



Research article

## RISK OF DEVELOPING HYPERTENSION IN UNDERGROUND WORKERS WHEN PSYCHO-VEGETATIVE STATUS IS TRANSFORMING

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*The present research work is vital given the importance of studying risk factors that can cause mortality due to diseases of the circulatory system, especially among population of employable age. Our research aim was to establish what factors might induce developing hypertension based on examining psycho-vegetative status, biochemical and functional parameters of the cardiovascular system in underground workers depending on their age.*

*We examined 109 men who were employed at a chromium mining enterprise and were exposed to occupational and psychosocial factors. The patients were divided into two groups; the test group was made up of 60 men who worked under ground under working conditions ranked as “hazardous” and belonging to hazard category 3.3–3.4; the reference group consisted of 49 men who dealt with surface works under working conditions belonging to hazard category 3.2. The test group was further divided into two sub-groups depending on workers’ age: people younger than 45 ( $n = 20$ , average age was  $38.45 \pm 2.95$ ) and people older than ( $n = 40$ , average age was  $50.90 \pm 1.46$ ). The reference group was also divided accordingly. The patients had their psycho-vegetative status examined profoundly with assessing neuropsychic stress, personal and situational anxiety, attention function, and subjective reflection of psycho-vegetative distress. The state of the cardiovascular system (CVS) was examined using results of functional and clinical-laboratory diagnostics.*

*Decreased attention, greater personal anxiety and a greater number of psycho-vegetative complaints were detected authentically more frequently among patients with hypertension (OR 7.50, 95 % CI 2.39–23.58; OR 11.06, 95 % CI 4.35–28.10; OR 22.50, 95 % CI 7.09–71.41). We detected differences in adaptation psycho-vegetative phenotypes between two sub-groups. A correlation between age and working experience and indicators of psycho-vegetative status was established for patients younger than 45 but there was no correlation with homeostasis indicators. There was a negative correlation between age and working experience and some indicators of psycho-vegetative status revealed for patients older than 45; there was a direct correlation between these parameters and certain homeostasis indicators given hypertension diagnosed in 95 % patients in this sub-group.*

*As age and working experience grew, adaptation psycho-vegetative phenotype transformed and the process involved inversion of correlations with psycho-vegetative indicators together with aggravating functional disorders of the CVS. When transformation of this phenotype is diagnosed, it allows assessing risks of developing hypertension and makes for primary hypertension prevention through determining risk groups among workers.*

**Key words:** psycho-vegetative status, hazardous underground work, functional changes, psycho-vegetative phenotype, hypertension, psychosocial factors.

Occupational and psychosocial factors included; given that, labor intensity also have great diagnostic significance in occurrence of work-related diseases and it is vital to examine them. Production is becoming more and more intense in many industries, mining and imbalance in the autonomic nervous sys-

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tem. All this leads to distress, basic metabolic disorders, activated free radical lipid oxidation, and endothelial dysfunctions in the vessels [1].

These pathological changes primarily influence the cardiovascular system. As working experience gets longer, adaptive psychological functions are being depleted, and pathologic psychic reactions occur as a response to a situation at a workplace; compensatory role and functions performed by psychological adaptation are also reduced. Psycho-vegetative tension becomes apparent via occurring somatic functional disorders and later leads to growing shares of psychosomatic pathologies, most frequently, developing hypertension [2, 3].

Hypertension is among risk factors that cause diseases of the cardiovascular system (CSDs) among employable population; it makes for growing arterial stiffness (as a pathognomonic syndrome of vascular ageing)<sup>1</sup>. In 2014 mortality due to diseases of the cardiovascular system accounted for 50.1 % of the total deaths in Russia in all age groups and this share remains disproportionately high in old age groups [4].

Psychosocial factors (low self-sufficiency, absence of social support and job dissatisfaction, depression, stress both at home and at work, poor financial situation, and misfortunes) also have a significant role in stress-related health disorders, CSDs included, and occupational stress assessment is recommended to be included into prevention programs implemented at industrial enterprises [5–9]. High CSDs prevalence among working population in Siberia was established to be related to wide spread of such psychosocial risk factors as high anxiety, depression, and sleeping disorders [10]. Significant contribution by vital exhaustion,

anxiety and depression symptoms was detected in patients at Bern University Hospital who suffered from acute coronary syndrome or myocardial infarction; most of them needed psychological counseling [11]. Besides, according to data provided by the American Heart Association, depression with anxiety is recommended to be included into risk factors of acute cardiovascular disorders [12].

