HEALTH RISK MANAGEMENT IN OCCUPATIONAL MEDICINE

UDC 613.1: 613.166.9: 613.6
DOI: 10.21668/health.risk/2018.2.08.eng

Read online

HEALTH RISKS FOR WORKERS CAUSED BY WEATHER AND CLIMATIC CONDITIONS DURING A COLD SEASON

R.S. Rakhmanov[1], S.A. Kolesov[1], M.Kh. Alikberov[1], N.N. Potekhina[1], N.I. Belous'ko[1], A.V. Tarasov[2], D.V. Nepryakhin[1], S.I. Zhargalov[3]

[1]Nizhniy Novgorod Scientific Research Institute for Hygiene and Occupational Pathology, 20 Semashko Str., Nizhnii Novgorod, 603950, Russian Federation
[2] Immanuel Kant Baltic Federal University, 14 A. Nevskogo Str., Kaliningrad, 236016, Russian Federation
[3]Military unit No. 51410, Nasrutdinov avenue, the 14-th kilometer, Makhachkala, 367000, Russian Federation

The authors assessed influences exerted on a body by physical environmental factors in autumn, winter, and spring in Dagestan and Kaliningrad region (the 4th climatic region where such assessments are not regulated) as per risks of exposure to cold; our assessments focused on Wind Chill Index (WCI), and frostbites of open body parts as per chilling conditions (CC) parameter under average temperature, average and maximum winds.

In Dagestan heat losses in winter under average winds were higher than optimal in the highest alpine region; but when winds reached their maximum power, such losses increased 1.35–1.48 times and overcooling was very much possible in alpine regions (WCI was higher than 1,190.0 kcal/m^2 *· h). In spring heat loss was higher than its optimal level in highlands under wind gusts. One could feel real discomfort in autumn at 1,661 meters high.*

Body chilling was quite possible in winter in Kaliningrad region when winds blew at their maximum; and discomfort could occur under wind gusts in spring and autumn.

As per CC parameter, frostbites risk was moderate in Dagestan in winter under average winds; and there was no such risk in autumn and spring. However, if winds were at maximum, the most critical risks occurred in Makhachkala district and in Khunsakhskiy district, and in Kaliningrad region as well. Risk was moderate in Kaspiyskiy district and Akhtyinskiy district. In spring and autumn risk was moderate under maximum winds in all Dagestan districts, but it was close to being critical in Kaliningrad region.

Nowadays, influences exerted by physical factors are determined as per temperature and wind speed. We detected that these influences could be adverse under different winds and could even become critical. Chilling and frostbite can occur even if a person is in winter clothing. However, influence exerted by air humidity is not taken into account. We can assume that this factor will potentiate influences exerted by temperature and wind, and it calls for working out a complex assessment of environmental factors in different seasons.

Key words: *chill, health risk, Chill Wind Index, integral parameter, body chilling conditions, the fourth climatic region.*

Rofail' S. Rakhmanov – Doctor of Medical Sciences, Professor, Director (e-mail: raf53@mail.ru; tel.: +7 (831) 419-61-94).

Sergei A. Kolesov – Candidate of Biological Sciences, Researcher at Clinical Department (e-mail: raf53@mail.ru; tel.: +7 (831) 419-61-94).

Murat Kh. Alikberov – Junior Researcher at Laboratory for Workers Nutrition Assessment (e-mail: recept@nniigp.ru; tel.: +7 (831) 419-61-94).

Natal'ya N. Potekhina – Doctor of Medical Sciences, Professor, Leading Researcher at Laboratory for Workers Nutrition Assessment (e-mail: recept@nniigp.ru; tel.: +7 (831) 419-61-94).

Nikolai I. Belous'ko – Candidate of Medical Sciences, Head of Information Support and Implementation Department (e-mail: recept@nniigp.ru; tel.: +7 (831) 419-61-94).

Andrei V. Tarasov – Candidate of Medical Sciences, Associate Professor at Fundamental Medicine Department (e-mail: drup1@yandex.ru; tel.: +7 (911) 468-15-31).

