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The Relevance of Bioclimatology to the Health of Airways

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Human beings, as well as other mammals and birds, have the ability to maintain bodily temperature (**homeothermy**) through behavioural and physiological mechanisms of production (**thermogenesis**) or dissipation (**thermolysis**) of heat, evaporative or not evaporative (vasoconstriction, vasodilation, sweating, increase or decrease in the respiratory rate, increase or decrease in metabolism, and so forth). These mechanisms are usually triggered by the capture of sensory information concerning environmental temperature, and they are under strong hypothalamic control. Associated with this homeothermic capability, the distribution of bodily heat is not uniform, being ruled by local needs of specific organs and situations and being related to a centrifugal thermal gradient.

Despite these physiological mechanisms (**fast and slow**) involved in homeothermia, there are environmental temperature tracks where minimal effort is needed to maintain a constant bodily temperature (**thermal comfort zone**). Above and below this thermal comfort zone, critical temperature zones can be reached (**maximum and minimum critical temperature zones**), and there are even lethal temperature zones (**superior and inferior lethal temperature zones**). Despite being able of easily adapting to different conditions, humans suffer influences from these adaptations and from the possible development of physiopathologic processes from these and from other factors that make up their **ambiance**, the so-called **ecobiological factors** (solar radiation and ambient temperature, atmospheric pressure, winds, moisture, and also, markedly, pollution). In the same way that these variations of environmental thermal conditions trigger thermo-regulatory mechanisms involving changes in respiratory frequency, so do variations in humidity, wind, atmospheric pressure, and pollution also induce other organic changes, especially in the **mucociliary system** of the respiratory tract.

The mucociliary system, a rug of ciliated cells covered by a layer of mucus, is extensively distributed throughout the respiratory system and participates actively in the mechanisms of heating, filtering, and humidification of inhaled air and in a local defense-system. Changes in the functioning of this system may cause changes in quality of inhaled air and consequent respiratory dysfunctions of variable intensities, and may facilitate the installation of infectious and inflammatory conditions in the airways. These changes can markedly harm the performance of many other organic functions dependent on the respiratory system.

Included in this context and subjected to these amendments as part of the cycle of life, human beings need this ambiance for survival, and they fully interact with it. The use of the respiratory system, essential to bodily homeostasis and for the development of physical and intellectual activities, is a hallmark of this process of survival. Integrating biology and the atmosphere and having as temporal scale the four seasons of the year or even larger time intervals, **bioclimatology** is precisely the ecological science that studies these relationships between climate and the distribution of creatures on earth. The importance of this subject, already covered by Hippocrates in his treaty *De aëre, aquis et locis*, and of resulting temporary or permanent, positive or negative, light or even fatal biologic changes underlines the intent of this section in demonstrating the important influence of ecobiological factors in functioning of the mucociliary system.

Mucociliary system

The epithelium of the nasal cavities has continuity with that of the paranasal sinuses and ears, and also has continuity with the epithelium of the nasopharynx, oropharynx, and hypopharynx, with specific local characteristics (transitional epithelium). These local features undergo important physiological modifications for the performance of specific functions (e.g. epithelial coverage of the vocal folds, having its continuity through the trachea, bronchi, bronchial tubes and alveoli). At the nasal level, the epithelium is mostly columnar pseudo-stratified, ciliated in 80% of the cells, and the remainder is distributed in non-ciliated cells, basal cells, and goblet cells, in addition to the olfactory epithelium. Widely innervated, it receives olfactory and autonomic fibers, the latter related to the vascular sinusoidal submucosal system, which makes possible volumetric increments in nasal structures such as the nasal turbinates.

