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HUMAN BIOMETEOROLGY WITH BIOTHROP WEATHER CONDITIONS AND METEOROTROPISM IN THE CONTEXT OF HEALTH TOURISM

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Abstract

Human biometeorology as a more specific field of Biometeorology, mainly studies the impact of weather conditions onto life and health of people. Medical meteoropathology, as a part of Human biometeorology, represents an applied scientific discipline that is focused on meteorotropism, that is, the impact of atmospheric conditions onto the course of illness, as well as, the dependence of chronic and epidemic diseases on weather conditions. Weather conditions that cause meteorotropic changes within the organism are closely related to: cerebrovascular, cardiovascular, gastrointestinal, rheumatic, pulmologic, as well as, mental diseases. Meteorotropic diseases and conditions are closely related to biotropic weather conditions that are divided into three areas: weather conditions of warmer periods of the year, weather conditions when maximal temperature is positive and minimal is negative and weather conditions of colder periods of the year. Health tourism in the context of meteoroprofilax is one of the key measures of preventing general, as well as, specific illnesses through a set of treatments, such as air bath, UV-rays, inhalation with negative ions, just to name a few.

Keywords: *biometeorology, meteorotropism, meteoprifilax*

Introduction

Earth's climate is a system that is constantly changing due to various natural factors. Therefore, over the last hundred years, extensive increase in human activity resulted in additional direct impact on climate.

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Temperature, rainfall and other climate elements are changing in complex interactions, as a consequence of alterations in solar radiation on Earth.

The impact of seasonal and meteorological conditions on physical and mental health of people was even studied by the father of medicine Hippocrates (around 400 BC) who in his work titled *On airs, waters and places* states that whoever wants to study medicine in an appropriate way, should initially consider weather seasons and the effects each season has on people.

Weather conditions significantly impact our physical and mental capabilities. While we are younger, we do not feel weather changes so intensely, as we do in our 40s for instance. If we are in a bad mood, if we suffer from insomnia, if we have fatigue that we can't explain or we feel some other discomfort that significantly impacts our daily life, there is a good chance that we are susceptible to influence of meteorological conditions. In fact, frequent and sudden changes in weather have unfavorable impact on overall health state of our organism. Headaches, irritability, pain in bones and joints, high or low blood pressure, worsening of chronic obstructive lung disease and many other problems are frequently due to weather changes reflected in rainfalls, snowfalls or sudden drops in temperatures.

Nowadays, we know that all individuals to some extent react on unfavorable weather conditions. According to some studies, approximately 80% of world population has discomfort related to weather change. Meteorotropism today affects not only older individuals with health issues, but it also affects youngsters of good health, even the children. Studies reveal that under the influence of cosmic radiation and radioactivity in the air, a process of ionization takes place resulting in creation of positive and negative ions. Positive ions have a negative impact on organism and they mainly appear in frontal movement of air, up to 24 hours prior to bad weather. In chronic patents, the initial state of discomfort can be followed by worsening health condition, resulting even in death. On the other hand, negative ions impact our organism in positive ways. They can be found in uncontaminated mountain areas, over the sea and forest regions, given that in urban environments they are easily absorbed by air pollutants.

Biometeorology

Biometeorology is a science that studies the impact of weather and climate on living organisms (humans, animals and plants) and it is a part of meteorology. According to scientific standards, biometeorology is a relatively young science. As a science it developed in the second half of the XX century. Namely, in that period numerous studies confirmed that meteorotropism is not only a psychological, but also a real physiological phenomenon, that is grounded on the laws of physical chemistry and electrophysiology. Research revealed that a wide range of meteorological parameters (that we call weather) have an impact on people and their health. With a weather change, many atmospheric conditions are changing simultaneously, including pressure, temperature, wind, air humidity, electromagnetic field, just to name a few. As a result, the human body needs to adapt to a whole range of new weather conditions in a relatively short period of time (Živanović, 2015).

The impact of weather changes on people

Weather conditions certainly have an impact on organism and psychological state of people. Statistically, most people are affected by shift in temperatures from warm to cold, because most people are physically not prepared so the process of adaptation is rather slow. Unlike chronic patients, who usually face health problems, healthy individuals do not report that they feel discomfort. It is noticed that once people enter the fourth decade of their life, they start to be more sensitive to changes in weather conditions.