Dmitrii V. Nepryakhin – Candidate of Medical Sciences, Researcher at Laboratory for Workers Nutrition Assessment (e-mail: mutasyvo@nniigp.ru; tel.: +7 (951) 769-57-18).

Sergei I. Zhargalov – medical officer (e-mail: szhargalov@mail.ru; tel.: +7 (920) 071-10-70).

Cold, or chilling environment, is a combination of physical factors (air temperature, air humidity, radiation temperature, and wind speed). This combination causes chilling of a human body and requires relevant measures to be taken to prevent heat losses[1]. Exposure to cold influences temperature homeostasis and it leads to emergence of cold-induced immune deficiency and activation of lipid peroxidation and metabolic processes. Shifts in protein, fat and hydrocarbon metabolism cause compensatory increase in heat production [1–5]; compensatory "cold vasodilatation" develops [6]. Cold wind is also harmful for human thermal physiological reactions. It results in higher blood pressure and heart rate which act as cardiovascular triggers [7]. When daily temperature changes occur during a cold season, it leads to elevated relative risks of non-accidental death due to respiratory diseases [8–9]. Nowadays a lot of researchers try to get better insights into how to predict hazards related to thermal health [10].

According to the RF Federal Law passed on December 28, 2013 г. No. 426-FL[2] microclimate parameters (air temperature, relative air humidity and air speed) are to be explored (tested) and measured when a specific assessment of working conditions is performed. However, according to the Order issued by the Ministry for Labor and Social Protection on January 24, 2014, No. 33[3], experts apply only a procedure for assigning working conditions to a working conditions category (subcategory) under influences exerted by heating or chilling microclimate in workrooms.

Hygienic requirements to a working regime during a cold season necessarily regulate an uninterrupted staying of workers outdoors when they are exposed to cold and a period of time which they can spend in a heated room in order to normalize their thermal state. These requirements are based on criteria which determine a permissible degree to which a human body protected from cold with specific clothing can be chilled, as well as how fast human thermal state gets back to normal in a heated room. And here standards for influences exerted by exposure to cold are fixed only for climatic regions which are specific in terms of temperature parameters and air speed[1].

But still, exposure to cold is well-known to cause health risks under high humidity [11, 12]. Military personnel run especially high risks under such conditions. Thus, when soldiers take part in military operations, and unfavorable weather conditions prevent them from proper tending to their boots, they have to stay in wet footwear, and it causes emergence of cold-induced damages without frostbites

[1] MR 2.2.7.2129-06. Rezhimy truda i otdykha rabotayushchikh v kholodnoe vremya na otkrytoi territorii ili v neotaplivaemykh pomeshcheniyakh [MG 2.2.7.2129-06. Work and leisure regimes for personnel during cold seasons on open air or in rooms without any heating]. *Federal'naya sluzhba po nadzoru v sfere zashchity prav potrebitelei i blagopoluchiya cheloveka: ofitsial'nyi sait*. Available at: http://rospotrebnadzor.ru/documents/details.php?ELEMENT_ID=4570 (03.03.2018) (in Russian).

[2] O spetsial'noi otsenke uslovii truda: Federal'nyi zakon RF № 426-FZ ot 28.12.2013 g. [On specific assessment of working conditions: The RF Federal Law passed on December 28, 2013 г. No. 426-FL]. *Konsul'tantPlyus*. Available at: http://www.consultant.ru/document/cons_doc_LAW_156555/ (03.03.2018) (in Russian).

[3] Ob utverzhdenii Metodiki provedeniya spetsial'noi otsenki uslovii truda, Klassifikatora vrednykh i (ili) opasnykh proizvodstvennykh faktorov, formy otcheta o provedenii spetsial'noi otsenki uslovii truda i instruktsii po ee zapolneniyu: Prikaz Ministerstva truda i sotsial'noi zashchity RF № 33n ot 24.01.2014 g. [On Approval of Procedure for conducting a specific assessment of working conditions, Classifier of adverse and (or) hazardous production factors, reporting form on a specific assessment of working conditions and instructions how to fill it in: The Order issued by the RF Ministry for labor and Social Protection on January 24, 2014 No. 33n]. *KODEKS: elektronnyi fond pravovoi i normativno-tekhnicheskoi dokumentatsii*. Available at: http://docs.cntd.ru/document/499072756 (03.03.2018) (in Russian).

