Changes in Lipid Peroxidation Indexes of the Republic of Sakha (Yakutia) Population Depending on Residence Location

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Abstract. The levels of TBA-active products and antioxidant defense indicators, such as low molecular weight antioxidants (LMWAO from now onward), Vitamin C, catalase, and uric acid, were higher in the new population if compared to indigenous people. When comparing the biochemical parameters by district type, the authors found that in the inhabitants of industrial districts (both new and indigenous), the prooxidant-antioxidant balance (PAB from now onward) was shifted towards higher peroxidation. The increase in antioxidants in the original population was due to higher levels of LMWAO. In the indigenous population it was caused by higher catalase activity. The new population had overstressed adaptive mechanisms, confirmed by higher levels of TBA-active products, Interleukins IL18 and IL6, and AST/ALT ratio. The indigenous residents of arctic districts had significantly lower TBA-active elements, LMWAO, catalase activity, but a higher ascorbic acid level (an endogenous antioxidant) compared to the indigenous population of industrial and agricultural districts. The decrease in lipid peroxidation and the increase in ascorbic acid in the population of Arctic districts may be explained by reduced anthropogenic stress and protein-lipid type nutrition, distinct from the population of other districts.

Keywords: Adaptation · TBA-active products · Total LMWAO capacity · Ascorbate · Catalase · Interleukin-6, Interleukin-18

1. Introduction

The modern geopolitical strategy of Russia sets the development of the Far North as one of the main objectives. Therefore, one of the most important tasks of medicine is preserving the health and working capacity of Arctic and Subarctic population.

The body’s adaptive mechanisms, which reflect its dynamic equilibrium with the environment, are an integral health criterion. Adaptation directly determines the risk of illnesses and, therefore, the health status. Thus, quantifying the adaptation capacity may be integral to evaluating and grading health.

The Far North environment of Yakutia negatively affects the human body in various ways. Previous studies have concluded that the Far North indigenous people have been influenced by millennia of rigorous natural selection [9]. They have several unique genetic (inheritable) adaptation mechanisms. However, the recent socio-economic transformations, urbanization of indigenous peoples, and their departure from the traditional lifestyle negatively affect their health [2, 14].

Today, the studies of nonspecific reactions that form the basis of adaptive-compensatory mechanisms (e.g., changes in PAB) are highly relevant [7]. The initiators of free radical oxidation, such as active
2. **Materials and Methods**

The research material was collected in spring, during a one-time medical-biological examination and survey of the Yakutia population. The authors tested 357 people aged 18 to 77 (average age of 47.12±0.37 years). Of those people, 102 were newcomers, and 253 were indigenous.

Blood serum tests were used for biological parameter identification. The free-radical lipid oxidation rate was determined by the TBA-active products content [12]. The antioxidant defense indexes were calculated by the sum of LMWAO contents [13], ascorbate levels [3], and catalase activity [8] using SPECORD 40 “AnalytikJena” spectrophotometer (Germany). Transaminase activity, i.e., Alanine transaminase (ALT) and aspartate aminotransferase (AST), was determined by the enzymatic method in “Labio” automated biochemical analyzer using the “Analyticon” reagents (Germany). Cytokine levels, i.e., interleukin-6 (IL6) and interleukin-18 (IL18), were determined by enzyme-linked immunosorbent assay (ELISA) in “Multiscan” analyzer (USA) using kits from ZAO “Vector-Best” (Russia).

The survey was conducted using the standard quality of life questionnaire, modified by the medical-sociological research lab at Yakut Science Centre of Complex Medical Problems (YSC-CMP). All respondents gave informed consent to the research (under the YSC-CMP Ethical Committee protocol No 49 dated 25.03.2018).

The daily food consumption Arctic indigenous population of was evaluated by the 24-hour food reproduction method, using an album of food and dishes. The chemical composition of the daily diet was determined using the “Tables of chemical composition and caloric content of Russian food products” reference book [15].

