ASSESSMENT OF LIPID SPECTRUM AND C-REACTIVE PROTEIN IN PEOPLE WORKING IN THE ARCTIC ZONE OF RUSSIA

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Adaptation to the extreme living conditions of the North causes dyslipidemia, a risk factor for cardiovascular diseases (CVD), in people working there. This study aimed to assess the level of lipids and C-reactive protein (CRP), a marker of inflammation in CVD cases, in the blood of men staying in the Arctic and Subarctic zones of Russia. Accordingly, the sample was divided into two group, Arctic and Subarctic, the former included 51 participants, aged 35.7 ± 0.6 years, the latter — 54 individuals, aged 34.2 ± 0.9 years (p = 0.167); the duration of their work/stay in the Arctic and Subarctic zones was 7.1 ± 0.2 and 6.4 ± 0.6 years (p = 0.447), respectively. We sampled blood of the participants and measured triglycerides, total cholesterol, low (LDL) and high (HDL) density lipoproteins, atherogenic index (AI), CRP content. Arctic group had higher levels of triglycerides (1.71 ± 0.03 and 1.38 ± 0.14 mmol/l, p = 0.021), total cholesterol (6.15 ± 0.08 and 5.47 ± 0.14 mmol/l, p =0.001), HDL (1.5 ± 0.06 and 1.1 ± 0.04 mmol/l, p = 0.001); the values of LDL did not differ significantly between the groups (4.07 ± 0.08 and 4.1 ± 0.15 mmol/l, p = 0.88), and AI and CRP values (3.41 ± 0.18 and 4.18 ± 0.2, p = 0.007; 3.41 ± 0.18 and 4.91 ± 0.22 mg/l, p = 0.006, respectively) were greater in the Subarctic group. By triglycerides, dyslipidemia was diagnosed in 49.0% and 18.4% of Arctic and Subarctic participants, respectively, by total cholesterol — in 98.0% and 57.8%, by LDL — in 94.1% and 88.0%. As for HDL, their level was lower than normal in 2.0% of the Arctic group subjects and 36.7% of the Subarctic group subjects, which means a higher risk of cardiovascular diseases in the Subarctic region. The level of CRP indicated that 90% of the Arctic group participants were at risk of CVD (moderate risk for 23.5%, high risk for 66.7%), and in the Subarctic group this number was 100% (moderate risk for 7.7%, high risk for 88.5%). The likely reasons behind this are the specifics of nutrition and living conditions. Program of prevention of CVD in the Arctic zone should include lipid profile and CRP tests as part of every periodic medical examination, regardless of age. It is necessary to implement dyslipidemia alimentary correction measures.

Keywords: Arctic zone, lipids, C-reactive protein, cardiovascular risk

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Compliance with the ethical standards: the study was approved by the Ethics Committee of the Privolzhsky Research Medical University of the Ministry of Health of the Russian Federation (Minutes #4 of March 14, 2022); all study participants signed a voluntary informed consent form.

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ОЦЕНКА ЛИПИДНОГО СПЕКТРА И С-РЕАКТИВНОГО БЕЛКА КРОВИ У РАБОТАЮЩИХ В АРКТИЧЕСКОЙ ЗОНЕ РОССИИ

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У людей, работающих на Севере, при адаптации к экстремальным условиям жизни развивается дислипидемия, фактор риска при сердечно-сосудистых заболеваниях (ССЗ). Целью работы была оценка уровня липидов и С-реактивного белка (СРБ), маркера воспаления при ССЗ, в крови у мужчин в Арктической зоне России. В крови двух групп: в Арктике (n = 51) и Субарктике (n = 54) (возраст — 35,7 ± 0,6 и 34,2 ± 0,9 лет (p = 0,167), длительность работ — 7,1 ± 0,2 и 6,4 ± 0,6 лет (p = 0,447)) определяли значения триглицеридов, общего холестерина, липопротеидов низкой (ЛПНП) и высокой (ЛПВП) плотности, коэффициента атерогенности (КА), СРБ. В Арктике выявлены более высокие уровни триглицеридов (1,71 ± 0,03 и 1,38 ± 0,14 ммоль/л, p = 0,021), общего холестерина (6,15 ± 0,08 и 5,47 ± 0,14 ммоль/л, p = 0,001), ЛПВП (1,5 ± 0,06 и 1,1 ± 0,04 ммоль/л, p = 0,001); равные значения — ЛПНП (4,07 ± 0,08 и 4,1 ± 0,15 ммоль/л, p = 0,88); менее значимые получены по КА (3,41 ± 0,18 и 4,18 ± 0,2, p = 0,007) и СРБ (3,41 ± 0,18 и 4,91 ± 0,22 мг/л, p = 0,006). Дислипидемия определена по триглицеридам у 49,0% и у 18,4%, по общему холестерину — у 98,0% и 57,8%, по ЛПНП — у 94,1% и 88,0%. ЛПВП ниже нормы у 2,0% и 36,7%, что указывает на более высокий риск сердечно-сосудистых заболеваний в Субарктике. Риск по СРБ в Арктике — у 90% (средний — у 23,5% и высокий — у 66,7%), Субарктике — у 100,0% (средний — у 7,7%, высокий — у 88,5%). Вероятно, это обусловлено особенностями питания и условий жизни. Для профилактики ССЗ в Арктической зоне исследование липидов и СРБ крови необходимо проводить при каждом периодическом медицинском обследовании независимо от возраста. Требуется алиментарная коррекция дислипидемии.

