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ASSOCIATION OF DEPRESSION AND HEART RATE VARIABILITY IN MEDICAL STAFF EXPOSED TO VARIOUS TYPES OF DIAGNOSTIC NON-IONIZING RADIATION

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Introduction. Magnetic resonance radiation and ultrasound are the most common types of non-ionizing radiation (NIR). Existing data on the biological effects of these types of non-ionizing radiation on the cardiovascular system and nervous system are of an ambiguous nature. There are no universal tools for assessing the long-term biological effects of NIR.

Aim. To investigate the relationship between heart rate variability indicators and depression among healthcare professionals based on their professional exposure to various types of non-ionizing radiation: ultrasound and magnetic fields.

Materials and methods. The study included 60 healthcare workers from magnetic resonance imaging (n=22), ultrasound (n=20) and ophthalmology (n=18) rooms. All medical workers had professional contact only with one type of NIR. The level of depression in all subjects was assessed using the PHQ-9 scale and the heart rate variability (HRV) indicators.

Results and discussion. 60% of the medical workers had various levels of depression. In the group of ultrasound room workers, 60% had mild depression and 25% had moderate to severe depression. When assessing intergroup differences using the Mann-Whitney criterion, statistically significant differences were found in depression (p=0.0001) and HF (p=0.001). In conducting multiple multivariate logistic regression (control group – medical staff of ophthalmological rooms), depression lost its significance, and only HF in the group of MRI room medical workers retained statistical significance (p=0.049)

Conclusions. Overall, our results demonstrate a high level of depression among medical workers, and HRV serves as an objective indicator reflecting a decrease in vagus nerve tone associated with depression symptoms. Further research is needed to assess the biological effects of ultrasound and radiation from MRI devices on the health of medical workers, which will help develop preventive measures.

Key words: medical staff; diagnostic radiation; mental health; MRI; ultrasound; HRV; depression assessment; non-ionizing radiation

INTRODUCTION

Magnetic resonance imaging (MRI) and ultrasonography (US) are popular diagnostic and research tools. The work of medical professionals in MRI and US rooms is associated with various occupational hazards: intense schedules, interaction with people, high risks of potential errors of different levels, the possibility of infection with infectious diseases, including COVID-19, and uncertainty regarding the effects of ultrasound and magnetic fields on their health [1]. Generally, MRI is considered a safe technology with a very good safety record. The highest RF energy deposited in tissues is 6 orders of magnitude below the ionization limit of molecules which are known to cause biological effects, as in the case of ionizing radiation. However, adverse effects, if any, must be understood, acknowledged and taken into consideration for safety of the patients, clinicians, staff and others working in and around MRI scanner [2].

The biological effects of MRI are related to the influence of three types of magnetic fields. The static magnetic field can cause dizziness, nausea, phosphenes, metallic taste, variability in blood pressure levels, heart rate frequency, appearance of ectopic rhythms, memory changes, and visual-motor coordination [3, 4, 5]. Patients commonly experience metallic tastes with the injection of iodinated contrasts used in radiography. However, the metallic taste an MRI patient may experience has nothing to do with the contrast material. It is actually caused by the release of secondary protons to currents induced by the magnetic field variations [5]. Time-varying magnetic fields can stimulate peripheral nerves, muscles, and acoustic noise [6]. In mild cases, this causes discomfort, and in more severe situations, it can lead to motor twitching of the limbs, atrial and ventricular fibrillation [7, 8, 9]. Radiofrequency magnetic fields can lead to tissue heating, burns, thermal shock, especially critical for pregnant women, hypertensive individuals, and those with heat dysfunction [11]. The biological effects of ultrasound, which is part of non-ionizing radiation (NIR), are attributed to two factors: thermal and acoustic cavitation. *In vitro* studies on cultivated human cells have shown the induction of prekallikrein into kallikrein by diagnostic ultrasound, which can activate the internal way of blood clotting. Ultrasound can initiate the production of reactive oxygen species, leading to intracellular oxidative stress and cellular apoptosis, endothelial dysfunction, and the formation of heat shock proteins, especially in nervous tissue, affect myocardial contractility, and generate arrhythmias [11, 12]. Ultrasound generates free radicals and is hense believed to contribute to genomic, genetic, and chromosomal abnormalities [13, 14]. The most important representative examples of potential adverse effects on cells are cell lysis, changes in cell division capability, ultrastructural changes, chromosomal and cytogenetic effects and functional changes (Health Protection Agency 2010). The effects of ultrasound on cells fall into two categories: gross effects, such as lysis, effects on cell division capability and damage to cellular ultrastructure; and subtle effects, such as chromosomal changes, functional changes and altered growth patterns (Health Protection Agency 2010) [16].

