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Table of Contents

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THEORETICAL AND EXPERIMENTAL MEDICINE

HYGIENE & OCCUPATIONAL MEDICINE

OPHTALMOLOGY

PSYCHIATRICS & MEDICAL PSYCHOLOGY

TRAUMATOLOGY & ORTHOPEDICS

TEACHING ISSUES & LECTURES

CYTOKINE PROFILE IN SEMINAL FLUID OF INFERTILE MEN WITH CONCOMITANT PATHOLOGIES

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Abstract

The mechanisms of formation of male infertility are increasingly becoming immune dependent. This study aims to study the role of pro-inflammatory and anti-inflammatory cytokines in seminal fluid to clarify their role in spermatogenesis. This research is carried out at rheumatology and urology departments of Danylo Halytsky Lviv National Medical University (Ukraine). 45 infertile men aged 22–48 were examined. They were divided into 2 groups: first group – 22 men with a systemic autoimmune disease – rheumatoid arthritis; second group – 23 somatically healthy patients with idiopathic infertility. The control group included 27 fertile healthy men aged 22–48 years. Student's *t*-test was used to compare the significant difference in mean values between groups. Patients with autoimmune diseases (rheumatoid arthritis) had the highest rate of leukocytospermia, indicating a possible long-term inflammatory process. The TGF-β1 level was higher in men with idiopathic infertility, and in patients with autoimmune pathology was reduced compared to the control group, however these changes were not significant. At the same time in patient of both group the level a pro-inflammatory cytokine IL-18 increased approximately by 2.5 times. In patients with idiopathic infertility and patients with autoimmune pathology, a simultaneous increase in the IFN-γ level and a decrease in the IL-1β level were found. The IL-6 level in seminal plasma of infertile men of both groups was increased. The ratio IL-10/TNF-α was decreased in seminal plasma of infertile men with rheumatoid arthritis. It was found that in autoimmune pathology, the increased level of IL-1β in blood serum compared to controls was associated with its reduced level in seminal fluid ($r=-0.51$, $p<0.05$). In idiopathic infertility, a low level of IL-1β in seminal fluid was also associated with a low concentration of this cytokine in blood serum ($r=0.62$, $p<0.05$). The functioning of the immune and reproductive systems of the male body is closely related and interdependent. Disorders of immune reactivity, which accompany the development of autoimmune pathology associated with disorders of reproductive function in men. The largest number of deviations of immune reactivity was found in infertile men with concomitant autoimmune diseases.

Keywords: *cytokines, male infertility, idiopathic infertility, rheumatoid arthritis*.

INTRODUCTION

The regulation of male reproductive function is realized through different levels, involving both the endocrine and immune systems. The mechanisms of formation of male infertility are increasingly becoming immune-dependent. Immunological isolation of the testes is provided by the anatomical blood-testis barrier and the special tolerance of the immune system to antigens expressed on male gametes. The seminal fluid ensures the microenvironment for differentiated gametes. It is a multicomponent solution and contains a range of active biological substances with immunomodulatory properties [1; 2]. In addition to hormones, cytokines TNF-α, IFN-γ, TGF-β2/β3, IL-1α/1β and IL-12 play an important role in the regulation of spermatogenesis. They regulate the penetrability of the barrier in normal physiological state and pathological conditions [3; 4]. The cytokines TGF-β2 / β3, TNF-α and IL-1α perform a leading role in the regulation of the blood-testis barrier. These cytokines in the germinal epithelium are synthesized by Sertoli cells and germ cells (specifically spermatocytes and early spermatids, since elongated spermatids produce exclusively TNF-α, receptors to which are located

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mostly on Sertoli cells). The interaction between polar proteins is regulated by cytokines. This is important both for the regulation of endocytic processes of protein transport and for the synergization of actin- and steroid-mediated effects on the blood-testis barrier [5].