Meta-analysis was performed to examine health and psychological state of Chinese workers; it revealed that depression and anxiety were associated with a risk of developing CSDs [13]. Depression, together with anxiety, results in mortality risks growing by 77 %, including mortality due to CSDs [15]. Complex studies focusing on psychoemotional and personal peculiarities of patients with cardiovascular pathology proved their significance; these studies were performed to provide an opportunity to improve activities aimed at correction of psychological risk factors causing ischemic heart disease (IHD) and its consequences as well as at reducing their negative impacts [16, 17]. At present psychological support is included into corporate labor protection programs provided for workers employed in many dangerous industries [18].

According to WHO experts' opinion (WHO, Fact sheet of mental health, 2015) and "The strategy for creating healthy lifestyle among population, prevention and control over non-communicable diseases up to 2025"<sup>2</sup> approved by the RF Government, an activity program was developed with its aim being to preserve workers' mental health in order to achieve stable labor productivity and long period of employment [19].

Given all that, it is vital to provide up-to-date diagnostics of workers' psycho-vegetative state. A set of activities aimed at revealing

<sup>1</sup> O sostoyanii sanitarno-epidemiologicheskogo blagopoluchiya naseleniya v Respublike Tatarstan v 2019 godu: Gosudarstvennyi doklad [On sanitary-epidemiologic welfare of the population in Tatarstan in 2019: The State Report]. Kazan, Rosпотrebнадзор Regional office in Tatarstan, 2020, 356 p. Available at: [http://16.rosпотrebнадзор.ru/c/document\\_library/get\\_file?uuid=e952e8fb-d3f5-467a-a301-f3b082a9b477&groupId=10156](http://16.rosпотrebнадзор.ru/c/document_library/get_file?uuid=e952e8fb-d3f5-467a-a301-f3b082a9b477&groupId=10156) (July 21, 2021) (in Russian).

<sup>2</sup> Ob utverzhenii Strategii formirovaniya zdorovogo obraza zhizni naseleniya, profilaktiki i kontrolya neinfektsionnykh zabolovaniy na period do 2025 goda: Prikaz Ministerstva zdravookhraneniya RF ot 15 yanvarya 2020 g. № 8 [On approval of The strategy for creating healthy lifestyle among population, prevention and control over non-communicable diseases up to 2025: The Order by the RF Public Healthcare Ministry dated January 15, 2020 No. 8]. *Garant: information and legal portal*. Available at: <https://www.garant.ru/products/ipo/prime/doc/73421912/> (July 03, 2021) (in Russian).

early signs of diseases and a procedure for providing periodical medical examinations (PME) for various occupational groups are stipulated in multiple legal documents: The Order by the RF Public Healthcare Ministry issued on January 28, 2021 No. 29-n “On approval of the procedure for performing preliminary and periodical medical examinations of workers stipulated in the Part 4, Clause 213 in the RF Labor Code, a list of medical contraindications to accomplishing works with harmful and (or) hazardous occupational factors as well as works that can be accomplished only after obligatory preliminary and periodical medical examinations provided for workers”; the RF Federal Law issued on November 21, 2011 No. 323-FZ “On basics of protecting citizens’ health in the Russian Federation” as well as standards for rendering medical aid and clinical recommendations<sup>3</sup>. Among other things, a worker is obliged to have obligatory psychiatric examination taking into account provisions stipulated by the RF Law issued on July 02, 1992 No. 3185-1 “On psychiatric aid and guarantee of citizens’ rights protection when rendering it”<sup>4</sup>.

A psychiatrist who participates in PME is responsible for establishing any possible psychiatric contraindication to occupational activities. However, bearing in mind the aforementioned importance of psychological adaptation when a psychosomatic pathology is developing, it seems advisable to perform a complex assessment of a worker’s mental state focusing on mental functions that have etiopathogenetic significance for psychosomatic pa-

thologies. Obtained data are consistent with information about structure and intensity of workers’ somatic pathology applied to create a set of examination procedures and further analysis of relations between mental functions and age, working experience, functional and organic signs of a somatic pathology. Thus, it is possible to create a clinical and psycho-vegetative phenotype of a worker who deals with intense labor [20], to develop and recommend prevention activities and principles of early somatic pathology diagnostics for determining risk groups.

**Our research aim** was to establish what factors may induce hypertension based on examining changes in psycho-vegetative status, biochemical and functional parameters of the cardiovascular system in underground workers of middle and older age.

