

PREVENTIVE MEDICINE

LEUKOCYTES AND PHAGOCYTOSIS IN MEN OF EXTREME PROFESSIONS IN THE SUBARCTIC REGION

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ABSTRACT

Men over the age of 45 are a socially significant group, most of whom have reached professional maturity and make a significant contribution to the country's economy and their families. In the Arkhangelsk Region, the health status of 40–45-year-old men (57 %) is characterized by cardiovascular pathology, 14.7 % – by gastrointestinal pathology, 47.4 % – by bronchopulmonary pathology, and 17.0 % – by musculoskeletal disorders. Male specialists from the Hydrographic Service in Arkhangelsk carry out planned and special hydrographic works during the navigation period on a rotational basis, making short-term frequent trips of 16 days in the Northern Seas.

The aim. To analyze the features of leukocyte content and phagocytosis in hydrographers of the Arkhangelsk region of the Hydrographic Service of the Russian Federation, taking into account their age and work experience in the northern seas.

Materials and methods. Thirty-six men working in the hydrographic service of the Federation Council of the Russian Federation were examined with short 16-day shifts: 15 men aged 30–40 with 10 years of work experience and 21 men aged 50–65 with 20 years of work experience. The leukocytes count and phagocytosis in peripheral venous blood were determined, taking into account age and work experience. For statistical processing, Microsoft Excel 2010 and SPSS 20.0 for Windows were used as software packages.

Results. It has been established that hydrographers of the younger age group with 10 years of work experience have a 1.5–2 times higher incidence of leukocyte, lymphocyte, and monocyte deficiency, which is associated with low phagocytosis activity. In the older age group of individuals with 20 years of work experience, leukocytosis, lymphocytosis, and monocytosis are recorded 1.5 times more frequently against the background of increased phagocytosis activity.

Conclusion. The phagocytic activity of neutrophils is higher in the older age group with 20 years of experience in extreme conditions.

Keywords: leukocytes, lymphocytes, phagocytosis, hydrographic service, subarctic region

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СОДЕРЖАНИЕ ЛЕЙКОЦИТОВ И ФАГОЦИТОЗ У МУЖЧИН ЭКСТРЕМАЛЬНЫХ ПРОФЕССИЙ В УСЛОВИЯХ СУБАРКТИЧЕСКОГО РЕГИОНА

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РЕЗЮМЕ

Мужчины старше 45 лет являются социально значимой группой, большинство из которых достигло профессиональной зрелости, вносит значительный вклад в экономику страны, своей семьи. В Архангельской области состояние здоровья 40–45-летних мужчин (57 %) характеризуется сердечно-сосудистой патологией, 14,7 % – патологией желудочно-кишечного тракта, 47,4 % – бронхолегочной патологией и 17,0 % – заболеваниями опорно-двигательного аппарата. Специалисты гидрографической службы г. Архангельска мужского пола выполняют плановые и специальные гидрографические работы вахтовым методом в течение навигационного периода, совершая кратковременные частые рейсы длительностью 16 суток в Северных морях.

Цель исследования. Проанализировать особенности содержания лейкоцитов и фагоцитоза у гидрографов Архангельского района гидрографической службы СФРФ с учетом возраста и стажа работы в условиях северных морей.

Материалы и методы. Обследовано 36 мужчин, работающих в гидрографической службе СФРФ, короткими вахтами по 16 суток: 15 человек в возрасте 30–40 лет со стажем работы 10 лет и 21 человек в возрасте 50–65 лет со стажем работы 20 лет. Определяли содержание лейкоцитов и фагоцитоз в периферической венозной крови с учетом возраста и стажа работы. Для статистической обработки применен пакет прикладных программ Microsoft Excel 2010 и SPSS 20.0 для Windows.

Результаты. Установлено, что у гидрографов младшей возрастной группы со стажем работы 10 лет в 1,5–2 раза чаще встречается дефицит лейкоцитов, лимфоцитов и моноцитов, взаимосвязанный с низкой активностью фагоцитоза. У старшей возрастной группы лиц со стажем работы 20 лет лейкоцитоз, лимфоцитоз и моноцитоз регистрируются в 1,5 раза чаще на фоне повышенной активности процессов фагоцитоза.

Заключение. Фагоцитарная активность нейтрофилов выше у старшей возрастной группы со стажем работы 20 лет в экстремальных условиях.