The effect of cytokines on sperm in the seminal fluid is a physiological phenomenon. IL-6, IL-10 levels and TNF-α level are positively correlated with sperm concentration, motility and normal morphology [6], and IL-6 level positively correlated with the ability of sperm to penetrate egg [7]. In the seminal fluid of a healthy man, in addition to a small number of leukocytes (about 1 million/ml), cytokines TGF-α/β and IL-1β and IL-6,8 and a soluble receptor for IL-2 were detected. Some of these molecules (IL-1 and TGF-β) are synthesized in the testes, others, probably, in the appendages or other male gonads. In the seminal fluid of healthy men except a small number of leukocytes (about 1 million/ml), cytokines TGF-α/β, IL-1β and IL-6,8 and a soluble IL-2 receptor were detected. Some of these molecules (IL-1 and TGF-β) are synthesized in the testes, others, probably, in the other male gonads [8]. For a better understanding of the immunopathogenetic mechanisms of infertility, a study of the role of various immune factors is required.

The aim of the work is to study the role of pro-inflammatory and anti-inflammatory cytokines in seminal fluid to clarify their role in spermatogenesis.

Materials & methods

Study population and semen collection

This research is carried out at rheumatology and urology departments of Danylo Halytsky Lviv National Medical University (Ukraine). Men underwent a thorough genitourinary examination to establish exclusion criteria. Individuals with normally developed urogenital organs were included in the study. The study included individuals with a diagnosis of rheumatoid arthritis without concomitant inflammatory diseases of the connective tissue, other inflammatory diseases and oncological pathology at the time of the study. The duration of the disease was from 6 to 360 months. All patients with rheumatoid arthritis were diagnosed with asthenozoospermia or leukocytospermia. The idiopathic form of infertility, characterized by an unstudied etiopathogenesis, was diagnosed by the lack of fertilization during the year of the couple's sexual life and the impossibility of finding out the cause of the disease. This form of infertility included men with oligozoospermia, oligoasthenozoospermia, asthenozoospermia, and leucospermia.

45 infertile men aged 22–48 were examined. They were divided into 2 groups: first group – 22 men with a systemic autoimmune disease – rheumatoid arthritis; second group – 23 somatically healthy patients with idiopathic infertility. The control group included 27 fertile healthy men aged 22–48 years.

Ethical approval was obtained from the Ethics Committee of Danylo Halytsky Lviv National Medical University and informed consent was obtained from all eligible, consenting participants.

Semen processing

Semen was collected, analyzed and classified according to the criteria of the WHO (2009) [9]. Semen was obtained by masturbation into sterile plastic containers following 3–5 days of abstinence. Semen analysis were performed within 30 min. of sample arrival in the laboratory. Seminal plasma was obtained by centrifugation of ejaculate samples at 3000 g for 10 min and sedimentation of spermatozoa. Seminal fluid was stored at –20°C until the beginning of the studies, mostly for two weeks.

Determination of the cytokines concentration in seminal plasma was carried out by the immunoenzymatic method. To determine the cytokines IL-1β, IL-6, IL-10, IL-18, IFN-γ, TNF-α in seminal fluid, kits from DIACLONE (France) were used, TGF-β1 – kit from DRG Diagnostics (Germany). The study was carried out according to the manufacturer's instructions. The microplayphotometer SUNRISE TECAN (Austria) was used for the analysis.

Statistical analysis

All quantitative variables were expressed as mean ± standard deviation, while qualitative data were shown in the form of number and percentage. Student's t-test was used to compare the significant difference in mean values between groups. $p<0.05$ was considered significant. SPSS 16.0 version for Windows (USA) was used for statistical analysis.

Results & discussion

Ejaculate analysis has of fundamental importance for diagnosis and determining the degree of severity of male factor in infertility. Although it is based on a quantitative change in parameters of ejaculate, functional defects are important. Spermatogenesis in humans lasts almost 3 months and the influence of exogenous factors can persist for 2–3 months.

Analysis of ejaculate was done according to WHO 5th guideline. Reduced number of normal

spermatozoa and their motility was detected in all examined groups (*Table 1*).

