Workplace stress and cognitive functions (a population based study of adults aged 25–44 years)

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Objective: *to investigate the effect of workplace stress on cognitive functions of younger men and women (25–44 years) in an open population of Novosibirsk.*

Patients and methods. *The study included a representative sample of Novosibirsk population aged 25–44 years (2013–2016 screening) within the budgetary theme №0541-2014-0004. We screened individuals aged 25–44 years: 463 men, mean age 35.94±5.957 years, and 546 women, mean age 36.17±5.997 years. Association of workplace stress with cognitive functions were assessed with standardized questions such as: «Has your specialty changed over the past 12 years?», «Do you like your job?» and «How do you rate your work responsibility over the past 12 months?». Cognitive evaluation during screening period included: A.R. Luria 10-words learning task (immediate and delayed recall), Burdon's test, exclusion of concepts «5th extra», animal naming test.*

Results and discussion. *We observed a decrease in semantic associations number among the respondents who did not change their occupation over the past year and among respondents who assess their work responsibility as «low». Verbal logical reasoning was lower in the respondents who assumed that they «did not like» or «did not like at all» their job and also assessed their work responsibility as «low». Auditory verbal short-term memory, long-term memory, memorization productivity, and attention were worse in the participants who had either «insignificant» or «average» work responsibility.*

Conclusion. *Younger adults experiencing workplace stress have a decrease in cognitive functions.*

Keywords: *workplace stress; cognitive functions; cognitive impairment; population.*

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Introduction. With an increase in life expectancy cognitive impairment has become a serious public health problem worldwide [1]. In Western Europe, the prevalence of cognitive impairment has recently been estimated at almost 7% in the population over the age of 60 [2]. Since there is still no specific treatment for cognitive impairment [3], modifiable risk factors are of paramount importance for effective primary prevention of cognitive impairment [4]. In addition to traditional risk factors for cardiovascular diseases (CVD) such as smoking, physical inactivity and obesity and associated chronic noncommunicable diseases (such as hypertension and diabetes mellitus), stress, including stress at the workplace, has been identified as a promising starting point for primary prevention of cognitive impairment [4, 5, 6].

Stress can have detrimental effects on the brain structure and cognitive function [7]. Hippocampal atrophy is associated with cognitive dysfunction in humans and animals [8]. Studies have shown that acute stressors can cause short-term, but reversible impairments in memory tasks, while chronic stress can lead to irreversible loss of hippocampal neurons and cognitive impairment [9]. Stress-related consequences, including cognitive impairment, can lead to decreased employee productivity or even injury [10]. Work-related stress can be defined as a process in which a person perceives work-related needs as something more than he can cope with, and thereby negatively affects the psychological and / or physiological state of a person [11]. People who experience prolonged work-related stress often complain of cognitive impairment [12]. They report having difficulty in concentrating, learning new things, and remembering plans and appointments. In addition, a growing body of research shows that cognitive complaints reported by patients are accompanied by objectively measurable cognitive impairment on neuropsychological testing. These disorders are most evident in complex tests for sustained attention, in particular when mental control is required, such as suppression of dominant (prevalent or spontaneous) responses, and when the task is associated with a lack of time [13]. Given the evidence for the adverse effects of stress on cognitive function, this issue requires special investigation.

Thus, **the aim** of our study was to assess the effect of stress at the workplace on the cognitive functions of men and women of young age (25–44 years) in the open population of Novosibirsk.

Materials and methods. A random representative sample of general population living in Novosibirsk aged 25–44 years (screening in 2013–2016) was examined within the framework of the budgetary theme No. 0541-2014-0004. There were 463 men, mean age 35.94±5.957 years, and 546 women, mean age 36.17±5.997 years. The study was approved by the Local Ethics Committee of the Research Institute of Therapy and Preventive Medicine.

The study of cognitive functions under screening conditions included performance of a 10-word memory test according to the method proposed by A.R. Luria (unified for screening purposes) [14] with subsequent reproduction of the words after interfering tasks (recall), conducting a proofreading test (a letter modification of Bourdon's test used for screening purposes), as well as test for exclusion of concepts (verbal version) with recording the time required for its implementation [15] (Table 1).

