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When Heat Becomes a Risk: The Impact of Heatwaves on Hypertension-A Systematic Review

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Abstract

Introduction: Hypertension is considered one of the most common chronic diseases affecting over 30 % of the population of adults in the world. Also is the most important modifiable risk factor for cardiovascular disease(CVD). Heatwaves, defined as periods of extremely high temperatures lasting at least 2–3 days, pose a growing threat to public health amid climate change. The climate is changing, and simultaneously leading to a higher frequency of extreme weather events, including heatwaves. The impacts of heatwaves on human health and their underlying mechanisms, particularly regarding the cardiovascular system, are well-known. Heatwaves can impact blood pressure and control of hypertension through many different mechanisms. Uncontrolled hypertension or sudden surges in blood pressure may lead to strokes, myocardial infarctions, acute kidney injury, and other conditions that pose a threat to human life and health. This paper aims to review the relationship between heatwaves and hypertension, including incidence, blood pressure variability, and cardiovascular outcomes. **Materials and methods:** A review of selected literature in the PubMed, Scopus, and ScienceDirect for studies published between 1990 and 2026.

Conclusions:

The rise of heatwaves as an increasingly concerning environmental issue that can affect cardiovascular health will contribute to blood pressure regulation. Heat causes vasodilation initially, but there are compensatory mechanisms like dehydration, activation of the sympathetic nervous system, hormonal response which will result in transiently elevated blood pressure and increased risk for cardiovascular events. Particularly at risk are people with hypertension, elderly people, and pregnant women, all of whom may be further impacted by medications and environmental factors. Despite mounting research evidence, the link between heatwaves and the development of hypertension is poorly understood, current literature contains limited heterogeneous data on this topic. Additional research is needed to evaluate whether heatwaves act as a causal or triggering agent to cause dysregulation of blood pressure in order to develop effective public health interventions.

Keywords:

Hypertension, Heatwaves, Blood Pressure, Cardiovascular Risk, Climate Change

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1. INTRODUCTION

Global warming has caused climate change around the world. These changes have led to an increase in various extreme weather events. Global climate change has also resulted in more frequent and more severe heatwaves. Extremely high temperatures, which are becoming increasingly frequent and intense, pose significant risks to human health, particularly the cardiovascular system. As a result of all this, heat waves have become and will continue to be one of the most serious challenges to public health today.

Hypertension is one of the most prevalent chronic conditions worldwide and a major risk factor for cardiovascular disease. Good control of blood pressure is necessary to avoid life-threatening conditions like strokes, heart attack, acute heart failure, pulmonary edema, and damage to the kidneys and eyes. The human body's physiological response to heat is vasodilation, which theoretically should lower blood pressure, but clinical reality is much more complicated. Sudden temperature spikes trigger a series of compensatory reactions—ranging from a rapid increase in heart rate, through disturbances in water and electrolyte balance, to activation of the sympathetic nervous system which can be dangerous, especially in older adults or those with cardiovascular disease. Despite extensive research, the precise mechanisms linking heatwaves to hypertension have yet to be fully elucidated . Understanding how extreme heat affects blood pressure regulation is critical for public health planning and future healthcare spending.

The aim of this review is to summarize the current state of knowledge regarding the relationship between heat waves and their impact on hypertension, including incidence, blood pressure variability, and cardiovascular outcomes.

2. Research Results

2.1. Physiological of human body response to heat stress

Exposure to high temperatures triggers immediate compensatory mechanisms in the body. [1] Under the influence of heat, heart rate increases and blood flow rises, leading to an increased load on the cardiovascular system. [2] The phenomenon of cutaneous vasodilation leads to an increase in cardiac output, forcing the heart to pump blood faster and more intensely. [3] An increase in body core temperature and the resulting loss of blood volume activate the sympathetic nervous system, which aims to maintain blood pressure by increasing heart rate and stroke volume. However, in patients with hypertension, these mechanisms may be impaired due to arterial stiffness and autonomic dysfunction. [4] Prolonged exposure to high temperatures leads to significant fluid loss due to sweating, which can result in hypovolemia and further complications in blood pressure management.