**Materials and methods.** We examined 60 men who performed their work tasks underground (the test group,  $n = 60$ , aged  $46.8 \pm 2.0$ , working experience equal to  $22.0 \pm 2.4$  years); they all gave their written informed consent to be examined. The reference group was made up of 49 workers who didn’t deal with underground labor (their age was  $43.6 \pm 3.8$  and working experience,  $16.6 \pm 1.6$  years). To examine workers’ health depending on their age, all patients in the test group were divided into two sub-groups using age classification recommended by the WHO; according to it, people younger than 45 are considered young and people aged 45–60 are considered middle-aged. Sub-group I ( $n = 20$ ) was made up of workers aged  $38.45 \pm 2.95$  with their working experi-

<sup>3</sup> Ob utverzhdenii Poryadka provedeniya obyazatel'nykh predvaritel'nykh i periodicheskikh meditsinskikh osmotrov rabotnikov, predusmotrennykh chast'yu chetvertoi stat'i 213 Trudovogo kodeksa Rossiiskoi Federatsii, perechnya meditsinskikh protivopokazanii k osushchestvleniyu rabot s vrednymi i (ili) opasnymi proizvodstvennymi faktorami, a takzhe rabotam, pri vypolnenii kotorykh provodyatsya obyazatel'nye predvaritel'nye i periodicheskie meditsinskie osmotry: Prikaz Minzdrava Rossii ot 28.01.2021 № 29n [On approval of the procedure for performing preliminary and periodical medical examinations of workers stipulated in the Part 4, Clause 213 in the RF Labor Code, a list of medical contraindications to accomplishing works with harmful and (or) hazardous occupational factors as well as works that can be accomplished only after obligatory preliminary and periodical medical examinations provided for workers: The Order by the RF Public Healthcare Ministry dated January 28, 2021 No. 29n]. *KonsultantPlus*. Available at: [http://www.consultant.ru/document/cons\\_doc\\_LAW\\_375353/](http://www.consultant.ru/document/cons_doc_LAW_375353/) (July 23, 2021) (in Russian); Ob osnovakh okhrany zdorov'ya grazhdan v Rossiiskoi Federatsii: Federal'nyi zakon № 323-FZ ot 21.11.2011 [On basics of protecting citizens’ health in the Russian Federation: The Federal Law No. 323-FZ issued on November 21, 2011]. *KonsultantPlus*. Available at: [http://www.consultant.ru/document/cons\\_doc\\_LAW\\_121895/](http://www.consultant.ru/document/cons_doc_LAW_121895/) (July 23, 2021) (in Russian).

<sup>4</sup> O psikhiatricheskoi pomoshchi i garantiyakh prav grazhdan pri ee okazanii: zakon RF № 3185-1 ot 02.07.1992 [On psychiatric aid and guarantee of citizens’ rights protection when rendering it: the RF Law No. 3185-1 issued on July 02, 1992]. *KonsultantPlus*. Available at: [http://www.consultant.ru/document/cons\\_doc\\_LAW\\_4205/](http://www.consultant.ru/document/cons_doc_LAW_4205/) (July 23, 2021) (in Russian).

ence being  $12.7 \pm 3.0$  years; the sub-group II ( $n = 40$ ) included workers aged  $50.90 \pm 1.46$  with their working experience being  $26.7 \pm 1.9$ . The reference group was also divided into two similar sub-groups; 23 workers aged  $38.0 \pm 2.8$  with their working experience being  $9.3 \pm 1.5$  years (workers from the reference group younger than 45); and 26 workers aged  $49.2 \pm 2.1$  with their working experience being  $24.0 \pm 1.8$  years (workers from the reference group older than 45). The groups were comparable as per age, gender, social-communal and occupational conditions; sub-groups I and II in both groups were comparable as per working conditions ( $p < 0.05$ ). Clinical examination was performed at the therapeutic department of the Rospotreb-nadzor's Federal Scientific Center for Medical and Preventive Health Risk Management Technologies.

