ARCTIC MEDICINE

I.L. Fateeva, T.P. Shiryaeva, L.V. Sokolova, D.M. Fedotov, O.S. Preminina

PARAMETERS FOR ASSESSING THE STATE OF CEREBRAL ENERGY EXCHANGE OF ELDERLY WOMEN LIVING IN THE ARCTIC ZONE OF THE RUSSIAN FEDERATION

DOI 10.25789/YMJ.2024.86.15

UDC 616.366-022-089:616-082.4

Neuroenergy exchange of the brain acts as a significant indicator affecting the preservation of neuropsychic activity in elderly age The aim of the study was to identify the features of the DC-potential level in various periods of old age in women living in the Arctic zone of the Russian Federation. The study involved 192 Northerners who were divided into age groups: 1 — 60-64 YO; 2 — 65-69 YO; 3 — 70-74 YO. The evaluation of cerebral energy exchange indicators was carried out by the hardware and software diagnostic complex "Neuroenergometer-KM" "Statokin". Registration of the DC-potential level was carried out monopolarly from 12 leads esTableished in accordance with the international scheme 10-20.

In the studied groups of elderly women, there is a change in the median values of the DC-potential level, demonstrating pronounced fluctuations in the distribution of brain energy consumption in the aging process. Brain metabolism decreases with age, but in old age there may be a multidirectional change between glucose metabolism and acid-base balance, indicating oxidative stress.

Then, at the age of 65-69, there is a gradual development of mental and physiological compensatory mechanisms, which leads to a relative normalization of neuroenergy exchange of the brain. The next increase in the DC-potential level of the brain begins to be traced at the age of 70-74 years. Probably, it is at this age that the decline of physiological compensatory processes begins to occur.

The obtained results made it possible to identify the peculiarities of the distribution of the DC-potential level in women of different age groups and to esTableish normative values. The developed standards will improve the quality of diagnostics of the functional state of the brain in women living in the Arctic Zone of the Russian Federation, and will also allow timely monitoring brain functional changes in aging.

Keywords: cerebral energy exchange, DC-potential level, gerontogenesis, brain, cents, women, elderly age.

FATEEVA Irina Leopolidovna – defectologist Novodvinsk orphanage for children with serious intellectual disabilities in development, e-mail: irana1307@mail.ru, http://orcid.org/0000-0003-4506-5871; **SHIRYAEVA Taisiya Petrovna** – PhD, Assistant Professor, The Department of Human Biology and Biotechnical Systems, The High School of Natural Science and Technologies, M.V. Lomonosov Northern (Arctic) Federal University, Arkhangelsk, e-mail: taisia.moroz@yandex.ru; http://orcid.org/0000-0001-9458-3224; **SOKOLOVA Ludmila Vladimirovna** – Doctor, Professor, Doctor of Biological Science, Professor, Deputy Director on scientific work of the Institute of Developmental Physiology of the Russian Academy of Education, Moscow, e-mail: sluida@yandex.ru, https://orcid.org/0000-0003-2211-049X; **FEDOTOV Denis Mikhailovich** – MD, PhD, Assistant Professor, Deputy Head of the Department for Health Development of the Ministry of Health of the Kamchatka Territory, Petropavlovsk-Kamchatsky, Russia, 683040; Associate Professor, Department of Hygiene, Northern State Medical University, Arkhangelsk, e-mail: doctorpro@yandex.ru, http://orcid.org/0000-0002-4067-8364; **PREMININA Oksana Sergevna** – PhD, Assistant Professor, The Department of Human Biology and Biotechnical Systems, The High School of Natural Science and Technologies, M.V. Lomonosov Northern (Arctic) Federal University, Arkhangelsk, e-mail: o.preminina@narfu.ru; http://orcid.org/0000-0001-9664-8773.

Introduction. Currently, in the most developed countries, there is an increase in the number of elderly people, which indicates the importance of research on the physiological mechanisms of aging. Gerontogenesis is an extremely complex multi–stage process, where the functional state of the human brain plays a leading role in the well-being and successful adaptation [5, 10].