Practically speaking, there is no living organism on the planet that is not subject to those factors. Such changes result in a wide range of symptoms and diseases among people. Biometeorology conditions are expressed through ten phases. Reactions of those who are subject to meteoropathy (chronic patients, particularly sensitive individuals) are proportional to the intensity and changes of certain meteorological parameters and weather conditions. Apart from morbidity, these phases have a significant impact on mortality of the general population.

Under the influence of cosmic radiation and the Lenard's effect, in lower atmospheric layers a natural ionization of air happens which is most intensive up to one meter above ground, due to polarized Earth's crust. As a result, positive and negative ions are formed (Kojić, 2008). When

unbound, such ions are called ‘light ions’, and when they are bounded to other particles in the air (such as, air pollutants or smog), then they are called ‘heavy ions’. Positive ions have a negative impact on organism and they mainly appear in frontal movement of air, the greatest problems are felt by those who suffer from meteoropathy. Negative ions have positive effect on health through strengthening serotonin effect, improving mental focus, attention, observation and mood. Instances in which they are particularly pronounced are biotrophic instances (Cvetanović et al., 1988; Jevtić et al., 2005).

Instances in which they are particularly present are biotropic situations. For instance, cerebrovascular diseases occur when there is stagnation of atmospheric pressure, rise of air temperature and decrease in air humidity. On the other hand, cardiovascular diseases are more frequent during cold periods with increase in air humidity, while rheumatic disease worsens as humidity increases, or when there are drops in temperature and decrease in air pressure. Worsening of chronic obstructive diseases is present on cloudy and foggy days and when the humidity increases and relapse of psychiatric illnesses is more common when there are severe weather changes, especially with the appearance of heat weaves. Such weather condition may result in lowering of attention and focus, resulting in increase of traffic accidents.

Lower intensity of sunlight during the cloudy periods also has an impact on health. During days with high levels of sunlight, autonomous nervous system is stimulated and activate, increasing overall physical activity, as well as, psychological sense of good mood. That is because sunlight stimulates chemical changes in synthesis of hormones and transmitters in the brain. In addition, it increases synthesis of epinephrine hormone, which stimulates all physical and psychological functions in the body. Due to this, during cloudy days, the level of these stimulating substances in blood is rather low, resulting in the feeling of sleepiness, dizziness and tiredness (Leung et al., 2008).

If quick and large temperatures variations occur in short time intervals, they can cause numerous physiological changes in human body. Sharp changes in temperatures also affect blood pressure, pH value of blood, capillary permeability in tissue and the presence of swelling. According to results of numerous studies, sudden and swift changes in atmospheric pressure are usually related to migraine attacks. However, some researchers have found that lower atmospheric pressure results in less

migraine attacks. That is, partially caused by shorter intervals of solar radiation, that usually follows intervals of lower atmospheric pressure – which are identified as key mechanisms for initiating migraine attacks. On the other hand, in a study carried in the Canada's Environment and Climate Change center showed that migraine attacks usually occur during days when pressure drops, humidity increases, accompanied with sharp changes in air temperature (Gajić et al., 2011). Finally, in some instances, epidemic outbreaks can be closely related to severe changes in temperatures.

The fundamental idea when analyzing the impact of these phases on out-of-hospital mortality was to determine some optimal amount of weather types, in such manner so that classification is neither simplified, nor too detailed. This way, difficulties when determining immediate classification can be avoided. Through cluster analysis a mutual hierarchical relationship among certain types of weather was determined. Such classification has a time component (chronological) as well. Weather change in some area, in ideal conditions, develops chronologically from the first to the last weather type. Majority of weather types are present throughout the year.