(CIDWF). For example, when military operations on the Falkland Islands (the Malvinas) took place, average day temperature was 10^0 C, and night one dropped up to $–4^0$ C; military personnel had to stay in wet trenches for a long time, and later 20 % of hospital patients suffered from CIDWF. A lot of soldiers who happily avoided hospitalization also suffered from symptoms which were similar to those of the initial CIDWF stages. When occurring, CIDWF can put military personnel out of action and cause a substantial decrease in their military efficiency [13].

There are some factors which are considered to cause CIDWF; they are long-term exposure to cold and (or) wet environment, and congestive effects in veins caused by a long-term staying in the same posture or by wearing tight boots. CIDWF emergence can also be stimulated by dehydration, insufficient nutrition, mental stress during military operations, fatigue, body weakening due to a concomitant diseases or a wound. There are several CIDWF types, namely "trench foot", "immersion foot", "tropical immersion foot", and "Irish foot", and it highlights their difference from frostbites.

"Trench foot" is a syndrome which results from damages to tissues when they are long-term exposed to cold under temperature from 15^0C to 1^0C.

At the initial CIDWF stages, feet get back to their normal state on the 8–9 the day after exposure to cold stops, and here intense paresthesia occurs. Patients suffer from piercing and shooting pains and almost continuous tingling for 3–4 weeks.

Cold traumas, frostbites in particular, which occurred in the North Caucasus, were apparently seasonable (autumn, winter, and spring). Military personnel most frequently suffered from such traumas when they were in an ambush or on a patrol (55.4 %); when scouting, 28.6 %; at blocks, 7.6 %; on armored troop carriers, 7.1 %; and on guard, 1.3 %. Damages to lower extremities prevailed (74.0 %). Damages to elbow joints (2.4 %), knee joints (2.4 %), and buttocks (1.3 %) most frequently occurred in case of snipers who had to lie on snow for a long time. 50.8 % patients had frostbites of I-II degree; 26.4 %, II-III degree; 21.7 %, III-IV degree. Overall chilling was detected in 1.1 % patients [14].

All the above-mentioned motivated us to choose our **research goal** which was to assess influence exerted on workers' health by physical factors of the environment in the Republic of Dagestan and Kaliningrad region.

To achieve this, we set **the following tasks:**

- to assess weather and climatic conditions in autumn, winter, and spring;
- to assess influences exerted by a chilling environment on a human body when workers had to perform their work tasks at various heights;
- to assess risks of frostbites of open body parts when working outdoors.

Data and methods. Parameters of microclimate underlie preservation of heat balance between a human body and the environment thus keeping body optimal or permissible heat status. Due to that, we applied methodical procedures and criteria fixed in the Rospotrebnadzor's methodical guidelines MG 2.2.7.2129-06 " Work and leisure regimes for personnel during cold seasons on open air or in rooms without any heating". Safety criteria for work which is performed in a chilling environment allowing for a duration of exposure to cold take into account combinations of different negative temperatures and energy losses borne by workers in the 1st climatic region (the 4th climatic zone) with the most probable wind speed being 1.3 m/sec; in the 2nd climatic region (the 3rd climatic zone) with the most probable wind speed being 3.6 m/sec; and in the 3rd climatic region (the 1st and the 2nd climatic zones) with the most probable wind speed being 5.6 m/sec.

We used meteorological data collected over 2012-2016 and obtained from the Dagestan regional and Kaliningrad regional centers for hydrometeorology and environmental monitoring. We estimated average air temperatures, air humidity, and air speed (average and maximum) during three seasons: autumn, wind, and spring. Environmental conditions in Dagestan varied depending on a height above the sea level; therefore, we performed our assessments at 4 meters height (near Makhachkala), at 16 meters height (near Kaspiysk), at 1,040 meters height (Akhtyinskiy district), and at 1,661 meters height (Khunzakhskiy district).