Patients with autoimmune diseases (rheumatoid arthritis) had the highest rate of leukocytospermia, indicating a possible long-term inflammatory process. When examining patients with autoimmune pathology, asthenozoospermia was found in 8 (36.36%) patients and leucocytospermia in 14 patients (63.64%). In patients with idiopathic infertility, oligozoospermia was diagnosed in 3 patients (13.04%), oligoasthenozoospermia in 7 patients (30.36%), asthenozoospermia in 8 patients (34.78%) and leucocytospermia in 5 patients (21.82%). In general, quantitative and qualitative changes in spermatozoa were found: in men with autoimmune diseases – in 8 patients (36.36%); in men with idiopathic infertility – in 12 patients (52.17%). The frequency of changes in spermatozoa did not differ in the examined groups. At the same time, leukocytospermia was determined much more often in patients with autoimmune pathology, compared to patients with idiopathic infertility. In infertile men with concomitant autoimmune pathology, the number of leukocytes in sperm probably exceeded the values in all other groups.

The next task was to determine the main cytokines in seminal fluid of men with infertility. To analyze the cytokine profile in seminal fluid, the levels of the following cytokines were determined: pro-inflammatory – interleukin 1β (IL-1β), interleukin 18 (IL-18), interleukin 6 (IL-6), tumor necrosis factor α (TNF-α), interferon γ (IFN-γ) and anti-inflammatory – interleukin 10 (IL-10), transforming growth factor β1 (TGF-β1) (*Table 2*). The TGF-β1 level was higher in men with idiopathic infertility and in patients with autoimmune pathology was reduced compared to the control group, however these changes were not significant. At the same time in patient of both group the level a pro-inflammatory cytokine IL-18 increased approximately by 2.5 times. In patients with idiopathic infertility and patients with autoimmune pathology, a simultaneous increase in the IFN-γ level and a decrease in the IL-1β level were found. The IL-6 level in seminal plasma of infertile men of both groups was increased.

Since male ejaculate is both an inducer of Th2 and an inhibitor of Th1 response, the Th2/Th1 balance coefficients in the seminal fluid of the examined groups were calculated (*Table 3*). The ratio IL-10/TNF-α was decreased in seminal plasma of infertile men with rheumatoid arthritis.

Table 1. Evaluation of the spermogram of infertile men with various accompanying pathologies

Parameters	Control group	Idiopathic infertility	Rheumatoid arthritis
Number of sperm in 1 ml (million)	58.27±7.51	38.42±4.73	49.37±6.82
Number of sperm in ejaculate (million)	195.69±24.32	107.9±12.64*	121.87±13.56
Sperm motility (%)	56.71±7.51	31.36±4.20*	42.16±5.42*
Morphologically normal sperm count (%)	68.83±8.95	38.11±5.23*	39.17±5.36*
Leukocytes (10^6/ml)	0.28±0.06	0.46±0.08	0.34±0.07

Note: * – *p* value between parameters is significant if $p<0.05$.

Table 2. The level of the cytokines in seminal plasma of infertile men

Parameters, pg/ml	Control group	Idiopathic infertility	Rheumatoid arthritis
TGF-β1	116.28±17.57	151.18±13.28	95.70±12.47
TNF-α	11.39±4.40	20.02±4.42	16.22±4.27
IFN-γ	59.76±7.10	79.40±6.48*	68.63±6.58
IL-1β	75.13±8.11	28.99±6.48*	44.34±9.79*
IL-6	27.49±4.76	41.33±5.08*	57.22±7.82*
IL-10	11.78±3.69	16.21±2.50	12.29±2.71
IL-18	9.62±1.61	23.54±3.07*	24.25±2.94*

Note: * – *p* value between parameters is significant if $p<0.05$.

Table 3. The ratio IL-10/TNF-α and IL-10/IFN-γ in seminal plasma of infertile men

Parameters, pg/ml	Control group	Idiopathic infertility	Rheumatoid arthritis
IL-10/TNF-α	1.05±0.12	0.86±0.19	0.78±0.10*
IL-10/IFN-γ	0.20±0.05	0.21±0.08	0.19±0.03

Note: * – *p* value between parameters is significant if $p<0.05$.