Duration of certain weather types in some geographical area is mostly determined by the general synoptic situation and the development of weather within areas, regions or some other geographical entity. Shift from the existing to the next weather type is usually easy to distinguish, although in some instances it can be imperceptible. Depending on the development of weather conditions in synoptic scales, some weather types can be sustained for longer periods of time, while the others can be literally skipped. Paskota (1994) and Ruml (2005) propose the following possible biometeorogical phases:

1. Cyclone, warm, dry – this weather type is characteristic for the front of the cyclone. Sunny weather dominates, but the weather conditions are moving towards high and medium cloud levels and stronger warm winds from the South are present. Air pressure drops, temperature and relative humidity are dropping as well.
2. Cyclone, warm, humid – the main trait of this weather type are rainfalls from compact and layered clouds. It is relatively warm, with winds from the South, air pressure is dropping, temperature raises or stagnates due to rainfalls and relative humidity increases.
3. Warm front – a couple of hours before and after the warm front weather is cloudy with rainfalls. At the moment of passing front sharp

change in wind direction occurs, temperature raises and relative humidity increases or stagnates.

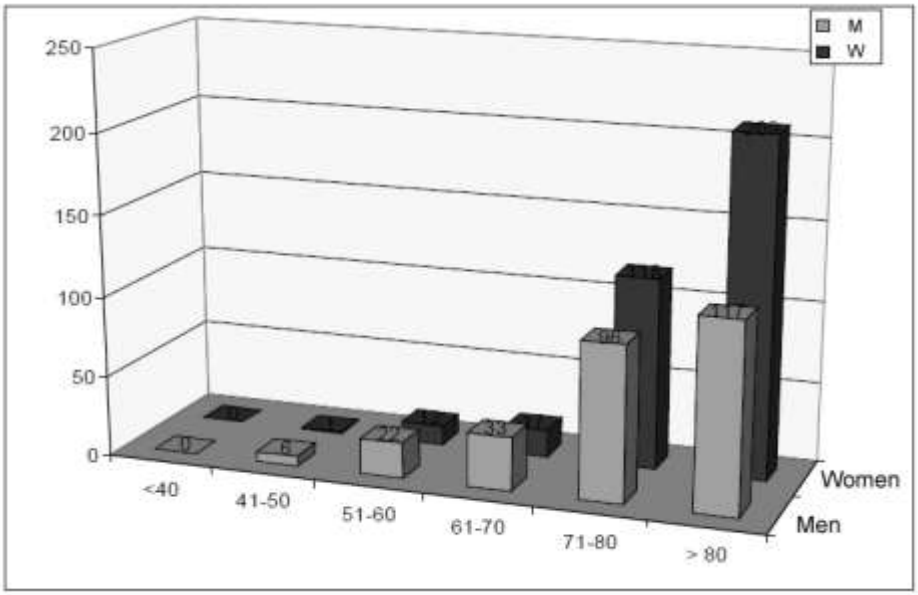
4. Cold front – in the zone of cold front the most tempestuous weather processes takes place in troposphere. Temperature usually sharply drops, air pressure sharply increases, while relative humidity increases due to rainfall, but quickly drops once the precipitation ends. Wind sharply changes direction, while its intensity grows. Heavy rainfall, thunders and strong winds are quite common.
5. Cyclone, cold, humid – if there is enough humidity, showers and thunderstorms develop. On certain occasions, rainfalls can be abundant, lasting longer than usual. Air pressure increases, temperature drops or stagnates, while humidity remians relatively unchanged and drops once the precipitation ends. Winds are stronger and are coming from the North.
6. Cyclone, cold, dry – cloudy weather dominates. Precipitation is possible, but it is usually short in duration and with modest intensity. The main characteristic of this weather type is cloudy and cold weather with seldom rainfalls and tendency of clearing up the sky.
7. Anticyclone, cold, dry – clear skies dominates with weak winds from the North. Air pressure, temperature and humidity remain relatively stable.
8. Anticyclone, cold, humid – if conditions are cold, during the evening and in the mornings there is fog, particularly in the winter period.
9. Anticyclone, warm, dry – clear skies and clam weather are typical for this type of conditions. Temperature is staying relatively stable.
10. Anticyclone, warm, humid – this weather type takes place in the summer. Sunny and warm weather dominates.