It is known that neuroenergy exchange of the brain acts as a significant indicator affecting the preservation of neuropsychic activity in elderly age [15]. This parameter allows us to indirectly judge neuro-glio-capillary activity in the metabolism and, first of all, carbohydrate metabolism. The level of constant potential (DC-potential level) – as a slow-changing potential of the millivolt range reflects the degree of intensity of energy consumption, which is different at each age stage [3, 4]. It has been shown that the intensity of carbohydrate metabolism decreases with age [14]. However, there are scientific papers proving that in the conditions of northern latitudes, this process occurs somewhat differently [15, 16].

The presented research is aimed at identifying changes in the neuroenergy exchange of the brain in elderly women, taking into account external (climate) and internal (age) environmental factors.

The purpose of the study is to identify the features of the DC-potential level in various periods of old age.

Materials and research methods. Elderly residents of the Arkhangelsk region took part in a voluntary one-stage study. The sample consisted of 192 women aged 60-74 years, who were divided into 3 age groups: 1 – 60-64 YO, average age – 62.37±1.13 years (n=64); 2 – 65-69 YO, average age – 66.63±1.51 years (n=63); 3 – 70-74 YO, average age – 73.95±2.57 years (n=65). The groups formed differed statistically significantly in average age ($p<0.001$). The exclusion criteria for participation in the study were: acute cerebral circulatory disorders, dementia, being registered in a neuropsychiatric dispensary, traumatic brain injuries, acute, as well as chronic diseases during exacerbation.

Before starting the study, all participants were consulted by a neurologist. Motor tests (Romberg Test, Index Tests) and diagnostics of sensory organs were carried out. To exclude dementia in the anamnesis, the screening technique "MCFAS" (Montreal Cognitive Function Assessment Scale) was used, which allows for rapid screening of cognitive impairment. A cardiologist monitored blood pressure and performed electrocardiography. If there was any disease or symptom of the above conditions in the results of the examination and in the anamnesis

(extracts from the medical records of the examined women were analyzed), they were not included in the total sample.

The assessment of brain neuroenergy exchange was carried out using a 12-channel hardware-software diagnostic complex "Neuroenergometer-KM" NMF "Statokin" [3, 4]. The examination procedure was carried out in the morning individually. The subjects were at rest, in a sitting position with their eyes open, in an isolated room without visual and auditory stimuli. DC-potential level registration was performed monopolarly from 12 leads (Fpz- frontal central lead, Fd- right frontal lead, Fs- left frontal lead, Cz- central lead, Cd- right central lead, Cs - left central lead, Pz- central parietal lead, Pd- right parietal lead, Ps- left parietal lead, Oz- occipital abduction, Td- right temporal abduction, Ts- left temporal abduction), esTableished in accordance with the international scheme 10-20. The References electrode was located on the wrist of the right hand. Registration of the DC-potential level was carried out 5-7 minutes after the electrodes were applied to the points of the head and lasted on average for 15 minutes.

Statistical processing of the obtained data was carried out using the SPSS 27.0 for Windows application software package. The normality of the distribution was assessed using the Shapiro–Wilk criterion. The Kraskel-Wallis criterion was used to identify differences between the compared groups. The critical significance level was assumed at $p<0.017$. For the formation of centile Tables, 10, 25, 50, 75 and 90 percentiles in each group were calculated.

Results and discussion. When analyzing the results obtained, it was revealed that statistically significant differences between the groups of 60-64 years and 65-69 years were found in the following leads: Oz ($p=0.016$), Td ($p=0.002$). Significant differences were found between groups 65-69 years old and 70-74 years old in all studied leads: Fpz ($p=0.011$), Fd ($p<0.001$), Fs ($p<0.001$), Cz ($p<0.001$), Cd ($p<0.001$), Cs ($p=0.001$), Pz ($p<0.001$), Pd ($p<0.001$), Ps ($p<0.001$), Oz ($p<0.001$), Td ($p<0.001$), Ts ($p=0.004$), Sum ($p<0.001$). In turn, significant differences were found between the groups of 60-64 and 70-74 years in the leads Fd ($p=0.007$), Fs ($p=0.005$), Cz ($p=0.010$), Cd ($p=0.001$), Pz ($p=0.003$), Ps ($p=0.018$), Sum ($p<0.001$).

