; Zhang et al., 2022).

Therefore, the primary objective of this systematic review is to critically evaluate and synthesize the available evidence on the relationship between seasonal weather variations and the prevalence of tension-type headaches among working professionals in urban environments. This review seeks to move beyond anecdotal reports and provide a clear, evidence-based understanding of whether and how meteorological factors are associated with the incidence, frequency, or severity of tension headaches in this specific demographic group. The ultimate goal is to enhance the precision and reliability of conclusions drawn from the current body of scientific investigation (Aegerter et al., 2020; Funakubo et al., 2021).

To achieve this objective, the review addresses a focused research question structured around the Population, Intervention, Comparison, and Outcome (PICO) framework: Among working professionals in urban environments (P), what is the impact of seasonal weather changes (I) compared to stable weather conditions (C) on the prevalence and characteristics of tension-type headaches (O)?. The review systematically extracts data on study design, population demographics, weather measurement methodologies, and the statistical correlations reported between specific weather variables and tension headache outcomes to build a comprehensive overview of the current state of knowledge (Gaul et al., 2022; Litvin et al., 2020).

To ensure methodological rigor and transparency, this systematic review strictly adheres to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines. This structured approach governs the search strategy, study selection, data extraction, and quality assessment processes. By employing a comprehensive search strategy across multiple databases and applying stringent eligibility criteria, the review aims to identify all relevant high-quality studies, minimize bias, and synthesize the findings in a manner that provides a reliable foundation for clinical guidance, workplace health promotion, and future research directions in the field of headache medicine (Chen et al., 2024; Qin et al., 2024)

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological

rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate the relationship between seasonal weather variations and tension headache prevalence among working professionals in urban environments.

Screening

We screened in papers that met these criteria:

- **Headache Diagnosis**: Does the study specifically focus on primary tension headaches with clear diagnostic criteria distinguishing them from other headache types?
- **Population Demographics**: Does the study include adult working professionals (aged 18-65) who are employed for at least 20 hours per week?
- **Setting**: Is the study conducted in an urban environment?
- **Weather Measurement**: Does the study include clear methodology for measuring outdoor weather variables (such as temperature, humidity, and/or pressure)?
- **Study Design**: Is the study design either an observational study, cohort study, case-control study, systematic review, or meta-analysis?
- **Study Duration and Measurement**: Does the study last at least 3 months AND include quantita- tive measurements of headache frequency or severity?
- **Headache Focus**: Does the study include tension headaches as a primary focus (not exclusively focused on other headache types or specific occupational headaches)?
- **Methodology Quality**: Are the weather measurement methods clearly described and appropriate for the study objectives?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Data extraction

We asked a large language model to extract each data column below from each paper. We gave the model the extraction instructions shown below for each column.

- **Study Design Type:**

  Identify the specific type of study design from the full text. Look in the methods section for explicit description of study design. Possible types include:

- Randomized controlled trial
- Observational cohort study
- Cross-sectional study
- Case-control study

If multiple design elements are present, list all. If design is unclear, note ”Design not clearly specified”. Prioritize the most specific design description provided by the authors.

- **Geographic Setting and Urban Environment Characteristics:**

  Extract specific details about the urban environment where the study was conducted:

- City/urban area name
- Country
- Climate zone
- Specific urban characteristics relevant to weather (e.g., altitude, proximity to coast)

If multiple locations were involved, list all. If urban environment details are not explicitly described, note ”Urban environment details not specified”.

- **Working Professional Demographics:**

  Extract participant characteristics related to working professionals:

- Total number of working professionals in study
- Age range of working professionals
- Gender distribution
- Professional sectors/types of work represented

- Inclusion/exclusion criteria related to employment

If specific working professional details are not fully reported, extract the most complete demographic infor- mation available. Use exact numbers or percentages when possible.