Adapting to unfavorable atmospheric conditions

Over the years, mankind has been adapting and getting used to changes in weather and climate. However over the last few decades there is a rapid change in climate conditions, resulting in reduced capacity of human organism to adjust to newly created weather and climate conditions. Most often we speak of global changes in atmosphere, as well as, about people's unhealthy habits. Furthermore, in the last few years we are witnessing that the weather seasons are changing without transition periods, so that daily temperatures can range 15-20°C, in a matter of couple of days. In addition, the way of modern life further distances man from the nature and the way of life that was dominant in the past.

Human organism is nowadays mainly used to closed rooms, so that mechanisms of self-regulation are not 'trained' anymore to react quickly enough to weather changes. Besides this, people that are frequently within air-conditioned rooms often foresee weather reports, as well as the signals that their body is sending them, thus creating addition unnecessary stress to their organism. As far as climate is concerned, some scientists suggest that global warming is not the only responsible factor for generating the 'green-house' effect. Another important factor is related to increase in Sun activity that is occurring recently. If this is true, some individuals could be more sensitive to Sun radiation in a similar manner as to how they they feel biometeorological changes (Gajić et al., 2011; Gajić & Gajić, 2009). Recently, Gajić et al. (2011) conducted a study on the impact of weather conditions through pre-determined biometeorological phases on the overall out-of-hospital mortality. The analysis of gender and age distribution of deceased shows that deaths related to biometeorological changes occurred mainly in females over 80 years of age, and in males between 71 and 80 years of age, as Graph 1 suggests.

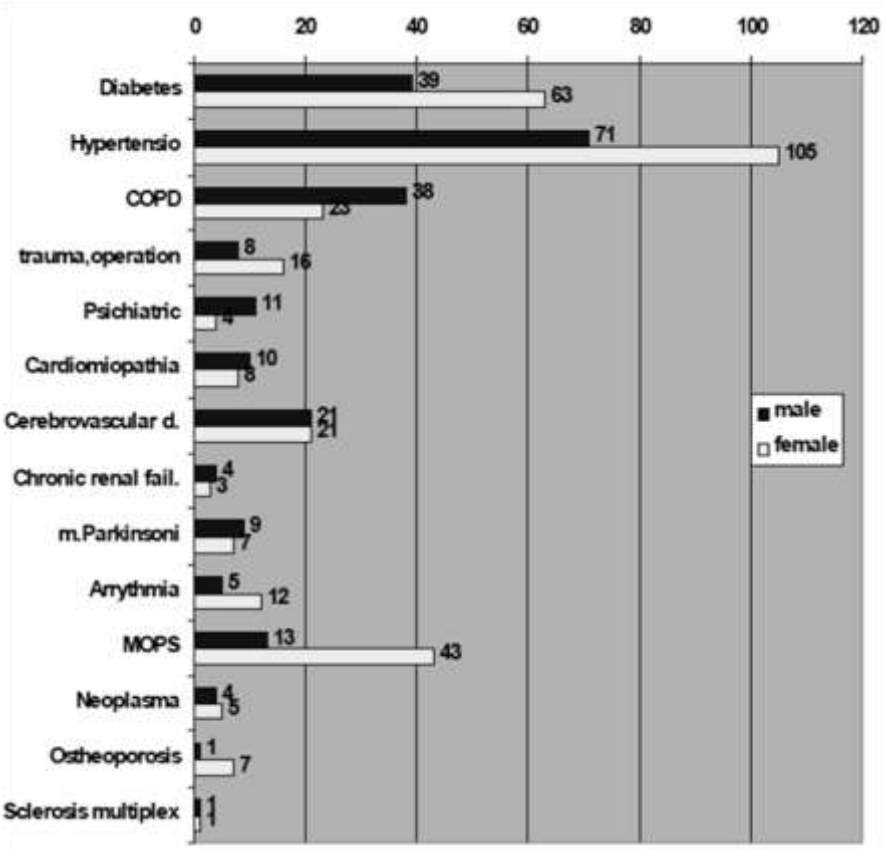
Graph 1: *Gender and age distribution of individuals whose death is related to biometeorological changes*



Source: *Gajić, V., Milojević, D., Smailagić, J., Đonović, N. & Gajić, S. (2011): Biometeorološki uticaj na kardiovaskularni mortalitet. PONS, Volume 8, Number 1, pp. 3-10.*

Apart from the main cause of death, study same study examined co-morbidity that can additionally lead to death outcome as shown in Graph 2. Results revealed that hypertension, which is more prevalent in women than in men, ranked as the most common co-morbidity factor. It is followed by diabetes, which is also more prevalent in women. In addition, analysis showed that besides the main reason of death, women and men with cerebrovascular disease as co-morbidity factor had almost identical level of death outcomes. Particularly interesting was the result that implied that there are three times more deaths in women with organic brain syndrome (OBS) as the co-morbidity factor, compared to men (Gajić et al., 2011; Gajić & Gajić, 2009).