Similar methods of performing a proofreading test, TSA (test for speech activity) and performing a 10-word memory test were evaluated during population screening within the framework of the international project HAPIEE (Determinants of Cardiovascular Diseases in Eastern Europe) [16]. The use of the above tests made it possible to assess memory, concentration and peculiarities of thinking under conditions of population screening.

To assess stress at work among the participants, the associations of CFs with such standardized questions as: «Has your specialty changed over the past 12 years?», «Do you like your job?» and «How do you rate the responsibility of your work over the past 12 months?» were studied. These questions have been proposed earlier for use in the international WHO MONICA program («Monitoring trends in morbidity and mortality from cardiovascular diseases, and their determining factors») [17].

Statistical processing of the study results was carried out using the free (freeware) statistical package «R» with a set of libraries [18]. The normality of the distribution of the analyzed quantitative data, such as, the scores obtained in psychometric testing, was determined by the Kolmogorov–Smirnov test. The data in the tables are presented as the median (Me) with the lower and upper quartiles [25%; 75%]. Categorical indicators are presented as absolute and relative values (n, %). In some cases, the arithmetic mean was calculated for cognitive factors with a 95% confidence interval (in the tables and in the text, they are presented as M (95% CI)). Differences were considered significant at a significance level of at least 95% ($p<0.05$) [19].

Results. In the open population of 25–44 years old, differences in cognitive functions were determined depending on the presence of stressors in the workplace. To assess stress at work, cognitive associations were investigated with standardized questions such as «Has your specialty changed over the past 12 years?» A decrease in the number of semantically mediated associations was revealed among those respondents who did not change their specialty over the previous year ($F=3.987$ $p<0.05$) (Table 2).

The next question asked to the respondents was: «Do you like your job?» Statistically significant connections of this question with the number of correctly chosen words in the test for exclusion of concepts were determined. Deterioration of verbal-logical thinking was found among those respondents who believed that they «did not like» or «did not like it at all» their job ($F=2.428$ $p<0.05$) (Table 3).

The question «How do you assess the responsibility at your workplace over the past 12 months?» was associated with the largest number of cognitive tests: immediate and delayed reproduction of words (A.R. Luria 10-word memory test), as well as with the number of animals named in 1 min. (Table 4). Decreased auditory-verbal short-term memory, long-term memory, and memorization productivity were found in persons experiencing either «minor» or «moderate» responsibility at the workplace, compared with those whose responsibility at work was «very high» ($F=5.851$ $p<0.001$). In addition, deterioration of attention was revealed in the groups of respondents who believed that their responsibility at work was «insignificant», in comparison with those who, on the contrary, assessed responsibility at work as «high» ($F=3.034$ $p<0.04$). Assessment of semantically mediated associations revealed lower rates among those who assessed their responsibility at work as «low», compared with respondents with «very high» responsibility at work ($F=3.529$, $p<0.05$). There was also some deterioration in verbal-logical thinking among those who believed that their responsibility at work was «low», in comparison with those whose responsibility at work was «very high», which was demonstrated as a decrease in scores ($F=3.575$, $p<0.05$) and in the number of correctly chosen words ($F=3.806$ $p<0.01$) (Table 4).

Comparison of young people in terms of the degree of professional responsibility at the workplace revealed statistically significant differences in cognitive functions between the groups with high and very high responsibility at work over the past 12 months (higher test results), compared with those who had little responsibility at work (they performed worse) (Table 5).

Table 1. *Neuropsycological assement used in the population screening in younger adults*

Test	Cognitive Assessment
A.R. Luria 10-word memory test, followed by recall after an interfering task	Auditory-verbal short-term memory, long-term memory, memorization productivity
Bourdon's test	Attention
Correction test	Psychomotor speed, persistence and activity of visual attention
Test for exclusion of concepts «5th extra»	Thinking
Test for speech activity in the form of naming animals for 1 min. (Animal Naming Test)	Assessment of semantically mediated associations

Discussion. From the biological point of view, it can be assumed that stimulation of cognitive activity increases the plasticity of neural circuits, allowing the brain to delay age-related decline in cognitive functions and pathological changes [20, 21]. This assumption is called the «use or lose» hypothesis. One of the main areas related to the cognitive activity of young and middle-aged people is associated with their professional tasks. Thus, studies of cognitive impairment in the field of occupational health psychology and epidemiology are primarily focused on the impact of various characteristics of mental tasks, such as «complexity» and «novelty», on cognitive function [22, 23]. These psychoso-