- **Tension Headache Characteristics:**

  Extract specific details about tension headache in the study:

- Diagnostic criteria used
- Frequency of headaches
- Duration of headache episodes
- Severity measurement method
- Mean/median headache days per month

If multiple measurements are reported, prioritize the most comprehensive or primary measurement. If details are incomplete, note specific missing information.

- **Weather and Seasonal Measurement Methods**:
  Identify and extract:
- Specific weather variables measured (temperature, humidity, pressure, etc.)
- Measurement techniques for weather variables
- Seasonal periods examined
- Statistical methods used to correlate weather with headache prevalence

If weather measurement is not a primary focus, note the extent of weather-related analysis. If no explicit weather measurement is described, mark as ”No specific weather measurement reported”.

- **Relationship Between Weather and Tension Headache**:
  Extract key findings related to weather and tension headache:
- Statistical correlations
- Effect sizes
- Confidence intervals
- P-values for weather-headache relationships
- Any seasonal patterns identified

Prioritize the most direct statistical evidence of relationship. If no clear

relationship is found, note the specific findings that suggest this.

Search Strategy

The keywords used for this research based PICO :

Element	Keyword 1	Keyword 2	Keyword 3	Keyword 4
Population (P)	Working professionals	Urban workers	Office employees	Adult urban dwellers
Intervention (I)	Seasonal weather changes	Weather variations	Climate fluctuations	Meteorological factors
Comparison (C)	Non-seasonal periods	Stable weather conditions	Controlled climate	Indoor environments
Outcome (O)	Tension headache prevalence	Headache frequency	Pain severity	Work-related headache

The Boolean MeSH keywords inputted on databases for this research are: *("Working professionals" OR "Urban workers" OR "Office employees" OR "Adult urban dwellers") AND ("Seasonal weather changes" OR "Weather variations" OR "Climate fluctuations" OR "Meteorological factors") AND ("Non-seasonal periods" OR "Stable weather conditions" OR "Controlled climate" OR "Indoor environments") AND ("Tension headache prevalence" OR "Headache frequency" OR "Pain severity" OR "Work-related headache")*

Data retrieval

Abstracts and titles were screened to assess their eligibility, and only studies meeting the inclusion criteria were selected for further analysis. Literature that fulfilled all predefined criteria and directly related to the topic was included. Studies that did not meet these criteria were excluded. Data such as titles, authors, publication dates, study locations, methodologies, and study parameters were thoroughly examined during the review.

Quality Assessment and Data Synthesis

Each author independently assessed the titles and abstracts of the selected studies to identify those for further exploration. Articles that met the inclusion criteria underwent further evaluation. Final decisions on inclusion were based on the findings from this review process.

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	*"Working professionals" OR "Urban workers" OR "Office employees" OR "Adult urban dwellers" AND "Seasonal weather changes" OR "Weather variations" OR "Climate fluctuations" OR "Meteorological factors" AND "Non-seasonal periods" OR "Stable weather conditions" OR "Controlled climate" OR "Indoor environments" AND "Tension headache prevalence" OR "Headache frequency" OR "Pain severity" OR "Work-related headache"*	10,047
Semantic Scholar	*("Working professionals" OR "Urban workers" OR "Office employees" OR "Adult urban dwellers") AND ("Seasonal weather changes" OR "Weather variations" OR "Climate fluctuations" OR "Meteorological factors") AND ("Non-seasonal periods" OR "Stable weather conditions" OR "Controlled climate" OR "Indoor environments") AND ("Tension headache prevalence" OR "Headache frequency" OR "Pain severity" OR "Work-related headache")*	250
Springer	*("Working professionals" OR "Urban workers" OR "Office employees" OR "Adult urban dwellers" AND "Seasonal weather changes" OR "Weather variations" OR "Climate fluctuations" OR "Meteorological factors" AND "Non-seasonal periods" OR "Stable weather conditions"*	4