We followed recommendations on hygienic requirements to a working regime during a cold season on open air[1] and determined an integral parameter of conditions for body chilling (IPCBC) in scores as per the formula: 34.654-0.4664×*at*+0.6337×v (where *at* is air temperature, ^{0}C; v is wind speed, m/sec). This parameter allows to assess risks of frostbites of open body parts. Thus, IPCBC ≤34 scores meant there were no such risks; 34 < IPCBC ≤ 47 meant the risk was moderate; 47< IPCBC ≤ 57, critical; and IPCBC > 57 meant there was a disastrous risk of frostbites of open body parts. When the risk was moderate, the document fixed safe staying out in the chill to be not longer than 60 minutes; when the risk was critical, it was safe to say out for 1 minute only; and went the risk was disastrous, staying outdoors shouldn't exceed half a minute.

Besides, we assessed chilling environmental effects as per the Wind Chill Index (WCI) which was equal to (10√v+10.45-v)×(33- t^{0}), where v was air speed, m/sec; t^{0} was air temperature ^{0}C [15]. WCI value equal to 761.6 kcal/(m^{2}×h) corresponded to comfortable weather conditions. A person in proper winter clothing gets chilled when WCI values are equal to 1193.34–1551.3 kcal/(m^{2}×h).

Results and discussion. Dagestan Republic and Kaliningrad enclave are located in the 4th climatic region in which working regimes on open air during a cold season have not been standardized yet.

In Dagestan, air temperature on open air varied from +1.0 to -3.2^{0}C in winter (Table 1). However, negative temperatures could drop to –14.0±0.7 – –15.7 ±0.9^{0}C in December-February, with their minimum values being detected at 1,040 and 1,661 meters heights above the sea level.

In Kaliningrad region, minimal temperatures also reached -12.5±1.5^{0}C (the lowest temperature was -24.3^{0}C). It made body chilling and frostbites of open body parts quite possible if workers had to work outdoors during this season.

Heat losses borne by a body which resulted from influences exerted by environmental conditions in Dagestan were higher than the optimal level only in the highest mountain region, only in winter, and when the wind speed was average. However, when the wind speed was maximum, heat losses due to convection increased substantially and exceeded their optimal level 1.35-1.48 times on lowlands, and as for highlands, body over-chilling could occur there, even if a person was in winter clothing (the Wind Chill Index was equal to or even higher than 1,190.0 kcal/m^{2} ×h) (Table 2).

Table 1

Parameters of physical environmental factors in 2012–2016 during different seasons and under different conditions of occupational activities, absolute values

Parameters	Districts where observations took place in Dagestan, Height above the sea level, m				Kaliningrad region
	16	4	1040	1661	
Winter					
Average air temperature, 0 C	3,53 ± 0,46	1,0 ± 2,3	–0,5 ± 1,7	–3,2 ± 2,8	–0,3 ± 0,8
Relative humidi-ty, %	87,3 ± 0,51	85,5 ± 3,5	68,3 ± 3,3	59,8 ± 3,3	84,5 ± 0,7
Air speed, m/sec (av./ max.)	3,1 ± 0,72 19,3 ± 2,2	1,7 ± 0,3 20,7 ± 2,7	1,6 ± 0,3 14,8 ± 2,5	1,9 ± 0,4 20,7 ± 3,4	2,0 ± 0,05 17,3 ± 0,8
Spring					
Average air temperature, 0 C	10,6 ± 1,15	11,0 ± 3,2	9,7 ± 2,8	5,4 ± 1,7	8,2 ± 1,2
Relative humidi-ty, %	80,3 ± 0,62	76,3 ± 2,5	66,0 ± 3,6	66,0 ± 3,5	72,5 ± 0,9
Air speed, m/sec (av./ max.)	2,8 ± 0,51 20,4 ± 1,9	3,3 ± 0,3 22,8 ± 1,1	1,8 ± 0,3 16,5 ± 2,3	2,7 ± 1,1 23,0 ± 3,2	1,9 ± 0,07 14,3 ± 0,5
Autumn					
Average air temperature, 0 C	14,5 ± 1,13	14,8 ± 3,5	10,6 ± 3,0	7,8 ± 2,8	9,0 ± 1,0
Relative humidi-ty, %	80,3 ± 0,81	79,3 ± 1,7	68,2 ± 3,3	65,5 ± 3,9	84,0 ± 1,0
Air speed, m/sec (av./ max.)	3,3 ± 0,68 21,2 ± 2,5	3,6 ± 0,3 24,2 ± 3,0	1,4 ± 0,3 13,3 ± 2,1	1,7 ± 0,2 18,8 ± 3,4	1,5 ± 0,1 14,7 ± 1,0

