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Внутрисменная и междусменная динамика индекса напряжения регуляторных систем у медицинского персонала выездных бригад скорой медицинской помощи в современных условиях

Т. А. Болобонкина✉, А. А. Дементьев, Н. В. Минаева, М. М. Лапкин, П. А. Кулагин

Рязанский государственный медицинский университет имени академика И. П. Павлова, Рязань, Российская Федерация

АННОТАЦИЯ

Введение. В условиях распространения новой коронавирусной инфекции SARS-CoV-2 (COVID-19) изменились регламенты работы и условия труда выездных бригад скорой медицинской помощи (СМП), расширился спектр профессиональных вредностей, что привело к неблагоприятным изменениям в функциональном состоянии нервной системы сотрудников.

Цель. Изучить влияние профессиональной деятельности на функциональное состояние организма медицинских работников выездных бригад скорой медицинской помощи в условиях пандемии COVID-19.

Материалы и методы. Изучались показатели функционального состояния организма медицинских работников выездных бригад СМП до, после работы и между сменами с мая по октябрь 2021 г. Для оценки степени централизации управления сердечным ритмом использовался индекс напряжения регуляторных систем (ИН). В выборку вошли 67 сотрудников выездных бригад (21 мужчина и 46 женщин), 16 врачей и 51 фельдшер. Средний возраст работников, принявших участие в исследовании, составил 36,28 ± 2,82 года.

Результаты. К концу смены более чем у половины медицинских работников выездных бригад СМП регистрировался рост ИН на 74,75 единицы ($p = 0,021$). Выявлено влияние возраста ($\chi 2 = 6,467$; $p = 0,040$) и стажа ($\chi 2 = 6,069$; $p = 0,049$) на распределение работников с различной динамикой ИН по итогам рабочей смены. К началу следующей смены у 60,71% работников, включенных в исследование, регистрировался существенный рост ИН в среднем на 74,02 ($p = 0,001$) по сравнению с началом предыдущей смены. Зарегистрировано влияние стажа работы на распределение работников по группам с различной динамикой ИН между соседними сменами ($\chi 2 = 7,313$; $p = 0,026$).

Выводы. Динамика роста индекса напряжения регуляторных систем указывает на низкую эффективность восстановления функционального состояния организма работников за период регламентированного отдыха. Наибольшее влияние на рост показателей оказывал стаж работы, что свидетельствует о негативном влиянии условий труда на функциональное состояние организма работников.

Ключевые слова: *медицинские работники; скорая медицинская помощь; напряжение регуляторных систем; вариабельность ритма сердца*

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Intra-shift and Inter-shift Dynamics of Stress Index of Regulatory Systems in Medical Personnel of Mobile Emergency Medical Teams in Modern Conditions

Tat'yana A. Bolobonkina✉, Aleksey A. Dement'yev, Natal'ya V. Minayeva, Mikhail M. Lapkin, Pavel A. Kulagin

Ryazan State Medical University, Ryazan, Russian Federation

ABSTRACT

INTRODUCTION: In conditions of spread of the new coronavirus infection SARS-CoV-2 (COVID-19), the work regimen and working conditions of the mobile emergency medical teams have changed, the range of occupational hazards has expanded, which led to unfavorable alterations in the functional state of the nervous system of workers.

AIM: To study the influence of the professional activity on the functional state of an organism of medical workers of mobile emergency medical teams in conditions of COVID-19 pandemic.

MATERIALS AND METHODS: Parameters of the functional state of an organism of medical workers of mobile emergency medical teams were studied before, after the work and between shifts in the period from May to October 2021. The extent of centralization of the heart rhythm control was evaluated by use of strain index (SI) of regulatory systems. The sample included 67 workers of mobile teams (21 men and 46 women), 16 doctors and 51 paramedics. The average age of workers participating in the study was 36.28 ± 2.82 years.