Ciliated cells, the largest component of nasal epithelium, have cilia with a vibratory capability with an approximate frequency of 10 Hz to 20 Hz, which produces a movement of mucous film of approximately 1 cm to 2 cm per minute. This mucous film contains seromucous material, exudated plasma, tears, and epithelial and immunocompetent cells, being mainly constituted of water (95%) and organic (3%) and mineral (2%) elements. With a slightly acid pH and a variable thickness between 10 µm and 15 µm, it contains a more fluid layer (sol phase) in continuous contact with the cells/cilia and a denser and more superficial layer (gel phase); its rheological features are dependent on neutral (fucomucin) and acid (sialomucin and sulfomucin) glycoproteins. The presence of albumin, lysozyme, lactoferrin, immunoglobulins, interferon, histamine, prostaglandins, and leukotrienes, among other substances, as well as polymorphonuclears, basophils and other immunocompetent cells, the source of which is the epithelium proper and its submucosal layer, provides the necessary features for a local defense system. This mucous nasal epithelium retains in the nose and pharynx particles which diameter is greater than 10 µm, while particles between 10 µm and 5 µm are diffusely retained in the pathways of other areas on toward the bronchi. The lungs directly receive particles with an average diameter between 5 µm and 2 µm; below this size contact is directly with pulmonary alveoli.

In adequate structural (nasal and ostiomeatal patency) and immunological conditions with a preserved ciliary function and a mucous film in ideal quantity and quality and in the presence of favorable weather conditions, this mucociliary system is able to fulfill its functions of preparing inhaled air, clearing gases, particulates and microorganisms and providing local defense. Numerous unfavorable conditions (local or systemic or caused by external agents) can cause mucociliary dysfunctions with or without clinical manifestations:

- local structural and functional conditions, congenital and/or acquired, such as ciliary dyskinesis, choanal atresia/stenosis, skull and facial dysostoses, naso-sinusal polyposis, benign or malignant tumors, septal deformities and turbinate hypertrophy, trauma, and so on;
- systemic conditions as temporary or permanent immunological dysfunctions, hormonal changes (pregnancy, use of contraceptives), anemia, dehydration, malnutrition, senility, gastro-esophageal reflux and the like;
- exposure to external factors (viruses, fungi, bacteria), allergens (dusty home, fungi, mites, pollen, insects, and such), chemicals and pollution (chlorine, cadmium, sulphur dioxide, carbon monoxide, fluoride, nitrogen, formaldehyde, ozone, volatile organic compounds, particulate matter and ultra-small dust), cigarette and other strong smells, abrupt changes/variations in weather, use of topical irritants (medicines in drops, drugs), and so on.

In this way, mucociliary dysfunctions may occur in degrees of varied intensity and causality, eventually symptomless. As a consequence the nasal mucosa may be considered normal only at a “clinical look” in relation to clinical manifestations; it is difficult to consider it normal under a microscopic view (Mygind and Winther, 1979). This subclinical inflammation may culminate with a corruption of the physiopathological aspects of rhinitis directly influencing its clinical manifestations and the conventional classifications we adopt.

Interaction Between Weather and Climate and the Mucociliary system

Weather is nothing more than a temporary condition defined by various adjectives, including rainy, dry, hot, cold, cloudy, sunny, snowy, and so forth, with many possible combinations. Ongoing repetition of these conditions defines what we call **climate**, generally characterized by the repetitive succession of weather over the years, causing humid, cool, temperate, or Mediterranean climates and so on. These climatic processes in turn have a strong influence on geographical distribution, physical characteristics, and the properties of living creatures.

Human beings, with our organic characteristics, generally adapt to changes in weather and climate. However, in unfavorable conditions (e.g., urban bioclimates with pollution of land, water and air, noise pollution, islands of pollution, heat islands) or abrupt changes, temporary or sustained problems can occur in adaptation to ambiance (represented by ecobiological factors). These conditions, aggravated by factors such as thermal inversions, can override the human processes of adaptation and cause organic damage. Some effects include cardiovascular diseases, respiratory infections and inflammatory diseases induced by exposure to pollutants, respiratory discomfort, injuries secondary to natural disasters, psychological problems induced by socio-environmental stress, and even deaths related to extremes of cold and heat (Diaz, 2006; Patz and Olson, 2006; Sarfaty and Abouzaid, 2009; Knol et al., 2009).