Ключевые слова: лейкоциты, лимфоциты, фагоцитоз, гидрографическая служба, субарктический регион

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INTRODUCTION

The Arkhangelsk region is located in a variety of climatic and geographic zones, including arctic, subarctic, and temperate regions. Approximately 40 % of the region lies beyond the Arctic Circle and within the permafrost zone, where it is influenced by moist air masses from the Atlantic Ocean and the cold waters of the White Sea and Arctic Ocean. This combination of factors results in unfavorable climate and geographical conditions, characterized by low air temperatures, high humidity, increased air mass mobility, dramatic seasonal photoperiodicity, significant barometric pressure fluctuations, and elevated geomagnetic activity [1–3].

In the Arkhangelsk region, mortality among working-age individuals remains high, despite an annual decline. For example, in 2014 the proportion of deaths among the working-age population was 27.3 % of all deaths (32.0 % in 2010). The mortality rate for men is higher than for women in all age groups, especially during the working age period. It has been noted that men over the age of 45 form a socially significant group, as the majority have reached professional maturity and contribute significantly to the national economy and their families [4–6]. In the Arkhangelsk region, the health of 40-year-old men is characterized by cardiovascular pathology (57 %), gastrointestinal pathology (14.7 %), bronchopulmonary pathology (47.4 %), and musculoskeletal disorders (17.0 %) [4, 5, 7].

The Hydrographic Service of Russia is a structural unit within the Ministry of Defense of the Russian Federation. Its main functions include providing navigational, hydrographic, hydrometeorological, topographical, geodetic and marine navigation support to Russian maritime activities in accordance with international obligations related to the safety of life at sea in the inland waters within the jurisdiction of the Russian Federation.

As a rule, the personnel are male employees of working age who are physically fit for duty and undergo an annual medical examination in accordance with Regulation No. 302-N at the facility of the 1st branch of the Federal State Institution “1469 Naval Clinical Hospital of the Northern Fleet”. Male specialists from the Hydrographic Service based in Arkhangelsk perform both planned and specialized hydrographic work throughout the entire navigational period, undertaking short, frequent voyages of up to 16 days, as well as voyages lasting 265 days, to maintain light-houses. It was of interest to study the leukocyte count and phagocytosis in the immune response of individuals who work short 16-day shifts in the Northern seas.

It is known that neutrophils constitute the most abundant population of peripheral blood cells, accounting for up to 70 % of total leukocyte count. However, in a routine analysis, only approximately 50 % of leukocytes, the circulating pool, can be assessed. These cells do not have a specialized function and can differentiate into antigen-presenting cells depending on the microenvironment. The remaining 50 % are marginated neutrophils that are ready to leave the blood vessels and enter tissues

to perform phagocytosis [8]. According to a study conducted by the Institute of Environmental Physiology of the Ural Branch of the Russian Academy of Sciences in Arkhangelsk among practically healthy residents aged 20–77 years with non-extreme occupations during the period 2014–2024 [9], neutrophil apoptosis was accompanied by an increase in the number of band neutrophils, without affecting their phagocytic activity. The level of necrosis in northern populations is significantly lower than that of programmed neutrophil death, which helps to maintain cellular homeostasis without the need for an inflammatory response [10, 11].

The relevance of this study is supported by its scientific originality, as it represents the first in-depth investigation of the association between leukocyte count and phagocytosis in the immune responses of working-age adults, considering work experience, age, and shift duration in extreme climatic and occupational conditions of the Arctic seas. A correlation between leukocyte count and various immune imbalances has been identified. The data obtained during the study on the collaboration of immunocompetent cells enhance our current comprehension of the physiological processes underlying adaptive immune responses in individuals who work on a shift schedule in the Arctic regions. These results will contribute to developing strategies for preventing secondary immunodeficiency disorders associated with environmental factors and occupational activities in the Arctic area of the European North of Russia. The results enhance our comprehension of individual resilience and contribute significantly to the field of environmental physiology. The identified correlations between innate and acquired immune responses will enable future investigations to elucidate the mechanisms of activation at each phase of the acquired immune response, which can be utilized for health prediction and to justify remedial measures for workers operating in the Arctic coastal region.

AIM

To analyze the features of leukocyte count and phagocytosis in hydrographers employed by the Arkhangelsk branch of the Hydrographic Service of the Russian Federation, considering their age and experience working in the Northern seas.

MATERIALS AND METHODS

The study was conducted at the Laboratory of Immune Cell Physiology, Institute of Environmental Physiology, N. Laverov Federal Center for Integrated Arctic Research, Ural Branch of the Russian Academy of Sciences in Arkhangelsk, Russia.

A total of 36 male participants working in the Arkhangelsk branch of the Hydrographic Service of the Northern Fleet of the Russian Federation on short-term shifts (16-day shifts) were examined. Of these participants, 15 were

aged 30–40 years and had 10 years of work experience, while 21 were aged 50–65 years and had 20 years of work experience.

