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Why Humans are Better Endurance Runners than Any Other Animal?

Abyt Ibraimov*, Stalbek Akhunbaev, Orozali Uzakov

International Higher School of Medicine, Intergelpo Str, 1F, Bishkek, Kyrgyzstan.

*Corresponding Author
Abyt Ibraimov, International Higher School of Medicine, Intergelpo Str, 1F, Bishkek, Kyrgyzstan.

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Abstract

It is well known that only man is capable of endurance running and in this sense he has no equal among animals. Why do other animals have us beat over short distances, but are not able to run long distances as long as humans? There are different answers. Walking upright has allowed us to become some of the best distance runners in the world, but at the expense of speed. It is also believed that to run long distances on the African savannah man needed to have an effective cooling system and it is believed that man has developed one. Firstly, heat exchange improved due to the disappearance of fur. Secondly, humans learned to sweat intensively. They also attach importance to the diet and the lifestyle. There are other answers, but they have little relevance to the question discussed here. Can the above answers be considered exhaustive? We believe that there is another important factor unique to man, which ultimately allowed him to occupy the top of the food chain. This factor is the peculiarity of the heat-conducting ability of the human body. Man became a good long-distance runner because among animals he has the most highly heat-conducting body, which allowed him to effectively dissipate excess heat outside the body.

Keywords: Long-Distance Runners, Endurance Running, Human Body Heat Conductivity, Chromosomal Heterochromatic Regions, Cell Thermoregulation.

Introduction

It is believed that among primates only *Homo sapiens* can run for a long time because it is upright. Indeed, all other primates can stand up and run on two legs for only a short time. It is generally believed that our tall, upright bodies create a lot of surface area for cooling, and the ability to breathe from both the nose and mouth helps dump heat as well.

In terms of running speed, humans are inferior to other animals, but in terms of running time they are unrivaled (if you run for a long time at the same pace). Why? It is known that fast running uses gluconeogenesis, which ends quickly, but long running uses fat (ketogenesis) and this is well used by humans. Fast running in both humans and animals is based on gluconeogenesis. Many animals run very fast due to gluconeogenesis. This type of fuel provides great speed, but its time capacity is limited. Unlike humans, animals cannot enter ketogenesis because their organism is not adapted to it.

When running, especially for long distances, a person faces the main threat: overheating of the body, which must be eliminated in a timely and effective manner to avoid the dangerous effects of high temperature on the normal vital activity of cells. It is known that for this purpose a man uses two ways of heat dissipation: evaporation of moisture from the body surface and respiratory tract. It is believed that this was facilitated by the disappearance of wool and the emergence of sweat glands for intense perspiration, which man acquired when he adapted to the hot and dry climate of the African savannah. Humans still use the characteristic of theirs for driven hunting, like wolves. It is not by chance that hunting is carried out at the hottest time of the day, thus taking advantage of the human advantage in terms of thermoregulation (for details see [1-3]).

Then the question arises whether the above means are sufficient to combat overheating of the body. At first glance, it seems that the answer should be positive. Indeed chimpanzees, for example, do not know how to sweat a lot. In addition, dogs do not know how to: evaporation of water comes only from sticking out the tongue. So humans have adapted to hunting in the savannah better than African wolves (or African wild dogs), which have wool and no sweat glands, etc.... However, the ways available to humans to combat hyperthermia are inherent in all homoeothermic organisms to different degrees, only they have developed to different degrees depending on their way of life and the peculiarities of the climate of the places of their permanent habitat. Animals that have a wool cover or no sweat glands does not mean that evolution or some laws of individual development forbid them to have such adaptive phenotypes. Apparently, they are quite satisfied with the means at their disposal to combat hyperthermia if they have existed in these climatic conditions for millions of years. Therefore, we believe that humans must possess an additional, perhaps inherent only to the species *H. sapiens* means of combating overheating of the organism. By this, we mean one poorly studied physical peculiarity of the human body, namely its heat-conducting ability. We came to this conclusion after many years of research on one of the forms of hereditary variability - polymorphism of heterochromatic regions of chromosomes in human populations.

Facts

In the process of studying the variability of chromosomal Q-heterochromatin regions (Q-HRs) in human populations living permanently in different climatogeographic conditions of Eurasia and Africa, as well as in newcomers, who have successfully adapted to some extreme natural conditions (high altitudes and the Far North of Eastern Siberia), the data were obtained that the amount of this material in the genome may be important for human adaptation. In particular, it turned out that in the karyotype of mountaineers the number of chromosomal Q-HRs was significantly lower than in the control sample and was close to that of the natives of high-altitude Pamir and Tien-Shan. The same results were obtained in a comparative study of newcomers (oil-borers working in the open air in the oil and gas fields of the Yamal Peninsula of Eastern Siberia) who have been working in the harsh climatic conditions of the Far North, the indigenous inhabitants of Siberia and their children [4,5].