Special assessment of working conditions was performed at workplaces of the major occupational group dealing with underground chromium mining; it revealed that equivalent noise varied from 65.3–70.9 dBA to 108.2–114.9 dBA at miners' workplaces (drift miners, blast-hole drillers, and drilling unit operators, hazard category 3.4). Local vibration at workplaces was higher than maximum permissible level (MPL is fixed at 126 dB) and reached 135 dB and overall vibration was 127 dB (MPL is fixed at 115 dB; hazard category 3.3). Physical loads and frequent necessity to keep an uncomfortable (forced) posture also gave grounds for assigning working conditions

of this occupational group into hazard category 3.3. Particulate matter (dusts) concentrations in workplace air corresponded to hazard category 3.1 at workplaces of drift miners, blast-hole drillers, drilling unit operators, and scraper winch operators. Chromium contents didn't exceed 0.002–0.012 mg/m<sup>3</sup> at workplaces; average shift concentration was lower than 0.5 mg/m<sup>3</sup> whereas single MPC fixed in hygienic standards was 1.0 mg/m<sup>3</sup>. Overall, working conditions at the examined workplaces were established to be "hazardous" and assigned into hazard categories 3.3–3.4 (Table 1).

Working conditions were hygienically assessed at 34 workplaces of workers from the reference group. The results are given in Table 2.

A periodical medical examination revealed that some workers had elevated blood pressure, higher than 140/90 mm Hg. To put a correct diagnosis, those patients were sent to the therapeutic department of the Rospotreb-nadzor's Federal Scientific Center for Medical and Preventive Health Risk Management Technologies. Complex examination performed at an inpatient clinic resulted in "I degree hypertension" diagnosed in 38 patients (63.3 %) from the test group; all of them were middle-aged people (sub-group II).

A clinical interview and questioning were used to identify patients' personality peculiarities. Psycho-vegetative dysfunction was assessed using a set of psychophysiological tests ("NS-Psychotest" computer compels) including "Determination of mental strain by T. Nemchin", 2011

Table 1

Working conditions at workplaces of underground miners from basic occupational groups dealing with chromium ore mining

Occupation	Working conditions category as per their hazard and (or) danger								
	Chemical factor	Aerosols	Noise (Lequiv.)	Vibration (total)	Vibration (local)	Microclimate	Labor hardness	Labor intensity	Overall assessment
Miner	2	3.1	2	–	–	3.3	3.2	1	3.3
Drift miner	2	3.1	3.4	3.2	3.3	3.3	3.3	1	3.4
Timber-man	2	3.1	3.2	–	3.2	3.3	3.2	1	3.3
Blast-hole driller	2	3.1	3.4	3.2	3.3	3.3	3.3	1	3.4
Scraper winch operator	2	3.1	3.3	3.1	3.1	3.3	3.3	1	3.4
Drilling unit operator	2	3.1	3.4	2	2	3.3	3.2	1	3.4

Table 2

Working conditions at surface workplaces of basic occupational groups dealing with chromium ore mining

Occupation	Working conditions category as per their hazard and (or) danger								
	Chemical factor	Aerosols	Noise (Lequiv.)	Vibration (total)	Vibration (local)	Microclimate	Labor hardness	Labor intensity	Overall assessment
Repairman	2	2	3.2	2	2	–	3.1	–	3.2
Conveyer operator	2	2	3.2	2	–	–	3.1	–	3.2
Jigging machine operator	2	2	3.2	2	–	–	3.1	–	3.2
Loader	2	2	2	–	–	–	3.2	–	3.2

(score estimate of mental strain); “Integrative anxiety test” (score estimate). Voluntary attention was analyzed with a test involving use of Shulte – Gorbov tables. Subjective reflection of psycho-vegetative function was assessed using “Intensity of psycho-vegetative syndrome symptoms” questionnaire, score estimates. Clinical examination included ECG, daily BP monitoring, and US of the heart; we also analyzed the results of total blood count and biochemical blood tests (glucose, creatinine, AST, ALT, sodium, potassium, uric acid in blood serum, lipid spectrum, and C-reactive protein). All the results were statistically analyzed using a built-in analysis module in Excel®2016 MSO (© Microsoft, 2016), and “Stat2015”, an author’s package of applied electronic tables (© V.S. Shelud’ko, 2001–2016).

**Results and discussion.** All patients from the test and reference groups participated in clinical-laboratory and instrumental examinations; the results show that homeostasis indicators were within reference values (Table 3).