Tables 1-3 show the percentile distribution of the DC-potential level of the main indicators from monopolar leads in women of the studied age groups, namely 60-64 years, 65-69 years, 70-74 years. During the analysis of the data obtained, it was found that with increasing age in all the studied groups, there was a fluctuation in the median values of the DC-potential level of the brain.

To make the presentation clearer, an analysis of the dynamics of total DC-potential level indicators (Sum), as well as the values of temporal leads and leads along the sagittal line of the brain in women of the studied groups was carried out (Fig.1). The choice of leads was determined by their informativeness and frequency of analysis in studies when assessing changes in neuroenergy exchange in various age groups [2, 11].

When analyzing the total values of the DC-potential level (Sum) of the brain of the examined, it was found that the median values of the DC-potential level of 65-69-year-old women decreased by 12.77% compared to the group of 60-64-year-old women, and then increased by 26.79% in the 70-74-year-old group. Probably, this may indicate the presence of specific age dynamics with fluctuations in brain neuroenergy exchange in different age segments.

When analyzing the median values for the main leads of the sagittal line (Fpz, Cz, Pz, Oz), the same trend was observed. Thus, in the frontal central lead (Fpz), central (Cz), parietal central (Pz), and occipital (Oz) leads, the median values of the DC-potential level of the brain in 65-69-year-old women compared to the 60-64-year-old group decreased by 5,86 %, 17,27%, 10,75%, 24,93%, and increased by 41.68 %, 18,31%, 28,07%, 5,35% in the group of 70-74 years, respectively.

Median values in the right (Td) and left (Ts) temporal leads of 65-69 women decreased by 37.31% and 11.31% compared to the 60-64 year group, and then increased by 32.11% and 13.73% in the 70-74 year group.