The authors employed the medical-economic district zoning of Yakutia, proposed by L. F. Timofeev, V. G. Krivoshapkin [16], in this research.

The statistical data was processed using IBM SPSS Statistics 19 suite. To test the credibility of the mean value differences, the authors employed the Mann–Whitney U test. Table data is presented in the M±m pattern, where M is the mean, and m is the mean error. The null hypothesis level of significance was at p<0.05

3. **Results**

The level of TBA-active products, denoting high peroxidation, in the population of industrial districts was 1.63 times and 1.28 times higher than that of arctic and industrial districts, respectively. Accumulation of lipid peroxidation products stimulates antioxidant defense, manifested in increased catalase activity, higher concentration of LMWAO, and ascorbate. Catalase activity in the industrial population was 1.5 times and 1.12 times higher than in the population of arctic and agricultural districts, respectively (see Table 1). LMWAO concentration in the population of industrial districts was 1.26 more elevated than in the rest. Ascorbate and uric acid concentration in the arctic community were higher than in populations of agricultural (2.24 times and 1.12 times higher, respectively) and industrial (1.43 times and 1.06 times higher, respectively) districts.

The level of TBA-active products and antioxidant defense indicators (LMWAO, ascorbate, uric acid, and catalase) were lower in the indigenous population.

This data signifies the changes in lipid peroxidation and antioxidant defense in the new and indigenous population of different medical-economic district types. The new population of industrial districts had a higher level of TBA-active products (1.4 times higher at p=0.009) and LMWAO (1.24 times higher at p=0.042) than the new population of agricultural districts.

The indigenous industrial population had higher levels of TBA-active products (1.53 times at p=0.002), LMWAO (1.48 times at p=0.004), and catalase activity (1.43 times at p=0.002), but a lower concentration of ascorbate (1.6 times at p=0.024) than that of the arctic districts.

Compared to the agricultural districts, the population of agricultural districts had higher catalase
activity (1.2 times at p=0.000), and ascorbate concentration (1.37 times at p=0.001).

**Table 1.** Lipid peroxidation indexes in the Republic of Sakha (Yakutia) population by district type.

| Parameter                  | No. | District type     | M±m         | p₁,₂ | p₁,₃  | p₂,₃  |
|----------------------------|-----|------------------|-------------|------|-------|-------|
| TBA-active products        | 1   | Arctic           | 2.371±0.201 |      | 0.024 | 0.007 | 0.002 |
|                            | 2   | Agricultural     | 3.026±0.119 |      |       |       |       |
|                            | 3   | Industrial       | 3.886±0.18  |      |       |       |       |
| LMWAO                      | 1   | Arctic           | 73.190±3.948| 0.001| 0.040 | 0.820 |
|                            | 2   | Agricultural     | 91.730±2.218|      |       |       |       |
|                            | 3   | Industrial       | 92.730±2.859|      |       |       |       |
| Catalase                   | 1   | Arctic           | 0.346±0.048 |      | 0.008 | 0.001 | 0.020 |
|                            | 2   | Agricultural     | 0.460±0.016 |      |       |       |       |
|                            | 3   | Industrial       | 0.516±0.014 |      |       |       |       |
| Ascorbate                  | 1   | Arctic           | 0.385±0.061 |      | 0.000 | 0.006 | 0.009 |
|                            | 2   | Agricultural     | 0.179±0.012 |      |       |       |       |
|                            | 3   | Industrial       | 0.240±0.015 |      |       |       |       |
| Uric acid                  | 1   | Arctic           | 322.860±16.983|    | 0.352 | 0.467 | 0.473 |
|                            | 2   | Agricultural     | 301.800±9.406|    |       |       |       |
|                            | 3   | Industrial       | 309.250±5.618|    |       |       |       |