Graph 2: *Distribution of deceased according to co-morbidity by analyzing biometeorological phases*



Source: *Gajić S., Gajić, V., Milojević, D., Smailagić, J. & Đonović, N. (2011): Biometeorološki vremenski uticaj na vanhospitalni mortalitet u gradu Kragujevcu u jednogodišnjem periodu, Naučni časopis urgentne medicine HALO 94, Volume 17, Number 1, pp. 1-12.*

Weather change impacts on humans

Besides having an effect on individual's health, weather conditions also impact mood, behavior and general organism condition of every individual. Each meteorological factor that describes weather (solar radiation, air pressure, temperature, humidity, rain, etc.) has its biological consequences because meteorological changes cause environmental changes as well. An organism receives stimulation from atmosphere through skin, lungs or directly via vegetative nervous system. Humans are capable to adjust to a relative wide range of stimulus from the environment, including atmosphere. Even thoush some individuals are not impacted by weather changes, most people are in fact more or less impacted by such changes.

In general, human organism has the need to maintain stable internal ambiance (body temperature, neurotransmission, physical and chemical balance) which is known as homeostasis. This term includes maintaining constant physiological conditions within cells, which are ensured by enzyme, hormone and neuron mechanisms, enabling normal metabolism, normal use of oxygen from atmosphere, appropriate food intake and normal secretion. In oreder to maintain homeostasis all organ systems are equally engaged, but two complementary regulatory systems stand out – nervous and endocrine.

Each meteorological change inflicts stress on the internal body ambiance and if the organism is not used to such changes the human body reacts by modifications in neuroendocrine system in order to adjust to a new situation. That situation depends on the body's capability to react appropriately. Some individuals don't react at all, while many other react differently to the very same impacts, therefore, resulting in different modifications in homeostasis (Shibasaki et al., 2001; Gregorczuk & Cena, 1967).

Defense mechanisms from unfavorable weather conditions

Organism reacts through a set of defending measures of internal protection (e.g. by increasing body temperature when exposed to cold and reduction in metabolic processes when exposed to heat). We refer to this as adaptation. When these measures enable optimal working setting in new climate conditions, we refer to it as acclimatization. Critical temperature, i.e. the lowest temperature in which the human body can

maintain its normal temperature without increasing metabolism is plus 20°C.

