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The effect of ambient temperature on the human blood cells

Adaptation and extract the onslaught of external factors, the new environment is an important issue. The response to adverse environmental factors makes changes in the human body. It primarily affects greatly the immune system and the circulatory system. The regulation of body temperature in the heat is critical, because of the great potential for lethal hyperthermia. To study attended 10 local people and 10 people, who came from other regions of Kazakhstan. People create heat stress lasting 1 hour at ambient temperature + 42 – 45 ° C and 76 – 80% relative humidity once and daily for 14 days.In people of all groups was measured rectal temperature and measured changes in blood cells by method Shilling. Blood for research was taken from the vein. The number of blood cells was determined by the standard technique with using hematology analyzer.The study set that mechanisms of regulation of body temperature on multiple high temperatures correspond to the maximum and minimum periodic rises of the body temperature. Adaptive responses to high ambient temperatures most adaptable people aged 15-18 than in aged 55-60.

Key words: blood, hyperthermia, adaptation, acclimatization, stress, homeostasis.

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Сыртқы орта температурасының адам ағзасының қан жасушаларына әсері

Сыртқы ортаның қолайсыз факторларына жауап реакциясы ретінде адам ағзасында үнемі өзгерістер орын алып отырады. Ол ең алдымен ағзаның иммунитет жүйесі мен қан айналым жүйесіне жоғары әсер етеді. Сыртқы ортаның жоғары температурасы жағдайында дене температурасын бақылау маңызды болып саналады, себебі ол гипертермияға себеп болуы мүмкін. Сыртқы ортаның жоғары температурасының адам ағзасында қан жасушаларына әсерін анықтау мақсатында зерттеуге қатысқан бүкіл топ адамдары ауа температурасы +42-45° С және ылғалдылық 76-80% жағдайында күнделікті 14 күн аралығында температуралық стресске ұшырады. Барлық топ адамдарында қан клеткаларындағы өзгерістер Шиллинг әдісімен анықталды. Зерттеу жұмыстары үшін қан көктамырдан алынды. Қан жасушаларының санын анықтау мақсатында гематологиялық анализатор пайдаланылады. Зерттеу жұмыстары нәтижесінде, сыртқы ортаның жоғары температурасының әсерінен қан жасушаларының қалыпты мөлшерінен әртүрлі өзгерістерге ауытқулары болатындығы анықталды. Алынған мәліметтер нәтижесінде сыртқы ортаның жоғары температурасының қан жасушаларының физиологиялық көрсеткіштеріне стрессорлық әсер ететіндігі байқалды. Сондай-ақ, бұл өзгерістер ағзаның жастық және жыныстық ерекшеліктеріне сәйкес әртүрлі деңгейде болатындығы байқалды.

Түйін сөздер: бейімделу, акклиматизация, гомеостаз, гипертермия, қан клеткалары, стресс.

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Влияние температуры окружающей среды на клетки крови человека

Адаптация и выдержка натиска внешних факторов новой среды обитания является важной проблемой. Ответная реакция на неблагоприятные факторы внешней среды вносит изменения в организме человека. Она в первую очередь сильно влияет на иммунную систему организма и систему кровообращения. Для изучения влияния теплового стресса на клетки крови люди всех групп подвергались действию теплового стресса продолжительностью 1 час при температуре воздуха +42 – 45° С и относительной влажностью 76 – 80 % однократно и ежедневно в течение 14 дней. У людей всех групп определяли изменения в клетках крови методом Шиллинга. Кровь для исследований брали из вены. Для получения числа клеток крови использовали гематологический анализатор. В результате исследования установлено, что приспособительные реакции к высокой температуре окружающей среды наиболее выражены у людей в возрасте 15-18, чем у людей в возрасте 55-60 лет. У людей развивается лимфопения и эозинопения.

Ключевые слова: температура, адаптация, клетки крови, стресс, гомеостаз, акклиматизация.