Myelin endings in the peripheral nervous system are the most sensitive to ultrasound, which can lead to demyelination and impairment of nerve-muscle conductivity [14]. All mentioned effects were studied briefly, had a transient nature, and high variability. There are insufficient convincing data on chronic occupational exposure, which affects the formulation of restrictive measures (EFSUMB and AIUM) [17]. The medical staff is constantly exposed to NIR (non-ionizing radiation), and its effects can have an accumulating long-term biological impact, overlaying daily stress. It is important to have accurate and reliable stress measurement methods, and to understand how medical workers can cope with it in the conditions of working with NIR. It is advisable to conduct a subjective assessment, for example, using scales, as well as an objective assessment such as using heart rate variability (HRV) measurements. Heart rate variability is the natural variability of time intervals between heartbeats (duration of cardiac cycles) in a normal sinus rhythm. These intervals are called NN intervals (Normal to Normal). The sequential series of cardiac intervals is not a set of random numbers, but has a complex structure, reflecting the regulatory influence on the sinus node of the heart by the autonomic nervous system and various humoral factors. Therefore, the analysis of the HRV structure provides substantial information about the state of autonomic regulation of the cardiovascular system and the whole body. Reduced levels of HRV often indicate a dysfunction of the autonomic nervous system and may indicate a deterioration in health and/or increased stress [16].

The aim of the study was to investigate the relationship between heart rate variability indicators and depression among healthcare professionals based on their professional exposure to various types of non-ionizing radiation: ultrasound and magnetic fields.

MATERIALS AND METHODS

Participants of the study

A pilot cross-sectional study was conducted in Karaganda city and Karaganda region, including Zhezkazgan city, from May to August in 2021 – 2022 during the easing of COVID-19 quarantine measures. The study included relatively healthy medical professionals who were divided into three groups: the first group consisted of MRI facility personnel (n=22); the second group was composed of ultrasound department staff (n=20); and the third group included ophthalmology department medical workers (n=18). The third group was designated as the control group. Thus, we considered that the group I had a combined exposure to only ultrasound and magnetic fields, the the group II – only ultrasound. The group III was considered the control group, as it consisted of individuals who did not have professional equipment in the office, except for a personal computer. We intentionally ignored and did not differentiate between the biological effects of different types of magnetic fields, as the medical personnel in the MRI offices constantly moved within all NIR exposure zones. Inclusion criteria: Participants were aged between 25 and 60 years. They had a minimum of 3 years of experience in their professional field. Regular contact with a single type of non-ionizing radiation equipment during their workweek (e.g., MRI or ultrasound equipment) was required. Participants had undergone regular medical check-ups and received medical clearance, indicating relative health. The work schedule included no more than 8 hours per day and 5 days per week, with no night shifts. Written consent to participate in the study was obtained from all participants. Exclusion criteria: Pregnant women were excluded from the study. Participants with severe, decompensated diseases of internal organs (e.g., chronic heart failure, decompensated diabetes, kidney diseases) were not included. Those with a history of oncological or hematological diseases were excluded. Individuals who had experienced severe fractures or injuries within the past 6 months were excluded. Participants working with equipment generating other types of non-ionizing radiation (e.g., X-ray equipment or lasers) were excluded. A history of mental health disorders, including severe depression, schizophrenia, or bipolar disorder, was an exclusion criterion to eliminate potential confounding factors. Participants using medications that significantly affect mental health or heart rate variability (e.g., antidepressants, anxiolytics, beta-blockers, and other cardiotropic drugs) during the study period were excluded. Only participants who provided written consent to participate were included in the study.

The recruitment for the study was conducted through several methods: phone calls to potential participants, sending messages to personal phone numbers via messengers, and discussing at the workplace before the start of the work schedule. All obtained information was anonymized to preserve confidentiality. All invitations were sent to 15 medical centers. Out of 122 people, 87 responded resulting in a response rate of 71.3%. During the personal interviews, individuals not meeting the inclusion criteria were excluded. The final sample consisted of 60 individuals, and allowed the for the selection process, we aimed to have an equal number of participants in each group.