2.2. Atmospheric temperature and blood pressure fluctuation

Studies on the impact of heat waves on blood pressure show that although there is generally a tendency for blood pressure to decrease during the summer months, a paradoxical increase in blood pressure occurs in certain vulnerable groups within the first 48 hours of extreme temperatures. The academic study results showed that during heat waves, the average increase in systolic blood pressure ranged from 3 to 5 mm Hg, while diastolic blood pressure rose by approximately 2 to 4 mm Hg. The study also noted that older adults and those with cardiovascular diseases were most at risk of elevated blood pressure. [5] This increase in blood pressure is likely due to a number of mechanisms, including activation of the sympathetic nervous system and the body's response to stress, which leads to the release of catecholamines and vasoconstriction. [6] This results in a temporary increase in blood pressure, which may raise the risk of complications in older adults and other at-risk groups. After this period, the body usually adapts, leading to a drop in blood pressure. These findings indicate that at risk groups are most vulnerable to heat-related cardiovascular risks.

2.3. Cardiovascular outcomes during heatwaves

Heat waves are clearly linked to a deterioration in cardiovascular health, as confirmed by numerous epidemiological and clinical studies. During periods of high temperatures, there is an increase in the number of deaths related to cardiovascular diseases. [7] Furthermore, during heat waves, there is an increased number of hospitalizations due to heart conditions, such as myocardial infarctions, strokes, and exacerbations of chronic cardiovascular diseases. [8] The scientific literature increasingly emphasizes that hypertension not only increases the risk of acute cardiovascular events during high temperatures but also acts as a mediator of these events. [9] High blood pressure during heat waves can exacerbate vascular

damage, contribute to the development of atherosclerosis, and increase the risk of complications such as strokes and myocardial infarctions. This mechanism works because high temperatures cause an increase in sympathetic nervous system activity, which leads to vasoconstriction and elevated blood pressure, thereby increasing the risk of serious cardiovascular events. [10] The academic literature demonstrates a link between high temperatures and an increased risk of cardiovascular complications, including those resulting from a temporary rise in blood pressure during heat waves.[11] Also in systematic search data confirms that for every 1°C increase above the regional threshold, there is a corresponding rise in hypertension-related hospitalizations.[12][13]

2.4. Pharmacological considerations regarding antihypertensive medications and heatwaves

The management of hypertension during heatwaves requires a nuanced approach, as several commonly used medications may impair thermoregulation.[14] Additionally, diuretics and other antihypertensive drugs may exacerbate dehydration and electrolyte imbalance, further compromising physiological adaptation to heat. These effects may increase the risk of heat-related illness and cardiovascular instability, particularly in vulnerable populations such as the elderly.[15][16] Importantly, medications affecting the renin–angiotensin–aldosterone system may also influence vascular responses to heat, potentially altering peripheral perfusion and impairing heat dissipation. Otherwise, polypharmacy, which is common among patients with hypertension, can lead to cumulative effects that significantly reduce the body's ability to maintain thermal homeostasis. Clinical management during heatwaves should therefore include careful monitoring of blood pressure, hydration status, and renal function, as well as consideration of temporary medication adjustments in high-risk patients. Patient education is equally essential, particularly regarding adequate fluid intake and early recognition of heat-related symptoms. Overall, individualized treatment strategies are critical to minimizing adverse outcomes during periods of extreme heat. [17]

2.5. The Impact of HeatWaves on Hypertension and Physical Activity

There are no direct studies linking the effects of heat waves to hypertension in physically active individuals. A small experimental study found that individuals with hypertension exhibit an altered thermoregulatory response during recovery from physical exercise in high-temperature conditions. Compared to healthy individuals, patients with hypertension exhibited greater heat exchange, suggesting more intense heat dissipation mechanisms, such as increased sweating and cutaneous blood flow. At the same time, this indicates a greater burden on the cardiovascular system during the return to equilibrium after exercise. The authors of this study suggest that altered thermoregulation in individuals with hypertension may increase the risk of hemodynamic disturbances and overheating in high-temperature conditions, particularly during or after physical activity. [18]

2.6. Can heat-waves cause new-onset hypertension?

A study was conducted to assess the impact of heat waves on hypertension and examining its spatial heterogeneity showed that exposure to heat waves increased the risk of hypertension by 9.7% (odds ratio (OR) = 1.097, 95% CI = 1.016–1.185, $p = 0.018$). GWLR models revealed a significantly higher risk of hypertension in southern China compared with

northern regions, with OR values ranging from 1.027 to 1.120. [19] The conclusions of this study are that a significant association was found between spatial heterogeneity in heat wave exposure and an increased risk of hypertension in both healthy and older adults. This may imply that greater attention should be paid to targeted public health interventions, particularly for populations at risk from heat waves.

