BIO-SOCIAL KNOWLEDGE: HUMAN ADAPTATION IN DIFFERENT ECOLOGICAL NICHES OF THE WORLD

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Keywords: Adaptation, acclimatization, body build, environments, ecological niches, human health, metabolism, nutrition

Contents

Summary

Geographic variations in body build and physiological traits in human populations are very large. Such qualities of the human species—Homo sapiens—were acquired over a very long period as humans settled the world, but were based upon highly developed plasticity of morpho-physiological traits for this species. Adaptation to new environments when humans were settling the world was accomplished not only through technological advances but also through biological changes to both the functional and the structural system of the body. The interaction of human species with the environment can be explained by the concept “adaptive type” as a normal reaction to the complex of environmental conditions. Adaptive type is an inherited norm of reaction to maintain homeostasis between the population and the environment.

Anthropoecological relationships in the large territory of the former USSR (where about 100 native populations living in different ecological zones were studied) with predominantly low average annual temperatures have shown that adaptive variability of human populations in this climatic and geographic area is expressed, in the first place, in response to “severe” weather factors.

1. Introduction

At the VII International Congress of Anthropological and Ethnological Sciences, which took place in Moscow in 1964, “rights of citizenship” were given to a new branch of anthropology—physiological anthropology. The main aim of this new branch became the investigation of adaptive variability in humans as a species, which manifests itself

not only on genetic, structural, and physiological levels, but also in demographic processes in populations.

The study of adaptation processes demanded a wide, complex approach to estimate the morphological and physiological peculiarities of human populations in specific environments, and the development of complex methods to investigate the population levels of different ecological niches.

An important role in solving adaptation problems on the population level was played by the International Biological Programme (IBP, 1964–1974). With the help of the IBP several summaries of the world population living in ecologically different territories were published.

In Russia, investigations of adaptation of human populations to the environment among the aboriginal populations in arctic and sub-arctic regions, deserts, high altitudes, inner Siberia, and the temperate zone were carried out over a period of more than 30 years. The results of these investigations were published in books and articles, and reported at international congresses and symposia.

The results of investigations into the adaptation of human populations to environments are used widely in educational programs of human ecology and in the monitoring of the health of populations.

Never before in its history has humankind experienced environmental pollution by industrial waste products, urbanization, and migration of the scale typical of the twentieth century. In order to preserve human health in the conditions created by the scientific and technological revolution it seems necessary to study adaptation, that is, human adaptability to different environments and specifically to extreme ones. The most important part in the adaptation process of human populations is played by socioeconomic factors. However, the study of geographic variations of body dimensions and metabolic indices in native peoples of the world show that adaptation takes place not only at the social but also at the biological level and its success largely depends on how adequate is the relationship between those two levels and the natural environment.

2. Patterns of Geographic Variability of the Human Physique and Metabolism

Current socioeconomic changes in many regions of the world are accompanied by intensive migrations of people, which necessitate scientific models of their subsistence in new environments. In this connection, data on broad biological norms of human reactions to the complex of environmental natural conditions are of particular importance. Those data have been derived from the analysis of geographic variations of morphological and physiological traits on territories settled by humans, as well as from research into the specificity of adaptive features in native populations of different ecological niches. Adaptation of native settlers to the environment occurs over many generations; therefore, their morpho-physiological individuality should mostly correspond to such environmental requirements.

Geographic variations in body build and physiological traits in human populations are

very large. These qualities of the human species—Homo sapiens—were acquired over a long period as humans settled the world, but were based upon highly developed plasticity of morpho-physiological traits typical for this species. The pattern of geographic distribution of body build and some metabolic characteristics is controlled by ecological factors. Energy processes as expressed by body mass, body proportions, and body surface—besides basal metabolic rate, protein, and lipid metabolism—depend on environmental temperatures, while mineral metabolism largely depends on geochemical factors.