Ethical aspects

All participants were informed about the objectives and procedures of the study and provided consent to participate by signing an informed consent form. All study procedures complied with the Helsinki Declaration of 1964 and its subsequent amendments. The research protocol was approved by the Bioethics Committee of Karaganda Medical University (approved by Protocol No. 4 dated September 8, 2020, under the number 11). The work was carried out within the framework of grant funding from the Committee of the Ministry of Education and Science of the Kazakhstan «Identification of negative effects of complex of non-ionizing radiation on the human body (medical personnel)», registration number AP09259923.

Assessments and outcomes

For the examination, a questionnaire was developed, consisting of two parts: a general section (age, work experience, work schedule, presence of internal organ diseases, oncological and hematological issues, undergoing medical checkups). These data were necessary for the correct selection for the study; a specific section (Patient Health Questionnaire-9 for depression screening, heart rate variability (HRV). We calculated the length of service by specialty working exclusively with one type of non-ionizing radiation. The research was conducted in stages as follows: Questionnaire with selection for the study, ECG after 24 hours, and after the ECG recording, a survey using the PHQ-9 scale. The electrocardiogram (ECG) was recorded using the Cardipia 406N device (USA) in the 2nd standard lead for 10 minutes. Heart rate variability (HRV) was analyzed using the Kubios HRV Standard version 2.2 computer program (Kubios, Finland, www.kubios.com). To record the electrocardiogram (ECG), efforts were made to select rooms with similar characteristics and comfortable conditions: air temperature +23 °C, air humidity 50%, absence of extraneous odors, and sounds. Temperature, humidity, and atmospheric pressure are known to affect HRV measurements [17, 18]. The research room was selected in such a way that during the ECG measurement, there was no influence of non-ionizing radiation, including mobile devices and other electronic equipment, except for the ECG apparatus and the researcher's laptop. The study was carried out the same morning time before the shift. Before the study, all participants were inspected to exclude the intake of caffeine-containing beverages, nicotine, alcohol, sexual activity, and fitness exercises on the day before and on the day of the study, and they were required to have sufficient sleep. Before conducting the ECG, all subjects stayed in the research room with dimmed lighting for 15 minutes, sitting on a chair with arm rests.

Considering the identical conditions, we assumed that the influence of the external environment was minimal. Prior to the study, the subjects were asked about their well-being once again. During the ECG procedure, the medical staff asked the subjects not to move, and if there were any movements or coughing, the ECG was temporarily stopped. All artifacts were excluded in manual mode during the ECG. Considering that the duration of the HRV was 10 minutes and based on international recommendations, the following parameters were selected: SDNN, ms (milliseconds) (Standard deviation of all NN intervals), RMSSD, ms (Square root of the mean sum of the squares of differences between adjacent NN intervals), pNN50, % (Value of NN50 divided by the total number of NN intervals), HR Max – HR Min, ms (Average difference between the highest and lowest heart rate during each respiratory cycle, MxDMn, ms), stress index (SI, units).

Spectral analysis of HRV: high-frequency range of HRV spectrum, 0.15-0.4 Hz (HF, ms 2); low-frequency range of HRV spectrum, 0.04-0.15 Hz (LF, ms^2); very low-frequency range of HRV spectrum, 0.04-0.003 Hz (VLF, ms^2); total power of HRV in the frequency range up to 0.4 Hz (TP, ms^2); LF/HF – ratio beween LF and HF band powers. The PHQ-9 scale was used to screen for depression in the past 2 weeks [19]. The PHQ-9 is derived from the Primary Care Evaluation of Mental Disorders (PRIME-MD), a diagnostic tool developed by Spitzer, Kroenke, and Williams in the late 1990s. The questions in PHQ-9 align with the nine diagnostic criteria for major depressive disorder (MDD) outlined in the DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition) and later validated for DSM-5. The total score on the PHQ-9 scale is 27 points, with scores of 0-4 indicating no depression, 5-9 indicating mild depression, 10-14 indicating moderate depression, 15-19 indicating severe depression, and 20-27 indicating very severe depression.