*Source: Compiled by the authors.*

**Table 2.** Lipid peroxidation indexes in the new and indigenous population of Yakutia.

| Parameter                  | M±m         | p    |
|----------------------------|-------------|------|
| TBA-active products        | Indigenous  | 3.089±0.153 | 0.551|
|                            | New         | 3.920±0.213 |      |
| LMWAO                      | Indigenous  | 90.090±2.288| 0.032|
|                            | New         | 101.94±3.886|      |
| Catalase                   | Indigenous  | 0.444±0.018 | 0.551|
|                            | New         | 0.496±0.032 |      |
| Ascorbate                  | Indigenous  | 0.151±0.013 | 0.151|
|                            | New         | 0.246±0.025 |      |
| Uric acid                  | Indigenous  | 293.280±11.124| 0.001|
|                            | New         | 331.82±19.075|      |

*Source: Compiled by the authors.*

**Table 3.** Peroxidation indexes in the new and indigenous population of agricultural districts.

| Parameter                  | M±m         | p    |
|----------------------------|-------------|------|
| TBA-active products        | Indigenous  | 3.038±0.147 | 0.947|
|                            | New         | 3.015±0.215 |      |
| LMWAO                      | Indigenous  | 92.530±2.738| 0.194|
|                            | New         | 87.250±4.191|      |
| Catalase                   | Indigenous  | 0.424±0.013 | 0.584|
|                            | New         | 0.502±0.026 |      |
| Ascorbate                  | Indigenous  | 0.165±0.012 | 0.170|
|                            | New         | 0.256±0.023 |      |
| Uric acid                  | Indigenous  | 290.40±5.265| 0.044|
|                            | New         | 330.98±11.968|    |
Table 4. Peroxidation indexes in the new and indigenous population of industrial districts.

| Parameter            | Indigenous   | New          | p    |
|----------------------|--------------|--------------|------|
| TBA-active products  | 3.728±0.106  | 4.228±0.352  | 0.049|
| LMWAO                | 91.480±3.194 | 108.440±6.747| 0.065|
| Catalase             | 0.513±0.016  | 0.522±0.042  | 0.840|
| Ascorbate            | 0.226±0.015  | 0.248±0.043  | 0.643|
| Uric acid            | 306.87±6.244 | 332.96±14.053| 0.153|

Source: Compiled by the authors.

Table 5. Peroxidation indexes in the indigenous population of arctic districts.

| Parameter            | Indigenous   |
|----------------------|--------------|
| TBA-active products  | 2.426±0.215  |
| LMWAO                | 73.191±3.94  |
| Catalase             | 0.357±0.229  |
| Ascorbate            | 0.361±0.066  |
| Uric acid            | 324.260±18.436|

Source: Compiled by the authors.

The new population is under-represented in arctic districts is shallow since they are rarely chosen as permanent residence places. Therefore, their biochemical parameters were not measured because there were not enough subjects to use the statistical analysis methods.

IL18 tended to be more expressed in the overall new population. IL6 secretes in stressful situations and is upregulated by catecholamines. AST and ALT activity was within normal limits. However, the new population had a higher AST/ALT ratio, which points to the prevalence of catabolism over anabolism.

Table 6. Biochemical and immunological parameters of Yakutia population.

| District type | No | Population type | IL18 (pg/mL) | IL6 (pg/mL) | ALT (IU/L) | AST (IU/L) | AST/ALT ratio |
|---------------|----|-----------------|--------------|-------------|------------|------------|---------------|
| Industrial    | 1  | Indigenous      | 83.43±18.90  | 2.12±0.44   | 20.75±2.46 | 27.93±2.44 | 1.38±0.08     |
|               | 2  | New             | 94.66±18.47  | 2.12±1.91   | 15.65±1.03 | 25.13±1.58 | 1.65±0.06     |
| Agricultural  | 3  | Indigenous      | 73.84±10.06  | 1.11±0.44   | 18.21±1.14 | 23.26±0.90 | 1.27±0.11     |
|               | 4  | New             | 86.95±23.49  | 2.56±1.34   | 17.85±1.47 | 26.78±1.90 | 1.54±0.08     |
| Arctic        | 5  | Indigenous      | 76.47±3.84   | 0.78±0.57   | 19.08±0.51 | 25.52±0.42 | 1.36±0.02     |

