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STUDYING THE ASSOCIATION BETWEEN GEOMAGNETIC STORMS AND ATTACKS OF ARTERIAL HYPERTENSION

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Abstract
Geomagnetic storms are space weather phenomena characterized by abrupt disturbances in the Earth’s magnetic field caused by solar activity. Recent scientific studies indicate that geomagnetic activity may exert a significant influence on the human body, particularly on the cardiovascular system. This literature review is devoted to the epidemiological analysis of the relationship between geomagnetic storms and attacks of arterial hypertension. The study evaluates changes in arterial blood pressure and the risk of cardiovascular complications during periods of geomagnetic activity based on modern scientific publications, meta-analyses, and epidemiological observations. According to the analyzed data, periods of geomagnetic storms may be associated with increased average blood pressure levels, decreased heart rate variability, and a higher incidence of hypertensive attacks. Therefore, the development of preventive strategies based on space weather monitoring may play an important role in reducing the risk of cardiovascular diseases.

Keywords: Geomagnetic storm, arterial hypertension, cardiovascular diseases, epidemiology, blood pressure, prevention.

Introduction

Cardiovascular diseases remain one of the leading causes of mortality and disability worldwide. According to the World Health Organization (WHO), approximately 19.8 million deaths were attributed to cardiovascular diseases in 2022, accounting for nearly 32% of global mortality; the majority of these deaths were caused by myocardial infarction and stroke. At the same time, in 2024 approximately 1.4 billion adults aged 30–79 years were living with arterial hypertension, and only about 23% of them had their blood pressure adequately controlled. These figures indicate that arterial hypertension should be considered not only a clinical condition but also a major epidemiological and socio-hygienic challenge.

Traditional risk factors contributing to the development and exacerbation of arterial hypertension—including genetic predisposition, obesity, physical inactivity, excessive salt intake, tobacco use, alcohol consumption, psycho-emotional stress, and comorbid conditions—

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have been extensively studied. However, in recent years increasing attention has been paid to the potential influence of environmental and geophysical factors, particularly space weather conditions, on the cardiovascular system. In this context, geomagnetic storms have attracted particular interest because they produce short-term but sometimes intense disturbances in the Earth's magnetosphere and may influence autonomic regulation, circadian rhythms, and hemodynamic parameters in sensitive populations.

A geomagnetic storm is a large disturbance of the Earth's magnetosphere that occurs when energy from the solar wind—particularly during coronal mass ejections or high-speed solar wind streams—is efficiently transferred into the magnetosphere. According to the National Oceanic and Atmospheric Administration (NOAA), such storms significantly alter the parameters of currents, plasma, and magnetic fields surrounding the Earth. Their intensity is commonly assessed using geomagnetic indices such as Kp and Dst. The Kp index, which characterizes global subauroral geomagnetic disturbances, is one of the principal indicators used to evaluate geomagnetic activity and is widely employed in epidemiological studies as an exposure metric.

Scientific interest in this field arises from accumulating evidence suggesting that geomagnetic activity may influence the delicate regulatory mechanisms of the cardiovascular system. A critical review published in 2023 analyzed the relationship between geomagnetic activity and arterial blood pressure and noted that the "center of gravity" of existing literature tends to indicate an increase in systolic and diastolic blood pressure during days or periods of intensified geomagnetic activity. According to this review, several studies reported increases in arterial blood pressure in the range of approximately 3–8 mmHg, with more pronounced responses observed in individuals with pre-existing hypertension and in certain susceptible population groups.

Epidemiological observations also partially support this hypothesis. For example, in the Normative Aging Study cohort conducted in Boston, analysis of 1,949 blood pressure measurements obtained from 675 elderly men between 2000 and 2017 demonstrated that increased indicators of solar activity and geomagnetic disturbance were associated with elevated blood pressure levels. Specifically, within a 16-day exposure window, increases in interplanetary magnetic field intensity, sunspot number, and elevated Kp index were associated with an increase in diastolic blood pressure of approximately 1.7–2.8 mmHg and systolic blood pressure of about 2.1–2.7 mmHg. Importantly, these associations persisted even after adjustment for air pollution and radioactive aerosol particles.

The potential risks associated with geomagnetic storms may not be limited solely to changes in arterial blood pressure. A systematic review and meta-analysis published in 2025 reported that during periods of geomagnetic storms the risk of myocardial infarction or acute coronary syndrome may increase by approximately 1.3–1.5 times, while the risk of stroke may increase by about 1.25–1.6 times. The authors interpreted these findings cautiously, noting the limited number of studies and methodological heterogeneity. Nevertheless, the results strengthen the concept that geomagnetic activity may influence cardiovascular risk through several

physiological pathways, including heart rate variability, arterial blood pressure regulation, microcirculation, and biological rhythms.