Patients’ personality peculiarities were determined during a clinical interview; they were circumstantiality, decision-making based on external circumstances and moral and ethical beliefs, orientation at wellbeing and worries about it. Attention function was rather low among underground workers from the test group ( $69.72 \pm 6.03$  sec,  $p < 0.05$ ) against the reference group; this level corresponded to peculiarities of long monotonous work under hazardous conditions and necessity to keep high concentration but without any attention switching as a result of workers being adapted to their

labor. We determined a significant level of personal anxiety ( $5.0 \pm 0.4$  scores,  $p < 0.05$ ) indicating readiness for changes in a situation both at work and in social-communal environment. Long-term exposure to personal anxiety is accompanied with constant tension of mental functions and activation of the sympathetic nervous system. Average level of personal anxiety is due to work-related peculiarities including occupational hazards, risks for workers’ life during a shift, worrying about one’s health and probable loss of a workplace and a right for early retirement, a risk that social status and financial position might deteriorate. We established average mental strain ( $42.7 \pm 1.5$  scores,  $p < 0.05$ ) as well as a greater number of psychosomatic complaints ( $1.5 \pm 0.3$  scores,  $p < 0.05$ ) than in the reference group. These peculiarities of patients’ mental state are considered mental adaptation to hazardous working conditions and are “a psychological profile” of an underground worker (Table 4).

We analyzed correlations between age, working experience, functional parameters of the cardiovascular system, blood test results and psycho-vegetative indicators. A correlation was established between working experience and mental strain ( $r = 0.301$ ,  $p = 0.0192$ ); between depleted attention function and level of creatinine ( $r = 0.310$ ,  $p = 0.0160$ ); between average SBP and pulse BP ( $r = 0.755$ ,  $p = 0.000$ ), atherogenic index and interventricular septum thickness (IST) ( $r = 0.407$ ,  $p = 0.0013$ ), atherogenic index and total cholesterol ( $r = 0.651$ ,  $p = 0.000$ ); interventricular septum thickness and total cholesterol ( $r = 0.369$ ,  $p = 0.0037$ ).

Table 3

Functional changes in the cardiovascular system and clinical-laboratory blood indicators detected in miners

Indicators	Test group ( <i>n</i> = 60), <i>M</i> ± 2 <i>m</i>	Reference group ( <i>n</i> = 49), <i>M</i> ± 2 <i>m</i>
Functional changes in the cardiovascular system		
Average SBP, mm Hg	131.20 ± 2.10	128.81 ± 2.21
Pulse BP, mm Hg	46.17 ± 1.88	46.23 ± 2.30
Interventricular septum thickness, cm	0.97 ± 0.06*	0.86 ± 0.07
Clinical-laboratory blood indicators		
Atherogenic index	2.12 ± 0.15*	1.76 ± 0.20
Total cholesterol, mmol/l	5.52 ± 0.37*	4.81 ± 0.29
HDLP, mmol/l	1.78 ± 0.09	1.77 ± 0.10
Uric acid, μmol/l	311.43 ± 13.69*	296.42 ± 19.43
Thrombocytes, 10 <sup>9</sup> /dm <sup>3</sup>	250.08 ± 13.05	231.19 ± 13.18

Note: \* means *p* < 0.05, that is, differences from the reference group are statistically significant.

Table 4

Indicators of psycho-vegetative state in workers form the test group

Indicators of psycho-vegetative state	Test group ( <i>n</i> = 60), <i>M</i> ± 2 <i>m</i>	Reference group ( <i>n</i> = 49), <i>M</i> ± 2 <i>m</i>
Attention fatigue, sec	69.72 ± 6.03*	40 ± 1.80
Mental strain index (MSI), scores	42.72 ± 1.50*	40.5 ± 1.10
Situational anxiety, scores	1.92 ± 0.40	1.91 ± 0.38
Personal anxiety, scores	5.00 ± 0.39*	4.3 ± 0.21
Psycho-vegetative complaints, scores	1.52 ± 0.28*	0.8 ± 0.10

Note: \* means *p* < 0.05, that is, differences from the reference group are statistically significant.