Source: Compiled by the authors.
According to the survey, the population of Yakutia predominantly eats three meals a day, the biggest of which is dinner. Local meat and dairy products form the population’s staple diet. The population consumes fruits and vegetables seasonally. Wild berries are consumed in jellies and drinks. The surveyed population of the arctic districts has a predominantly protein-lipid-based diet, as is the case with many indigenous peoples of the North. The populations of industrial and agricultural districts have an unbalanced dietary structure, with an overabundance of carbohydrates and lack of proteins.

4. Discussion
The medical-economic zoning of Yakutia helped identify district groups with relatively uniform public health. There are significant differences in quality of life and population health between the selected district types.

We have examined the changes in lipid peroxidation and antioxidant defense in new and indigenous populations of different district types. The new industrial population had higher levels of TBA-active products, compared to that of agricultural districts, meaning that their PAB balance was shifted towards peroxidation. In the industrial community, PAB is maintained by higher levels of LMWAO.

The anthropogenic stress of the mining industry may be responsible for the higher concentration of TBA-active products. The developers of medical-economic district zoning, Timofeev et al. [17], using the data of Rospotrebnadzor on water and air pollution, concluded that the environment is the worst in industrial areas and the best in arctic districts.

It is argued that the harsh environment of Far North activates lipid peroxidation in the human organism, and the indigenous peoples have evolutionarily adapted by developing a lifestyle capable of inhibiting these reactions [4, 6]. This study confirms said claims. The level of TBA-active products and antioxidant defense indicators (LMWAO, ascorbate, uric acid, and catalase) were lower in the indigenous population (see Table 2).

We have noted an increase in peroxidation in the indigenous population of industrial districts. However, in contrast to the new population of said districts, PAB was mostly maintained by catalase activity. Moreover, we have observed an increase in IL18, IL6, and AST/ALT ratio in the modern population, which speaks of the prevalence of catabolic and inflammatory processes.

The indigenous people of arctic districts have a lower level of TBA-active products, LMWAO, and catalase activity, but a higher ascorbate concentration. The decrease in lipid peroxidation and increase in ascorbic acid, an exogenous antioxidant, can be explained by the reduced anthropogenic load and the preservation of protein-lipid nutrition in the Arctic district group. This diet was preserved due to the unavailability of imported produce.

The traditional way of life and reduced anthropogenic stress help maintain PAB in the population of Far North.

5. Conclusion
The level of TBA-active products and antioxidant defense indicators (LMWAO, ascorbate, uric acid, and catalase) were higher in the new population. When comparing the biochemical parameters, the authors found that PAB was shifted towards higher peroxidation in the population of industrial districts. The increase in antioxidants was caused by higher levels of LMWAO in the new population and by higher catalase activity in the indigenous population. The new population had overstressed adaptive mechanisms, confirmed by higher levels of TBA-active products, Interleukins IL18 and IL6, and AST/ALT ratio.

The indigenous residents of arctic districts had significantly lower TBA-active elements, LMWAO, catalase activity, but higher ascorbic acid level, an endogenous antioxidant, compared to the indigenous population of industrial and agricultural districts. The decrease in lipid peroxidation and the increase in ascorbic acid in the population of Arctic districts may be explained by reduced anthropogenic stress and protein-lipid nutrition, distinct from the population of other districts.
6. Acknowledgments
This study was funded by RFBR, project number 19-09-00361. The study results from completing the state assignment of the Ministry of Science and Higher Education of the Russian Federation (FSRG-2020-0019).

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