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THE INFLUENCE OF CLIMATIC FACTORS ON THE MORPHOLOGY OF THE UPPER RESPIRATORY TRACT AND NOSE

Abstract. The morphological features of the upper respiratory tract, in particular the nose, play a key role in ensuring thermoregulation, humidification and purification of air entering the lungs. One of the factors that significantly influence the formation of anatomical variations of these structures is the climatic conditions of the habitat. In different geographical regions, differences in the structure of the nose and upper respiratory tract have formed during evolution, which contributed to human adaptation to cold, heat, humidity or dryness of the air. The relevance of the topic is due to the need for a better understanding of the relationship between climate and the morphology of the respiratory tract as an important aspect of evolutionary biology, anthropology and medicine. The aim of the study is to analyze scientific

data on the influence of climatic factors on the morphological features of the nose and upper respiratory tract in humans. Materials and methods. To achieve this goal, a systematic search and analysis of scientific publications over the past 15 years was conducted in the Google Scholar database. The selection of sources was carried out using the following keywords: "nasal morphology", "climatic adaptation", "upper respiratory tract", "human anatomy", "climate influence". Publications containing data from anatomical, anthropological and clinical studies were selected. Results. The analysis of the literature confirmed the presence of a significant relationship between the type of climate and the morphology of the nose and upper respiratory tract. In particular, in cold and dry regions there is a tendency towards narrower and longer nasal passages, which allows for more effective warming and humidification of the air. In warm and humid climates, wider nasal openings prevail, which provide more effective heat exchange. In addition, it was found that the shape of the nose may be not only an adaptive response to the climate, but also the result of genetic heredity modified under the influence of the environment. Studies also show the influence of nasal morphology on the risk of developing respiratory diseases in conditions of climate change. Conclusions. The morphology of the nose and upper respiratory tract is closely related to the climatic factors of the environment. Understanding these adaptive changes is important for evolutionary medicine, anthropology, as well as in planning reconstructive surgeries and predicting respiratory diseases.

Keywords: nasal morphology, upper respiratory tract, climatic factors, anatomical adaptation, structural variability.

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ВПЛИВ КЛІМАТИЧНИХ ФАКТОРІВ НА МОРФОЛОГІЮ ВЕРХНІХ ДИХАЛЬНИХ ШЛЯХІВ ТА НОСА

Анотація. Морфологічні особливості верхніх дихальних шляхів, зокрема носа, відіграють ключову роль у забезпеченні терморегуляції, зволоження та очищення повітря, що потрапляє до легень. Одним із чинників, які суттєво впливають на формування анатомічних варіацій цих структур, є кліматичні умови середовища проживання. У різних географічних регіонах упродовж еволюції сформувалися відмінності у будові носа та верхніх дихальних шляхів, що сприяли адаптації людини до холоду, спеки, вологості або сухості повітря. Актуальність теми зумовлена потребою у кращому розумінні зв’язку між кліматом і морфологією дихальних шляхів як важливого аспекту еволюційної біології, антропології та медицини. Метою дослідження є аналіз наукових даних щодо впливу кліматичних факторів на морфологічні особливості носа та верхніх дихальних шляхів у людини. Матеріали і методи. Для досягнення поставленої мети було проведено систематизований пошук і аналіз наукових публікацій за останні 15 років у базі даних Google Scholar. Відбір джерел здійснювався за ключовими словами: "nasal morphology", "climatic adaptation", "upper respiratory tract", "human anatomy", "climate influence". Було відібрано публікації, що містять дані анатомічних, антропологічних і клінічних досліджень. Результати. Аналіз літератури підтвердив наявність значущого зв’язку між типом клімату та морфологією носа й верхніх дихальних шляхів. Зокрема, у холодних і сухих регіонах спостерігається тенденція до вужчих і довших носових ходів, що дозволяє більш ефективно зігрівати й зволожувати повітря. У теплих і вологих кліматах переважають ширші носові отвори, що забезпечують ефективніший теплообмін. Крім того, виявлено, що форма носа може бути не лише адаптивною реакцією на клімат, але й результатом генетичної спадковості, модифікованої під впливом навколишнього середовища. Дослідження також показують вплив морфології носа на ризик розвитку респіраторних захворювань в умовах зміни клімату. Висновки. Морфологія носа та верхніх дихальних шляхів тісно пов’язана з кліматичними факторами середовища. Розуміння цих адаптивних змін має важливе значення для еволюційної медицини, антропології, а також при плануванні реконструктивних хірургічних втручань і прогнозуванні захворювань дихальної системи.

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Ключові слова: морфологія носа, верхні дихальні шляхи, кліматичні фактори, анатомічна адаптація, варіабельність будови.

Statement of the problem. The morphology of the upper respiratory tract, in particular the nose, is the result of a complex interaction of biological, ecological and evolutionary factors. One of the important determinants of the formation of these anatomical structures is climatic conditions, which for millennia have influenced the adaptation of the human body to the environment. Climate not only changes living conditions, but also causes gradual morphophysiological changes, which over time are fixed at the population level. Modern anthropology recognizes the influence of climatic factors as key in understanding human biological variability [1].