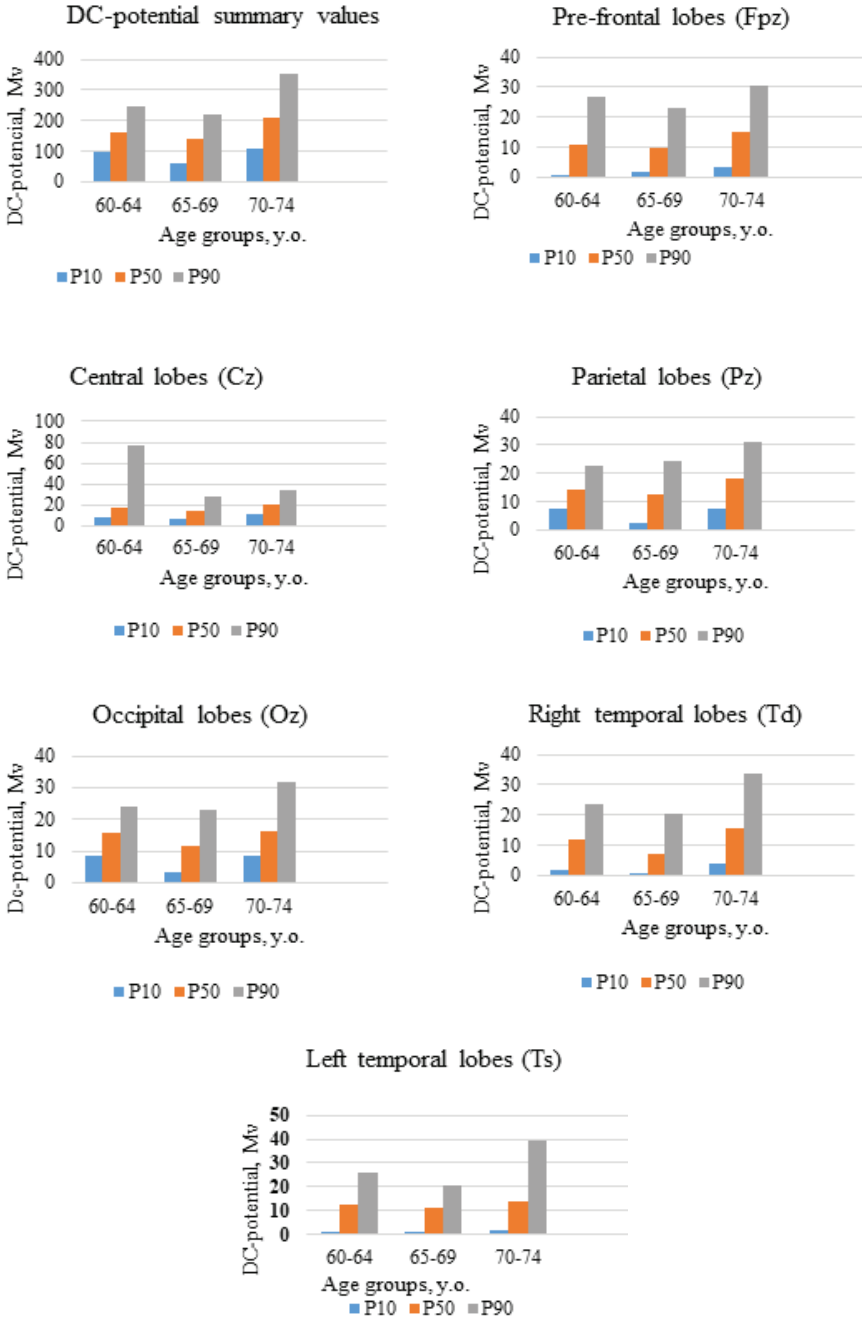
According to the study of Klimenko L.L., Deeva A.I., Fokina V.F., the metabolism of the brain decreases with age [1]. But in old age, there may be a multidirectional change between glucose metabolism and acid-base balance, indicating oxidative stress [17]. Many researchers explain this by an increase in acidity in the brain tissue caused by degenerative processes (a decrease in blood flow and cerebral pH balance) [9, 12].

It is generally believed that neuroenergometabolism is extremely sensitive to stress factors and in many studies is an indicator of the level of adaptation to stress [5, 6, 18]. In our study, in the elderly (60-64 years), high rates of DC-potential level of the brain are observed. Probably, this can be explained by a complex polymorphic combination of external (change of social role, completion of working age and retirement, etc.) and internal (growth of psycho-emotional load, hormonal changes in the postmenopausal period, physiological changes in the body) stress factors in the life of an elderly woman [13].

Then, at the age of 65-69, there is a gradual development of mental and phys-

Percentile distribution of constant potential level in the examined women

Leads	Percentiles		
	10	50	90
60–64 (Мв)			
Fd	-1.11	8.02	23.43
Fpz	0.15	10.58	26.91
Fs	0.46	8.98	22.54
Cd	5.41	14.73	24.49
Cz	7.71	17.37	76.64
Cs	5.22	15.47	24.12
Pd	3.96	15.11	25.02
Pz	7.50	14.32	22.39
Ps	5.43	14.68	26.80
Oz	8.58	15.66	23.87
Td	1.56	11.74	23.71
Ts	0.89	12.38	25.76
Sum	95.33	161.10	245.79
65–69 (Мв)			
Fd	-2.06	8.40	16.73
Fpz	2.07	9.96	23.18
Fs	0.88	6.17	21.76
Cd	0.90	14.02	25.17
Cz	5.99	14.37	27.23
Cs	4.26	14.54	23.99
Pd	2.41	11.30	22.96
Pz	2.70	12.78	24.59
Ps	4.06	12.65	24.08
Oz	3.52	11.76	23.06
Td	0.79	7.36	20.47
Ts	1.54	10.97	20.72
Sum	60.33	140.52	220.02
70–74 (Мв)			
Fd	1.99	12.66	28.58
Fpz	3.54	14.99	30.24
Fs	3.33	12.99	30.31
Cd	9.25	19.56	34.11
Cz	10.92	20.55	34.09
Cs	8.45	18.40	34.94
Pd	7.68	17.33	32.95
Pz	7.76	18.34	30.87
Ps	7.87	19.46	32.02
Oz	8.70	16.49	31.76
Td	3.97	15.51	33.61
Ts	1.88	14.08	39.53
Sum	107.07	207.26	352.87