It was important to determine whether changes in cytokines in blood serum were correlated with corresponding changes in seminal fluid. It was found that in autoimmune pathology, the increased level of IL-1β in blood serum compared to controls was associated with its reduced level in seminal fluid ($r=-0.51$, $p<0.05$). In idiopathic infertility, a low level of IL-1β in seminal fluid was also associated with a low concentration of this cytokine in blood serum ($r=0.62$, $p<0.05$). Such a result can explain the reduced number sperm in the ejaculate of this group, since IL-1β in physiological concentrations contributes to the maturation of spermatozoa.

The interaction of cells of the immune system with each other depends on their production many biologically active substances, in particular cytokines, which can have both pro-inflammatory and anti-inflammatory effect. A change in the cytokine profile is one of the immunopathogenetic mechanisms of many diseases, in particular the reproductive system [10]. Elevated serum levels of proinflammatory cytokines are a characteristic feature of impaired immune reactivity for autoimmune pathology [11].

The immune system functions as a single integrated mechanism, and under physiological conditions, the cytokines synthesis with multidirectional effects is usually interdependent. Therefore, the correlations between pro- and anti-inflammatory cytokines are important. In some cases, antagonistic cytokines inhibit each other's synthesis. In another case, the over synthesis of cytokines of one effect causes a homeostatic increase in the cytokines synthesis of the opposite effect [12; 13]. As a rule, various pathological conditions are accompanied by changes in the number and nature of correlation relationships between different parameters of immune reactivity, including serum levels of cytokines of different effects in comparison with correlations in healthy persons.

In patients with autoimmune diseases, there was no correlation between cytokines of different effects, which may indicate an imbalance in the adequate immune response. Negative correlations were observed in these groups of patients, especially in chronic inflammatory diseases. Men with idiopathic infertility showed three significant correlates different from those found in healthy fertile men. Systemic disruption of cytokine balance is closely related to shifts in local cytokine balance in individual compartments, including the reproductive tract. Taking into account the above we analyzed the cytokine profile of seminal fluid. Seminal fluid contains a wide range of cytokines. The level and properties of cytokines determines the final stages of post-testicular maturation of spermatozoa and the effectiveness of fertilization under physiological conditions.

Male seminal fluid is both an inducer of Th2 and an inhibitor of Th1 response. It induces and potentiates a cascade of events, the result of which is an increase in the endogenous expression/production of cytokines (LIF, GM-CSF and other growth factors) with embryotrophic properties. Factors of seminal fluid play a positive role in the preimplantation development and implantation of the embryo. Cytokines play a leading role in the inflammatory process of the urogenital tract. They also potentiate the pro-inflammatory effects of other inflammatory mediators. Under normal conditions, IL-1β contributes to the maturation of spermatozoa, under pathological conditions it facilitates the development of an inflammatory reaction, not only acting chemotactically on neutrophils and monocytes, but also promoting the release of histamine, which accelerates the formation of the entire inflammation cascade. IL-6 is synthesized by monocytes and macrophages under the influence of IL-1 and exhibits pro-inflammatory properties.

In seminal fluid and sperm membranes, the elevated level of IL-6 positively correlates with the level of lipid peroxidation and negatively with sperm motility and their number, as it inhibits DNA synthesis during meiosis of spermatogenic cells [6]. The anti-inflammatory cytokine IL-10 is found in high concentrations in the seminal fluid of healthy men, since it maintains immunological balance at the local level and protects spermatozoa from damage [14].

The level of TNF-α in seminal fluid probably correlates with the number of leukocytes and the proportions of their subpopulations in the ejaculate.

Therefore it can serve as an indicator of the presence of infection or inflammation. Increased level of TNF-α does not affect the ability to fertilize [15], however has a negative effect on motility and the degree of DNA damage in spermatozoa [16] and on all spermatogenesis, since it inhibits the synthesis of testosterone by Leydig cells [17].