Nutrition as an ecological factor influencing metabolism and human physique is in many ways determined by geographic environment, and that is why there is no need to oppose temperature conditions, geochemical situation, or diet to one another. Similarly, there is no need to oppose environment to genetics when considering adaptation to a certain ecological niche. There is much evidence of hereditary determination of individual metabolism and physique. At the same time, when examining geographic variations of such traits, conclusions can be drawn on their being influenced by environment. This process can be most probably explained in the following way: in a given environment, the morpho-physiological combinations that are advantageous are those that possess a genotype most adequate to the geographic conditions.

Geographic variability of morpho-physiological traits may be demonstrated with several examples.

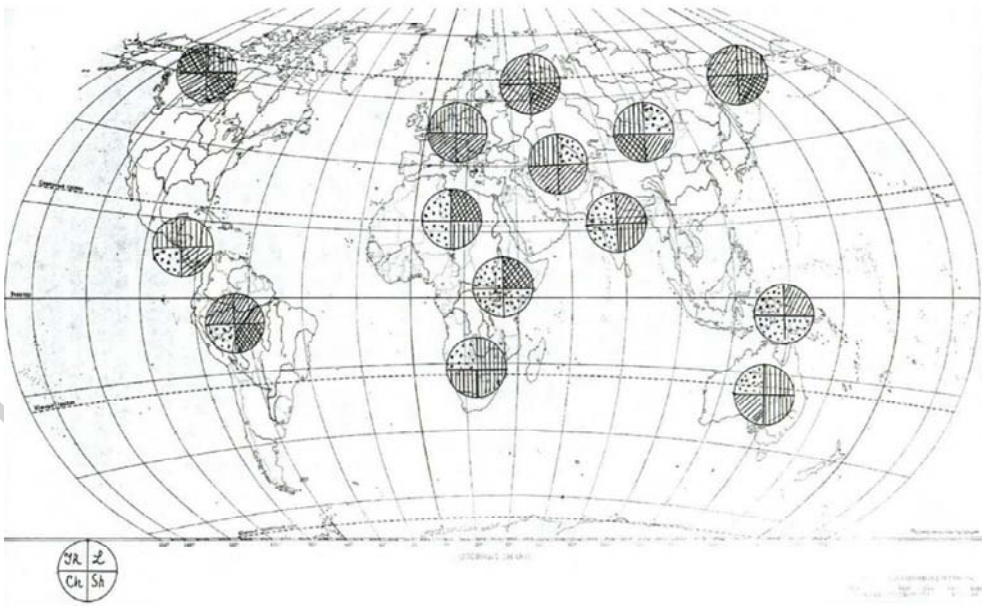

Figure 1. General direction of the morphological variability of human aboriginal populations. JR = index of Rohrer, CH = holisterol, L = leg length as a percentage of body growth, SH = shoulder as a percentage of body growth.

Rohrer ponderal index: $R = P:L^3$, where P is body weight, and L is body length.

This is an index of body density that can be considered to some extent a characteristic of

energy expenditure. Throughout the world, the highest values of the index are typical for non-tropical populations. Relatively lighter populations are usually concentrated in the tropical belt. However, there are some exceptions: in Africa for populations of Egypt, the Republic of South Africa, and some Congo basin peoples; and in Australia and Oceania, where minority groups with higher than usual body density for the tropics can also be found.

In New World territories, the ponderal index does not follow the pattern shown for the populations of the eastern hemisphere. The native populations of the Americas (American Indians, Eskimos, Aleuts) are characterized by considerable body density but the differences between Eskimos, Aleuts, and North American Indians on the one hand, and Mesoamerican and South American Indians on the other are quite noticeable. It may be pointed out that in a zone close to the equator, body density in native populations is decreasing, even in the New World.

Body surface is a characteristic of heat irradiation and evaporation. Relative body surface (body surface per kg of body weight) is highest in the tropics.

Body proportions (proportion of leg length to body length or trunk length). There is a gradient of increase in dolichomorphia (elongated proportions with long legs and shortened trunks) towards the tropical zone.

Basal metabolic rate. As a rule, in field studies this is calculated from body weight, body length, and air temperature. It may be considered a general metabolic index of the organism demonstrating its energy level. Its values are decreasing from the north to equatorial regions. According to experimental data on oxygen absorption, the basal metabolic rate of the native arctic population is higher than in tropical aboriginal populations.

