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ON CHANGES IN HUMAN BODY CONDITION DURING THE PERFORMANCE IN PERSONAL PROTECT CLOTHES AT THE AIR TEMPERATURE OF 10 °C AND 50 °C

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The investigation with volunteers as subjects who performed a short-term hard exercise (at power 50–70 W) in the insulated protect clothes at the air temperature of 10 °C and 50 °C was carried out. There were determined shifts of acid-alkali balance in the arterial and venous blood as indexes of PH, carbonic gas (PCO2) and oxygen (P02) tensions, plasma hydrogen-carbonate content (HC03~), alkali (BE) and hemoglobin (Hb) contents and blood oxygen saturation (SAT). The degree and characteristics of such changes were revealed. The distinct acid-alkali disbalance induced by respiratory and metabolic changes at the air temperature of 10 °C was measured. At the air temperature of 50 °C along with the recorded changes there were observed PH shift in blood and impairment of oxygen uptake by the tissues.

Key words: *performance, high and low ambient temperature, insulated protect clothes, shifts of acid-alkali balance.*

Introduction

During the performance put out in the personal protect clothes under different warm exchange conditions the special attention was paid to the estimation of the internal human body condition indexes along with the warm state. The purpose of this investigation was to determine the charac-teristics of acid-alkali balance changes in the arterial and venous blood during the short-term hard exercise in the insulated protect clothes under satisfactory (10 °C) and extremely severe (50 °C) ambient conditions. Accordingly, two series of experiments were held with 6 volunteers at the age of 30–45 years old.

Materials and Methods

The first series (12 experiments) was carried out at the air temperature of 50 °C and under the heat radiation exposure at 2000 W/m. The insulated protect suit was used as the protective clothes which consisted of the overalls, rubber boots and gloves. The second serie (9 experiments) was performed at the air temperature of 10 °C (without heat radiation exposure) and in the same protect suit. The test subjects changing feet and hands on the veloergometers were exposed to short-term (20 min) hard exercise at the power of 50–70 W.

The acid-alkali balance in the arterial and venous blood was measured pre-to posttraining

on the basis of such indexes as PH, carbonic gas (PCO2) and oxygen (PO2) tensions and plasma hydrogencarbonate content (HCO3)The acute and standard shifts of the alkaline (ABE and SBE), hemoglobin content (Hb) and blood oxygen saturation (SAT) were determined as well. The analyses were performed at the ABL-330 apparatus (Denmark). The received data were processed statistically with the calculation of mean values (M) and standard deviation (± m).

Results and Discussion

The final results are presented in Table I and Table 2. There are changes of $PC0_2$, $P0_2$, HC03, SAT, ABE and SBE at the air temperature of 10 °C. Thus, PCO2 tension in the arterial blood posttraining is decreased from 49.0 ± 0.60 to 39.7 ± 0.73 (by 19 %) and in the venous blood – from 57.8 ± 1.28 to 50.6 ± 1.76 (by 12 %); HCO3 content is also decreased (by 5 % and 9 %

Table 1

Indexes of acid-alkali balance during the performance in the insulated clothes at the air temperature of 10 °C and 50 °C (M ±)

Air temperature, °C	Indexes		Hb (g %)		PH (unit)		PCO_2(mm Hg)		HC03~ (mmol/1)	
			pre	post	pre	post	pre	post	pre	post
			training		training		training		training	
10	Arterial		19,5 ± 0,26	19,8 ± 0,43	7,375 ± 0,009	7,374 ± 0,005	49,0 ± 0,60	39,7 ± 0,73	24,0 ± 0,32	22,8 * ± 0,60
	Venous		19,5 ± 0,26	19,8 ± 0,43	7,316 ± 0,007	7,330 ± 0,006	57,8 ± 1,28	50,6 * ± 1,76	28,8 ± 0,77	26,1 * ± 0,89
	Arteriovenous difference		–	–	- 0,059	- 0,044	+ 8,8	+ 10,9	+ 4,8	+ 3,3
	Change to pretraining in %	Arterial		+ 1,5		0		- 19 *		- 5
		Venous		+ 1,5		+ 0,2		- 12 *		- 9
50	Arterial		18,4 ± 0,22	19,0 * ± 0,10	7,381 ± 0,002	7,428 * ± 0,007	42,6 ± 0,93	33,4 * ± 1,17	24,9 ± 0,42	21,8 * ± 0,78
	Venous		18,4 ± 0,29	19,2 ± 0,57	7,350 ± 0,007	7,400 * ± 0,004	52,9 ± 0,86	39,4 * ± 0,87	28,4 ± 0,34	24,3 * ± 0,77
	Arteriovenous difference		–	–	- 0,031	- 0,028	+ 10,3 *	+ 6,0	+ 3,5	+ 2,5
	Change to pretraining in %	Arterial		+ 3,2 *		+ 0,6 *		- 21 *		- 12 *
		Venous		+ 4,2		+ 0,6 *		- 26 *		- 14 *

* Significant difference p ≤ 0,05.