The study was conducted in accordance with the ethical principles outlined in the Helsinki Declaration, as revised and amended in 2013 by the World Medical Association. Approval for the study was granted by the Ethics Committee of N. Laverov Federal Center for Integrated Arctic Research (Protocol No. 001-20/01 dated January 20, 2025), under state assignment No. 125021902582-1 “Physiological significance of the features of adaptive and innate immune responses in the development of immune homeostasis reserves among Arctic residents, taking into account age, sex, and occupational status”.

The immunological examination of the subjects involved the assessment of peripheral blood leukocytes, lymphocytes, monocytes, eosinophils, and neutrophils, as well as the neutrophil phagocytic activity. The determination of neutrophil and lymphocyte counts in the peripheral blood was performed using a Pentra 60 ABX hematology analyzer (absolute values). The phagocytic activity and cell counts were determined by incubating the blood with latex particles for 30 minutes at 37°C, followed by Romanowsky–Giemsa staining. The cell counting was performed using an immersion microscope (Nikon Eclipse 50i). Statistical analysis was performed using Microsoft Excel 2010 and SPSS 20.0 for Windows. The differences between the compared parameters were assessed using Student’s *t*-test (for normal distribution) and considered significant at $p < 0.05$ – 0.01 .

RESULTS AND DISCUSSION

The study conducted by Boscolo P. et al. demonstrated that the type of professional activity affects the activity of T-lymphocytes (CD5⁺) and natural killer (NK) cells. It was shown that high levels of work-related stress in factory and construction workers are correlated with decreased activity of NK lymphocytes and T cells (CD5⁺), whereas office workers and artists have increased NK cell activity due to lower levels of stress [12, 13]. Long-term studies on the immune status of northern populations conducted by Balashova S.N. et al. found that activation of granulocytes with the CD95⁺ antigenic determinant in individuals with non-extreme working conditions is strongly correlated with an increase in the concentration of band forms of leukocytes and, simultaneously, with a significant decrease in the number of mature differentiated cells. It has been suggested that neutrophil apoptosis may not affect phagocytic response. However, it has been noted that a decrease in its intensity is associated with a lower phagocytic activity [14, 15].

The unique working conditions associated with shift-based employment in the Northern seas of the subarctic region can lead to physiological stress due to professional activity, lifestyle, and shift duration. This stress can affect the health of hydrographic professionals

by disrupting various bodily systems, including the immune system [1]. The prolonged exposure to extreme occupational and environmental factors can contribute to a decrease in immune homeostasis, leading to the development of secondary immunodeficiencies that are dependent on environmental factors. These deficiencies can manifest as a tendency towards chronic pathology [16].

Professional activity in the challenging conditions of the northern region, including military service, hydrographic work, outdoor activities, and others, requires intense physical energy expenditure. Prolonged exposure to extreme environmental conditions further weakens the immune system [17–19].

It should be noted that the total leukocyte count in the peripheral blood of the examined individuals was within the generally accepted physiological range. However, it is worth noting that the levels of neutrophils, eosinophils, and monocytes were slightly elevated (Table 1).

It was found that the total leukocyte count among men with 10 years of work experience was $6.63 \pm 0.50 \times 10^9$ cells/L, and among men with 20 years of work experience it was $7.02 \pm 0.54 \times 10^9$ cells/L. Leukopenia was not observed in either group. Leukocytosis was noted in 6.7 % and 14.3 % of cases, respectively.

The mean lymphocyte count in the study groups was $2.27 \pm 0.23 \times 10^9$ cells/L and $2.88 \pm 0.32 \times 10^9$ cells/L, respectively. Analysis of the frequency of abnormalities revealed that lymphopenia was present in 13.3 % and 4.8 % of cases, whereas elevated lymphocyte levels were seen in 6.7 % and 14.3 % of the examined individuals, respectively.

The total monocyte count was $0.44 \pm 0.06 \times 10^9$ cells/L and $0.43 \pm 0.05 \times 10^9$ cells/L, respectively. No significant decrease in this parameter was recorded among men with 10 years of work experience, whereas in the group of men with 20 years of experience, a deficiency of this parameter was observed in 4.8 % of cases (Table 2). Conversely, elevated monocyte levels were more frequent in the group with 20-year work experience (6.7 % and 14.3 %, respectively).

The total eosinophil count for both groups was $0.20 \pm 0.03 \times 10^9$ cells/L. Elevated values were observed in 20 % and 19 % of cases, respectively, without significant difference based on age or work experience.

The total neutrophil count among men with 10 years of work experience was $3.73 \pm 0.36 \times 10^9$ cells/L, and among men with 20 years of work experience it was $3.52 \pm 0.36 \times 10^9$ cells/L. A slight neutrophil deficiency was observed twice as frequently in the older group.