Ключевые слова: Арктическая зона, липиды, С-реактивный белок, сердечно-сосудистый риск

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Dyslipidemia is one of the risk factors for cardiovascular diseases (CVD) [1]. The pathogenesis of CVD includes not only lipid metabolism disorders, but also inflammation, with C-reactive protein (CRP) being one of the most important markers thereof [2, 3]. It can participate in all stages of development of atherosclerotic process [4, 5]. CRP test is part of both primary (distribution into CVD risk groups, qualification for statin therapy) and secondary CVD prevention programs (prognosis of CVD and treatment complications, evaluation treatment efficacy in moderate CVD risk groups) [6].

Extreme cold causes polar hypoxia, which ups body's energy metabolism and switches nutrients processing from carbohydrate to lipid type. Thus, a polar metabolic type is formed [7]. The traditional way of life and nutrition of indigenous people of the North enable adaptation to extreme climatic and geographical factors and prevent cardiovascular and other metabolic diseases. Individuals not native to that zone and arriving there develop specific biochemical changes in the body manifesting as hormonal and metabolic shifts [8, 9].

This study aimed to evaluate the lipid spectrum and the content of C-reactive protein in blood of men working in the Arctic zone of Russia.

METHODS

The study was conducted in July–August 2022 and involved two groups of men working in the Arctic and Subarctic zones, 73rd parallel north (n = 51, group 1) and 69th north latitude (n = 54, group 2), respectively. The inclusion criteria were lack of history of cardiovascular diseases, obesity, inflammatory process in the body. Indigenous people of the North practicing the traditional way of life, as well as people that temporarily left the Arctic zone, were excluded from the study. The participants were practically healthy people aged 35.7 ± 0.6 and 34.2 ± 0.9 years (p = 0.167), undergoing routine periodic examination. None of them expressed any health complaints at the time of examination. Their duration of stay in the Arctic and Subarctic conditions was, respectively, 7.1 ± 0.2 and 6.4 ± 0.6 years (p = 0.447).

We evaluated the conditions of living and work environment of the participants. Almost all of them were smokers. As for the body mass index, no one was obese or underweight. Group 2 worked in the city of Norilsk, which is a zone with anthropogenic pollution [9, 10].

All participants donated blood samples in Norilsk; unfrozen, they were brought to the airport of Norilsk, flown to Krasnoyarsk therefrom, then delivered to the Central Research Laboratory of Krasnoyarsk State Medical University, and analyzed there.

We used an AU5800 analyzer (Beckman Coulter; USA) to establish the lipid metabolism parameters (triglycerides (TG), total cholesterol (TC), low and high density lipoproteins (LDL, HDL), atherogenic index (AI), and a Cobas Integra 400 Plus analyzer (Roche Diagnostics; Switzerland) to reveal the levels of C-reactive protein.

Triglycerides reference values: 1.7 mmol/l; 1.7–2.25 mmol/l — moderately elevated, 2.26–5.65 mmol/l — elevated. TC reference values: 3.5–5.2 mmol/l; 5.2–6.2 mmol/l — borderline high; > 6.2 mmol/l — high. LDL reference values: up to 3.37 mmol/l; 3.37–4.27 mmol/l — elevated; > 4.27 mmol/l — high. HDL reference values: 0.9–1.3 mmol/l [1]. Normal atherogenic index value — ≤ 3.5. CRP reference values — up to 6 mg/l. The levels < 1.0 mg/l, 1.0–2.9 mg/l, ≥ 3.0 mg/l were associated with low, medium and high risk of occurrence and progression of CVD [11, 12]. We established means of the considered indicators that accord with the reference values or are below/above the respective ranges.