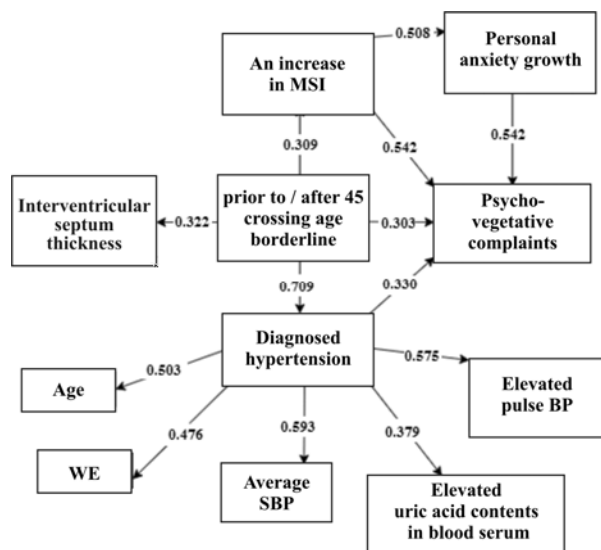


Figure 1. Correlations between functional parameters of the cardiovascular system, blood indicators and psycho-vegetative parameters of workers form the test group

Besides, we established that when an age borderline (45 years) was overcome, it resulted in both greater number of psycho-vegetative complaints and diagnosed hypertension (Figure 1).

These determined correlations gave grounds for assessing risks of deteriorating psycho-vegetative and clinical-functional parameters in patients with hypertension.

Lower attention functions, elevated personal anxiety and a greater number of psychosomatic complaints were authentically more frequent in patients with hypertension (OR 7.50, 95 % CI 2.39–23.58; OR 11.06, 95 % CI 4.35–28.10; OR 22.50, 95 % CI 7.09–71.41). We also detected elevated SBP (OR 4.48, 95 % CI 1.80–11.16), pulse BP (OR 3.00, 95 % CI 1.14–7.86), interventricular septum thickness (OR 2.98, 95 % CI 1.26–7.06), atherogenic index (OR 3.20, 95 % CI 1.08–9.50), and uric acid contents in blood serum (OR 3.86, 95 % CI 1.41–10.55) authentically more frequently in such patients. Therefore, patients from the examined groups with diagnosed hypertension are exposed to elevated risks of psycho-vegetative changes such as lower attention functions, greater personal anxiety and a greater number of psycho-vegetative complaints.

Table 5

## Results of psychophysiological and clinical examinations in sub-groups I and II

Parameters / indicators	Sub-group I in test group (< 45 years) (n = 20)	Reference group (< 45 years) (n = 23)	p	Sub-group II in test group (> 45 years) (n = 40)	Reference group (> 45 years) (n = 26)	p
Demographic parameters						
Age, years	38.45 ± 2.95	38.00 ± 2.75		50.90 ± 1.46	49.15 ± 1.50	
Working experience, years	12.75 ± 3.02	9.30 ± 1.51		26.68 ± 1.99	23.92 ± 1.27	
Indicators of psycho-vegetative state						
Attention, sec	67.20 ± 6.68*	36.39 ± 2.58	0.0001	70.98 ± 8.44*	39.15 ± 2.12	0.0000
MSI, scores	40.15 ± 1.53*	40.04 ± 1.83	0.0018	44.00 ± 2.01*	41.04 ± 1.48	0.0074
Psycho-vegetative complaints, scores	1.05 ± 0.44*	0.65 ± 0.20	0.0017	1.75 ± 0.33*	0.92 ± 0.24	0.0002
Personal anxiety, scores	4.85 ± 0.61	4.22 ± 0.72	0.3015	5.08 ± 0.50*	4.23 ± 0.62	0.0423
Functional indicators of the cardiovascular system						
SBP, mm Hg	128.45 ± 3.60	126.96 ± 2.90	0.4147	132.58 ± 2.51*	128.81 ± 2.21	0.0441
Pulse BP, mm HG	42.75 ± 2.52	44.43 ± 2.54	0.7326	47.88 ± 2.37	46.23 ± 2.30	0.1993
IST, cm	0.86 ± 0.10	0.84 ± 0.08	0.4465	1.02 ± 0.07*	0.86 ± 0.07	0.0032
Clinical and laboratory homeostasis indicators						
Atherogenic index (IA)	2.04 ± 0.32*	1.83 ± 0.16	0.0067	2.16 ± 0.16*	1.76 ± 0.20	0.0032
HDLP, mmol/l	1.72 ± 0.18*	1.68 ± 0.08	0.0035	1.81 ± 0.10	1.77 ± 0.10	0.3264
AST, U/l	16.20 ± 2.84*	12.52 ± 1.33	0.0292	14.85 ± 1.33*	12.35 ± 1.11	0.0061
ESR, mm/h	8.15 ± 1.71*	5.74 ± 1.24	0.0283	9.48 ± 1.49*	6.31 ± 1.19	0.0056
Total cholesterol, mmol/l	5.03 ± 0.41	4.73 ± 0.29	0.2111	5.77 ± 0.51*	4.81 ± 0.29	0.0021
Creatinine, µmol/l	69.10 ± 6.18	66.96 ± 4.98	0.5059	71.53 ± 6.37*	66.58 ± 4.67	0.0346
Potassium in serum, mmol/l	4.22 ± 0.22	4.10 ± 0.23	0.6669	4.48 ± 0.20*	4.03 ± 0.21	0.0048
Uric acid in serum, µmol/l	300.45 ± 22.28	297.26 ± 22.03	0.8027	316.93 ± 17.19*	296.42 ± 19.43	0.0456
C-reactive protein, mg/l	5.05 ± 1.17	4.18 ± 0.92	0.4560	7.23 ± 1.14*	4.23 ± 0.84	0.0001
Thrombocytes, 10 <sup>9</sup> /dm <sup>3</sup>	231.30 ± 16.30	226.96 ± 14.76	0.8850	259.48 ± 17.19*	231.19 ± 13.18	0.0129