Statistical analysis

Statistical analysis was conducted using the Python programming language and SPSS 21 (SPSS Inc., Chicago, IL, USA).The non-parametric

Mann-Whitney test was used to compare the results of HRV between groups of medical workers exposed to magnetic fields and ultrasound, and the group of ophthalmologists (control group). The Wilcoxon signed-rank test was used for within-group comparisons. The values had an abnormal distribution and were described using the median (M) and quartiles (Q1; Q3). To control the Type I error due to multiple comparisons, the p-values were adjusted using the Benjamini-Hochberg method at a significance level of 0.05. In all statistical tests, a p-value less than or equal to 0.05 was considered a significant indicator. To calculate this correction for the Python programming language, we installed the statsmodels and pandas modules. (https://www.statsmodels.org/stable/index.html, https://github.com/ pandas-dev/pandas/releases/tag/v1.1.0). Gender age, education level, and length of service were compared between the groups using the chi-squared criterion. Logistic univariate and multivariate regressions were used to assess the relationship between HRV indices, PHG9, and the groups of medical professionals. In the multivariate logistic regression, three models were constructed based on the medical professional groups. The results were presented as odds ratios (OR) with 95% confidence intervals (95% CI). We accepted the significance level at p <0.05.

RESULTS

Group characteristics are presented in Table 1.

Demographic characteristics and professional workload of medical personnel are presented in Table 1. The study groups were divided based on their professional environment: MRI room (group I, n=22), ultrasound room (group II, n=20), and ophthalmology room (group III, n=18).

The median age varied across the groups: 35.4 years [27.1;50.2] in the group I, 47.1 years [30.2;49.7] in the group II, and 48.49 years [44.1;50.2] in the group III, with borderline statistical significance (p=0.05). The proportion of female participants increased from 72% in the group I to 100% in the group III; however, these differences were not statistically significant (p=0.3).

Educational background significantly differed between groups: in the group I, the majority had secondary vocational education (68%), whereas in the groups II and III, the proportion of professionals with higher education was 90% and 67%, respectively (p=0.001).

Work experience also varied: the median total work experience was 5 years [4;15] in the group I, 25 years [13.8;30] in the group II, and 20.5 years [11;27] in the group III; however, these differences were not statistically significant (p=0.08).

Specific professional experience was lowest in the group I (7 years [4;8]), increasing in the group II (11.5 years [7;21.8]) and the group III (13 years [8;23.3]) with borderline statistical significance (p=0.05).

The number of examinations per day and the duration of each examination did not significantly differ between groups (p=0.5 and p=0.2, respectively), although the time per examination was slightly longer in the group I (31.5 minutes [30;40]) compared to the group II (20 minutes [15;30]) and the group III (25 minutes [20;30]).

The MRI room medical staff was predominantly represented by middle personnel (p=0.001). This can be explained by the selection criteria – mandatory constant contact only with one type of non-ionizing radiation. The results of the depression level and HRV indices are presented in Table 2.

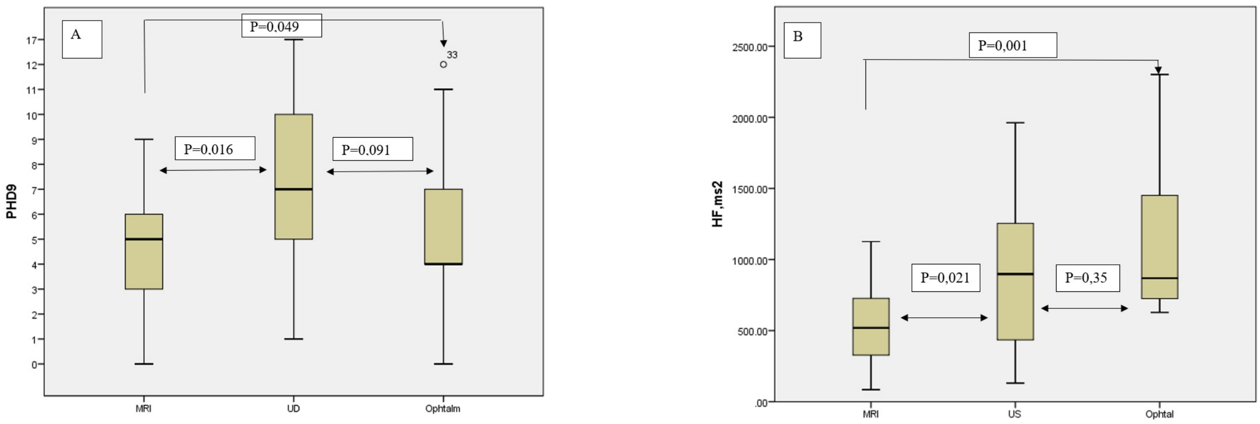
Table 1 – Demographic data and professional workload of medical personnel under different types of non-ionizing radiation