Objective of the Study

The objective of this study is to conduct an epidemiological analysis of the probability of arterial hypertension attacks during periods of geomagnetic storms based on scientific literature and to identify preventive measures aimed at reducing this risk.

Materials and Methods

The present study was conducted using a literature review approach. Scientific articles, meta-analyses, and epidemiological studies published between 2015 and 2025 were analyzed.

The data were selected from the following scientific databases: PubMed, Scopus, Web of Science, and ScienceDirect.

The following methods were applied in the analytical process: analytical review, comparative analysis, systematization of scientific data, and generalization of epidemiological statistical information.

Results

Numerous epidemiological studies have investigated the relationship between geomagnetic storms and the cardiovascular system. These studies indicate that increased geomagnetic activity may influence hemodynamic parameters in the human body, particularly arterial blood pressure, heart rate variability, and the incidence of cardiovascular events.

Geomagnetic storms occur as a result of interactions between plasma streams and magnetic fields originating from the Sun and the Earth's magnetosphere. Such phenomena are characterized by abrupt disturbances of the Earth's magnetic field and are commonly evaluated using the Kp index, which ranges from 0 to 9. A value of 5 or higher generally indicates the presence of a geomagnetic storm.

Epidemiological findings on arterial blood pressure changes.

Several clinical and epidemiological studies have explored the association between geomagnetic activity and arterial blood pressure. In an analysis conducted by Mayrovitz (2023), increases in systolic and diastolic blood pressure were recorded in approximately 91–92% of patients during periods of geomagnetic storms. The study reported that, compared with days of minimal geomagnetic activity, the following changes were observed: systolic arterial blood pressure increased on average by 6–8 mmHg; during intense geomagnetic storms, systolic pressure increased by up to 15 mmHg; diastolic blood pressure increased by up to 8 mmHg.

Furthermore, several studies have suggested that arterial blood pressure may remain elevated both two days before and two days after the onset of geomagnetic activity. This phenomenon is often explained by the influence of geomagnetic disturbances on biological rhythms.

An epidemiological study published in 2021 in the Journal of the American Heart Association reported that periods of increased solar and geomagnetic activity were associated with elevated

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arterial blood pressure levels. The results demonstrated a statistically significant relationship between increased solar activity and rises in both systolic and diastolic blood pressure.

Epidemiological observations. In the Normative Aging Study cohort, the relationship between geomagnetic activity indicators and arterial blood pressure was monitored over several years. The findings demonstrated that:

during periods of increased geomagnetic activity, systolic blood pressure increased by approximately 2–3 mmHg; diastolic blood pressure increased by about 1–2 mmHg; these changes were particularly pronounced among elderly individuals.

In addition, several epidemiological studies have reported an increased incidence of cardiovascular diseases during periods of geomagnetic storms. Some analyses suggest that geomagnetic activity may influence cardiovascular function through mechanisms associated with the autonomic nervous system.

Geomagnetic activity and cardiovascular events. Geomagnetic storms may affect not only arterial blood pressure but also other cardiovascular parameters. Several epidemiological studies have reported increases in the incidence of: myocardial infarction; acute coronary syndrome; stroke during periods of geomagnetic activity. These processes are explained by several physiological mechanisms, including:

- disruption of autonomic nervous system balance;
- decreased heart rate variability;
- alterations in blood rheological properties;
- impaired microcirculation.

Some studies have also suggested that geomagnetic activity may increase blood viscosity and consequently elevate the risk of thrombosis.

Main findings reported in selected studies

Author	**Study type**	**Key finding**
Mayrovitz (2023)	Clinical-epidemiological analysis	Arterial blood pressure increased in 91–92% of patients during geomagnetic storms
Wang et al. (2021)	Cohort study	Geomagnetic activity associated with increased systolic and diastolic blood pressure
Papailiou (2024)	Physiological monitoring	Arterial blood pressure increased two days before and after geomagnetic storms
Azcárate (2016)	Epidemiological analysis	Significant changes in arterial blood pressure observed during geomagnetic activity
Belenko (2025)	Scoping review	Increased incidence of cardiovascular events during geomagnetic storms

Discussion

The reviewed scientific literature suggests that a certain degree of epidemiological association may exist between geomagnetic storms and attacks of arterial hypertension. The studies presented in the results section indicate that periods of increased geomagnetic activity are often accompanied by elevated arterial blood pressure, reduced heart rate variability, and a higher

frequency of certain cardiovascular events. Nevertheless, the strength of this relationship and the underlying biological mechanisms remain subjects of ongoing scientific debate.