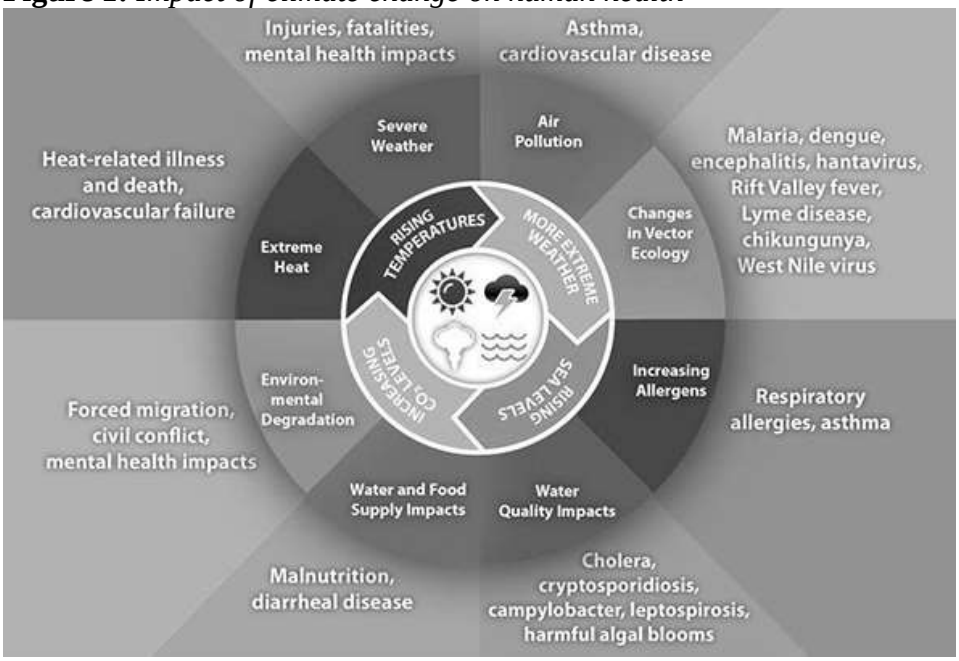
When arriving to warm regions, the adaptation of three days progresses in such a manner that there is increase in pulse and breathing rate, more sweating, decline in systole pressure. Loss of salt can lead to hypoacidity and gastrointestinal discomfort (usually it occurs on the tenth day). As a consequence of lowering pressure, situation can worsen to the level of collapse. Longer daily resting is necessary with moderate Sun exposure and reduced activity.

When adapting to low temperatures, body reacts with higher pulse rates and increased blood pressure, while the breathing is not affected. Harm to human body due to impact low temperatures can occur even when temperatures are above 0 ºC (even up to 13 ºC), because the impact itself depends on other weather parameters, such as humidity for instance. In some colder regions, diet should be protective and more caloric.

Even the old Greeks, 2400 years ago, noticed the impact of 'warm and cold winds' on aches and illnesses, while many testimonials in the XX century speak of people who feel intense pain in amputated parts of their body. The first written trace on the impact of weather conditions on human body was given by Hippocrates, who warns that sick people should particularly pay attention to sharp weather changes. The significance of atmospheric influence on humans is well described in the statement that suggests that an atmosphere is an ocean consisting of air, whose bottom is populated by humans. Evidently, humans are very impacted by the atmosphere and all living organisms are subject to the works of atmospheric phenomena and should adjust to them constantly.

Studies revealed that the most unfavorable weather conditions are cyclones and fronts. Their occurrence can bring changes in certain areas of air mass that have different traits from the air masses that are currently present in that area, leading to changes in temperatures, air pressure, winds, forcing people to adapt to them (Wexler, 2002; Radaković et al. 2007). Furthermore, with the ongoing changes in global climate, a set of new challenges for human health can be expected as the Figure 1 suggests.

Figure 1: *Impact of climate change on human health*



Source: *Patz, J. A., Campbell-Lendrum, D., Holloway, T. & Foley, J. A. (2005): Impact of regional climate change on human health, Nature, Volume 438, Number 7066, pp. 310-317.*

Meteoropathy

Even though the human organism is quite adaptable to changes in atmospheric environment, in the case of severe and large deviations from usual meteorological conditions, the capacity to adapt physiological functions seems to be inappropriate, allowing us to note differences in reactions among healthy and ill individuals. In healthy individuals a physiological stress occurs, but they are able to quickly adapt to atmospheric changes. Chronically ill individuals have a hard time in adapting to atmospheric changes, so the existing difficulties are even more present or the new ones emerge.

People sensitive to weather changes are called meteoropaths. The term itself comes from the Greek word *meteoron* (sky phenomena) and *pathos* (illness). Almost all individuals react to unfavorable weather conditions. Very few individuals feel well in the periods of extremely high or low temperatures or in the case of sharp changes in air pressure. Particularly sensitive are the ones who have weak adaptation mechanisms, including

children and older people. Lower levels of adaptation are also noticed among chronic patients, especially when we speak of meteoropathic disease, that is, illnesses that are susceptible to the impact of weather – including, cardiovacular, rheumatic and lung disease, just to name a few.

The most exposed individuals to meteoropathy are middle aged females, older individuals and chronic patients – in other words, ever third person on the planet. Apart from having an impact on person's health, weather conditions also influence people's mood and behavior. Usually, in sensitive individuals, one to two days prior to weather change, a number of discomforts appear that we can describe as meteoropathy. With the improvement in weather conditions symptoms of meteoropathy weaken or completely disappear (Conrad & Pollak, 1950).