To date, two types of heterochromatin are known: C- and Q-heterochromatin. There are significant differences between them: 1) C-heterochromatin regions (C-HRs) is found in the chromosomes of all the higher eukaryotes, while Q-heterochromatin regions (Q-HRs)-only in man, the chimpanzee and gorilla; 2) despite the fact that chromosomal Q-HRs exist in the genome of three higher primates, their broad quantitative variability is only inherent in human populations; 3) individuals in population differ in the number of chromosomal Q-HRs in the genome; 4) in individuals of a population the number of chromosomal Q-HRs ranges from zero to ten. These differences proved to be related to features of the climatic-and-geographic conditions of the place of permanent residence, and not to racial and ethnic composition of the population [6-8].

There are studies that individual performance depends on endogenous factors such as anthropometric, genetic and physiological characteristics [9, 10] and environmental factors that affect all athletes [11-13]. In this regard, it is of interest to observe the athletes who are engaged in marathon running [14]. For example, athletes' nationalities were categorized into one of the six world regions: Africa, Asia, Europe, North America, South America and Oceania. For each year and both sexes, the contribution of each continent in the top 100 was calculated. It turned out that the best performances by men in marathons were by athletes from East Africa (mainly Kenya and Ethiopia) and this trend has been progressive from 1990 to 2011 (16% to 94%). Conversely, other nationalities, initially dominant in the list of top 100 performers (from Europe, Asia, South America, North America and Oceania), are increasingly less prominent over the same period, 84% in 1990 to 6% in 2011. This change in domination also occurred in the speed of the 10 best performers from each continent since 1990.

More and more countries situated at southern latitudes have started taking part in the world sport movement lately. The most notable in this process is that, natives of this region achieve great success in sports, requiring (in addition to other factors) effective heat-loss (football, professional boxing and marathon race). While sportsmen from northern latitudes prevail in water and winter sports and in mountaineering.

At last, high-altitude pulmonary edema (HAPE) occurs in unacclimatized individuals who are rapidly exposed to altitude in excess of 2500 m above sea level. However, the question remains: why HAPE develops only in some individuals, who are rapidly exposed to high-altitudes? Our experience has shown that HAPE can develop in individuals with high than population average chromosomal Q-HRs [15].

Discussion

We believe that all of the above observations can be explained by cell thermoregulation. The essence of hypothesis of cell thermoregulation (CT) is elimination of the temperature difference between the nucleus and cytoplasm when the nucleus temperature becomes higher than the cytoplasm temperature. The condensed chromatin (CC), the densest structure in an interphase cell, localized between a nucleus and cytoplasm is made of chromosomal HRs. The density of the CC packing depends on the quantity of chromosomal HRs in its structure that can affect upon its heat-conducting ability [16-18].

It has been experimentally shown that the effect of CT can be indirectly assessed by the level of the body heat conductivity (BHC). In particular, the amount of chromosomal Q-HRs influence on the level of the human BHC. In other words, there are some parallels in the distribution of the number of chromosomal Q-HRs and variability of human BHC (for details see [19]. Indeed, a sportsman with high heat conductivity cannot make much progress in mountaineering and water sports because their body cools rapidly. However, this sportsman can be more successful in sports, which require effective heat-loss.

Athletes runners from Kenya and Ethiopia have been repeatedly mentioned here. We have shown in our time that the greatest number of chromosomal Q-HRs are contained in the genome of indigenous people of subequatorial Africa [8,20]. Since there is a close relationship between the level of human BHC and the quantitative content of chromosomal Q-HRs in its genome, there is nothing unexpected in the fact that athletes from not only Kenya and Ethiopia, but in general from subequatorial Africa differ in sports that require, among other things, effective heat dissipation outside the body. Besides, the very fact of outstanding achievements of runners from Kenya and Ethiopia is remarkable also because they live on the territory where modern human originated. Perhaps our ancestors acquired their unique ability-endurance running-when they were struggling for existence on the African savannahs.

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I apologize to those authors, whose works were not cited, or were cited only through reviews, owing to space limitations.

Conflicts of Interest

None.

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Statement of Consent/Ethical Approval

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