Blood serum lipids. Cholesterol. Some decrease in cholesterol levels is found from north to south. Cholesterol content in blood serum is known to be positively connected to dietary protein and fat, and negatively to carbohydrate. The decrease in cholesterol level southward correlates with the food habits of tropical populations, scanty in proteins and fats, that appear to support the key role of nutrition in blood serum lipid concentration. At the same time there are some convincing data on the hereditary nature of this trait.

Blood serum proteins. The serum proteins that show clear-cut geographic variations are gamma globulins and albumins. The former are responsible for the immune system, the latter mostly for the building up of proteins in bodily construction. Gamma globulin level tends to increase towards the equator, while albumin content decreases. Most authors are inclined to explain the decrease of blood serum albumins as protein food deficiency, and the increase of gamma globulin content as the effect of malaria parasites and other pathogenic agents. However, there is some evidence that hereditary factors are responsible for protein content of the organism.

Mineral content of bone tissue. Unlike the abovementioned characteristics, this trait does not show any clinal geographic distribution. It is connected with the content of

mineral and trace elements in the environment, and this content is greatly dispersed. The highest degree of mineralization is found in inhabitants of regions with optimal proportions of osteogenic (bone forming) mineral elements (e.g. the Chernozem (Black Earth) zone). Pathological abnormalities in growth and mineral content of the body may occur in areas deficient in or with an imbalance of vital minerals (the Lake Baikal area and Tajikistan). There is not much data concerning skeletal mineralization in different human populations. Those that exist were mostly collected in numerous field trips by Russian anthropologists to different ecological zones of the former Soviet Union, India, and Mongolia. In spite of considerable dependency of mineral skeletal content on geochemical environmental conditions, the role of genetic factors should not be forgotten. Mineral metabolism, like all other factors, is influenced by heredity.

To sum up the influence of geographic variations on body build and internal physiological milieu as indicated in different metabolic types, the following conclusion should be drawn: the human body is influenced by geographic environment. This influence can be described by climatic "rules" obtained for animals. According to these rules, the more massive and short-legged specimens are concentrated in the north, and those with longer legs and less body mass are concentrated more towards the south (Allen's and Bergmann's rules); larger body surface is typical for tropical zone inhabitants, and smaller for the arctic zone (Rubner's rule).

Interestingly, such geographic determination of body dimensions is found even in a relatively small territory and in groups of comparatively recent inhabitancy, as was shown by the American researchers Newman and Munro for the U.S. White population. Like all living organisms, human beings are not influenced by climatic conditions alone. The role of gravitation in developing the geometric shape of living organisms, including humans, is well known. It has been shown by many Western and Russian authors. A.L. Chizhevsky revealed close links between electromagnetic phenomena in terrestrial space and physiological reactions of the human body. V.P. Alekseev noted the effect of gravitation and electromagnetic forces on race formation in humans.

The influence of pathogenic agents on humans and their biochemical adaptation to such influence has been repeatedly shown in different concentrations of blood groups or other genetic traits in various geographic areas. Russian researchers demonstrated territorial similarities between skeletal size and mineral and trace element content in the soil. In areas with a high concentration of osteogenic minerals, especially phosphorus and calcium, people are taller, their skulls are longer and narrower, and their faces are elongated. In areas with low concentrations or an imbalance of minerals, it is the reverse: people are shorter, with broader and shorter heads, and broader faces.

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Biographical Sketch

Tatiana Ivanovna Alexeeva, born 1928 in Kazan, USSR, studied in the Biology Department of Moscow State University from 1946 to 1951 and undertook postgraduate studies in the Department of Anthropology of Moscow State University from 1951 to 1954. She has been awarded a Ph.D. in physical anthropology, and a D.Sc. in history. She was a junior scientist of the Institute of Anthropology of MGU (1955–1966); a senior scientist of the Institute of Anthropology of MGU (1967–1982); chief of the Human Ecology Department of the Institute of Anthropology of MGU (1983).

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