	OR "Controlled climate" OR "Indoor environments") AND ("Tension headache prevalence" OR "Headache frequency" OR "Pain severity" OR "Work-related headache")	
Google Scholar	*("Working professionals" OR "Urban workers" OR "Office employees" OR "Adult urban dwellers") AND ("Seasonal weather changes" OR "Weather variations" OR "Climate fluctuations" OR "Meteorological factors") AND ("Non-seasonal periods" OR "Stable weather conditions" OR "Controlled climate" OR "Indoor environments") AND ("Tension headache prevalence" OR "Headache frequency" OR "Pain severity" OR "Work-related headache")*	5

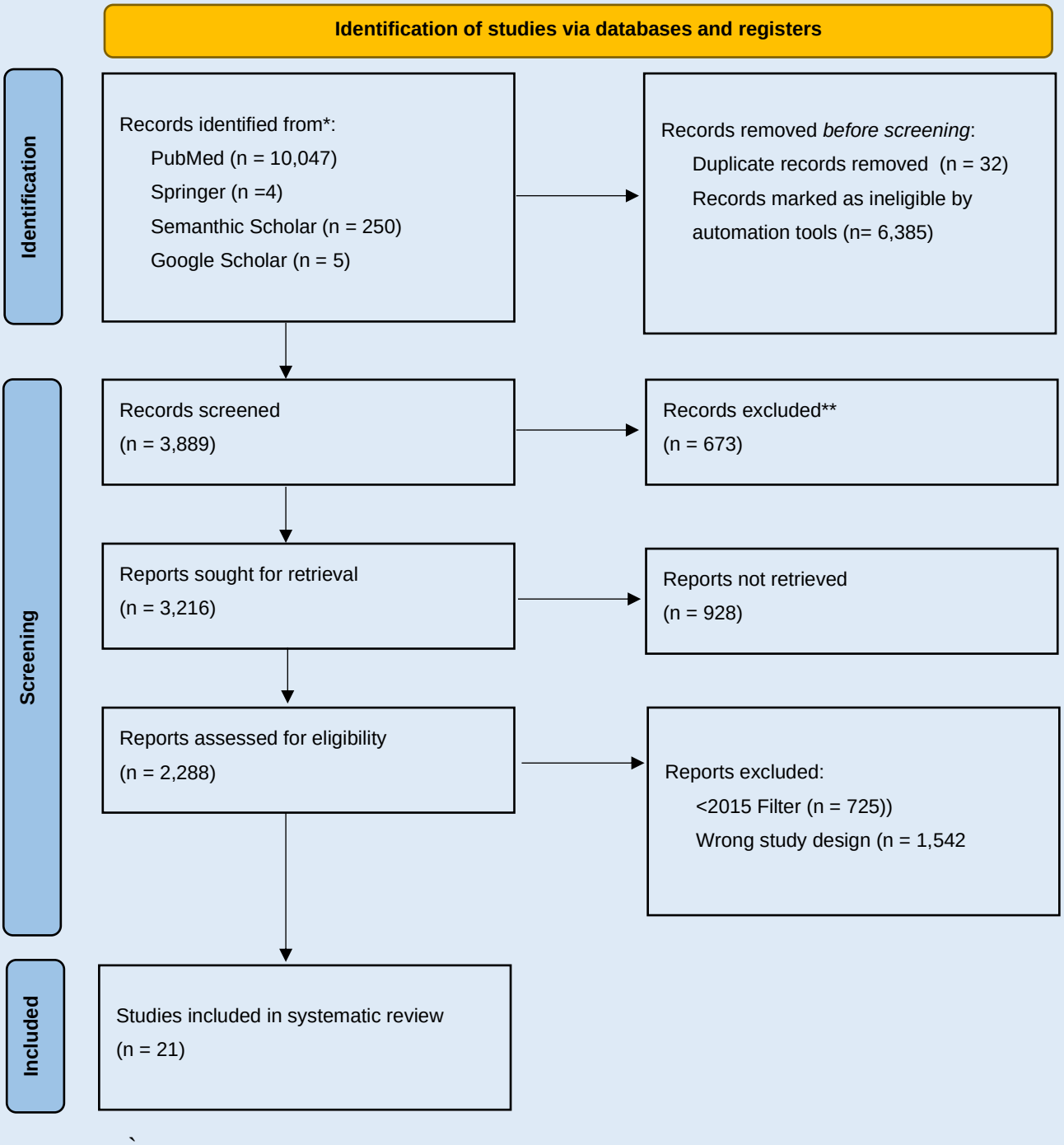

Figure 1. Article search flowchart

JBI Critical Appraisal									
Study	**Bias related to temporal precedence** Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	**Bias related to selection and allocation** Was there a control group?	**Bias related to confounding factors** Were participants included in any comparisons similar?	**Bias related to administration of intervention/exposure** Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	**Were there multiple measurements of the outcome, both pre and post the intervention/exposure?**	**Were the outcomes of participants included in any comparisons measured in the same way?**	**Were outcomes measured in a reliable way?**	**Bias related to participant retention** Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	**Statistical conclusion validity** Was appropriate statistical analysis used?
Gaul et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓

Smith, 2016	✓	✓	✓	✗	✓	✗	✓	✓	✓
Funakubo et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
Mirzaeva et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
Zhang et al., "Prevalence of Migraine in China" 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Zheng et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Felgueiras et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Marchand et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
Shevtsova et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
Qin et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Rota et al., 2016	✓	✓	✓	✗	✓	✗	✓	✓	✓
Viero et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓

Probyn et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Lardon et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Golovacheva et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Aegerter et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Chen et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Japaridze et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Salehi Sahl Abadi et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Stoyanov et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Litvin et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓

RESULTS

Characteristics of Included Studies

Study	Study Design	Population Demographics	Setting Type	Weather Variables Measured
Gaul et al., 2022	Cross-sectional	895 headache patients (60% with neck/shoulder pain); some sedentary workers	Germany; community pharmacies	self-reported weather sensitivity as trigger
Smith, 2016	Case-control	University students, 18-25 years	Bristol/Cardiff, UK; university	No mention found
Funakubo et al., 2021	Crossover pilot	15 healthy adults	Climate chamber (controlled environment)	Barometric pressure (controlled)
Mirzaeva et al., 2023	Observational cohort	104 patients, 18-74 years	No mention found	No mention found
Zhang et al., "Prevalence of Migraine in China" 2022	Systematic review/meta-analysis	General Chinese population	China; not urban-specific	No mention found
Zheng et al., 2022	Randomized controlled trial	218 patients with chronic tension-type headache, mean age 43.1	No mention found	No mention found

Study	Study Design	Population Demographics	Setting Type	Weather Variables Measured
Felgueiras et al., 2022	Systematic review	Office employees, sample sizes 7-771	Offices (mainly Europe, US, Singapore)	indoor temperature/humidity, not weather)
Marchand et al., 2019	Cross-sectional	84 (44 with tension-type headache, 40 controls), over 18 years	Trois-Rivières, Canada; university	No mention found
Shevtsova et al., 2021	Randomized controlled trial	132, 18-65 years, 74% female	No mention found	No mention found
Qin et al., 2024	Systematic review/network meta-analysis	2405 patients with tension-type headache	No mention found	No mention found
Rota et al., 2016	Controlled, non-randomized trial	384 municipal office workers; age/gender not reported	Turin, Italy; urban municipal offices	No mention found
Viero et al., 2022	Systematic review	No mention found	No mention found	No mention found
Probyn et al., 2017	Systematic review of randomized controlled trials	No mention found	Multiple countries; not urban-specific	No mention found