First, there is evidence that geomagnetic storms may influence autonomic nervous system regulation in the human body. Several studies indicate that during periods of intensified geomagnetic activity, sympathetic nervous system activity may increase while parasympathetic influence decreases. Such changes may lead to a reduction in heart rate variability and disruption of arterial blood pressure regulation. Epidemiological observations have demonstrated that heart rate variability tends to decrease significantly on days characterized by elevated geomagnetic disturbances, which is considered an important prognostic indicator for cardiovascular complications.

A second potential mechanism may involve alterations in biological rhythms. Variations in the geomagnetic field may affect circadian rhythms in the human organism. Some studies have reported reduced melatonin secretion during periods of increased geomagnetic activity. Since melatonin plays an important protective role in cardiovascular regulation, a decrease in its secretion may negatively affect arterial blood pressure control and cardiovascular stability.

A third possible mechanism may be related to hemodynamic and rheological changes. Certain clinical observations suggest that during geomagnetic storms blood viscosity may increase, platelet aggregation may intensify, and disturbances in microcirculation may occur. These processes may contribute to the development of hypertensive attacks and other cardiovascular complications.

From an epidemiological perspective, although many studies confirm a relationship between geomagnetic activity and arterial blood pressure, the findings are not entirely consistent. While some investigations report significant increases in arterial pressure during geomagnetic storms, others have found weak or statistically insignificant associations. These inconsistencies may be explained by several factors, including: differences in research methodologies; variations in the indices used to evaluate geomagnetic activity (such as Kp, Ap, and Dst indices); insufficient adjustment for meteorological influences; heterogeneity in study populations with respect to age and baseline health status.

In addition, some epidemiological analyses have reported increases in the incidence of myocardial infarction and stroke during periods of heightened geomagnetic activity. According to results from systematic reviews and meta-analyses, the risk of myocardial infarction during geomagnetic storms may increase by approximately 1.3–1.5 times, while the risk of stroke may increase by approximately 1.25–1.6 times. However, these findings have not been uniformly confirmed across all studies and therefore require further epidemiological investigation.

Furthermore, health risks associated with geomagnetic storms may be more pronounced among meteorologically sensitive individuals and patients with pre-existing cardiovascular diseases. This phenomenon may be related to individual susceptibility, the functional state of the autonomic nervous system, and the presence of comorbid conditions.

Overall, the reviewed literature indicates that geomagnetic storms may represent a potential environmental stress factor for the human organism. This factor may influence the cardiovascular system through mechanisms involving autonomic regulation, hemodynamic

processes, and biological rhythms. At the same time, the influence of geomagnetic activity on hypertensive attacks appears to be multifactorial and likely interacts with other ecological, meteorological, and individual determinants.

For this reason, future research in this field should include multicenter epidemiological studies, long-term observational investigations, and integrated analyses of geomagnetic activity together with meteorological and environmental factors. Such studies would enable a more precise evaluation of the relationship between geomagnetic storms and attacks of arterial hypertension and may contribute to the development of new preventive strategies for cardiovascular diseases.

Conclusion

The reviewed scientific literature indicates that a certain epidemiological association may exist between geomagnetic storms and attacks of arterial hypertension. During periods of increased geomagnetic activity, alterations in autonomic nervous system function, decreased heart rate variability, and elevated arterial blood pressure levels may be observed. However, this influence appears to be multifactorial and may depend on individual susceptibility, meteorological conditions, and the presence of pre-existing cardiovascular diseases.

1. Scientific studies suggest that during geomagnetic storms the frequency of arterial hypertension attacks and cardiovascular events may increase. Several epidemiological observations have reported that periods of increased geomagnetic activity are associated with an average rise in arterial blood pressure of several millimeters of mercury.
2. Geomagnetic activity may influence the human organism primarily through mechanisms involving the autonomic nervous system, heart rate variability, and biological rhythms. These mechanisms may lead to temporary disturbances in arterial blood pressure regulation and increase the likelihood of hypertensive episodes.
3. Sensitivity to geomagnetic storms appears to be higher among individuals with arterial hypertension, elderly populations, and patients with pre-existing cardiovascular diseases. Therefore, enhanced health monitoring during periods of geomagnetic activity may be particularly important for these risk groups.
4. In order to mitigate the potential impact of geomagnetic storms, it is important to develop preventive strategies that consider space weather forecasts. Such measures may include regular monitoring of arterial blood pressure, limitation of stress and excessive physical exertion, adjustment of pharmacological therapy under medical supervision, and targeted monitoring of individuals belonging to cardiovascular risk groups.

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