Table 2. *Associations of cognitive functions and the question «Has your specialty changed over the past 12 years?» in younger adults*

Indicator	«Has your specialty changed over the past 12 years?»	n	M	σ	S.E	95% CI		F	p
						Lower	Upper		
Animal naming test: animals named in 1 min.	Yes	332	24.89	6.655	0.365	24.17	25.60	3.987	0.046
	No	378	23.87	6.883	0.354	23.17	24.56		
	Total	710	24.34	6.791	0.255	23.84	24.84		

Note. M – arithmetic mean; σ – standard deviation; S.E. – standard error of the mean

Table 3. *Associations of cognitive functions and the question «Do you like your job?» in younger adults*

Indicator	Answer to the question «Do you like your job?»	n	M	σ	S.E	95% CI		F	p
						Lower	Upper		
Test for exclusion of concepts: the number of correctly chosen words	Do not like at all	16	14.19	2.257	0.564	12.98	15.39	2.428	0.047
	Do not like	35	13.94	3.058	0.517	12.89	14.99		
	Indifferent	248	14.49	2.882	0.183	14.13	14.85		
	Like	350	14.95	1.813	0.097	14.76	15.14		
	Like very much	60	14.77	2.994	0.386	13.99	15.54		
	Total	709	14.71	2.43	0.091	14.53	14.89		

Table 4. *Associations of cognitive functions and the question «How do you rate your work responsibility over the past 12 months?» in younger adults*

Indicator	Level of responsibility	n	M	σ	S.E	95% CI		F	p
						Lower	Upper		
Luria test, average	Insignificant	47	7.6951	1.24112	0.18104	7.3307	8.0595	5.851	0.001
	Moderate	240	7.975	0.96924	0.06256	7.8517	8.0982		
	High	341	8.1941	0.94792	0.05133	8.0931	8.295		
	Very high	74	8.2838	1.00331	0.11663	8.0513	8.5162		
	Total	702	8.0952	0.99308	0.03748	8.0216	8.1688		
Luria test, delayed playback	Insignificant	47	7.98	1.674	0.244	7.49	8.47	3.034	0.029
	Moderate	240	8.09	1.414	0.091	7.91	8.27		
	High	341	8.43	1.438	0.078	8.27	8.58		
	Very high	74	8.22	1.838	0.214	7.79	8.64		
	Total	702	8.26	1.500	0.057	8.15	8.37		
Animal Naming Test: animals named in 1 min.	Insignificant	47	22.13	6.371	0.929	20.26	24.00	3.529	0.015
	Moderate	240	23.72	6.907	0.446	22.84	24.59		
	High	341	24.79	6.619	0.358	24.08	25.49		
	Very high	74	25.46	7.122	0.828	23.81	27.11		
	Total	702	24.31	6.794	0.256	23.81	24.82		
Test for exclusion of concepts: score	Insignificant	47	6.09	2.466	0.360	5.36	6.81	3.575	0.014
	Moderate	240	6.90	1.939	0.125	6.66	7.15		
	High	341	7.01	1.695	0.092	6.83	7.20		
	Very high	74	7.05	1.908	0.222	6.61	7.50		
	Total	702	6.92	1.873	0.071	6.78	7.06		
Test for exclusion of concepts: the number of correctly chosen words	Insignificant	47	13.62	3.314	0.483	12.64	14.59	3.806	0.010
	Moderate	240	14.68	2.506	0.162	14.36	14.99		
	High	341	14.87	2.153	0.117	14.64	15.10		
	Very high	74	14.84	2.564	0.298	14.24	15.43		
	Total	702	14.72	2.427	0.092	14.54	14.90		

Notes: M – Arithmetic mean. σ – Standard deviation. S.E. – Standard error of the mean. 95% CI – 95% confidence interval for the mean (lower and upper CI limits are shown).