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THE EFFECT OF AMBIENT TEMPERATURE ON THE HUMAN BLOOD CELLS

Introduction

Today on our planet almost no place where people don`t live. Humanity has spread over the entire surface of the Earth and able to adapt to a variety of climate-geographical conditions with using active means of protection from harmful influences and to create an artificial environment. However, completely eliminate the influence of climate on the human organism is impossible. In countries with a hot climate lives much of the population of the Earth, and constant influence of environmental factors has a certain effect on the inhabitants of these regions of the world.

During the functioning the body of humans and animals are constantly faced with various stressors. Currently, stress is attracts attention of researchers of various branches of biology, medicine and veterinary. This is due mainly to the fact that stress on the one hand, determines the maintenance of homeostasis of the organism, on the other – it leads to the development of adaptation and finally the cause of diseases [1].

Studies of the effect of various stress factors in experimental and natural conditions are devoted to the study of the state of the natural and specific immunity. The research results indicate the effect of stress on the immune system and that changes in the activity of the immune system under stress. Heat acclimation or acclimatization plays a large part in the body's physical responses and overall ability to cope with heat exposure. Heat acclimation is a broad term that can be loosely defined as a complex series of changes or adaptations that occur in response to heat stress in a controlled environment over the course of 7 to 14 days. These adaptations are beneficial to exercise in the heat and allow the body to better cope with heat stress. Heat acclimatization describes the same process, but happens in a natural environment.

Other changes include decreased salt losses in sweat and urine as well as an improved blood pressure response.

It is also important to note that factors affecting these changes determine the extent to which adaptations occur. For example, acclimation in hot and dry environments has been shown to be different from that in hot and humid environments (a greater sweat rate increase has been seen in the latter case)

Complete heat acclimatization requires up to 14 days, but the systems of the body adapt to heat exposure at varying rates. The early adaptations (initial 1-5 days) involve an improved control of cardiovascular function, including expanded plasma volume, reduced heart rate, and autonomic nervous system habituation which redirects cardiac output to skin capillary beds and active muscle. Plasma volume expansion resulting from increased plasma proteins and increased sodium chloride retention, ranges from +3 to +27%, and is accompanied by a 15-25% decrease in heart rate. This reduction of cardiovascular strain reduces rating of perceived exertion, which is proportional to central cardiorespiratory stress, also decreases during the first five days of exercise-heat exposure. Plasma volume expansion is a temporary phenomenon, which decays during the 8th to 14th days of heat acclimatization (as do fluid-regulatory hormone responses, see below), and then is replaced by a longer-lasting reduction in skin blood flow that serves to increase central blood volume [2].

The regulation of body temperature in the heat is critical, because of the great potential for lethal hyperthermia. Thermoregulatory adaptations (i.e., increased sweat rate, earlier onset of sweat production), coupled with cardiovascular adjustments, result in a decreased central body temperature. This response is maximized after 5 to 8 days of heat acclimatization. However, the adaptations of eccrine sweat glands are different during humid and dry heat exposures. Heat acclimatization performed in a hot-humid condition stimulates a greater sweat rate than heat acclimatization in a hot-dry environment. Also, the absolute rate of sweating influences thermoregulation. If hourly sweat rate is small (<400-600 ml), a peripheral adaptation of whole body sweat rate may not occur.

Humans live their entire lives within a very small, fiercely protected range of internal body temperatures. The maximal tolerance limits for living cells range from about 0°C (ice crystal formation) to about 45°C (thermal coagulation of intracellular proteins); however, humans can tolerate internal temperatures below 35°C or above 41°C for only very brief periods of time. To maintain internal temperature within these limits, people have developed very effective and in some instances specialized physiological responses to acute thermal stresses. These responses–designed to facilitate the conservation, production or elimination of body heat–involve the finely controlled coordination of several body systems [3].