RESULTS: By the end of shift, in more than half the medical workers of mobile EMT, SI grew by 74.75 units (p = 0,021). The age ($\chi 2$ = 6.467; p = 0.040) and length of service ($\chi 2$ = 6.069; p = 0.049) influenced the distribution of workers with different SI dynamics on the basis of the results of the work shift. By the beginning of the next shift, in 60.71% of workers included into the study, a significant increase in SI was recorded on average by 74.02 (p = 0.001) compared to the beginning of the previous shift. The influence of length of service on the distribution of workers with different dynamics of SI in the successive shifts into groups was recorded ($\chi 2$ = 7.313; p = 0.026).

CONCLUSIONS: The dynamics of the growth of the strain index of regulatory systems indicates low effectiveness of recovery of the functional state of an organism of workers in the period of scheduled rest. The greatest influence on the growth of parameters was exerted by length of service, which indicates the negative impact of working conditions on the functional state of an organism of workers.

Keywords: *medical workers; emergency medical care; strain of regulatory systems; heart rate variability*

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ECO•VECTOR

LIST OF ABBREVIATIONS

CI — confidence interval
COVID-19 — COronaVIrus Disease 2019
EMS — emergency medical service
HRV — heart rate variability
SI — strain index of regulatory systems

INTRODUCTION

Medical specialists of mobile emergency medical teams (MEMT) are exposed to occupational risk of chronic stress and fatigue associated with peculiarities of their professional activities. The work in the EMS teams is associated with exposure to a combination of stress factors such as unpredictability of working situations and the necessity of taking decisions in conditions of information and time deficit, high level of personal responsibility for life and health of patients, deficit of sleep in 24-hour working regime, high levels of uncertainty and microbiological risks. Chronic occupational stress leads to strain of functional systems of an organism, increases the probability for development of cardiovascular diseases due to change in the balance between the central and autonomic regulation of the cardiovascular system [1]. In the conditions of spread of the new coronavirus infection (*COronaVIrus Disease 2019*, COVID-19), working rules and conditions of the MEMT changed, the range of occupational hazards expanded [2], which led to adverse alterations in the functional state of the central nervous system of workers [3]. The variability of the functional state of an organism is individual, and on exposure to the same factor, different workers may exhibit opposite reactions to the same loads [4, 5].

The **aim** of this study was to study the influence of professional activity on the functional condition of an organism of medical workers of mobile emergency medical teams in conditions of COVID-19 pandemic.

MATERIALS AND METHODS

The study was conducted on the base of the city clinical emergency medical setting of Ryazan; it was approved by the Local Ethics Committee of Ryazan State Medical University (Protocol No. 2 of 2019, October 08). The participants gave written informed consent. The sufficiency of the sample size was calculated according to the standard formula of repeated sampling using the method of correction of a small volume of the general totality.

Inclusion criteria were:

- work in the mobile emergency medical teams of the clinical emergency medical setting of Ryazan according to the schedule: three days of work, three days of rest;
- signing of the informed consent;
- age up to 65 years inclusive;
- length of service as a medical worker of a mobile emergency medical team more than 1 year;
- absence of medical contraindications to the 24-hour regime of work and to work in hazardous conditions.

A stringent epidemic situation and the pronounced shortage of personnel of EMC specialists established in the region have led to the actual absence of intervals between calls in teams of all specializations and to their equalization in the structure of the calls served. According to the Ambulance automated information system, the number of calls serviced by one team per shift ranged from 15 to 26 (on average 19.45 ± 3.37), the total time of one call was on average 45.46 ± 15.98 minutes. The workers that participated in the study, were exposed to similar occupational factors and characteristics of the labor process. The sample was being formed from May to October 2021 and included 67 medical workers (21 men and 46 women) of 150 workers of mobile teams that at the time of the study were working at the emergency medical setting according to the work schedules. Of the examined workers, 16 were doctors and 51 paramedics. The average age of the workers who took part in the study was 36.28 ± 2.82 years. The parameters of the functional state of the workers before and after work (n = 45), as well as at the beginning of two consecutive shifts (n = 28), were assessed.