Note: \* means  $p < 0.05$ , that is, differences from the reference group are statistically significant.

We analyzed clinical and psycho-vegetative state through comparing two age-subgroups, I and II, to reveal any adaptation peculiarities (Table 5).

Workers from the test-group, sub-group I had lower attention function, elevated mental strain index with sympathicotonia, and a greater number of psycho-vegetative complaints in comparison with the reference group. We didn't reveal any authentic differences in personal or situational anxiety between the two sub-groups.

Having analyzed parameters of the cardiovascular system, we revealed an ascending trend in average systolic blood pressure (SBP) and in interventricular septum thickness. Total cholesterol and C-reactive protein also tend to be slightly higher.

We analyzed correlations in the sub-group I (Figure 2) to establish there was an apparent one between working experience and mental strain

index ( $r = 0.726$ ,  $p = 0.0003$ ), an apparent one between mental strain index and a number of psycho-vegetative complaints ( $r = 0.645$ ,  $p = 0.0021$ ), a moderate one between age and attention function ( $r = 0.554$ ,  $p = 0.011$ ). We didn't establish any correlations between psycho-vegetative indicators and functional changes in the cardiovascular system.

Assessment of risks as per psycho-vegetative and clinical-functional indicators didn't reveal any authentic correlations with diagnosed hypertension in this group.

Therefore, underground miners who are younger than 45 have a specific adaptation clinical-psycho-vegetative phenotype which we label as "*psychologically implemented adaptation phenotype*". It becomes apparent through lower attention function, increased mental strain index, and a greater number of psycho-vegetative complaints with all these parameters correlating with age and working

experience. These results indicate that psycho-vegetative tension is implemented by predominantly psychological mechanisms and is not accompanied with cardiovascular disorders which were not detected in this age group.

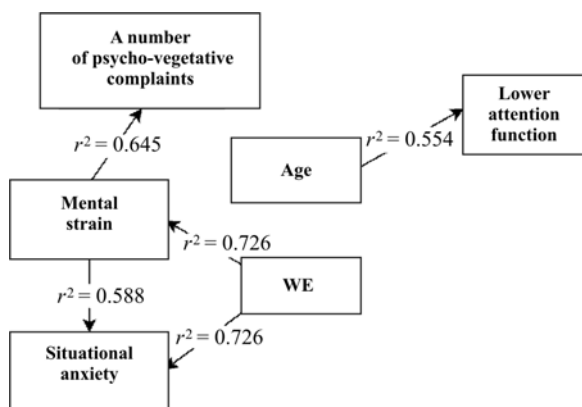


Figure 2. Correlations between age and working experience and psycho-vegetative indicators in workers from sub-group I

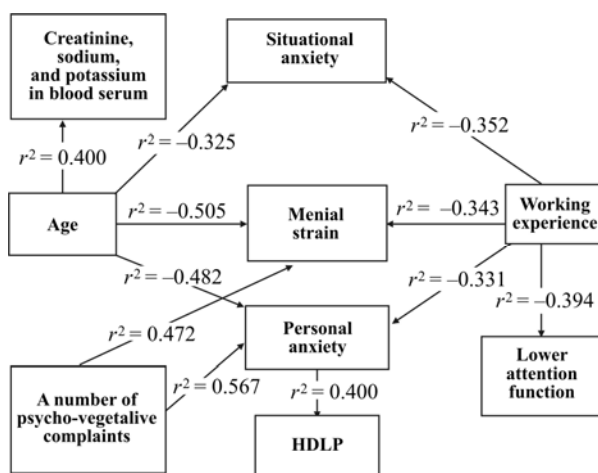


Figure 3. Correlations between age and working experience and psycho-vegetative indicators and laboratory changes in homeostasis in workers from sub-group II

Workers from sub-group II had lower attention function, elevated mental strain index with sympathicotonia, a greater number of psycho-vegetative complaints, and authentically higher personal anxiety. Besides, we detected elevated SBP, growing interventricular septum thickness, elevated atherogenic index and contents of total cholesterol.