By far, the largest source of heat imparted to the body results from metabolic heat production (M). Even at peak mechanical efficiency, 75 to 80% of the energy involved in muscular work is liberated as heat. At rest, a metabolic rate of 300 ml O_2 per minute creates a heat load of approximately 100 Watts. During steady-state work at an oxygen consumption of 1 l/min, approximately 350 W of heat are generated–less any energy associated with external work (W). Even at such a mild to moderate work intensity, body core temperature would rise approximately one degree centigrade every 15 min were it not for an efficient means of heat dissipation. In fact, very fit individuals can produce heat in excess of 1,200 W for 1 to 3 hours without heat injury (Gisolfi and Wenger 1984).

Heat can also be gained from the environment via radiation (R) and convection (C) if the globe temperature (a measure of radiant heat) and air (dry-bulb) temperature, respectively, exceed skin temperature. These avenues of heat gain are typically small relative to M, and actually become avenues of heat loss when the skin-to-air thermal gradient is reversed. The final avenue for heat loss–evaporation (E)–is also typically the most important, since the latent heat of vaporization of sweat is high–approximately 680 W-h/l of sweat evaporated. These relations are discussed elsewhere in this chapter.

In particular, heavy work (high energy expenditure which increases M -W), excessively high air temperatures (which increase R + C), high humidity (which limits E) and the wearing of thick or relatively impermeable clothing (which creates a barrier to effective evaporation of sweat) create such a scenario. Finally, if exercise is prolonged or hydration inadequate, E may be outstripped by the limited ability of the body to secrete sweat (1 to 2 l/h for short periods).

For purposes of describing physiological responses to heat and cold, the body is divided into two components–the «core» and the «shell». Core temperature (T_c) represents internal or deep body temperature, and can be measured orally, rectally or, in laboratory settings, in the oesophagus or on the tympanic membrane (eardrum). The temperature of the shell is represented by mean skin temperature (T_{sk}).

When confronted with challenges to thermal neutrality (heat or cold stresses), the body strives to control T_c through physiological adjustments, and T_c provides the major feedback to the brain to coordinate this control. While the local and mean skin temperature are important for providing sensory input, T_{sk} varies greatly with ambient temperature, averaging about 33 °C at thermoneutrality and reaching 36 to 37 °C under conditions of heavy work in the heat. It can drop considerably during whole-body and local exposure to cold; tactile sensitivity occurs between 15 and 20 °C, whereas the critical temperature for manual dexterity is between 12 and 16 °C. The upper and lower pain threshold values for T_{sk} are approximately 43 °C and 10 °C, respectively[4].

Precise mapping studies have localized the site of greatest thermoregulatory control in an area of the brain known as the pre- optic/anterior hypothalamus (POAH). In this region are nerve cells which respond to both heating (warm-sensitive neurons) and cooling (cold-sensitive neurons). This area dominates control of body temperature by receiving afferent sensory information about body temperature and sending efferent signals to the skin, the muscles and other organs involved in temperature regulation, via the autonomic nervous system.

The body's control system is analogous to thermostatic control of temperature in a house with both heating and cooling capabilities. When body temperature rises above some theoretical «set point» temperature, effector responses associated with cooling (sweating, increasing skin blood flow) are turned on. When body temperature falls below the set point, heat gain responses (decreasing skin blood flow, shivering) are initiated. Unlike home heating/cooling systems however, the human thermoregulatory control system does not operate as a simple on-off system, but also has proportional control and rate-of-change control characteristics. It should be appreciated that a «set point temperature» exists in theory only, and thus is useful in visualizing these concepts. Much work is yet to be done toward a full understanding of the mechanisms associated with the thermoregulatory set point.

Early laboratory studies on women seemed to show that they were relatively intolerant to work in heat, compared with men. However, we now recognize that nearly all of the differences can be explained in terms of body size and acquired levels of physical fitness and heat acclimatization. However, there are minor sex differences in heat dissipation mechanisms: higher maximal sweat rates in males may enhance tolerance for extremely hot, dry environments, while females are better able to suppress excess sweating and therefore conserve body water and thus heat in hot, humid environments. Although the menstrual cycle is associated with a shift in basal body temperature and slightly alters thermoregulatory responses in women, these physiological adjustments are too subtle to influence heat tolerance and thermoregulatory efficiency in real work situations.