Indicators	Group I	Group II	Group III	p
Age, years	35,4 [27,1;50,2]	47,1 [30,2;49,7]	48,49 [44,1;50,2]	0,05
Gender (female), %	72	90	100	0,3
Education				
Secondary vocational, n (%)	15 (68)	2 (10)	6 (33)	0,001*
Higher, n (%)	7 (32)	18 (90)	12 (67)	0,001*
Total work experience, years	5 [4;15]	25 [13,8;30]	20,5 [11;27]	0,08
Professional experience, years	7 [4;8]	11,5 [7;21,8]	13 [8;23,3]	0,05
Number of examinations per day	20 [19;20]	15[12;22]	19 [12,8;23,8]	0,5
Time per one examination, minutes	31,5 [30;40]	20 [15;30]	25 [20;30]	0,2

*statistically significant p < 0,05

Table 2 – HRV indices and PHQ-9 depression scale for medical personnel under different types of NIR

Indicators	Group I	Group II	Group III	p
PHQ-9	5 [3;6,25]	7 [5;9,25]	4 [4;7]	0,0001*
No depression, n (%)	11 (50)	3 (15)	10 (55,6)	
Mild depression, n (%)	11 (50)	12 (60)	5 (27,8)	
Moderate depression, n (%)		4 (20)	3 (16,6)	
Severe depression, n (%)		1 (5)		
HR, beats per minute	76,4 [71,6;84,9]	73,5 [70,8;83]	75,2 [68,4;79,7]	0,8
RMSSD, ms	32,3 [21;48,5]	31,7 [19,5;58,7]	28,2 [21,3;32,3]	0,5
pNN50, %	7,1 [1,3;23,1]	7,5 [1,1;12,7]	6,84 [2,1;11,6]	0,9
SDNN, ms	37 [30,5;49,5]	44,23 [34,2;67,4]	38,5 [34,6;54,3]	0,13
MxRMn	1,25 [1,2;1,4]	1,26 [1,2;1,4]	1,3 [1,2;1,3]	0,8
SI	228,5 [129,7;347,2]	166,4 [114;401,8]	151,2 [116;262,5]	0,25
TP, ms^2	5170,7 [1504,3; 8263,7]	3197,03 [1143,3;11020,1]	1358,3 [920,6;3168,9]	0,152
LF, ms^2	10,79 [9,13;11,5]	20 [15;30]	25 [20;30]	0,162
VLF, ms^2	32,3 [21;48,5]	31,7 [19,5;58,7]	28,2 [21,3;32,3]	0,231
ULF, ms^2	311,9 [160,1;528,2]	371,4 [114,6;1533,2]	161,9 [59,2;316,3]	0,432
LF/HF	1,12 [0,8;2,4]	1,7 [0,5;2,3]	2,1 [1,2;2,5]	0,360
HF, ms^2	624,2 [436,6;1353,6]	898,1 [426,8;1200,3]	868,75 [738,1;1381,9]	0,001*



(a) (b)

Figure 1. Intergroup differences in depression levels according to the PHQ-9 scale (a), HF, ms^2 (b) in groups of medical professionals (MRI – medical personnel in MRI rooms, UD – medical personnel in ultrasound diagnostic rooms, Ophthalm – medical personnel in ophthalmology rooms, statistically significant p<0.05)

Table 3 – Results of multivariate logistic regression between groups of medical professionals

Factors	X2	p
PhD9	5,626	0,06
HF	3,534	0,171

Two indicators reached a statistically significant level – the level of depression according to the PHQ-9 scale (p=0.0001) and HF, ms^2 (p=0.001). Figure 1 illustrates intergroup differences in depression levels according to the PHQ-9 scale, HF, ms^2, in the groups of medical professionals.

Results of univariate logistic regression and multivariate logistic regression between groups of medical professionals are presented in Table 3.

Analysis of Depression Levels (PHQ-9 Scale): Statistically significant differences in depression levels between groups were identified (p=0.0001). The highest level of depression was observed among ultrasound room employees (Me [Q1;Q3] = 7 [5;9.25]), while the lowest level was recorded in the ophthalmology room group (4 [4;7]). MRI room staff demonstrated an intermediate depression level of 5 [3;6.25].