In clinically normal individuals or individuals without prior background diseases involving the nose and sinuses, these are generally limited to the phenomena of nasal obstruction and dryness with eventual bleeding. However, in individuals with previous changes in these regions, conditions for the development/ aggravation of respiratory dysfunctions or allergic and infectious processes are established; this can occur repetitively with consequent clinical manifestations. In this direction and as noted earlier, the respiratory mucosa, in particular that of the nose, can be regarded as always presenting changes compatible with evolving inflammatory processes.

This continued inflammation has been corroborated in the demonstration of an increase in frequency of respiratory pollen-induced allergy in people living in urban environments, facilitated by the respiratory inflammatory process secondary to exposure to environmental pollution (D'Amato et al., 2001; D'Amato and Cecchi, 2008). Air pollutants can promote inspecific sensitization of ciliary epithelium, up-modulating allergenicity as well as facilitating local interaction between allergens and cells of the immune system by stasis of mucus and decreased mucociliary clearance. Allergic rhinitis and bronchial asthma, with its related physiopathological and immunopathogenic dependence on environmental conditions, have direct influence on the concept of a single respiratory airway (ARIA, 2001, 2008). As has been more recently detected, ultra-small dust (diameter up to 0.0025 mm) exemplifies this issue by directly reaching the alveoli and hence the circulatory system, causing respiratory (runny nose, sneezing, asthma, cough) and cardiovascular (heart attack, thrombosis, atherosclerosis) diseases.

Changes in local nasal conditions (e.g. dryness and stasis of mucus or increased local humidity, physical barriers, reduction or abolition of ciliary movement) and the nose functioning as one common respiratory airway may also provide for installation and spread of infectious agents, as outlined above. A relationship between dysfunctions of the mucociliary system and installation of nasosinusal and bronchopulmonary infectious processes has largely been demonstrated in the medical literature. Murray, in his treatise on medical microbiology, underlines the installation of any infectious agent as being highly dependent on local factors:

- Viruses: local conditions at an entry port, access to the targeted organ, tropism of tissues, cellular permissiveness to viral replication;
- Bacteria: adherence to the targeted tissue, replication, invasion;
- Fungi: breaking protective barriers in mucosa and skin.

This localized mucociliary dysfunction associated with increase in relative humidity and respiratory infections can encourage the installation and carriage of non-capsulated meningococci in the mucociliary system, increasing the epidemiological risk of meningococcal meningitis induced by serotypes not covered by vaccination (Mueller et al., 2008).

Conclusions

Among the great range of factors that may cause functional changes in the respiratory system, the relevant influence of ecobiological factors should always be stressed. Understanding and correct identification of the participation of these factors in triggering or exacerbating respiratory conditions, with local and systemic consequences in the human body, can minimize or even abolish some of these conditions. In this regard, physiological, medical, and cultural measures should be taken:

- In what concerns the already established climatic changes, **adaptative individual measures** must be executed. Medical orientation and therapy are essential in cases of acute or chronic active diseases;
- Sensitive individuals prone to changes in the mucociliary system or who have a background history with these changes related to weather/climate should always be oriented to seek specialized medical assessments and be treated preventively (systemic and local hydration, vaccinations, use of specific medicines such as antihistamines) according to the time/season of the year to which they are more sensitive. Early detection of changes in weather (e.g. forecast thermal changes, hygrometric and barometric extremes, advance evaluation of weather in travels) should always be sought. Awareness and searches for this information emanate from medical guidance but should extrapolate this feature, since they are also the responsibility of the individual or their relatives who may deem there to be need for **individual preventive measures;**
- Finally, the association between medical and public awareness regarding the important influence of bioclimatology on the health of the airways requires a continuous and urgent joint action, even in architectural approaches to bioclimatology (ventilation, cooling, heating, shading, humidification and such) in family and public buildings. Pressure and influence on governmental policies at local, regional, national and global levels must always be sought, so that it may lead to **adaptative and preventive environmental measures.**

Recommended readings

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