Adapting to hot environments is as complex as adapting to cold ones. However, cold adaptation is usually more difficult physiologically for humans since we are not subarctic animals by nature.

The effect of heat on our bodies varies with the relative humidity of the air. High temperatures with high humidity make it harder to lose excess body heat. This is due to the fact that when the moisture content of air goes up, it becomes increasingly more difficult for sweat to evaporate. The sweat stays on our skin and we feel clammy. As a result, we do not get the cooling effect of rapid evaporation [5].

Scientific novelty of the research: Firstly given comparative characteristics to functional behavior of the system, which ensuring consistency of homeostasis with single and daily operation of the thermal stress factor to the different ages human organism. Studied the morphological and biochemical composition of the blood of humans exposed to daily for fourteen days exposed to temperature stress factor. Installed stages of oppression and improve of natural immunity, the timing of reversal of functional systems after termination of the actions of critical temperature.

Purpose and objectives of the study. To study of adaptive reactions of humans of different ages to the single and frequentative effect of the thermal stress factor.

Material and methods

To achieve the goals and objectives, studies were conducted in treatment-and-health center «Saryagash», which is located in the South Kazakhstan region, Saryagash district, village Kokterek and in the research centre of medical clinic DostarMed in June and July. To study attended 10 local people and 10 people, who came from other regions of Kazakhstan. Most of them from North Kazakhstan region. All people, who involved in the study divided to 2 groups. The ages of people in Group 1 was 15-18 years old, and in Group 2 was 55-60years old. Local people were regarded as control group. The ages of people in local group was 55-60 years old.

People create heat stress lasting 1 hour at ambient temperature + 42 – 45 ° C and 76- 80% relative humidity once and daily for 14 days.In people of all groupsblood for research was taken from the vein before and after 5 minutes, 8 and 24 hours of single thermal exposure. Then, after three, seven, fourteen times heat exposure.

The number of red blood cells and white blood cell count, hemoglobin, erythrocyte sedimentation rate was determined by the standard technique with using hematology analyzer.

Digital material of results of the study were treated by variational statistics with using Microsoft Excel computer program. Thestatistical accuracy of the survey results, *p<0,05, **p<0,01, ***p<0,001, compared with Student's *t*-distribution.

Results and discussion

On 7-fold influence of critical temperature the organism of group 1 peoples decrease in quantity of erythrocytes by 13,2% and hemoglobin 12,8% in comparison with control. To 10 – and 15-fold thermal impacts on an organism group 1 peoples led to decrease in maintenance of erythrocytes by 22,6% and 19,2%, and hemoglobin for 25,6% and 13,2%, respectively in comparison with control.

Group 1 peoples on 3-and 7-fold influence of a stressor have answered with decrease in maintenance of erythrocytes to 4,6±0,4x10^{12}/l (p <0,05) that is 24% lower than value in control. Content of hemoglobin after the 7th influence was 9,8±0,2 g/l (p <0,05) that below control for 13,3% and SSE was 2,3±0,4 mm/h, above control for 35,3%. During the period with 10th on the 15th influences the maintenance of erythrocytes and hemoglobin was lower 11% and 4,5%, respectively, in comparison with control group. SSE in group 1was 2,2±0,2 mm/h, in control 1,8±0,2 mm/h

It is established that in response to influence of critical temperature there is a certain reaction of leukocytes. After 3-fold influence the quantity of leukocytes increases by 21,8%, and 7-fold decreases to 5,9±0,2x10^{9}/l, at norm 6,1±0,5x10^{9}/l. Reliable decrease in leukocytes to 4,5±0,0x109/l (p <0,01) is noted after 14-fold influence (32,8%) and 15-fold thermal impact on 38,7% in comparison with control. Research of maintenance of leukocytes during the post-stressful period has shown that for the 3rd day the quantity of leukocytes in blood of control group has reached values of control group and had no differences during all term of researches.