Studies conducted on different continents, in particular in South America, confirm the existence of a specific climatic “imprint” in cranial anatomy, including structures associated with respiratory functions, which indicates an adaptive response to moderate climatic conditions [2]. These changes are not isolated and are consistent with similar patterns found in other parts of the human body, such as the shape of the pelvis, which also shows a dependence on climate and population history [3].

The Earth's climate is a dynamic system that is constantly changing both as a result of natural factors, such as volcanic activity [4], and under the influence of anthropogenic processes, including global warming and changing humidity regimes, which, in turn, indirectly affect human biological adaptations. Accordingly, human mobility is changing - people move to regions with different climatic conditions, which creates new adaptive challenges for the respiratory system [5].

Although the study of the paranasal sinuses was previously proposed as an indicator of climatic adaptations in fossil hominids, recent studies question the unambiguousness of this relationship, indicating the complexity and multifactorial nature of the influence [6]. Instead, other morphological parameters, in particular the size of the nasal cavity, are considered more reliable markers of functional adaptation to different temperature and humidity conditions, since these structures are directly involved in thermoregulation and humidification of inhaled air [7].

Therefore, studying the influence of climatic factors on the morphology of the upper respiratory tract and nose is a relevant task for both physical anthropology and medical science. This approach allows for a deeper understanding of the evolutionary mechanisms of human adaptation and predicting the consequences of modern climate change for the health of the respiratory system.

The purpose of the article – to investigate, analyze and organize literature data on the influence of climatic factors on the morphology of the upper respiratory tract and nose.

Research objects and methods. A review of scientific publications related to climate change and its impact on the morphology of the upper respiratory tract and nose was conducted, in particular taking into account ethnic and sexual

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dimorphisms. The selection criterion for the review was the publication age of the article no more than 15 years. The Google Academy search database was used. Of the 29 publications found, 19 were included in the review. PRISMA was used for organization and the PRISMA flow diagram for visualization of the process of selecting publications for review of literary sources in accordance with international standards for writing review articles [8].