Table 2

The WCI parameters in various districts of Dagestan and Kaliningrad region during various seasons at average and maximum wind speed, kcal/m^2 ×h

Season	Districts where observations took place in Dagestan, Height above the sea level, m				Kaliningrad region
	4	27	1040	1661	
Winter	773,8 ± 13,8 1127,9 ± 21,8	735,3 ± 2,0 1033,8 ± 11,5	720,2 ± 14,8 1143,0 ± 16,5	808,3 ± 15,5 1938,5 ± 23,6	752,3 ± 13,5 1611,5 ± 17,1
Spring	557,0 ± 12,4 778,8 ± 11,1	544,3 ± 1,6 772,1 ± 1,9	467,5 ± 13,9 805,5 ± 15,2	667,4 ± 16,0 977,3 ± 14,9	553,9 ± 13,2 937,8 ± 13,4
Autumn	469,9 ± 14,1 645,8 ± 16,9	468,2 ± 7,3 652,8 ± 9,3	467,7 ± 12,8 753,1 ± 15,5	549,1 ± 14,6 882,2 ± 17,0	234,0 ± 9,2 920,2 ± 8,9

Table 3

IPCBC calculations as per seasons in districts where observations took place, scores

Season	Districts where observations took place in Dagestan, Height above the sea level, m				Kaliningrad region
	4	16	1040	1661	
Winter	34,2 ± 0,7 47,29 ± 1,5	34,97 ± 0,5 45,23 ± 1,8	35,9 ± 1,0 44,26 ± 1,5	37,35 ± 0,9 49,25 ± 1,6	37,1 ± 1,0 48,05 ± 1,7
Spring	31,61 ± 0,4 43,96 ± 1,1	31,48 ± 0,6 42,62 ± 1,3	30,32 ± 0,7 39,19 ± ± 1,1	31,26 ± 0,9 40,57 ± 1,2	33,84 ± 0,9 46,69 ± 1,4
Autumn	30,03 ± 0,4 43,07 ± 1,6	29,98 ± 0,3 41,31 ± 1,3	28,24 ± 0,4 39,13 ± 1,5	30,6 ± 0,6 38,13 ± 1,4	32,09 ± 0,6 42,91 ± 1,7

Body heat exchange went down in spring. However, when wind speed was maximum, and air humidity was high, physical environmental factors exerted rather adverse influence even on lowlands. Heat losses in highlands exceeded optimal level under harsh wind gusts.

In autumn, when air humidity was high, and wind speed was average, weather conditions could cause overheating in lowland Dagestan; but when wind gusts occurred, weather conditions probably got close to being comfortable. In highlands, when wind speed was average, conditions for body overheating could also occur; a person probably felt comfortable under wind gusts at 1,040 meters height; but a feeling of discomfort could occur under the same conditions at 1,661 meters height.

In Kaliningrad region, maximum winds in winter created adverse conditions which could cause body chilling. Uncomfortable conditions could also occur in autumn and spring under wind gusts.

IPCBC calculations showed that average winds in winter resulted in moderate risks of frostbites of open body parts at all places of observations; in spring and autumn there were no risks under the same weather conditions. However, when winds were maximum, it caused critical risks in Dagestan (near Makhachkala and in Khunsakhskiy district), as well as in Kaliningrad region. Risks of frostbites near Kaspiysk and in Akhtyinskiy district were moderate under the same weather conditions. In autumn and spring, risks of frostbites were moderate under maximum winds in all the districts where observations took place. In Kaliningrad region, risks were close to the upper boundary of being moderate and were nearly critical; they were more apparent near Makhachkala in spring and autumn (Table 3).