Important component of blood are leukocytes. All types of leukocytes participate in protective reactions of an organism, each look carries out it in the special way (production of interferon, a lizotsim, properdin, histamine and other biologically active agents, the main role of humoral immunity).

The organism of group 1 people reacted to single thermal influence increase of maintenance of leukocytes to 7,4±0,2 x 109 /l (p<0,05) that is 32,1% higher, than in control group. The blood test after 8 hours has shown that the maintenance of leukocytes in group 1 has decreased to 5,4±0,2109/l, and after 24 hours has reached values of control group – 5,6±0,5x109/l

At group 1 people have established reliable increase in maintenance of young neutrophils up to 1,1±0,1% (p<0,05) and the stab neutrophils to 31,3±2,9% (p <0,05). In group 1 decrease in small lymphocytes to 32,8±0,8%, average to 9,6±0,8% and big to 3,9±0,7%.

After 8 hours from single thermal influence contents young and the segmented neutrophils remained raised – 1,4±0,7% and 24,7±2,6%, respectively, and big lymphocytes were below control group and has made 3,9±0,8%, the maintenance of average lymphocytes has increased to 10,7±0,8%.

Restoration of percentage of neutrophils in blood of group 1 people came within 24 hours after influence. During this period the maintenance of young neutrophils has decreased to 0,5±0,2%, and the stab neutrophils to 19,6±1,3%. Decrease in percent of highly segmented neutrophils to 2,5-2,7% has been noted in both of group.

Single impact of critical temperature on an organism of group 2 people has led to decrease in maintenance of leukocytes to 5,3±0,2109/l that is 20,9% lower than control group. In 8 hours after influence a stress factor observed increase of maintenance of leukocytes up for 14,9% of a reference level. In 24 hours the maintenance of leukocytes in skilled group corresponded to control

Peoples of control group had an increase of maintenance of leukocytes in blood. So, for the 7th day of researches the quantity of leukocytes in blood has increased by 8,9%, on the 14th – for 19,6%. Authentically high value 6,8±0,2$10^{9}$/l, (p< 0,05), in comparison with initial level, was for the 14th day after the last influence. Leukocytic reactions reflect a condition of an organism more precisely. Proceeding from it we have carried out studying the leukocytic reactions at group 1 peoples(Table 1).

14-fold influence of critical temperature, in comparison with 7-fold, has caused decrease in number the segmented neutrophils to 20,7±1,6%, but exceeding value of control for 3,2% (17,5±1,7%). The quantity of highly segmented neutrophils in control has made 3,3±0,7%, in skilled group of 2,4±0,2%. During this period the low level of lymphocytes remained

During the period from the 3rd on 14-fold thermal influences in group 2 the maintenance of eosinophils was low – 0,8±0,2% – 0,6±0,2%, in comparison with control of 1,3±0,3%, and after the 14th influence their contents has increased to – 1,2±0,1%.

Table 1 – Leukocytichemogram for 15-18 years old people at repeated exsposure of the critical temperature (+42 – 45^{0}C) duration 1 hour

Leucocytes		Control group	Initial indexes	After 1st influence of stress	After 7th influence of stress	After 10th influence of stress	After 14th influence of stress
Total number of white blood cells, x10^{9}/l		5,6	5,6	5,6	6,7	5,9	4,5
Neutrophils, %	Young	0,4	0,4	0,6	0,9	1,3	1,3
	Segmented	20,3	19,9	19,6	31,4	30,1	26,2
	Stab	19,3	20,6	14,7	17,9	23,5	20,7
Eosinophils, %		0,9	0,9	1,6	0,8	0,6	0,6
Basophils, %		0,7	0,8	0,5	0,5	0,6	1,1
Monocytes, %		2,4	2,0	2,7	2,3	2,2	1,9
Lymphocytes, %	Small	38,2	37,6	41, 5	36,4	30,7	36,3
	Avarage	12,2	11,7	12,5	9,6	7,6	9,4
	Big	6,6	6,1	6,4	1,1	3,4	2,5

Increase of total of leukocytes in group 2 was after the 3rd influence to 16,6% and after the 14th impact on 9,2% of a reference level. On the 14th influence of high temperature the maintenance of leukocytes in group 2 was 6,9±0,6x10^{9}/l, in control – 6,5±0,9x10^{9}/l. Only for the 14th day observed increase of leukocytes in group 2 for 10,6%.