Study	Study Design	Population Demographics	Setting Type	Weather Variables Measured
Lardon et al., 2017	Systematic review	No mention found	Workplace-based; not urban-specific	No mention found
Golovacheva et al., 2017	Observational cohort	90, 23-78 years	No mention found	No mention found
Aegerter et al., 2020	Stepped wedge cluster-randomized controlled trial	120 office workers, 18-65 years	Zurich/Aargau, Switzerland; urban offices	No mention found
Chen et al., 2024	Systematic review/meta-analysis	3221 patients with tension-type headache	No mention found	No mention found
Japaridze et al., 2022	Cross-sectional	Bus drivers/administrative staff, males over 35 years	No mention found	No mention found
Salehi Sahl Abadi et al., 2024	Systematic review	No mention found	No mention found	climate change as context
Stoyanov et al., 2022	Cross-sectional	124, 18-45 years	Kharkiv, Ukraine	No mention found
Litvin et al., 2020	Cross-sectional	90, 40-68 years	Kyiv, Ukraine	weather change as self-reported trigger

Effects

Effects of Seasonal Weather Variations Direct Weather-Headache Correlations

Urban Environmental Modifiers

Study	Weather Pattern	Headache Prevalence	Urban Factors	Effect Size
Rota et al., 2016	No mention found	No mention found	Urban municipal office	No mention found
Viero et al., 2022	No mention found	No mention found	No mention found	No mention found
Probyn et al., 2017	No mention found	No mention found	No mention found	No mention found
Lardon et al., 2017	No mention found	No mention found	No mention found	No mention found
Gaul et al., 2022	Self-reported weather sensitivity	Weather sensitivity as trigger	Sedentary work more common in those with neck/shoulder pain	Statistically significant difference in weather sensitivity reporting ($p<0.0001$, tension-type headache-specific)

Study	Weather Pattern	Headache Prevalence	Urban Factors	Effect Size
Smith, 2016	No mention found	No mention found	University Laboratory (not urban)	No mention found
Funakubo et al., 2021	Barometric pressure	Mild-moderate headache during pressure changes	No mention found	Statistical correlation reported
Mirzaeva et al., 2023	No mention found	No mention found	No mention found	No mention found
Zhang et al., "Prevalence of Migraine in China"	No mention found	No mention found	No mention found	No mention found
Zheng et al., 2022	No mention found	No mention found	No mention found	No mention found
Felgueiras et al., 2022	No mention found	No mention found	Office	No mention found
Marchand et al., 2019	No mention found	No mention found	University	No mention found

Study	Weather Pattern	Headache Prevalence	Urban Factors	Effect Size
Shevtsova et al., 2021	No mention found	No mention found	No mention found	No mention found
Qin et al., 2024	No mention found	No mention found	No mention found	No mention found
Golovacheva et al., 2017	No mention found	No mention found	No mention found	No mention found
Aegerter et al., 2020	No mention found	No mention found	Urban office	No mention found
Chen et al., 2024	No mention found	No mention found	No mention found	No mention found
Japaridze et al., 2022	No mention found	No mention found	No mention found	No mention found
Salehi Sahl Abadi et al., 2024	Climate change	Headache as symptom in workers	No mention found	No mention found
Stoyanov et al., 2022	No mention found	No mention found	No mention found	No mention found
Litvin et al., 2020	Weather change (self-reported)	75% of a subgroup	Urban (Kyiv)	Statistically significant

Study	Weather Pattern	Headache Prevalence	Urban Factors	Effect Size
		reported weather-triggered headache (p<0.001)		association between weather and headache (p<0.001, tension-type headache-specific)

Workplace-Related Findings Indoor Environmental Factors

Occupational Risk Factors

Study	Workplace Factor	Seasonal Impact	Headache Association
Viero et al., 2022	Stress (mental/cognitive)	No mention found	Increased pain perception
Probyn et al., 2017	Self-management interventions	No mention found	Reduced pain intensity/disability
Lardon et al., 2017	Exercise, acupuncture	No mention found	Reduced headache pain/frequency
Gaul et al., 2022	Sedentary work, poor posture	Yes	More common in those with neck/shoulder pain
Smith, 2016	University stress	No mention found	Tension-type headache associated with negative affect