Indicators of DC-potential level of the brain in women in the studied age groups: 60-64 years, 65-69 years, 70-74 years

iological compensatory mechanisms, which leads to a relative normalization of neuroenergy exchange of the brain. According to the results of our study, the stabilization of DC-potential level occurs precisely in the period of 65-69 years.

The next increase in the DC-potential level of the brain begins to be traced at the age of 70-74 years. At the same time, an increase in DC-potential level can act as an unfavorable sign of age-related degenerative changes in brain tissue [12]. Probably, it is at this age that the decline of physiological compensatory processes begins to occur.

Thus, changes in the DC-potential level in old age are a reflection of the polymorphism of external and internal factors that affect the functional state of the brain of an elderly woman.

Conclusion. In the studied groups of elderly women, there is a change in the median values of the DC-potential level, demonstrating pronounced fluctuations in the distribution of brain energy consumption in the aging process. Studies of the age dynamics of energy metabolism allow us to reveal the mechanisms of functional activity of the brain in old age, the understanding of which can increase the objectivity of functional diagnostics, and, ultimately, will contribute to the timely diagnosis and prevention of neurodegenerative changes, which will delay the period of decline of compensatory mechanisms of the nervous system of an elderly person.

It is important to note that the presented age percentile Tables were calculated based on a study of a sample of elderly women living in the Arctic zone of the Russian Federation. To increase the effectiveness of the diagnostic potential of the study, it is important to create standard centile Tables for men and expand the coverage of the sample by studying older people in other regions of Russia.

The research was carried out with the financial support of the grant of the President of the Russian Federation for young scientists – candidates of sciences within the framework of the scientific project No. MK-4405.2022.1.4. And also with the support of the World-Class Scientific and Educational Center "Russian Arctic: new materials, technologies and research methods".

References

1. Klimenko L.L., Deev A.I., Fokin V.F. Energeticheskij metabolizm mozga v gerontologicheskom aspekte [Brain energy metabolism in gerontological aspect]. Klinicheskaya gerontologiya [Clinical gerontology. 2010; 9-10: 37-38 (In Russ.).]

2. Kotsova O.N., Anikina N.YU., Gribanov A.V. Polovye razlichiya cerebral'nogo energoobmena u zhitelej Arkticheskoj zony RF [Sexual differences of cerebral energy exchange in residents of the Arctic zone of the Russian Federation]. Vestnik ural'skoj medicinskoj akademicheskoj nauki [Bulletin of the Ural Medical Academic Science. 2021; 18 (1): 4-12 (In Russ.).]

3. Maksimova A.A., Silina Yu.M. Diagnostricheskie vozmozhnosti nejroenergokartirovaniya pri gipoksicheskih porazheniyah golovnogo mozga [Diagnostic possibilities of neuroenergic mapping in hypoxic brain lesions]. Mezhdunarodnyj nauchno-issledovatel'skij zhurnal [International Scientific Research Journal. 2021; 1(103) Part 3: 46-51 (In Russ.).]