Our research revealed that climatic conditions in Dagestan and Kaliningrad region were rather similar in terms of air temperature, air speed, and relative air humidity. In Russia, existing conventional procedures for determining influences exerted on a body by physical environmental factors in cold seasons take into account only two basic parameters: air temperature and wind speed. Our data prove that effects on a body can be adverse under various wind speeds, and they can become even critical. Body chilling and frostbites of open body parts can occur even if a person is in winter clothing.

We can assume that elevated humidity can make adverse influences on workers' bodies even worse. Besides, to assess biological climatic conditions and their influences on people, we should implement up-to-date assessment procedures and technologies which is also proved by results of foreign research [16, 17].

Conclusions:

1. We should develop scientific justification for the assessment of working conditions as per degree of their hazard and danger which result from outdoor microclimate parameters in all seasons of the year, and especially under extreme climatic conditions in summer and winter time.

2. Regulation of a single time period which can be spent outdoors during a work shift in a cold season in various climatic zones which is accepted in our country is based on assessments depending on air temperature and energy losses. It doesn't take into account influences exerted on a body by air humidity. It calls for the development of new approaches to assessing complex effects which environmental factors have on a body.

3. The data obtained in the course of our research prove it is necessary to assess

working conditions on open air in all the climatic zones in the country.

Funding. Our research was not granted any sponsors' support.

A conflict of interests. The authors state there is no conflict of interests

References

1. Azhaev A.N., Berzin I.A., Deeva S.A. Fiziologo-gigienicheskie aspekty deistviya nizkikh temperatur na organizm cheloveka [Physiological-hygienic aspects of effects exerted on a human body by low temperatures]. Moscow, Meditsina Publ., 2008, 120 p. (in Russian).

2. Golokhvast K.S., Chaika V.V. Nekotorye aspekty mekhanizma vliyaniya nizkikh temperatur na cheloveka i zhivotnykh (literaturnyi obzor) [Several aspects of the mechanism of low temperature effect upon human beings and animals (literary review)]. *Vestnik novykh meditsinskikh tekhnologii*, 2011, vol. 18, no. 2, pp. 486–488 (in Russian).

3. Korobitsyna E.V., Mel'kova L.A., Gudkov A.B. Vliyanie lokal'nogo okhlazhdeniya kozhi kisti i stopy na pokazateli perifericheskoi gemodinamiki u yunoshei i devushek Evropeiskogo Severa Rossii [Impact of local hand and foot skin cooling on peripheral hemodynamic parameters in young men and women in the European North of Russia]. *Vestnik Severnogo (Arkticheskogo) federal'nogo universiteta. Seriya: Mediko-biologicheskie nauki*, 2016, no. 4, pp. 22–29 (in Russian).

4. Kulakov Yu.V., Kaminskii B.V. Meteogeofizicheskii stress i puti ego preodoleniya [Meteo-geo-physical stress and ways to overcome it]. Vladivostok, Meditsina DV Publ., 2003, 200 p. (in Russian).

5. Govorushko S.M. Vliyanie pogodno-klimaticheskikh uslovii na biosfernye protsessy [The influence of weather conditions on biosphere processes]. *Geofizicheskie protsessy i biosfera*, 2012, vol. 11, no. 1, pp. 5–24 (in Russian).

6. Bocharov M.I. Termoregulyatsiya organizma pri kholodovykh vozdeistviyakh (obzor). Soobshchenie II [Thermoregulation in cold environments (Review). Report II]. *Vestnik Severnogo (Arkticheskogo) federal'nogo universiteta. Seriya: Mediko-biologicheskie nauki*, 2015, no. 2, pp. 5–16 (in Russian).

7. Ohashi Y., Katsuta T., Tani H., Okabayashi T., Miyahara S., Miyashita R. Human cold stress of strong local-wind "Hijikawa-arashi" in Japan, based on the UTCI index and thermo-physiological responses. *International Journal of Biometeorology*, 2018. Available at: https: //link.springer.com/article/10.1007 % 2Fs00484-018-1529-z (03.04.2018).