Correlation analysis performed in sub-group II revealed the following (Figure 3): a moderate negative correlation between age and

mental strain index ( $r = -0.505, p = 0.0009$ ), age and personal anxiety ( $r = -0.325, p = 0.026$ ); a moderate negative correlation between age and lower attention function ( $r = -0.394, p = 0.0119$ ), working experience and mental strain index ( $r = -0.343, p = 0.0303$ ), working experience and personal ( $r = -0.331, p = 0.037$ ) as well as situational anxiety ( $r = -0.352, p = 0.026$ ). Besides, there is moderate correlation between atherogenic index and interventricular septum thickness (invention claim has been submitted). Therefore, there are qualitative changes in psycho-vegetative indicators among workers older than 45; these changes are related to age and working experience and occur against more apparent functional changes in the cardiovascular system and blood indicators. It allows us to determine it as “adaptation phenotype implemented by psychosomatics”.

We analyzed risks of deteriorated psycho-vegetative and clinical-functional parameters among patients with hypertension who were older than 45.

Lower attention function and elevated mental strain index were detected authentically more frequently among patients with hypertension (OR 4.98, 95 % CI 1.45–17.07; OR 2.97, 95 % CI 1.07–8.26) but a number of psycho-vegetative complaints was authentically lower (OR 0.17, 95 % CI 0.04–0.85). A risk of changes in psycho-vegetative state among patients with diagnosed hypertension who are older than 45 is different from that among patients without the disease primarily by a decrease in a number of psycho-vegetative complaints thus confirming there is age-related inversion in peculiarities of psycho-vegetative responses.

Therefore, revealed adaptation psycho-vegetative phenotypes show how underground workers adapt psychologically to adverse occupational conditions in different age groups. Workers who are younger have “psychologically implemented adaptation phenotype” with typical elevated mental strain index, a lot of psycho-vegetative complaints, and lower attention function during their first working years. These changes are adaptation in their essence, do not go beyond standard psychological responses and sympathicotonia occur-



ring due to their influence preserves its regulatory function and doesn't induce any changes in the cardiovascular system. As working experience becomes longer, psychological adaptation potential is depleted and workers who are older than 45 have "adaptation phenotype implemented by psychosomatics" which is characterized with lower attention function, elevated mental strain index, a growing number of psycho-vegetative complaints and personal anxiety, elevated SBP, growing interventricular septum thickness, elevated atherogenic index and total cholesterol. As working experience and age grow, there is an inversion of their correlation with psycho-vegetative changes and strain of psychological adaptation functions accumulated with working experience begins to be implemented through psychosomatic mechanisms, sympatheticotonia loses its regulatory potential, gets involved into hypertension pathogenesis and makes for its development and creates elevated risks of hypertensive disease.

**Conclusion.** There are changes in psycho-vegetative status of underground miners combined with certain functional changes in the cardiovascular system and biochemical changes in homeostasis against developing hypertension. Attention function deteriorates,

personal anxiety grows, and there is also a growing number of psycho-vegetative complaints (OR 7.50, 95 % CI 2.39–23.58; OR 11.06, 95 % CI 4.35–28.10; OR 22.50, 95 % CI 7.09–71.41). Examination of psycho-vegetative status allows identifying 2 age-dependent phenotypes, "psychologically implemented adaptation phenotype" and "adaptation phenotype implemented by psychosomatics". As working experience and age grow, adaptation psycho-vegetative phenotype transforms together with inversion of correlations with psycho-vegetative indicators against growing functional disorders of the cardiovascular system. Formation of adaptation clinical-psycho-vegetative phenotype in underground miners underlies predicting risks of developing hypertension disease and makes for preventing hypertension in case psychological support is provided (acknowledgment of receipts has been handed in regarding the patent entitled "Method for predicting risks of developing hypertension disease in underground workers", registration No. 2020137973).

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