Table 2

Indexes of acid-alkali balance during the performance in the insulated clothes at the air temperature of 10 °C and 50 °C (M ± m)

Air temperature, °C	Indexes		$P0_2$ (mm Hg)		SAT (%)		ABE (mmol/1)		SBE (mmol/1)	
			pre-	post-	pre-	post-	pre-	post-	pre-	post-
			training		training		training		training	
10	Arterial		73,5 ± 1,30	82,8 * ± 3,40	93,7 ± 0,36	95,2 * ± 0,59	- 0,88 ± 0,34	- 1,88 ± 0,50	- 0,87 ± 0,31	- 1,87 ± 0,57
	Venous		20,3 ± 1,00	31,3 * ± 4,70	27,7 ± 3,20	48,5 * ± 7,60	0,83 ± 0,55	- 0,76 ± 0,74	2,70 ± 0,69	0,51 * ± 0,86
	Arteriovenous difference		- 53,2	- 51,5	- 66,0	- 46,7	+ 1,71	+ 1,02	+ 3,57	+ 2,38
	Change to pretraing in %	Arterial		+ 12,4		+ 1,6 *		- 114		- 144
		Venous		+ 54 *		+ 75 *		- 92		- 81,2 *
50	Arterial		72,6 ± 2,20	83,2 * ± 1,00	93,6 ± 0,57	96,2 * ± 0,14	- 0,18 ± 0,14	- 1,22 * ± 0,30	0,10 ± 0,18	- 2,0 * ± 0,42
	Venous		27,7 ± 1,93	54,2 * ± 4,50	47,0 ± 5,40	85,5 * ± 5,70	1,49 ± 0,1	0,08 * ± 0,39	2,82 ± 0,29	- 0,04 * ± 0,18
	Arteriovenous difference		- 44,9	- 29,0	- 46,6	- 10,7	+ 1,67	+ 1,30	+ 2,72	+ 1,96
	Change to pretraing in %	Arterial		- 14,6 *		+ 2,7 *		- 578 *		- 2000 *
		Venous		+ 96 *		+ 82 *		- 96		- 101 *

* Significant difference p J 0.05.

respectively), while PH in blood is remained at the initial level.

The oxygen tension (PO2) posttraining in the arterial blood is increased from 73.5 ± 1.30 to 82.8 ± 3.40 (by 12.4 %) and in the venous blood – from 20.3 ± 1.00 to 31.3 ± 4.70 (by 54 %). The arterial and venous oxygen difference did not change pre-to posttraining keeping the level of 53–51 mm Hg. There is an increase of SAT index the value of which makes up 1.6 % and 75 % in the arterial and venous blood, respectively. The decrease of ABE and SBE values to the lower limit of the norm is occured.

Along with the recorded changes there were observed PH shift and hemoglobin increase at the air temperature of 50 °C. Thus, PH value in the arterial blood is increased from 7.381 ± 0.002 to 7.428 ± 0.007 (by 0.6 %) and in the venous blood – from 7.350 ± 0.007 to 7.400 ± 0.004 (by 0.6 %), and hemoglobin content is increased by 3.2 % and 4.2 %, correspondingly. The changes of PCO2 and HCO3 are more pronounced at the test temperature while those of ABE are produced as at the air temperature of 10 °C. Thus, PCO2 in the arterial and venous blood is decreased by 21 % and 26 %, respectively and HCO3 – by 12 % and 14 % (table 1).

It is necessary to note that on a par with the increase of PO2 in blood there is observed a significant decrease of the arterial and venous oxygen difference (from 44.9 to 29 mm Hg) posttraining (tabl. 2). From data analysis it follows that the exercise performance at the air temperature of 10 °C, which is not accompanied with the changes of initial warm state causes shifts of acid-alkali balance towards a respiratory alkalosis. These data are supported by PCO2 and HCO3 decreases without PH changes in blood. The metabolic changes in the direction to acidosis (SBE changes) which do not exceed the standard limit are observed as well. The same performance under temperature exposure of 50 °C inducing acute warm exchange is accompanied with more significant shifts of acid-alkali balance which are exhibited in PH changes and marked decrease of PCO2, that point to the compensatory respiratory alkalosis [1, p. 49; 2, p. 241; 3].

The shifts towards metabolic acidosis have been shown to be similar to those at the temperature of 10 °C. The recorded increase of the arterial and venous oxygen difference may indicates a hindered uptake by the tissues.

Conclusion

The performance of a short-term exercise (50–70W ; 20 min) in insulated protect clothes at the air temperature of 10 °C is accompanied with definite changes of acid-alkali balance in the arterial and venous blood caused by respiratory metabolic shifts.

The similar performance at the air temperature of 50 °C has shown distinct acid-alkali disbalance in the arterial and venous blood together with PH changes in blood and probably the impairment of oxygen uptake by the tissues.

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ИЗМЕНЕНИЯ В ФУНКЦИОНАЛЬНОМ СОСТОЯНИИ ОРГАНИЗМА ЧЕЛОВЕКА, ОБУСЛОВЛЕННЫЕ ВЫПОЛНЕНИЕМ ФИЗИЧЕСКОЙ РАБОТЫ В ИНДИВИДУАЛЬНОЙ ЗАЩИТНОЙ ОДЕЖДЕ ПРИ ТЕМПЕРАТУРАХ ВОЗДУХА 10 °С И 50 °С

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Проведены исследования на людях в условиях выполнения кратковременной тяжелой работы в изолирующей защитной одежде при температуре воздуха 10 °С и 50 °С. Определены изменения кислотно-щелочного баланса в артериальной и венозной крови по показателям РН крови, напряжению CO_2 и O_2, содержанию гидрокарбонатов в плазме, щелочных оснований и гемоглобина. Выявлены отчетливые изменения кислотно-щелочного равновесия вследствие респираторных и метаболических сдвигов при температуре 10 °С. При температуре 50 °С, кроме того, определены сдвиги РН крови и снижение потребления кислорода тканями.

Ключевые слова: *физическая нагрузка, охлаждающий и нагревающий микроклимат, защитная одежда, изменения кислотно-щелочного равновесия.*