The primary data acquired were processed with a Statistica 6.1 software package (StatSoft; USA). We used the Kolmogorov-Smirnov test to check whether the distribution of values is normal or not, established means and standard errors, (M ± m), applied Student's t-test (p < 0.05) to confirm/disprove reliability of differences in the parametric samples, and analyzed individual indicators.

Using the averaged statistical data peculiar to the Arctic, we investigated the relationship between lipidograms and CRP indicators, i.e., established the Pearson correlation coefficients (rxy) and their statistical reliability. With values ranging from 0 to 0.3, the linear connection was considered weak, from 0.3 to 0.5 — light, from 0.5 to 0.7 — moderately strong, from 0.7 to 0.9 — high, and from 0.9 up — very strong.

RESULTS

The conditions of living and work environment were different between the groups. In the Arctic zone, the participants ate in the canteens, their meals were cooked from canned food; additionally, they received foodstuffs as prescribed for people working in the Far North [13]. Drinking water was melted. Accommodation was provided in the specially equipped modules. They worked 24-hour shifts with 48 hour of rest between them, in enclosed spaces as well as in the open (hard, strenuous labor). In the Subarctic zone, the participants lived in comfortable urban apartments, and worked in rooms that meet hygienic standards. Their food was homemade. Fresh vegetables, fruits, berries were consumed rarely; they ate fish twice or thrice a week. However, the food intake pattern was uneven, with 47.3% of group 2 subjects having 3 meals a day, and 52.7% — 2 meals a day; anthropogenic environmental pollutants had an obvious effect on their living. The work of these men was strenuous, but implied little motor activity.

The lipid metabolism data allowed identifying statistically significant differences among a number of means (Table 1): in group 1, the average level of TG was higher by 24.6%, total cholesterol — by 12.4%, HDL — by 36.5%, but AI — 22.6% lower than in group 2.

As for the individual indicators, 51.0% of group 1 participants had TG within the normal range, same as 81.6% of men from group 2. Accordingly, TG tests returned moderately elevated values for 47.1% and 4.1% of the blood samples, and elevated for 2.0% (1 person) in the Arctic group and 14.3% in the Subarctic group (Table 2). In the latter group, the proportion of samples with moderately elevated TG level was more significant: higher by 8.3%.

The level of total cholesterol in the Arctic group was normal in 1 person only, while in the Subarctic group it was within the normal range in 42.2% of the participants. Borderline TC values were registered in 60.8% and 24.4% of subjects, high values — in 37.3% and 33.3%, respectively (Table 3). Overall, group 2 had less borderline TC occurrences and similar number of high TC cases.

In group 1, the level of LDL was normal in 5.9% of the participants, in group 2 — in 12.0%; it was elevated in 64.7% and 48.0% of them, and high — in 29.4% and 40.0% of the subjects, respectively (Table 4). We registered no LDL values beyond the reference range in either of the groups.

In group 1, 35.3% of the participants had HDL within the normal range, 62.7 — above normal, less than 2.0% — below normal. In group 2, the respective figures were 48.3% (normal), 32.3% (above normal), 19.4% (below normal).

As for the AI, it was normal in 56.8% of group 1 participants and 29.4% of group 2 subjects, while 43.1% and 70.6%, respectively, had it above the normal range (Table 5). There was significant difference between normal and high AI values.

Table 1. Lipid metabolism indicators, both groups, absolute values

№	Lipid spectrum indicators	Arctic zone, M ± *m*		*p*
		Arctic	Subarctic	
1	Triglycerides	1.72 ± 0.03	1.38 ± 0.14	0.021
2	Total cholesterol	6.15 ± 0.08	5.47 ± 0.14	0.001
3	Low-density lipoproteins	4.07 ± 0.08	4.1 ± 0.15	0.88
4	High-density lipoproteins	1.5 ± 0.06	1.1 ± 0.04	0.001
5	Atherogenic index	3.41 ± 0.18	4.18 ± 0.2	0.007

Table 2. Blood plasma triglycerides, both groups, absolute values

№	Arctic Zone	Assessment, M ± *m*		
		Normal	Moderately elevated	Elevated
1	Arctic	1.61 ± 0.03	1.8 ± 0.01	2.56
2	Subarctic	1.0 ± 0.07	1.95 ± 0.07	3.31 ± 0.4
p		0.001	0.001	–

In group 1, only 9.8% of the participants had low CRP, while in 23.5% the level thereof was moderate, and in 66.7% — high. In group 2, these values were 0%, 7.7% and 88.5%, respectively (Table 6).