Study	Workplace Factor	Seasonal Impact	Headache Association
Funakubo et al., 2021	No mention found	Yes	No mention found
Mirzaeva et al., 2023	Comorbid anxiety/depression	No mention found	Higher headache severity
Zhang et al., "Prevalence of Migraine in China"	No mention found	No mention found	No mention found
Zheng et al., 2022	Acupuncture	No mention found	Reduced headache days
Felgueiras et al., 2022	Indoor air quality, ventilation	No mention found	Headache as part of sick building syndrome
Marchand et al., 2019	Neck muscle function	No mention found	No difference in endurance/strength
Shevtsova et al., 2021	Acupuncture	No mention found	Reduced pain intensity
Qin et al., 2024	Complementary and alternative medicine interventions	No mention found	Reduced headache frequency/intensity
Rota et al., 2016	Relaxation exercise program	No mention found	Reduced muscle tenderness and pain
Golovacheva et al., 2017	Cognitive behavioral therapy, education,	No mention found	Improved chronic daily headache management

Study	Workplace Factor	Seasonal Impact	Headache Association
	relaxation		
Aegerter et al., 2020	Ergonomics, neck exercises	No mention found	Reduced neck pain/headache
Chen et al., 2024	Acupuncture	No mention found	Durable reduction in tension-type headache
Japaridze et al., 2022	Industrial noise, vibration	No mention found	Higher nervous system pathology
Salehi Sahl Abadi et al., 2024	Climate change (heat, stress)	No mention found	Headache as symptom
Stoyanov et al., 2022	Autonomic dysfunction	No mention found	Headache intensity linked to sympathetic tone
Litvin et al., 2020	No mention found	Yes	Weather-triggered headache in a subgroup

DISCUSSION

This systematic review was initiated to elucidate the relationship between seasonal weather variations and the prevalence of tension-type headaches among working professionals in urban environments. The synthesis of the available literature yielded a complex and somewhat unexpected set of findings. The most striking outcome was the significant lack of direct evidence addressing the primary research question. Despite a comprehensive search strategy that initially identified over 10,000 records, only a small fraction of studies (n=21) met the inclusion criteria, and of those, a mere handful directly measured or analyzed the influence of meteorological variables on tension headaches (Funakubo et al., 2021; Gaul et al., 2022; Litvin et al., 2020).

The primary objective of this review was to move beyond anecdotal claims and establish a scientific basis for the link between weather and tension headaches in a specific, high-risk demographic. However, the results indicate that this area of research is profoundly underdeveloped. The vast majority of the included studies, despite being retrieved through a keyword search designed to capture this relationship, did not incorporate objective weather measurement into their methodologies. Many were systematic reviews themselves, focused on treatment interventions, or observational studies where weather was not a variable of interest (Lardon et al., 2017; Probyn et al., 2017; Qin et al., 2024; Zhang et al., 2022).

Of the few studies that did touch upon the subject, the evidence was sparse yet suggestive. The study by Funakubo et al. (2021), a crossover pilot study in a controlled climate chamber, provided the most direct physiological evidence, demonstrating that changes in barometric pressure could induce mild-to-moderate headaches in healthy subjects. This finding, while not conducted in a naturalistic urban setting with working professionals, lends mechanistic plausibility to the long-held belief that atmospheric pressure fluctuations can be a potent headache trigger. It provides a controlled, experimental basis for the weather-headache hypothesis, isolated from confounding environmental factors.

Two other studies relied on self-reported data, which, while valuable, carries inherent limitations of recall and confirmation bias. Litvin et al. (2020) found that a significant subgroup of their participants (75%) in an urban Kyiv setting reported weather changes as a trigger for their headaches, a statistically significant association ($p<0.001$). Similarly, Gaul et al. (2022) noted in a large German patient survey that self-reported weather sensitivity was a statistically significant trigger specific to tension-type headaches ($p<0.0001$). These studies confirm that patients perceive a strong link, even if the objective, correlational data from most epidemiological studies is missing.