An analysis of depression severity distribution revealed that the highest proportion of individuals without depression was found among ophthalmology (55.6%) and MRI (50%) personnel, whereas this proportion was lowest in the ultrasound group (15%). Mild depression was most prevalent among ultrasound room employees (60%), while moderate and severe depression were exclusively observed in this group (20% and 5%, respectively).

These findings suggest that ultrasound room staff experience the highest levels of depressive symptoms. This may be attributed to specific occupational factors, such as increased cognitive workload and potential environmental stressors associated with ultrasound exposure.

Analysis of Heart Rate Variability (HRV) Indices: Among all HRV parameters, only the high-frequency component (HF, ms^2) demonstrated statistically significant differences between groups (p=0.001). HF, which reflects parasympathetic nervous system activity, was lowest among MRI room employees (624.2 [436.6;1353.6]), potentially indicating reduced adaptive capacity. In the ultrasound group, HF values were slightly higher (898.1 [426.8;1200.3]), while the highest values were observed among ophthalmology employees (868.75 [738.1;1381.9]).

Other HRV parameters, including heart rate (HR), SDNN, RMSSD, pNN50, SI, and spectral components (LF, VLF, ULF), did not show statistically significant differences between groups (p>0.05). This suggests a generally similar level of autonomic regulation across all groups, with the exception of parasympathetic activity.

For analysis, a statistical processing of quality of life indicators among medical personnel was conducted (table 4). A comparative analysis of the average values of respondents' quality of life indicators revealed that the "Physical and Psychological Well-being" indicator was higher among MRI medical staff (82.0±2.9%) than among ultrasound (US) medical staff (68.8±2.8%) and ophthalmology office personnel (79.2±3.1%). This indicates that the qualitative assessment of the «physical and psychological well-being» quality of life indicator was classified as «increased» in groups 2 and 3, while it reached «high» in group 1.

DISCUSSION

Our study highlights a significant prevalence of depression among healthcare workers exposed to non-ionizing radiation (NIR), particularly among those working with ultrasound. Our study revealed that among the medical staff in MRI rooms, the frequency of both the absence of de-pression and mild depression was equal. In contrast, among the medical personnel in ophthalmological rooms, 55.6% showed no signs of depression, 27.8% had mild depression, and 16.6% had moderate depression. The Patient Health Questionnaire-9 (PHQ-9) results indicate that 60% of the participants experienced some level of depression. Ultrasound is a versatile imaging technique widely used as an initial diagnostic method in various clinical scenarios worldwide. Continuous advancements in US technology provide new opportunities for medical diagnoses and therapies, solidifying its importance in medical imaging [33]. However, the highest prevalence was among ultrasound room staff, with 60% reporting mild depression and 25% reporting moderate to severe depression. In contrast, MRI room personnel exhibited an equal distribution between no depression and mild depression, while ophthalmology staff, serving as the control group, had the lowest overall depression levels. Depression has a profound impact on work efficiency, absenteeism [22, 23, 24], and the quality of patient care. In 2014, a population-based study in the USA already reported 10% serious medical errors and 6% suicidal thoughts among physicians [25]. There are numerous reasons for the development of depression. In our study, we made efforts to minimize potential short-term irritating effects, conducted assessments in the morning, and excluded behavioral and dietary factors such as alcohol, nicotine, and caffeine. Thus, it can be assumed that the significant level of medical personnel in ultrasound rooms, experiencing varying degrees of depression, is due to prolonged exposure to the professional environment. It is known that the working environment (including speed/quantity, fragmentation/unpredictability, breadth of decision-making, and social support) increases the risk of depression among medical workers [26,30]. The human body absorbs ultrasound waves, which can cause various effects depending on the dose and duration of exposure. Most research on assessing adverse effects is focused on patients. However, long-term biological effects on medical personnel have not been defined [31].

Heart rate variability (HRV) indices were analyzed to assess autonomic nervous system activity. Among all HR V parameters, the high-frequency (HF) component showed statistically significant differences across groups (p=0.001). The lowest HF values were observed among MRI workers, suggesting reduced parasympathetic tone and potential autonomic dysfunction.