Based on our data, the phagocytic index was 6.04 ± 0.13 among men with 10 years of work experience and 7.11 ± 0.50 among men with 20 years of work experience. The percentage of active phagocytes was 67.57 ± 2.84 % and 65.75 ± 2.32 %, respectively, without a significant difference by age or work experience. The mean level of neutrophil phagocytic activity in the peripheral blood of hydrographers working

TABLE 1

THE AVERAGE LEUKOCYTE COUNT IN THE PERIPHERAL BLOOD OF MALE HYDROGRAPHERS IN THE ARKHANGELSK REGION OF THE HYDROGRAPHIC SERVICE OF THE FEDERATION COUNCIL OF THE RUSSIAN FEDERATION (M=+/-M, OF THE PHAGOCYTIC NUMBER AND PERCENTAGE OF ACTIVE PHAGOCYTES (%))

Parameter	Sample size, n=15	Sample size, n=21	Reference range	Student's t-test
	10 years of work experience, age 30–40 years	20 years of work experience, age 50–65 years		
Total leukocyte count, $\times 10^9$ cells/L	6.63 $\pm$ 0.50	7.02 $\pm$ 0.54	4–8.8	0.526
Total lymphocyte count, $\times 10^9$ cells/L	2.27 $\pm$ 0.23	2.88 $\pm$ 0.32	1.5–3.5	0.080
Total monocyte count, $\times 10^9$ cells/L	0.44 $\pm$ 0.06	0.43 $\pm$ 0.05	0.09–0.6	0.898
Total eosinophil count, $\times 10^9$ cells/L	0.20 $\pm$ 0.04	0.20 $\pm$ 0.03	0.02–0.3	0.950
Total neutrophil count, $\times 10^9$ cells/L	3.73 $\pm$ 0.36	3.52 $\pm$ 0.36	1.5–5.5	0.664
Phagocytic number	6.04 $\pm$ 0.38	7.11 $\pm$ 0.50	4–9	0.067
Active phagocytes, %	67.57 $\pm$ 2.84	65.75 $\pm$ 2.32	>50	0.592

TABLE 2

FREQUENCY OF OCCURRENCE OF IMMUNE IMBALANCES IN MALE HYDROGRAPHERS OF THE ARKHANGELSK DISTRICT OF THE HYDROGRAPHIC SERVICE OF THE FEDERATION COUNCIL OF THE RUSSIAN FEDERATION, (%)

Parameter	Sample size, n=15	Sample size, n=21
	10 years of work experience, age 30–40 years	20 years of work experience, age 50–65 years
Leukocytes, $\times 10^9$ cells/L, <4.0	no	no
Leukocytes, $\times 10^9$ cells/L, >8.8	6.7	14.3
Lymphocytes, $\times 10^9$ cells/L, <1.5	13.3	4.8
Lymphocytes, $\times 10^9$ cells/L, >3.5	6.7	14.3
Monocytes, $\times 10^9$ cells/L, <0.09	no	4.8
Monocytes, $\times 10^9$ cells/L, >0.6	6.7	14.3
Eosinophils, $\times 10^9$ cells/L, >0.3	20.0	19.0
Neutrophils, $\times 10^9$ cells/L, <1.5	6.7	14.3
Neutrophils, $\times 10^9$ cells/L, >5.5	6.7	4.8
Phagocytic number >9	6.7	38.1
Decreased active phagocytes, %	6.7	4.8

in extreme professional conditions in the northern seas is near the upper limit of the physiological reference range.

Based on the results from long-term studies on the immune status of individuals engaged in extreme professions, such as hydrographers, in the Arctic regions, we strongly suggest including an assessment

of cellular and humoral immunity as part of the standard medical examination for shift workers. This would allow for the timely identification of immune imbalances and the correction of the immune system status. Based on these data, preventive measures can be implemented to prevent the development of environmentally-induced secondary immunodeficiency.

CONCLUSION

Therefore, in younger men who have worked in the harsh conditions in the Northern seas (the Barents and the White Seas) in the Arkhangelsk branch of the Hydrographic Service of the Northern Fleet of the Russian Federation, deficiencies in leukocytes, lymphocytes, and monocytes, associated with low phagocytic activity, occur 1.5–2 times more often than in older workers with 20 years of work experience, who have leukocytosis, lymphocytosis, and monocytosis occurring 1.5 times more often, along with increased phagocytic activity. The neutrophil phagocytic activity is slightly higher in the older age group with 20 years of work experience in extreme conditions ($p < 0.05$).

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Conflicts of interest

The authors declare no conflicts of interest.

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