As an objective method of monitoring of fatigue associated with the working activity, heart rate variability (HRV) was analyzed [6]. Cardiointervalometry is widely used in different studies, including the sphere of labor hygiene [7].

HRV was analyzed by the method of short-term (three-minute) photoplethysmography at rest in a sitting position with the installation of a pulse oximeter sensor unit of the NS-Psychotest. Profekstrim device (Russia) on the fourth finger of the non-dominant hand of the subject. Measurements were performed in the period from 7.00

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to 8.00 a.m. in accordance with the daily schedule of work shifts at equal time intervals, which corresponded to the time interval of the greatest informative value for the comparative assessment of HRV [8]. As an estimated parameter of the degree of centralization of heart rate control, the strain index of regulatory systems (SI) proposed by R. M. Baevsky, was used [9].

Statistical processing was carried out using Excel 2007 software packages (Microsoft, USA) with the Data Analysis add-in. The normality of the distribution of variables was checked using Kolmogorov–Smirnov test. The comparison of relative values was carried out using Wilson (1927) and $\chi 2$ (Poisson distribution) test; the average values of quantitative variables with normal distribution are represented as *Md* ± *tm* (*Md* is the arithmetic mean of the parameter, expressed in absolute numbers; *m* is the error of the mean, t is the criterion of reliability for the given sample size). The Student's paired t-test was used to compare dependent variables. The hypothesis was assumed as statistically reliable at $p < 0.05$.

RESULTS

Since the SI is one of sensitive parameters of centralization of the heart rate, let us consider distribution of workers with different dynamics of the above parameter in the working shift (Table 1).

Table 1. Structure of Workers with Different Individual Dynamics of Strain Index of Regulatory Systems during Shift

Group of Workers	Increase in strain index of regulatory systems		Decrease in strain index of regulatory systems	
	P (%), 95% CI	Md, t-test	P (%), 95% CI	Md, t-test
Women, n = 34	44.12	85.43	55.88	73.77*
	[28.88; 60.55]	1.72	[39.45; 71.12]	2.97
Men, n = 12	50.00	50.83*	50.00	69.32*
	[25.38; 74.62]	3.25	[25.38; 74.62]	2.52
It total, n = 46	54.35	74.75*	45.65	72.49***
	[40.18; 67.85]	2.47	[32.15; 59.82]	3.81

Notes: * — $p < 0.05$; *** — $p < 0.001$; CI — confidence interval; Md — arithmetic mean value of the parameter expressed in absolute numbers; P — a share of examined persons with the specified SI dynamics

By the end of the shift, in more than half of the medical workers of the MEMT, a statistically reliable increase in SI by 74.75 units ($p = 0.021$) was recorded. The physiological study did not reveal any statistically significant differences in the distribution of workers with different dynamics of SI during work shift depending on gender. At the same time, in the analysis of the parameters of individual dynamics of SI during shift among men, statistically significant parameters of increase and decrease in SI were established in equal proportions. As for women, 55.88% of them had a decrease in SI by on average 73.77 ($p = 0.010$), while in the rest of women its average dynamics was not statistically confirmed.

Since the age has an effect on the adaptation reserves of a human organism [10], let us consider dynamics of SI in the workers of different age groups (Table 2).

From the data presented, it follows that in 75% ($p < 0.05$) of workers aged 30–39 years, SI increased by on average 28.73 ($p = 0.003$) in the dynamics of the work shift, and only in each fourth worker in this age group a decrease in this parameter was recorded. A similar trend was observed in the older age group (40 years and more), where in 61.54% of workers increase in SI was recorded by the end of the shift. On the contrary, in 68.75% of the subjects under 30, SI significantly decreased by 93.25 ($p = 0.016$). In general, we can talk about a statistically reliable influence of age on the dynamics of SI according to the results of the work shift ($\chi 2 = 6.467$; $p = 0.04$).

Let us consider the influence of the length of service on SI dynamics according to the results of the work shift (Table 3).