8. Sharafkhani R., Khanjani N., Bakhtiari B., Jahani Y., Entezar M.R. Diurnal temperature range and mortality in Urmia, the Northwest of Iran. *J. Therm. Biol.*, 2017, vol. 69, pp. 281–287. DOI: 10.1016/j.jtherbio. 2017.08.011.

9. Fallah G.G., Mayvaneh F. Effect of Air Temperature and Universal Thermal Climate Index on Respiratory Diseases Mortality in Mashhad, Iran. *Arch. Iran Med.*, 2016, vol. 19, no. 9, pp. 618–624. DOI: 0161909/AIM.004.

10. Pappenberger F., Jendritzky G., Staiger H., Dutra E., Di Giuseppe F., Richardson D.S., Cloke H.L. Global forecasting of thermal health hazards: the skill of probabilistic predictions of the Universal Thermal Climate Index (UTCI). *Int. J. Biometeorol*, 2015, vol. 59, no. 3, pp. 311–323. DOI: 10.1007/s00484-014-0843-3.

11. Alenikova A.E., Tepisova E.V. Analiz izmenenii gormonal'nogo profilya muzhchin g. Arkhangel'ska v zavisimosti ot faktorov pogody [Analysis of the changes in male hormone pro-

file depending on weather conditions in Arkhangelsk]. *Vestnik Severnogo (Arkticheskogo) federal'nogo universiteta. Seriya: Mediko-biologicheskie nauki*, 2014, no. 3, pp. 5–15 (in Russian).

12. Bocharov M.I. Termoregulyatsiya organizma pri kholodovykh vozdeistviyakh (obzor). Soobshchenie I [Thermoregulation in cold environments (Review). Report I]. *Vestnik Severnogo (Arkticheskogo) federal'nogo universiteta. Seriya: Mediko-biologicheskie nauki*, 2015, no. 1, pp. 5–15 (in Russian).

13. Skvortsov Yu.R., Kichemasov S.Kh. Otmorozheniya v sovremennoi boevoi patologii [Frostbites in contemporary military pathology]. *Voenno-meditsinskii zhurnal*, 2002, no. 1, pp. 23–27 (in Russian).

14. Shelepov A.M., Sidel'nikov V.O., Karailanov M.G., Kazar'yan S.M., Chmyrev K.V., Tkachuk I.V. Kholodovye porazheniya voennosluzhashchikh, uchastvovavshikh v kontrterroristicheskikh operatsiyakh na Severnom Kavkaze (1994–1996, 1999–2001 gg.) [Frostbites amongst service men, participants of contreterroristic operations on North Caucasus (1994–1996, 1999–2001)]. *Voenno-meditsinskii zhurnal*, 2007, no. 10, pp. 4–7 (in Russian).

15. Novozhilov G.N., Lomov O.P. Gigienicheskaya otsenka mikroklimata [Hygienic assessment of microclimate]. Leningrad, Meditsina LO Publ., 1987, 112 p. (in Russian).

16. Blazejczyk K., Epstein Y., Jendritzky G., Staiger H., Tinz B. Comparison of UTCI to selected thermal indices. *Int. J. Biometeorol.*, 2012, vol. 56, no. 3, pp. 515–535. DOI: 10.1007/s00484-011-0453-2.

17. Bröde P., Błazejczyk K., Fiala D., Havenith G., Holmér I., Jendritzky G., Kuklane K., Kampmann B. The Universal Thermal Climate Index UTCI compared to ergonomics standards for assessing the thermal environment. *Ind. Health*, 2013, vol. 51, no. 1, pp. 16–24.

Rakhmanov R.S., Kolesov S.A., Alikberov M.Kh., Potekhina N.N., Belous'ko N.I., Tarasov A.V., Nepryakhin D.V., Zhargalov S.I. Health risks for workers caused by weather and climatic conditions during a cold season. Health Risk Analysis, 2018, no. 2, pp. 70–77. DOI: 10.21668/health.risk/2018.2.08.eng

Received: 15.03.2018
Accepted: 14.06.2018
Published: 30.06.2018