Table 5. *Subgroup analysis depending on the answers to the question «How do you rate your work responsibility over the past 12 months?»*

Indicator	Level of responsibility		Δ	S.E.	p	95% CI	
						Lower	Upper
Luria test, average	Insignificant	High	-0.499*	0.153	0.007	-0.9037	-0.0944
		Very high	-0.589*	0.183	0.008	-1.0738	-0.1036
	High	Moderate	0.2191	0.083	0.05	0	0.4382
Luria test, delayed playback	Moderate	High	-0.336*	0.126	0.046	-0.67	0
Animal Naming Test: Animals named in 1 min.	Insignificant	Very high	-3.332	1.26	0.05	-6.67	0
Test for exclusion of concepts: score	Insignificant	Moderate	-0.819*	0.297	0.036	-1.61	-0.03
		High	-0.930*	0.29	0.008	-1.7	-0.16
		Very high	-0.969*	0.347	0.033	-1.89	-0.05
Test for exclusion of concepts: the number of correctly chosen words	Insignificant	Moderate	-1.058*	0.385	0.037	-2.08	-0.04
		High	-1.254*	0.375	0.005	-2.25	-0.26
		Very high	-1.221*	0.45	0.041	-2.41	-0.03

Notes: Δ – Average difference (I–II groups). S.E. – Standard error of the mean. 95% CI – 95% confidence interval for the mean (lower and upper CI limits are shown).

cial job characteristics were also formulated and implemented as job requirements (lack of time and required concentration) as well as job control (freedom of action, variety of tasks, learning opportunities, freedom of decision making and autonomy) in accordance with the well-known statement of Karasek RA: «Demand – control» [24]. Accordingly, higher levels of job demands and job control are assumed to contribute to the cognitive health of employees. The combined impact of both high work demands and control constitutes «active work», according to the model, stimulating learning and strengthening the brain capacity through neurocognitive stimulation. The results of most prospective studies of the requirements for mental work in general [25–26], as well as the requirements for work and control over work in particular [27, 28] tentatively or partially support the «use or lose» hypothesis.

In our study, we focused on how professional activity of the respondents had changed over the previous year, whether the respondents enjoyed the job, and how they assessed their responsibility at work. Among those who did not have any fundamental changes in their work during the year, there was a decrease in cognitive functions which was reflected in a decrease in the number of semantically mediated associations. Deterioration of speech functions, i.e. expressive speech (naming objects, searching for words, speech activity, grammar and syntax), as well as receptive speech, was observed among those participants who rated their responsibility at work as «low». Impairment of verbal-logical thinking was observed among those respondents who either «did not like their work» or «did not like it at all». Among those who assessed their responsibility at work as «insignificant» or «average», deterioration of auditory-speech short-term memory, long-term memory, as well as the productivity of memorization and deterioration of attention and verbal-logical thinking was noted. In general, when comparing young people in terms of professional responsibility at work, we found that individuals with high or very high responsibility at work showed higher results of cognitive testing, compared with those who had little responsibility at work. The patterns we found can be explained from the point of view of neurophysiology. Certain processes in the brain's reward circuits are involved in cognitive activity [29]. For example, positive expectation of a reward for learning is associated with dopaminergic neurons [30], deficiency of which may explain impaired information processing and decreased working memory. Behavioral and movement disorders associated with these impairments have been observed in patients with Alzheimer's disease or frontotemporal dementia [31]. Conversely, the propensity for positive affectivity in reward-based learning has been conceived as a characteristic of healthy aging [29]. In a professional context, rewarding is highly dependent on social interaction with colleagues and superiors and is usually associated with successful completion of tasks, thus eliciting positive emotions of self-esteem and increasing work-related motivation with a beneficial effect on cognitive attention, stimulation and productivity [32].

Thus, high effort, high reward, and lack of over-commitment are positively associated with cognitive change [24]. In other words, a psychosocial work environment that supports learning processes by offering positive rewards, such as career prospects, recognition and respect, can keep the cognitive functions of working people from declining or at least slow down their decline [33].

Conclusions. In the open population of 25–44 years old, a decrease in the number of semantically mediated associations was revealed among those respondents who did not change their job over the past year, as well as among respondents who assessed their responsibility at work as «low», in comparison with respondents with «very high» responsibility at work. Deterioration of verbal and logical thinking was found among those respondents who believed that they either «did not like their work» or «did not like it at all», and who rated their responsibility at work as «low», in comparison with those whose responsibility was «very high». Decreased auditory-verbal short-term memory, long-term memory, memorization productivity, as well as deterioration of attention was revealed among the participants experiencing either «insignificant» or «medium» responsibility at the workplace, in comparison with those who assessed the responsibility at work as «high».

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Conflict of Interest Statement

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