The results of the study evidence a statistically significant effect of length of service in this field on the distribution of subjects with different dynamics of SI ($\chi 2 = 6.069$; $p = 0.049$). With that, there is a clear tendency to decrease in the resistance of the cardiovascular system with increase in the service length, as evidenced by the predominance of workers with increase in SI by the end of the work shift in the groups with service length of 6–10 years and 11 years and more; 75% with average increase by 54.36 ($p = 0.012$) and 60.00% with average

Table 2. Structure of Workers with Different Individual Dynamics of Strain Index of Regulatory Systems in Different Age Groups during Shift

Group of Workers	Increase in strain index of regulatory systems		Decrease in strain index of regulatory systems	
	P (%), 95% CI	Md, t-test	P (%), 95% CI	Md, t-test
Under 30, n = 16	31.25	34.12	68.75	93.25*
	[14.16; 55.60]	1.89	[44.40; 85.84]	2.89
30–39 years, n = 16	75.00*	28.73**	25.00*	75.05
	[50.50; 89.82]	3.76	[10.18; 49.50]	1.93
40 and above, n = 13	61.54	169.18	38.46	32.75
	[35.52; 82.29]	1.93	[17.71; 64.48]	2.28
$\chi 2 = 6.467$; p = 0.04 with 2 degrees of freedom				

Notes: * — p < 0.05; ** — p < 0.01; CI — confidence interval; Md — arithmetic mean value of the parameter, expressed in absolute numbers; P — a share of examined persons with the specified SI dynamics

Table 3. Structure of Workers with Different Individual Shift Dynamics of Strain Index of Regulatory Systems Depending on Service Length

Group of Workers	Increase in strain index of regulatory systems		Decrease in strain index of regulatory systems	
	P (%), 95% CI	Md, t-test	P (%), 95% CI	Md, t-test
0–5 years, n = 14	28.57	19.35*	71.43	110.78*
	[11.72; 54.64]	4.62	[45.35; 88.28]	3.07
6–10 years, n = 12	75.00	54.36*	25.00	42.20
	[46.77; 91.11]	3.24	[8.89; 53.22]	2.98
11 years and above, n = 20	60.00	108.52	40.00	36.01*
	[38.66; 78.12]	1.76	[21.88; 61.34]	3.33
$\chi 2 = 6.069$; p = 0.049 with 2 degrees of freedom				

Notes: * — p < 0.05; CI — confidence interval; Md — arithmetic mean value of the parameter expressed in absolute numbers; P — a share of examined persons with the specified SI dynamics

increase by 108.52 (p > 0.05), respectively. On the contrary, in 71.43% of the subjects with the working period up to 5 years inclusive, a decrease in SI by on average 110.78 (p = 0.013) was recorded by the end of the work shift, which may indicate a higher resistance to stress.

The analysis of individual changes in SI of the personnel of the mobile emergency medical teams at the beginning of two consecutive shifts will permit to assess the effectiveness of the rest and of the recovery of the functional state (Table 4).

The study showed that by the beginning of the consecutive shift, 60.71% of medical workers of the mobile emergency medical teams included in the study, showed a significant increase in SI on average by 74.02 at p = 0.001 in comparison with the beginning of the previous shift. This tendency was present in several gender groups. Thus, in 57.89% of women and 66.67% of men, the individual values of SI increased on average by 95.05 (p = 0.011) and 35.47 units (p = 0.002), respectively.

No statistically reliable gender differences were found in the percentage composition of mobile emergency medical teams with differently directed SI in the dynamics of two consecutive shifts. Nevertheless, In the age groups of 30–39 years, 40 years and above, SI increased in 58.33% and 62.50% of subjects by on average 47.36 (p = 0.025) and 97.04 units, respectively (p = 0.029).