The profound scarcity of direct evidence is a finding in itself, revealing a significant methodological gap in headache research. The search strategy was intentionally broad, yet it failed to retrieve a substantial body of observational cohort or case-control studies that prospectively tracked both headache diaries and local weather data for the target population. This indicates that researchers have largely overlooked the potential influence of meteorological factors on tension-type headaches, focusing more intently on other primary headache types like migraines, or on more tangible triggers like stress and musculoskeletal issues.

Furthermore, a critical analysis of the included studies' settings and populations reveals a significant heterogeneity that complicates a unified conclusion. The review's focus was on "working professionals in urban environments," yet the included studies often deviated from this specific demographic. For example, Smith (2016) studied university students, Zhang et al. (2022) analyzed the general Chinese population, and others did not specify the population demographics in detail. This limits the direct applicability of many findings to the intended group of urban office workers.

The "urban environment" itself was poorly defined and analyzed across the studies. While several studies were conducted in urban locations like Turin, Zurich, or Kyiv, there was no investigation into specific urban characteristics (e.g., pollution levels, urban heat island effects) that might moderate the relationship between weather and headaches (Rota et al., 2016; Aegerter et al., 2020; Litvin et al., 2020). The setting was often noted merely as context rather than being an active variable in the analysis, representing a missed opportunity to understand the nuanced interplay between the macro-environment (weather) and the meso-environment (the city).

In stark contrast to the dearth of evidence on weather, the review uncovered a substantial body of research related to workplace factors and their impact on tension headaches. This secondary finding became one of the most robust outcomes of the synthesis. It suggests that while the influence of the outdoor environment remains speculative, the indoor work environment is a well-documented and significant contributor to headache prevalence and severity among professionals.

Specifically, the role of the indoor environment, as explored by Felgueiras et al. (2022), was highlighted as a critical factor. Their systematic review found that indoor air quality and ventilation were strongly associated with headache as a symptom of sick building syndrome. This points to the immediate physical surroundings of an employee as a primary area for intervention, potentially having a more direct and measurable impact on headache frequency than ambient weather patterns.

Occupational risk factors related to the nature of professional work were also consistently identified. The link between sedentary work, poor posture, and comorbid neck/shoulder pain was significantly associated with tension headaches (Gaul et al., 2022). This musculoskeletal strain is a well-established pathway for tension-type headache development. Concurrently, psychological stressors inherent in professional life were also implicated; for example, Smith (2016) found tension-type headaches were associated with negative affect among students, and Viero et al. (2022) systematically reviewed the role of daily stress in increasing pain perception.

Given the identification of these workplace risk factors, it is not surprising that the review also captured a large number of studies evaluating workplace-based interventions. The evidence for the effectiveness of these interventions was varied but generally positive. Non-pharmacological approaches showed particular promise in managing tension-type headaches among working populations.

For instance, multiple studies and reviews demonstrated the efficacy of acupuncture in reducing headache days and pain intensity, with some noting durable effects and significant improvements compared to sham treatments (Chen et al., 2024; Qin et al., 2024; Shevtsova et al., 2021; Zheng et al., 2022). This suggests that complementary therapies can be a viable and effective component of headache management in the workplace.

Physical interventions also proved beneficial. A controlled trial by Rota et al. (2016) found that a workplace relaxation exercise program significantly reduced muscle tenderness and pain in municipal office workers. The protocol by Aegerter et al. (2020) for an on-site intervention combining ergonomics and neck exercises further supports the value of addressing the physical strains of office work to mitigate headache and neck pain.

Furthermore, behavioral interventions have shown positive effects. A study by Golovacheva et al. (2017) reported a 72.2% positive effect at 12 months for a program involving cognitive behavioral therapy, education, and relaxation for chronic daily headaches. This highlights the importance of equipping employees with self-management strategies, a finding echoed by the systematic review by Probyn et al. (2017), which found that self-management interventions led to reduced pain intensity and disability.