Our study was a pilot one. Only healthcare professionals participated in the study, and their number was limited to 60 people. We deliberately did not consider and did not separate the biological effects of different types of magnetic fields and ultrasound. For the study, the PHQ-9 scale and HRV values were selected, demonstrating the best results of association between them. However, further research is needed to find additional tools to assess the long-term biological effects of NIR on medical personnel.

Comparisons with studies on ionizing radiation exposure reveal a similar trend, with radiation oncologists and radiology technologists reporting lower quality of life scores due to chronic stress and perceived radiation risks. However, our study provides new insights by suggesting that even NIR exposure, particularly ultrasound, may negatively impact well-being.

This study was relevant, as it represents the first attempt to search for universal tools for assessing the long-term biological effects of various types of NIR. The uncertainty of professional effects does not allow for the development of limiting methods

CONCLUSIONS

1. Our findings indicate that medical staff exposed to ultrasound and MRI exhibit significant levels of depression and altered HR V, suggesting chronic stress and autonomic dysfunction. Further research is needed to assess the biological effects of ultrasound and radiation from MRI devices on the health of medical workers, which will help develop preventive measures.

2. Healthcare workers exposed to non-ionizing radiation (ultrasound, MRI) need the implementation of depression prevention programs and heart rate variability (HRV) monitoring. Regular screening of psycho-emotional state is necessary: the use of the PHQ-9 scale for early detection of depression among employees and the organization of psychological support, including consultations with a psychologist or group stress management training. The inclusion of HRV monitoring as an indicator of chronic stress and autonomic nervous system dysfunction is essential. Regular breaks to reduce cognitive and emotional stress, control of working hours (especially in ultrasound departments, where the level of depression is higher).

Author contributions:

L. K. Ibrayeva, I. V. Bacheva – conceptualization.

L. K. Ibrayeva, A. K. Ospanbek, I. V. Bacheva, B. K. Omarkulov – methodology.

D. Kh. Rybalkina – validation.

I. V. Bacheva – formal analysis.

B. K. Omarkulov – investigation, supervision

L. K. Ibrayeva, I. V. Bacheva, D. Kh. Rybalkina, S. Yu. Perov – data curation.

L. K. Ibrayeva, A. K. Ospanbek, I. V. Bacheva – writing – original draft preparation.

L. K. Ibrayeva, I. V. Bacheva – writing – review and editing.

S. Yu. Perov – visualization.

Conflicts of Interest:

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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Institutional Review Board Statement:

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Bioethics Committee of Karaganda Medical University (approved by Protocol No. 4 dated September 8, 2020, under the number 11).

Informed Consent Statement:

The patients enrolled provided written consent for data collection as part of clinical routine practice, quality assessment, and for scientific research purposes. The data protection and privacy regulations were strictly observed in capturing, forwarding, processing, and storing the patient data.

Data Availability Statement:

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to data protection directive 95/46/EC.

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СВЯЗЬ ДЕПРЕССИИ И ВАРИАБЕЛЬНОСТИ СЕРДЕЧНОГО РИТМА У МЕДИЦИНСКИХ РАБОТНИКОВ, ПОДВЕРЖЕННЫХ ВОЗДЕЙСТВИЮ РАЗЛИЧНЫХ ТИПОВ ДИАГНОСТИЧЕСКОГО НЕИОНИЗИРУЮЩЕГО ИЗЛУЧЕНИЯ

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Введение. Магнитно-резонансное излучение и ультразвук являются наиболее распространёнными видами неионизирующего излучения (НИИ). Существующие данные о биологических эффектах этих видов НИИ на сердечно-сосудистую и нервную системы носят неоднозначный характер. Универсальных методов для оценки отдалённых биологических эффектов НИИ в настоящее время не существует.

Материалы и методы. В исследование были включены 60 медицинских работников, работающих в кабинетах магнитно-резонансной томографии (n=22), ультразвуковой диагностики (n=20) и офтальмологии (n=18). Все участники имели профессиональный контакт только с одним видом НИИ. Уровень депрессии у всех испытуемых оценивался с помощью шкалы PHQ-9, а также по показателям вариабельности сердечного ритма (ВСР).