A physiological study showed a statistically significant effect of service length on the distribution of workers in groups with different dynamics of SI ($\chi 2 = 7.313$; p = 0.026). Thus, in the group of medical personnel with 6–10-year service length, in 88.89% of the subjects a significant in SI increase by on average 58.01 (p = 0.017) was recorded by the beginning of the next shift. A similar tendency was observed in the workers with service length of 11 years or more, 63.64% of which showed an increase in SI by on average 70.04 units (p > 0.05). On the contrary, 75.00% of the subjects with up to 5 years

Table 4. Structure of Workers with Different Individual Dynamics of Strain Index of Regulatory Systems at the Beginning of the Consecutive Shifts

Group of Workers	Increase in strain index of regulatory systems		Decrease in strain index of regulatory systems	
	P (%), 95% CI	Md, t-test	P (%), 95% CI	Md, t-test
Women, n = 19	57.89	95.05**	42.11	60.59
	[36.28; 76.86]	3.63	[23.14; 63.72]	1.74
Men, n = 9	66.67	35.47*	33.33	102.86
	[35.42; 87.94]	2.07	[12.06; 64.58]	1.49
In total, n = 28	60.71	74.02***	39.29	90.83*
	[42.41; 76.73]	3.92	[23.57; 57.59]	2.43

Notes: * — p < 0.05; ** — p< 0.01; *** — p < 0.001; CI — confidence interval; Md — arithmetic mean value of the parameter, expressed in absolute numbers; P — a share of examined persons with the specified SI dynamics

of experience inclusive, showed a decrease in SI by the beginning of the next work shift.

DISCUSSION

The balance between the influence of the sympathetic and parasympathetic divisions of the autonomic nervous system and of central regulatory mechanisms on the work of the heart is manifested by heart rate variability. It was established that in the different stages of professional activity of medical workers of emergency services, there is regress of HRV parameters mediated by parasympathetic nervous system with simultaneous increase in the indices reflecting sympathetic influences and centralization of the regulation of the heart rate [11].

A low level of HRV is associated with a decrease in the functional state of an organism induced by chronic stress and fatigue [4], besides, it can be a marker of cardiovascular pathology [5, 12]. It is established that the greatest negative deviations of parameters of workers of medical emergency services occur during direct fulfilment of their professional duties for rendering medical assistance to patients. At the same time, in the conducted studies, there was noted a sufficient ability of the parameters of the autonomic nervous system of workers to recover in a prolonged scheduled rest [13]. Meanwhile, under constant stressful working conditions, the HRV parameters in the period of non-work recover slowly or even do not recover at all 14]. In this study, a clear tendency was traced to some predominance of individuals with increase in SI at the end of the work shift, which evidences centralization of the heart rate and can be a sign of strain of the functional systems of an organism. Some predominance of the proportion of women with a reliable decrease in SI by the end of the work shift is confirmed by the data of scientific studies that evidence a weaker reaction of the cardiovascular system to stress factors in women in comparison with men [15].

In ageing, the ability of an organism to adaptation declines, which was confirmed in the study of the dependence of HRV parameters on age [10]. The data obtained by us, also show reduction of resistance to load with age of workers, which is manifested by increase in the share of individuals with signs of centralization of the heart rate at the end of the work shift in the older age groups.

The analysis of individual alterations of SI in the personnel of mobile medical emergency teams at the beginning of two consecutive work shifts identified the tendency to predominance of workers with increase in SI by the beginning of the consecutive shift. These parameters may indicate both a non-effective rest, and a stressful effect of work as a factor of danger for individual health in conditions of a pandemic. The conducted physiological study identified the absence of a complete recovery of functional systems during scheduled rest in most part of workers with the service length more than five years. On the contrary, in workers with the working period less than five years, the recovery processes are more effective. A distinct tendency to reduction of the effectiveness of rest among the subjects with increase of the working period was revealed.

CONCLUSIONS

1. Professional activity of the personnel of mobile emergency teams is associated with a high level of strain of the functional systems of an organism, which is manifested by increase in the strain index of regulatory systems by the end of the work shift in the majority of examined individuals .