4. Maksimova A.A. [et al.]. Nejroenergokartirovanie: novyj instrument diagnostiki patofiziologicheskih izmenenij central'noj nervnoj sistemy u detej s narusheniyami razvitiya [Neuroenergomapping: a new diagnostic tool for pathophysiological changes in the central nervous system in children with developmental disorders]. Universum: medicina i farmakologiya: elektron. nauchn. zhurn. «Medicina i farmokologiya» [Universum: medicine and pharmacology: electron. scientific. journal 'Medicine and pharmacology'. 2021; 1(74)

5. Sokolova L.P. [et al.]. Osobennosti adaptacii metabolizma mozga i formirovanie zabolevanij nervnoj sistemy [Features of adaptation of brain metabolism and the formation of diseases of the nervous system]. Evrazijskij Soyuz Uchenyh [Eurasian Union of Scientists. 2016; 29-1: 65-68 (In Russ.).]

6. Gribanov A.V., Anikina N.Yu., Kozhevnikova I.S., [et al.]. Reakciya cerebral'nogo energometabolizma na holodovoj stress u molodyh lyudej, prozhivayushchih v Arkticheskom regione Rossijskoj Federacii [The reaction of cerebral energy metabolism to cold stress in young people living in the Arctic region of the Russian Federation]. Ekologiya cheloveka [Human Ecology. 2019; 3: 17-23 (In Russ.).]

7. Romanchuk N. P. Mozg cheloveka i priroda: sovremennye regulyatory kognitivnogo zdorov'ya i dolgoletiya [Human brain and nature: modern regulators of cognitive health and longevity]. Byulleten' nauki i praktiki [Bulletin of Science and practice. 2021; 6: 146-190 (In Russ.).]

8. Galimov N.M. [et al.]. Sverhmedlennye fiziologicheskie processy golovnogo mozga cheloveka i zhivotnyh v eksperimental'nyh i klinicheskih issledovaniyah [Super-slow physiological processes of the human and animal brain in experimental and clinical studies]. Medicinskij vestnik Bashkortostana [Medical Bulletin of Bashkortostan. 2009; 3: 63-69 (In Russ.).]

9. Sibil V.I. Vozrastnaya dinamika mozgovoj aktivnosti [Age dynamics of brain activity]. Vestnik eksperimental'nogo obrazovaniya [Bulletin of Experimental Education. 2017; 4 (13): 628-630 (In Russ.).]

10. Sokolova L.P., Chernyaev S.A. Nejrofunkcional'naya aktivnost' mozga: vozrastnoj aspekt [Neurofunctional brain activity: age aspect]. Terapiya [Therapy]. 2020; 6 (3):15-20 (In Russ.).]

11. Gribanov A.V. [et al.]. Starenie golovnogo mozga cheloveka: morfofunkcional'nye aspekty [[Aging of the human brain: morphofunctional aspects]. Zhurnal nevrologii i psihiatrii im. S.S. Korsakova. Specvypuski [S.S. Korsakov Journal of Neurology and Psychiatry . Special issues. 2017; 117 (1-2):3-7 (In Russ.).]

12. Akarachkova E.S. [et al.]. Stressy, komorbidnost' i kachestvo zhizni pozhilogo pacienta [Stresses, comorbidity and quality of life of an elderly patient]. Trudnyj pacient [Difficult patient. 2019; 10:19-27 (In Russ.).]

13. Fokin V.F., Ponomareva N.V. Energetich-eskaya fiziologiya mozga [Energetic physiology of the brain. M.: Antidor. 2003: 288 (In Russ.).]

14. Gribanov A.V. [et al.]. Funkcional'naya aktivnost' golovnogo mozga u pozhilyh zhenshchin Arkticheskoj Zony Rossijskoj Federacii s razlichnym vegetativnym tonusom [Functional brain activity in elderly women of the Arctic Zone of the Russian Federation with different vegetative tone]. Ekologiya cheloveka [Human Ecology. 2023; 3: 231-240 (In Russ.).]

15. Fateeva I.L. [et al.]. Funkcional'noe sostoyanie golovnogo mozga u pozhilyh zhenshchin s razlichnoj stepen'yu vyrazhennosti trevogi [Functional state of the brain in elderly women with varying degrees of anxiety]. Klinicheskaya gerontologiya [Clinical gerontology. 2022; 28 (7-8): 55-60 (In Russ.).]