Searching for correlations between lipid metabolism and CRP, we established only one, with TG, which was moderately strong, negative, statistically significant (Table 7).

The correlations between individual indicators of the lipid spectrum and the AI turned out to be interesting. We established a significant positive strong relationship between TC, LDL and TG, but in case of HDL, it was insignificant and weak. Triglycerides had a moderately strong significant positive association with LDL. We have also identified significant relationships between AI and HDL (negative, rather strong), AI and LDL (moderately strong, positive) (Table 8).

DISCUSSION

The land and marine areas comprising the Arctic zone of Russia are stipulated by the Russian legislation [14]. Extreme weather and climatic conditions that undermine health and influence morbidity, mortality, and working capacity of the population are common to all of those areas [15–21].

People coming to the North and staying there for a long time begin to adapt to the said conditions; rearrangement of lipid metabolism is one of the aspects of that adaptation, and it entails dyslipidemia. Several studies report that already in the first year of living in the high latitudes, TC grows up to borderline-high and high values. This is when the body responds with mobilization of its reserves, which manifests in the increasing level of HDL and prevents atherogenic changes. However, after five years in the North, residents not native to this zone start suffering dyslipidemia with hyperglyceridemia, high TC and LDL levels, while those of HDL in them decrease 1.4-fold compared to the first year [22, 23].

The participants of our study, who came to the Arctic zone to work there, had the mean level of HDL high for a longer period of time than registered in non-native residents, which indicates an adequate mobilization of the body's reserves in response to the conditions of the North. In group 1, the proportion of people with such a level of HDL was 1.9 times higher, and with a low level — 9.7 times less, which shows that those working in the Arctic adapt better. Comparing the Arctic and Subarctic groups, we may conclude that higher share of those with elevated HDL levels in the former points to a greater importance of the compensatory action of lipid metabolism in that group, as confirmed by the AI.

Dyslipidemia is associated with an increased risk of cardiovascular events [24]. There is evidence confirming the inverse relationship between HDL levels and the risk of coronary heart disease [25]. HDL condition reverse cholesterol transport from arterial wall and peripheral tissues to the liver, protect LDL from oxidation, produce anti-inflammatory and vasodilating effects on vascular wall cells [26]. Thus, a significant proportion of those working in the Subarctic had the HDL perform their protective functions to a lesser degree. The list of reasons for low plasma HDL includes insufficient intake of cholesterol with food and low motor activity [27]. Anthropogenic environmental pollutants may have caused the decrease of levels of HDL, but it is impossible to arrive at such a conclusion without further research.

Table 3. Plasma cholesterol, both groups, absolute values

№	Arctic Zone	Assessment, M ± *m*		
		Normal	Borderline	High
1	Arctic	5.11	5.83 ± 0.04	6.74 ± 0.11
2	Subarctic	4.41 ± 0.15	5.49 ± 0.09	6.64 ± 0.1
p		–	0.011	0.542

Table 4. Low-density lipoproteins, both groups, absolute values

№	Arctic Zone	Assessment, M ± *m*		
		Normal	Borderline	High
1	Arctic	2.8–3.3	3.83 ± 0.04	4.77 ± 0.1
2	Subarctic	1.79–2.36	3.73 ± 0.05	4.86 ± 0.08
p			0.122	0.498

Table 5. Atherogenic index, both groups

№	Arctic Zone	Assessment, M ± *m*	
		Normal	Above normal
1	Arctic	2.56 ± 0.13	4.47 ± 0.2
2	Subarctic	2.68 ± 0.1	4.46 ± 0.16
p		0.729	0.988

Table 6. C-reactive protein levels, both groups, absolute values

№	Assessment	Arctic zone, M ± *m*		*p*
		Arctic	Subarctic	
1	CRP by group	3.41 ± 0.18	4.91 ± 0.22	0.006
2	Low CRP	0.87 ± 0.09 (5)	0.86	–
3	Moderate CRP	2.0 ± 0.17 (12)	2.45–2.89	–
4	High CRP	4.97 ± 0.15 (34)	5.12 ± 0.12	0.467