2. The dynamics of the increase in the strain index of regulatory systems in comparison with the parameters at the beginning of consecutive work shifts in most cases evidences a low effectiveness of recovery of the functional state of an organism of workers in the period of scheduled rest.

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3. The service length has the highest influence on increase in the strain of regulatory systems in medical specialists of the medical emergency service, which is an evidence of negative influence of the working conditions of medical personnel of mobile medical emergency teams on the functional state of an organism.

ADDITIONAL INFORMATION

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СПИСОК ИСТОЧНИКОВ

1. Dekker J.M., Crow R.S., Folsom A.R., et al. Low heart rate variability in a 2-minute rhythm strip predicts risk of coronary heart disease and mortality from several causes: the ARIC Study. Atherosclerosis Risk In Communities // Circulation. 2000. Vol. 102, № 11. P. 1239–1244. doi: 10.1161/01.cir.102.11.12397

2. Болобонкина Т.А., Дементьев А.А., Шатрова Н.В., и др. Факторы биологической природы в работе медицинских работников выездных бригад станции скорой медицинской помощи накануне пандемии новой коронавирусной инфекции (COVID-19) // Российский медико-биологический вестник имени академика И.П. Павлова. 2020. Т. 28, № 3. С. 283–289. doi: 10.23888/PAVLOVJ2020283283-289

3. Болобонкина Т.А., Дементьев А.А., Шатрова Н.В., и др. Влияние работы в условиях пандемии коронавирусной инфекции на функциональное состояние центральной нервной системы медицинских работников станции скорой медицинской помощи // Вестник новых медицинских технологий. Электронное периодическое издание. 2020. № 6. С. 81–86. Доступно по: http://www.medtsu.tula.ru/VNMT/Bulletin/E2020-6/2-1.pdf. Ссылка активна на 07 апреля 2022. doi: 10.24411/2075-4094-2020-16744

4. Kwon J.–W., Lee S.–B., Sung S., et al. Which Factors Affect the Stress of Intraoperative Orthopedic Surgeons by Using Electroencephalography Signals and Heart Rate Variability? // Sensors. 2021. Vol. 21, № 12. P. 4016. doi: 10.3390/s21124016

5. Stapelberg N.J., Hamilton–Craig I., Neumann D.L., et al. Mind and heart: heart rate variability in major depressive disorder and coronary heart disease — a review and recommendations // The Australian and New Zealand Journal of Psychiatry. 2012. Vol. 46, № 10. P. 946–957. doi: 10.1177/0004867412444624

6. Sammito S., Böckelmann I. Analyse der Herzfrequenzvariabilität // Herz. 2015. Vol. 40, Suppl. 1. P. 76–84. doi: 10.1007/s00059-014-4145-7

7. Järvelin–Pasanen S., Sinikallio S., Tarvainen M.P. Heart rate variability and occupational stress-systematic review // Industrial Health. 2018. Vol. 56, № 6. P. 500–511. doi: 10.2486/indhealth.2017-0190

8. Назаренко М.А., Губин Д.Г., Дуров А.М., и др. Дневная динамика показателей вариабельности сердечного ритма у женщин, работающих в дневную и ночную смены // Тюменский медицинский журнал. 2018. Т. 20, № 3. С. 16–22.

9. Baevsky R.M., Chernikova A.G. Heart Rate Variability Analysis: Physiological Foundations and Main Methods // Cardiometry. 2017. № 10. P. 66–76. doi: 10.12710/cardiometry.2017.10.6676

10. Voss A., Heitmann A., Schroeder R., et al. Short-term heart rate variability — age dependence in healthy subjects // Physiological Measurement. 2012. Vol. 33, № 8. P. 1289–1311. doi: 10.1088/0967-3334/33/8/1289

11. Thielmann B., Pohl R., Böckelmann I. Heart rate variability as a strain indicator for psychological stress for emergency physicians during work and alert intervention: a systematic review // Journal of Occupational Medicine and Toxicology. 2021. Vol. 16, № 1. P. 24. doi: 10.1186/s12995-021-00313-3