16. Lisova N.A., Chereneva E.A., Shilov S.N., Nikiforova N.V. Harakteristika cerebral'nogo energeticheskogo metabolizma u lic pozhilogo vozrasta s narusheniem kognitivnyh funkcij [Characteristics of cerebral energy metabolism in elderly people with impaired cognitive functions]. Siberian Journal of Life Sciences and Agriculture. 2022; 5: 246-261 (In Russ.).]

S.I. Vdovenko

COMPARATIVE ANALYSIS OF EXTERNAL RESPIRATION SYSTEM OF THE NORTHERNERS IN THE AGE ASPECT

DOI 10.25789/YMJ.2024.86.16

UDC 612.216.2; 612.66

This study aimed at the specific performance of respiration system based on the ontogeny. Four hundred and fifty-two male residents of Magadan aged 15-74 participated in a comprehensive age-associated survey that involved 4 groups: adolescents, early adults, workable men of mature age and the elderly. The lungs volumetric and velocity characteristics were analyzed using computer spirometry. Most indicators of external respiration proved to be significantly age specific. The maximum values were observed in the early adulthood followed by a fall in men of older age groups. The revealed changes indicated lowered reserve capabilities of the respiration performance with increasing duration of residence under the North conditions and suggested reduced adaptabilities of the body owing to the chronic adverse effects of natural and climatic environmental factors.

Keywords: North, adaptation, respiration system, men.

Introduction. Severe ecological and climatic factors of Russia's North-East are provided by not a long-term low atmospheric temperatures only, but a combination of abiotic environmental factors (the weather extremes, humidity and wind conditions, shifting daily and seasonal light periods, the influence of heliophysical effects, etc.). At the same time, this territory (Magadan Region, Chukotka, and Yakutia) receives the most dramatic climate changes [8]. Among all the body physiological systems, the external respiration is the first to face the outer environment and it experiences constant stress, due to continuous contact with natural extremes [9]. The increasing age results in pronounced changes in the breathing system, thereby aggravating the stress at various levels, from respiratory muscles to the conductive and convective zone of the lungs [2, 6, 12, 13]. Since the body experiences increased metabolic needs under the cold conditions, the optimal performance of the respiration system is the key to adequate oxygen supply and is crucial because of hypoxic changes in lungs resulting from a fall in the tissue respiration with increasing age [7]. Following on from the above, we see it is relevant to study changes in the respiration system functioning in men of different age groups – permanent residents of Magadan city.

Materials and Methods. Four hundred and fifty-two male residents of Magadan city, Caucasian by origin, participated in the survey. All subjects were divided into four groups based on their ages: adolescents, n = 85 (mean age 16.2±0.06 yrs, body height 179±0.75 cm, body mass 66.5±1.27 kg), young adults, n = 235 (19.2±0.5 yrs, 178.9±0.7 cm, 66.4±1.2 kg), mature men, n = 89 (37.1±0.59 yrs, 180.3±0.68 cm, 84.1±0.9 kg), and elderly men, n = 43 (65.6±1.09 years, 174.1±1.16 cm, 86.1±2.18 kg). The external respiration (or external breathing) function (EBF) of men was assessed by the standard and well-proven method of indexing volumetric pressure and pneumatic flow on a medical Diamant-C spirograph. All basic characteristics of the EBF were automatically compared with the proper values which are the values calculated for the population of residents of the Central part of Russia [5] We studied 21 indicators: vital and forced lung capacity (VC and FVC, l), forced expiratory volume in the first second (FEV_1, l), peak expiratory flow

VDOVENKO Sergei Igorevich – PhD (Biol.), Senior Researcher, Laboratory for Physiology of Extreme States, Research Center "Arktika", Far Eastern Branch of the Russian Academy of Sciences (SRC "Arktika" FEB RAS), http://orcid.org/0000-0003-4761-5144, Vdovenko.sergei@yandex.ru