2.7. Pregnancy, exposure to heat waves and the risk of pregnancy-induced hypertension

In the era of advancing climate change, extreme heat events, including heat waves, are becoming a significant determinant of public health. Pregnant women constitute a particularly high-risk group, as their circulatory and thermoregulatory homeostasis is subject to physiological stress. Epidemiological data and meta-analyses indicate a direct link between exposure to high ambient temperatures and an increased incidence of hypertensive disorders of pregnancy (HDP), including gestational hypertension and preeclampsia.[20] Exposure to heat waves induces oxidative stress and an inflammatory response, leading to the release of anti-angiogenic factors and endothelial dysfunction, which increases vascular resistance and promotes the development of hypertension. At the same time, under conditions of hyperthermia, there is increased cutaneous vasodilation and redistribution of blood flow, which may lead to placental hypoperfusion. [21]Placental hypoxia activates compensatory mechanisms, including the sympathetic nervous system, causing an increase in blood pressure. Additionally, heat waves promote dehydration and electrolyte imbalances, which lead to activation of the renin–angiotensin–aldosterone system. Increased angiotensin II activity intensifies vasoconstriction and sodium retention, which further exacerbates the development of hypertension. Collectively, these mechanisms indicate a significant impact of heat stress on blood pressure regulation during pregnancy.[22]

2.8. Populations Vulnerable to Heat-Induced Hypertension

Exposure to heatwaves disproportionately affects specific people groups, particularly those with increased cardiovascular vulnerability. Among these, elderly individuals represent the most extensively studied and consistently identified high-risk group. Age-related impairments in thermoregulation, reduced sweat gland function, and diminished cardiovascular reserve contribute to an increased susceptibility to heat stress and blood pressure instability.[23]Epidemiological studies have demonstrated that older adults experience significantly higher rates of heat-related morbidity and mortality, especially in the presence of pre-existing hypertension. Pregnant women also represent a particularly sensitive population. Physiological changes during pregnancy, including increased blood volume and altered vascular tone, may interact with heat stress to disrupt hemodynamic stability. [16]. Patients with established hypertension constitute another key vulnerable group. Chronic vascular dysfunction, reduced arterial compliance, and impaired endothelial function limit their ability to adapt to thermal stress. Heat exposure in these individuals has been associated with increased blood pressure variability and a higher risk of acute cardiovascular events. Additionally, antihypertensive medications, such as diuretics and beta-blockers, may exacerbate dehydration or impair thermoregulatory responses, further increasing vulnerability during heatwaves .[24] Overall, current evidence indicates that vulnerability to heatwaves hypertension is

multifactorial, involving an interplay between biological susceptibility, comorbidities, pharmacological treatment, and environmental exposure. Identification of these high-risk groups is essential for targeted prevention strategies in the context of increasing global temperatures.

3. Summary and Conclusion

Heatwaves represent an increasingly important environmental determinant of cardiovascular health, with significant implications for blood pressure regulation and hypertension. The relationship between heat exposure and blood pressure is complex, involving acute physiological responses, compensatory mechanisms and interactions with pre-existing chronic disease and pharmacological treatment of them. While heat exposure may initially promote vasodilation, compensatory processes such as sympathetic activation, dehydration and hormonal changes can lead to fleeting increases in blood pressure and heightened cardiovascular risk. Topical evidence indicates that patients with hypertension, the elderly people and pregnant women are particularly vulnerable to the adverse effects of heatwaves. Likewise, antihypertensive medications and environmental factors may further modify and endanger individual susceptibility. Despite growing interest in researchers' and also amount of evidence linking heatwaves to cardiovascular risk, the relationship between extreme heat exposure and the development of hypertension remains insufficiently understood. Academic current literature is limited by methodological heterogeneity also because of a lack of long-term cohort data and inconsistent physiological findings. Future research should focus on standardized exposure definitions and longitudinal designs to clarify whether heatwaves act as a causal factor or a trigger of underlying blood pressure dysregulation. In the context of ongoing climate change, understanding the interaction between heatwaves and hypertension is essential for effective public health planning. Future research should focus on long-term research and personalized risk assessment and also the development of targeted prevention strategies to mitigate the cardiovascular burden associated with extreme heat.

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Supplementary Materials:

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