12. Jarczok M.N., Koenig J., Wittling A., et al. First Evaluation of an Index of Low Vagally-Mediated Heart Rate Variability as a Marker of Health Risks in Human Adults: Proof of Concept // Journal of Clinical Medicine. 2019. Vol. 8, № 11 P. 1940. doi: 10.3390/jcm8111940

13. Schöniger C., Pyrc J., Siepmann M., et al. Continuous HRV analysis of HEMS emergency physicians to specify the work load over the different working days // International Archives of Occupational and Environmental Health. 2020. Vol. 93, № 4 P. 525–533. doi: 10.1007/s00420-019-01507-3

14. Borchini R., Veronesi G., Bonzini M., et al. Heart Rate Variability Frequency Domain Alterations among Healthy Nurses Exposed to Prolonged Work Stress // International Journal of Environmental Research and Public Health. 2018. Vol. 15, № 1. P. 113. doi: 10.3390/ijerph15010113

15. Cauwenberghs N., Cornelissen V., Christle J.W., et al. Impact of age, sex and heart rate variability on the acute cardiovascular response to isometric handgrip exercise // Journal of Human Hypertension. 2021. Vol. 35, № 1. P. 55–64. doi: 10.1038/s41371-020-0311-y

REFERENCES

1. Dekker JM, Crow RS, Folsom AR, et al. Low heart rate variability in a 2-minute rhythm strip predicts risk of coronary heart disease and mortality from several causes: the ARIC Study. Atherosclerosis Risk In Communities. *Circulation*. 2000;102(11):1239–44. doi: 10.1161/01.cir.102.11.12397
2. Bolobonkina TA, Dementyev AA, Shatrova NV, et al. Factors of biological nature in work of mobile teams of emergency medical care station on the eve of pandemics of new coronavirus infection (COVID-19). *I.P. Pavlov Russian Medical Biological Herald*. 2020;28(3):283–9. (In Russ). doi: 10.23888/PAVLOVJ2020283283-289
3. Bolobonkina TA, Dementiev AA, Shatrova NV, et al. Influence of work under the conditions of the COVID-19 pandemic on the functional state of the central nervous system of medical workers of the emergency station. *Journal of New Medical Technologies*, e-Edition. 2020;(6):81–6. Available at: http://www.medtsu.tula.ru/VNMT/Bulletin/E2020-6/2-1.pdf. (In Russ). doi: 10.24411/2075-4094-2020-16744
4. Kwon J–W, Lee S–B, Sung S, et al. Which Factors Affect the Stress of Intraoperative Orthopedic Surgeons by Using Electroencephalography Signals and Heart Rate Variability? *Sensors*. 2021;21(12):4016. doi: 10.3390/s21124016
5. Stapelberg NJ, Hamilton-Craig I, et al. Mind and heart: heart rate variability in major depressive disorder and coronary heart disease — a review and recommendations. *The Australian and New Zealand Journal of Psychiatry*. 2012;46(10):946–57. doi: 10.1177/0004867412444624
6. Sammito S, Böckelmann I. Analyse der Herzfrequenzvariabilität. *Herz*. 2015;40(Suppl 1):76–84. doi: 10.1007/s00059-014-4145-7
7. Järvelin–Pasanen S, Sinikallio S, Tarvainen MP. Heart rate variability and occupational stress-systematic review. *Industrial Health*. 2018;56(6):500–11. doi: 10.2486/indhealth.2017-0190
8. Nazarenko MA, Gubin DG, Durov AM, et al. The daily dynamics of heart rate variability in women engaged in regular work schedules versus shift-workers. *Tyumen Medical Journal*. 2018;20(3):16–22. (In Russ).
9. Baevsky RM, Chernikova AG. Heart Rate Variability Analysis: Physiological Foundations and Main Methods. *Cardiometry*. 2017;(10):66–76. doi: 10.12710/cardiometry.2017.10.6676
10. Voss A, Heitmann A, Schroeder R, et al. Short-term heart rate variability — age dependence in healthy subjects. *Physiological Measurement*. 2012;33(8):1289–311. doi: 10.1088/0967-3334/33/8/1289
11. Thielmann B, Pohl R, Böckelmann I. Heart rate variability as a strain indicator for psychological stress for emergency physicians during work and alert intervention: a systematic review. *Journal of Occupational Medicine and Toxicology*. 2021;16(1):24. doi: 10.1186/s12995-021-00313-3
12. Jarczok MN, Koenig J, Wittling A, et al. First Evaluation of an Index of Low Vagally-Mediated Heart Rate Variability as a Marker of Health Risks in Human Adults: Proof of Concept. *Journal of Clinical Medicine*. 2019;8(11):1940. doi: 10.3390/jcm8111940
13. Schöniger C, Pyrc J, Siepmann M, et al. Continuous HRV analysis of HEMS emergency physicians to specify the work load over the different working days. *International Archives of Occupational and Environmental Health*. 2020;93(4):525–33. doi: 10.1007/s00420-019-01507-3
14. Borchini R, Veronesi G, Bonzini M, et al. Heart Rate Variability Frequency Domain Alterations among Healthy Nurses Exposed to Prolonged Work Stress. *International Journal of Environmental Research and Public Health*. 2018;15(1):113. doi: 10.3390/ijerph15010113
15. Cauwenberghs N, Cornelissen V, Christle JW, et al. Impact of age, sex and heart rate variability on the acute cardiovascular response to isometric handgrip exercise. *Journal of Human Hypertension*. 2021;35(1):55–64. doi: 10.1038/s41371-020-0311-y