On 7-fold influence thermal a stress factor the maintenance of young neutrophils was raised, and the stab neutrophils has decreased to 16,5±1,5%. During this period contents the segmented neutrophils to 19,5±1,3% has increased ($p<0,05$). With increase of percent the segmented neutrophils the maintenance of the hyper segmented neutrophils has increased to 7,9±0,8% ($p <0,01$). The percent of eosinophils has considerably decreased to 0,6±0,1% ($p <0,01$). The maintenance of basophiles in control and group 2 was identical. In group of lymphocytes the low maintenance of average lymphocytes and raised small remained. Lymphocytes has increased to 47,3±2,4% ($p <0,05$). In this time the maintenance of monocytes has decreased to 1,7±0,4% ($p< 0,05$) (table 2).

Table 2 – Leukocytichemogram for 55-60 years old people at repeated exsposure of the critical temperature(+42 – 45^{0}C) duration 1 hour

Leucocytes		Control group	Initial indexes	After 1st influence of stress	After 7th influence of stress	After 10th influence of stress	After 14th influence of stress
Total number of white blood cells, 10^{9}/l		6,3	5,8	6,6	7,1	6,1	6,7
Neutrophils, %	Young	0,6	0,5	0,5	1,3	1,2	1,1
	Segmented	12,1	11,5	11,3	16,6	15,6	20,2
	Stab	14,1	12,4	14,2	14,3	16,5	10,1
Eosinophils, %		2,3	3,0	2,0	1,6	0,6	0,4
Basophils, %		1,2	1,3	1,4	2,1	1,8	1,1
Monocytes, %		2,1	2,1	2,0	2,6	2,2	1,7
Lymphocytes, %	Small	37,4	36,5	41,0	41,6	41,5	43,7
	Avarage	19,3	23,5	16,0	9,1	10,1	9,8
	Big	4,5	3,4	5,6	3,6	4,4	5,3

Conclusions

1.We regard the changes of indicators of blood established in experiences as responses of an organism to thermal influence. At humans organism of all two skilled groups the quantity of erythrocytes and hemoglobin decreased at once after single thermal influence. In group of 15-18 years old people the maintenance of erythrocytes has gone down for 20,7%,and hemoglobin for 10,4%. In group of 55-60 years old people the maintenance of erythrocytes has decreased 25,5%.

2. In our work we have tracked recovery of the contents of erythrocytes after single influence of high temperature. So, the maintenance of erythrocytes and hemoglobin reached values of control group at 15-18 years old people within 24 hours after thermal influence, in group of 55-60 years old people these indicators came back to norm within 24 hours that is connected with more perfect mechanisms of system of thermal control.

3. The analysis of a leukogramma has shown dynamics of changes in the maintenance of various groups of leukocytes on a thermal stress. Single influence of high temperature caused reliable increase in percent young and the stab neutrophils in all age groups. The increased contents young and the stab neutrophils in group of 15-18 years old people remained till 24 o'clock after single influence. At 55-60 years old people in 8 hours after the 1st influence the maintenance of young neutrophils has gone down to values of control group, and the stab neutrophils in 24 hours. At 55-60 years old people in 24 hours after single influence contents young and the stab neutrophils authentically didn't differ from values of control group.

4. At humans develops limfopeniye and an eozinopeniye, (development signs a stress reaction). At 15-18 years old people the level of monocytes respectively decreases by 34,7% and 58,4%, at 55-60 years old people the limfopeniya is characterized by relative increase of quantity of small lymphocytes, against decrease in average and big lymphocytes. The system of blood of 55-60 years old people for preservation of a homeostasis reacts increase of level of basophiles in blood.

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