The pathogenesis of most CVD of athero- and thrombogenic origin involves both lipid metabolism disorders and inflammatory processes; CRP is the leading mediator of the acute phase and a marker of inflammation [2, 28–30]. It is considered a real risk factor for cardiovascular diseases, like TC and LDL, which expands the concept of residual risk of cardiovascular inflammation [30]. CRP deposits in atherosclerotic plaques and damaged tissues [3, 26, 27]. The higher the content of CRP, the greater the association with the relative risk of occurrence and progression of cardiovascular events [11–12]. In our study, CRP values were within the reference range. However, 90% of those working in the Arctic zone ran the risk of CVD, more than 2/3 of them — high risk thereof; for the Subarctic zone, this figure was 100%, with the proportion of those at high risk of CVD 21.8% higher than in the Arctic zone.

The investigation of correlations revealed that CRP has relationship only with TG, which confirms it is an independent CVD risk factor for people working in the Arctic zone.

Thus, the risk of cardiovascular diseases is more pronounced among those working in the Subarctic than in the Arctic zone. The likely reasons behind this are the specifics of nutrition and living conditions. Thus, dyslipidemia requires alimentary correction measures, and, possibly, therapeutic interventions to reduce the level of CRP.

It is recommended to test for CVD risk factors, including dyslipidemia, men aged 40 and above, and women once they turn 50 or begin menopausal transition [1]. Our study highlights the need for lipid spectrum assessments and CRP tests in connection not with age, but with employment in the Arctic zone; such assessments and tests should be done annually, during periodic routine medical examinations, since they would allow timely correction of atherosclerotic and inflammatory changes in the body and reduction of the risk of CVD.

CONCLUSIONS

In the Arctic zone, as compared to the Subarctic, we established higher values of triglycerides (1.71 ± 0.03 and 1.38 ± 0.14 mmol/l, $p = 0.021$), total cholesterol (6.15 ± 0.08 and 5.47 ± 0.14 mmol/l, $p = 0.001$), high-density lipoproteins (1.5 ± 0.06 and 1.1 ± 0.04 mmol/l, $p = 0.001$); equal values of low-density lipoproteins (4.07 ± 0.08 and 4.1 ± 0.15 mmol/l, $p = 0.88$); less significant differences in the atherogenic index (3.41 ± 0.18 and 4.18 ± 0.2, $p = 0.007$) and C-reactive protein levels (3.41 ± 0.18 and 4.91 ± 0.22 mg/l, $p = 0.006$). By triglycerides, dyslipidemia was diagnosed in 49.0% of the Arctic group participants and 18.4% of the Subarctic subjects; by total cholesterol — in 98.1% and 57.7%, by low-density lipoproteins — in 94.1% and 88.0%, respectively. As for HDL, their level was lower than normal in 2.0% and 19.4% the participants, respectively, which points to a higher risk of cardiovascular diseases in the Subarctic region. As shown by the level of CRP, 90% of the Arctic group participants were at risk of CVD (moderate risk for 23.5%, high risk for 66.7%), and in the Subarctic group this number was 100% (moderate risk for 7.7%, high risk for 88.5%). Prevention of cardiovascular diseases and sound basis for decisions related to medical assistance, as they concern people working in the Arctic zone, require lipid spectrum assessments and CRP tests to be part of every periodic routine medical examination, regardless of age.

Table 7. Correlations between lipid spectrum indicators and CRP

№	Lipid spectrum – CRP indicators	Pearson's test	*p*
1	Total cholesterol	–0.022	0.917
2	High-density lipoproteins	–0.06	0.675
3	Low-density lipoproteins	–0.081	0.588
4	Triglycerides	–0.453	0.02
5	Atherogenic index	0.097	0.497

Table 8. Correlations between lipid spectrum indicators

№	Indicator	HDL		LDL		Triglycerides		AI	
		Pearson's test	*p*	Pearson's test	*p*	Pearson's test	*p*	Pearson's test	*p*
1	Total cholesterol	0.282	0.172	0.837	0.001	0.894	0.001	0.164	0.435
2	Triglycerides	0.129	0.528	0.51	0.008	–	–	0.009	0.986
3	Low-density lipoproteins	–0.155	0.298	–	–	0.51	0.008	0.412	0.004
4	Atherogenic index	–0.912	0.001	0.412	0.004	0.009	0.966	–	–

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