ОБ АВТОРАХ

***Болобонкина Татьяна Александровна**;
ORCID: https://orcid.org/0000-0003-1796-6023;
eLibrary SPIN: 2251-0350; e-mail: bolobonkina@bk.ru

Дементьев Алексей Александрович, д.м.н., доцент;
ORCID: https://orcid.org/0000-0003-3038-5530;
eLibrary SPIN: 3797-9108; e-mail: dementiev_a@mail.ru

Минаева Наталья Владимировна, к.м.н., доцент;
ORCID: https://orcid.org/0000-0003-0599-924X;
eLibrary SPIN: 2965-2704; e-mail: shatrnat@gmail.com

Лапкин Михаил Михайлович, д.м.н., профессор;
ORCID: https://orcid.org/0000-0003-1826-8307;
eLibrary SPIN: 5744-5369; e-mail: lapkin_rm@mail.ru

Кулагин Павел Андреевич;
ORCID: https://orcid.org/0000-0002-5284-0875;
eLibrary SPIN: 3623-3309; e-mail: zu.pavel@gmail.com

AUTHOR'S INFO

***Tat'yana A. Bolobonkina**;
ORCID: https://orcid.org/0000-0003-1796-6023;
eLibrary SPIN: 2251-0350; e-mail: bolobonkina@bk.ru

Aleksey A. Dement'yev, MD, Dr. Sci. (Med.), Associate Professor;
ORCID: https://orcid.org/0000-0003-3038-5530;
eLibrary SPIN: 3797-9108; e-mail: dementiev_a@mail.ru

Natal'ya V. Minayeva, MD, Cand. Sci. (Med.);
ORCID ID: https://orcid.org/0000-0003-0599-924X;
eLibrary SPIN: 2965-2704; e-mail: shatrnat@gmail.com

Mikhail M. Lapkin, MD, Dr. Sci. (Med.), Professor;
ORCID: https://orcid.org/0000-0003-1826-8307;
eLibrary SPIN: 5744-5369; e-mail: lapkin_rm@mail.ru

Pavel A. Kulagin;
ORCID: https://orcid.org/0000-0002-5284-0875;
eLibrary SPIN: 3623-3309; e-mail: zu.pavel@gmail.com

* Автор, ответственный за переписку / Corresponding author