Two major types of meteoropathy are identified (Brooks, 1953). Primary (or basic) metoropathy occurs in healthy persons through change in mood, body weakness or aches during the weather change. On the other hand, secondary meteoropaty happens when some already existing diseases (high blood pressure, heart and lung disease, etc.) worsen as a direct result in weather change. The following symptoms of meteoropathy have been identified (Conrad & Pollak, 1950; Brooks, 1953):

- Physical: tiredness; sharp changes in mood; lower capacity to concentrate, think or coordinate; indifference, irritability, apathy and insomnia; sickness, depression, vertigo, headache, migraine, high or low blood pressure, overall dizziness, tiredness, sleepiness, muscle pain and pain in joints.
- Worsening among healthy patients is manifested through rapid heart work, stronger heart beating, and increase in blood pressure. In heart patients, older individuals and smokers, hearth and brain strokes are more common.
- In individuals who suffer from issues with lungs and bronchia there is a greater chance of asthma or respiratory inflammation.
- Increased frequency of kidney and bile attack, particularly during the night or early in the morning.
- Worsening of gastritis and pain in stomach due to peptic ulcer.

Rheumatism

Patients that suffer from rheumatic issues sense discomfort a couple of days prior to weather change. This is manifested in pain within bones and joints. However, such pain has nothing to do with change in atmospheric

pressure. In fact, it has been proved that before weather change, strong infrared waves are formed and these waves span just prior the weather change with a light of speed, i.e. much faster than clouds and storms. These waves cause changes in scars and joints that have been modified due to rheumatism. These changes are felt by people as pain in their joints (Walker & Littlejohn, 2007).

Cardiovascular diseases

According to many doctors, acute phase of blood vessels disease has an extremely meteorothropic character. In other words, frequent appearance of infarct, stroke and lung emboli is in their opinion closely related to weather conditions. For that reason, weather and meteorological conditions are examined as risk factors in addition to other risk factors already present in the organism (or outside of it) at the moment of acute manifestation of disease. Most frequent risk factors that contribute to acute heart attack include: hypertension, smoking, issues with coagulation, diabetes, obesity, lack of walking, physical stress and lately this list of risks was expanded by weather and metorological conditions. Certainly, weather – even with unfavorable factors – will not lead to heart attack or stroke in healthy individuals. Mechanisms for adaptation to environmental changes, that every healthy person possesses, can successfully combat weather based stress. However, if such mechanisms are damaged by some types of illness, then the adaption to atmospheric changes are determined by various health discomforts resulting in heart attack or stroke among cardiovascular patients, causing death or terminal handicap. Aware of the possibility that weather, among other risks, has an important role in influencing one's health, a number of doctors started to explore the impact of weather on illness such as Tromp (1963).

Lung diseases

Weather conditions in winter days mostly affect older patients, who are suffering from bronchial asthma. Furthermore, unfavorable atmospheric condition can provoke severe asthma attacks. Studies regarding the impact of meteorological factors on emerging of spontaneous pneumothorax based on weather conditions (temperature, atmospheric pressure, air humidity, etc.) found that there are no significant differences in frequency of pneumothorax depending on the values of atmospheric pressure, nor minimum, maximum or average air temperature (Schwarze et al., 1997; Haathela et al, 1990). Maximum daily amplitudes of

temperature and atmospheric pressure in certain weather conditions in days with and without pneumothorax, were not either significantly different.

Conclusion

Human biometeorology as a science that studies all changes in weather conditions that have an impact on health, physical and mental capability of people, plays an important role in meteorology, which studies atmosphere with special focus on weather processes and weather forecasting. These two focuses are of essential importance as an anticipative measure, i.e. prevent the emergence of bad weather effects in existing chronic patients and hamper health of individuals sensitive to weather changes, known as meteoropathy sufferers. Sensitivity to weather conditions, that is, meteorotropism, seen as the dependence of certain state of illness from biotrophic weather conditions can be prevented through adequate types of health tourism.

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