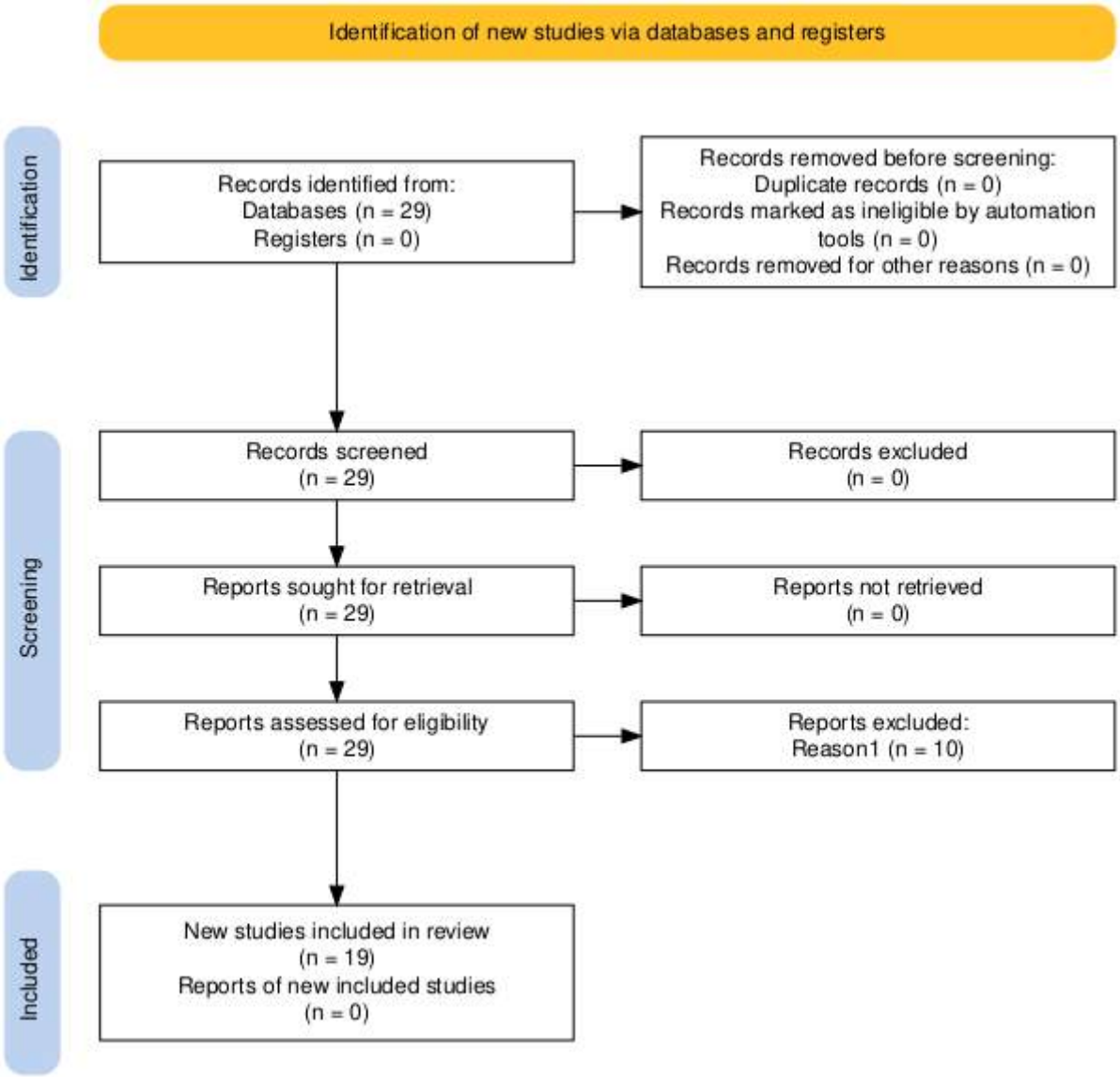

Fig. 1. The PRISMA flow diagram of literary sources search results.

Presentation of the main material.

Research results and their discussion. The morphology of the upper respiratory tract, including the nasal cavity and its anatomical components, shows marked variability among modern human populations. This variability is largely due to adaptation to different climatic conditions, which is confirmed by the results of numerous anthropological and morphometric studies. Recent three-dimensional

reconstructions indicate a wide range of morphological types of the upper respiratory tract, which can be partially explained by ecological and geographical factors, as well as the evolutionary history of populations [9]. One of the key components that responds to climatic factors is the inferior nasal concha (concha nasalis inferior). Studies conducted on samples from Arctic and equatorial populations have shown significant morphofunctional differences in the shape and volume of this structure. In inhabitants of cold climates, the nasal conchae have a larger surface area, which contributes to more efficient heating and humidification of the air, while in tropical populations these structures are less developed [10]. Thus, the morphology of the inferior turbinate acts as an adaptive indicator of environmental conditions.

Geographic variation in the shape of the nasal cavity is also well documented in Japanese populations. In particular, residents of the northern islands demonstrate longer and narrower nasal passages compared to residents of the southern regions, which is consistent with the concept of climatic adaptation to cold conditions [11]. Such morphological features have not only evolutionary significance, but also practical - they affect ventilation, voice resonance and susceptibility to respiratory diseases.

In addition to the nasal cavity, the maxillary sinus (sinus maxillaris) plays a significant role in thermal adaptation. A positive morphological co-variation has been found between the size of this structure and the shape of the midface, which is due to the need to maintain thermoregulation of inhaled air in cold climates [12]. Such co-adaptation confirms the integrity of the anatomical and functional restructuring of the midfacial zone.

Another study outlines ecogeographic patterns in the morphofunctional units of the nose: the width of the nasal opening, the shape of the nasal septum, the configuration of the nasal floor. These components, considered in unity, demonstrate clear connections with climatic gradients - from cold to warm and from dry to humid [13]. In cold climates, there is a tendency to form narrower and longer nasal structures, which provides more effective heat conservation.

Data from three-dimensional modeling and comparative morphology prove that the nasal cavity has adaptive morphological plasticity. In particular, Noback et al. demonstrated a statistically significant relationship between the width of the nasal entrance and the average annual air temperature [14]. These results confirm the hypothesis that the human nose, as a functional organ of thermoregulation, changes its parameters depending on long-term climatic influences.

In addition to geographical variability, age-related (ontogenetic) dynamics of nasal morphology should also be taken into account. According to the study by Butaric et al., the shape of the nose changes throughout life, demonstrating ontogenetic plasticity caused by both genetic factors and environmental influences [15]. Nicholas and Franciscus separately noted a change in the shape of the nasal cavity floor during growth, which may also be an adaptive response to environmental changes with age [16].

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Three-dimensional analyses by Bastir et al. showed that the shape of the nasal cavity and nasopharynx in humans is not only the result of adaptation to climate, but also a reflection of functional needs, in particular air exchange, phonation and even smell [17]. These morphofunctional units are closely related to the external structures of the face, which indicates the integration of the cranial complex [18].

Sexual dimorphism in the morphology of nasal structures has also been found: in men, there is a tendency towards larger volumes of nasal passages and a larger total cross-sectional area, which may have an adaptive significance due to greater body mass and oxygen requirements [19].

In summary, the results of modern studies indicate a high degree of adaptive variability in the morphology of the upper respiratory tract in humans. Climatic conditions, such as temperature, humidity and seasonality, have a powerful influence on the formation of nasal structures, which, in turn, affect the efficiency of breathing, thermoregulation and protection from external factors. The relevance of further research in this direction is increasing against the background of global climate change, which creates new challenges for the adaptive mechanisms of the human body.

Conclusions. Thus, the results of modern morphometric and anatomical studies confirm that climatic factors play a key role in shaping the morphology of the upper respiratory tract and nose in humans. The revealed variation in the size, shape and structure of the nasal cavity, inferior turbinates and adjacent anatomical units is the result of adaptation to different temperature and humidity conditions of the environment. These morphological features should be taken into account not only in the context of evolutionary anthropology, but also in clinical practice, in particular in functional rhinosurgery, otolaryngology and in the assessment of respiratory health in changing climates.

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