Результаты и обсуждение. У 60% медицинских работников были выявлены различные уровни депрессии. В группе сотрудников ультразвуковых кабинетов 60% имели лёгкую депрессию, а 25% — умеренную или тяжёлую степень депрессии. При сравнении межгрупповых различий с использованием критерия Манна – Уитни были выявлены статистически значимые различия по уровню депрессии (p=0,0001) и показателю HF (p=0,001). При проведении множественной многомерной логистической регрессии (контрольная группа – сотрудники офтальмологических кабинетов) значимость депрессии исчезла, и только показатель HF в группе работников кабинетов МРТ сохранил статистическую значимость (p=0,049).

Выводы. В целом, результаты продемонстрировали высокий уровень депрессии среди медицинских работников, а вариабельность сердечного ритма является объективным показателем, отражающим снижение тонуса блуждающего нерва, связанного с симптомами депрессии. Для дальнейшей оценки биологических эффектов ультразвукового и магнитно-резонансного излучения на здоровье медицинских работников необходимы дополнительные исследования, что позволит разработать профилактические меры.

Ключевые слова: медицинский персонал; диагностическое излучение; психическое здоровье; МРТ; ультразвук; вариабельность сердечного ритма; оценка депрессии

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ӘРТҮРЛІ ДИАГНОСТИКАЛЫҚ ИОНДАУШЫ ЕМЕС СӘУЛЕЛЕНУГЕ ҰШЫРАҒАН МЕДИЦИНА ҚЫЗМЕТКЕРЛЕРІНДЕ ДЕПРЕССИЯ МЕН ЖҮРЕК РИТМІНІҢ ВАРИАБЕЛЬД ДІЛІГІНІҢ БАЙЛАНЫСЫ

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Кіріспе. Магниттік-резонанстық сәуле және ультрадыбыстық толқындар – иондамайтын сәулеленудің (ИС) ең көп таралған түрлері болып табылады. Осы сәулелену түрлерінің жүрек-қантамыр және жүйке жүйелеріне биологиялық әсері туралы қолда бар деректер біржақты емес. ИС-тың ұзақ мерзімді биологиялық әсерлерін бағалауға арналған әмбебап әдістер әлі әзірленбеген.

Материалдар және әдістер. Зерттеуге магниттік-резонанстық томография (n=22), ультрадыбыстық диагностика (n=20) және офтальмология (n=18) бөлімдерінде жұмыс істейтін 60 медицина қызметкері қатысты. Барлық қатысушылар тек бір түрдегі ИС-пен кәсіби байланыста болған. Барлық сынаққа қатысушыларда депрессия деңгейі PHQ-9 шкаласы арқылы және жүрек соғу жиілігінің вариабельділігі (HRV) көрсеткіштері арқылы бағаланды.

Нәтижелер және талқылау. Медицина қызметкерлерінің 60%-ында әртүрлі деңгейдегі депрессия белгілері анықталды. Ультрадыбыстық диагностика бөлімінде жұмыс істейтін қызметкерлер арасында 60%-ында жеңіл дәрежелі, ал 25%-ында орташа немесе ауыр дәрежелі депрессия тіркелді. Манн-Уитни критерийі арқылы топаралық айырмашылықтарды бағалау кезінде депрессия деңгейінде (p=0,0001) және HF көрсеткішінде (p=0,001) статистикалық маңызды айырмашылықтар анықталды. Көп айнымалы логистикалық регрессия жүргізген кезде (бақылау тобы – офтальмология бөлімінің медицина қызметкерлері) депрессияның маңыздылығы жоғалды, ал магниттік-резонанстық томография бөлімінің қызметкерлері тобында HF көрсеткіші статистикалық маңыздылығын сақтады (p=0,049).

Қорытынды. Жалпы алғанда, зерттеу нәтижелері медицина қызметкерлері арасында депрессия деңгейінің жоғары екенін көрсетті, ал жүрек соғу жиілігінің вариабельділігі депрессия белгілерімен байланысты кезбе жүйке тонусының төмендеуін объективті түрде бейнелейтін көрсеткіш болып табылады. Медицина қызметкерлерінің денсаулығына ультрадыбыстық және магниттік-резонанстық сәулеленудің биологиялық әсерлерін толық бағалау үшін әрі қарайғы зерттеулер қажет, бұл алдын алу шараларын әзірлеуге мүмкіндік береді.

Кілт сөздер: медицина қызметкерлері; диагностикалық сәулелену; психикалық денсаулық; МРТ; ультрадыбыс; жүрек соғу жиілігінің вариабельділігі; депрессияны бағалау; иондамайтын сәулелену