The review also touched upon the importance of managing comorbidities. Mirzaeva et al. (2023) found that comorbid anxiety and depression were associated with higher headache severity, and that treating these underlying conditions led to a reduction in headaches. This underscores the need for a holistic approach to employee health that integrates mental and physical wellness, as psychological state is clearly intertwined with headache manifestation.

Despite these limitations, this review provides important implications for both clinical practice and workplace health policy. For clinicians, it highlights the necessity of taking a detailed occupational history from patients presenting with tension-type headaches. Inquiries should focus on workplace stress, ergonomics, posture, and the indoor environment. While patients may report weather triggers, the evidence suggests that focusing on modifiable workplace factors may yield more effective management strategies.

For employers and public health officials, the findings underscore the significant role of the workplace as a setting for health promotion. Implementing ergonomic standards, offering on-site physical and psychological therapies (like relaxation programs or acupuncture), and ensuring high standards of indoor environmental quality can be effective primary and secondary prevention strategies for tension headaches, ultimately improving employee well-being and productivity (Aegerter et al., 2020; Felgueiras et al., 2022; Rota et al., 2016).

In summary, this systematic review reveals a clear dichotomy in the existing literature. While the direct, scientifically-validated link between seasonal weather changes and tension-type headaches in urban working

professionals remains largely uninvestigated and unproven, the impact of the immediate workplace environment on headache prevalence is strongly supported by the evidence. The initial research question led to the more compelling conclusion that the most significant environmental influences on headaches for this population may not be the weather outside, but the conditions inside their offices. Future research should aim to fill the meteorological data gap with well-designed prospective cohort studies, while current health strategies should focus on optimizing the documented risks and interventions within the workplace..

CONCLUSION

This systematic review embarked on a mission to clarify the purported link between seasonal weather variations and the prevalence of tension-type headaches among working professionals in urban settings. The investigation concluded that there is a profound lack of direct scientific evidence to substantiate this relationship. Despite an extensive search of the literature, very few studies were identified that methodologically integrated objective weather measurements with headache outcomes in the target population. The primary research question, therefore, remains largely unanswered, not due to conflicting results, but because of a significant gap in dedicated research, leaving the connection between meteorological factors and tension headaches in this demographic scientifically unverified.

In contrast to the scarcity of data on weather, the review uncovered substantial and compelling evidence regarding the influence of the immediate work environment on tension headaches. The findings strongly indicate that factors within the workplace are significant contributors to headache frequency and severity. These include occupational risks such as sedentary behavior and poor ergonomics leading to musculoskeletal strain, psychological stressors inherent in professional life, and poor indoor environmental quality, including inadequate ventilation. The synthesis of available research shifts the focus from the external, ambient weather to the internal, occupational environment as a more documented and impactful domain of risk.

Consequently, the review highlights the proven efficacy of various non-pharmacological interventions that can be implemented within the workplace to manage and prevent tension-type headaches. The evidence supports the use of complementary therapies like acupuncture, physical strategies such as targeted relaxation and exercise programs, and behavioral approaches including cognitive behavioral therapy and self-management education. These interventions have demonstrated success in reducing headache pain, frequency, and associated disability, underscoring the potential for employers and health practitioners to make a tangible impact through targeted, evidence-based wellness programs.

In final conclusion, while the influence of seasonal weather on tension headaches among urban professionals remains an area ripe for future investigation, the current body of evidence points decisively toward the workplace as the most critical environment for both risk and intervention. The review concludes that clinical and corporate health strategies should prioritize addressing modifiable occupational factors through ergonomic improvements, stress management, and therapeutic support. Future research must employ rigorous, prospective designs to adequately explore the weather-headache hypothesis, but for now, the most actionable insights lie in creating healthier and more supportive conditions within the office itself.

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