The cytokine TGF-β1 in seminal fluid has an immunoregulatory effect on the cellular elements of the female genital tract to support sperm survival and preservation of fertilizing capacity [18]. The cytokine IFN-γ is a pro-inflammatory cytokine, the increased level of which in seminal fluid reflects the presence of an infection or an autoimmune disease. In autoimmune orchitis, IFN-γ works in synergy with IL-12 [19], which, in turn, interacts with IL-18 in the implementation of many of its functions. IL-18 belongs to the IL-1 family and is also produced by activated macrophages. Like IL-1 it interacts with TLRs by signaling through the MyD88 gene, which activates TGF-receptor-associated factor and NF-κB. An important function of IL-18 is the regulation of functionally different subpopulations of T-helpers necessary for cell-mediated immune response. It enhances the synthesis of FasL, which mediates the cytotoxic effect of NK cells and together with IL-12 affects the functions of NK cells (induction of IFN-gamma synthesis, increased cytotoxicity and proliferation) [20].

An increased level of IL-18 in the seminal fluid correlates with a decrease in sperm motility. IL-18 inhibits the harmful effects of infection/inflammation on spermatogenesis by enhancing the proliferation of germ cells, therefore it can be called a paracrine protective factor in the male gonads [21].

Cytokine IL-1β has pleiotropic properties, it is not only a mediator of inflammation, but also a modulator of innate and acquired immunity. IL-1β is able to influence regulatory T-lymphocytes, which leads to the masking of autoreactive effector cells from the control of suppressor cells. IL-1β is able to be included in the negative modulation of the immune response. This can be explained by the fact that due to a decrease in the IL-1β level the immune system will be more ready to synthesize antibodies, especially to autoantigens [22]. TGF-β1 in normal concentrations also inhibits the function of T cells with regulatory properties, therefore its reduced concentration promotes the synthesis of autoantibodies.

It was demonstrated that the functioning of the immune and reproductive systems of the male body is closely related and interdependent. Immune reactivity disorders accompanying the development of autoimmune pathology are associated with reproductive function disorders in men.

Conclusion

The functioning of the immune and reproductive systems of the male body is closely related and interdependent. Disorders of immune reactivity, which accompany the development of autoimmune pathology associated with disorders of reproductive function in men. The largest number of deviations of immune reactivity was found in infertile men with concomitant autoimmune diseases.

DECLARATIONS:

Disclosure Statement

The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

Data Transparency

The data can be requested from the authors.

Statement of Ethics

The authors have no ethical conflicts to disclosure.

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All authors give their consent to publication.

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"HUMAN FACTOR" IN EMERGENCY SITUATIONS DEVELOPMENT AT NUCLEAR POWER PLANTS IN THE CONDITIONS OF WAR

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Abstract

Since the beginning of Ukraine's full-scale war with the russian federation, the personnel of two Ukrainian Nuclear Power Plants (NPP) (Chornobyl and Zaporizhzhya) have been held hostage by the russian occupiers and subjected to intimidation and abuse. An additional strong stress factor can significantly affect the decision-making of NPP control panel operators, increases the probability of erroneous actions in the event of emergency situations, and can even become their cause. The purpose of our study was to determine the possible influence of the "human factor" on the development of emergency situations, as well as additional parameters for monitoring the health and psychological state of NPP operators working as hostages. Fourteen expert psychologists with at least 10 years of experience in the field of extreme psychology were involved in the study. After the introductory seminar, they were offered a questionnaire to determine the range of professionally important qualities that have the greatest impact on the effectiveness of professional activity. The results of the expert evaluation became a hypothesis for the next stage of research on the possible influence of the temperament of operators on resistance to the stress of captivity. The technique of professiograms and psychograms separation, methods of scaling and balancing, methods of mathematical statistics and system analysis were used for the research. One hundred and twenty-four anonymous psychological examination cards and occupational profiles of NPP control panel operators who received a license for professional activity in Ukraine or improved their qualifications within the period of 2017–2020 were analyzed. The predominant types of psychological reactions according to subjective-objective indicators in response to significant stressful situations were studied, and the types of temperaments were determined. The ability to perform professional functions at high and medium levels was recorded in 79 sanguine operators (63.2% of the total number of examined), in 16 choleric operators (12.8%), and was not recorded in melancholic operators. Also, high and medium levels of neuropsychological stability of operators were recorded in 74 sanguine operators (59.2% of the total number of examined), in 6 choleric operators (4.8%), and was not recorded in melancholic operators. To assess the psychological state of NPP control panel operators, it is proposed to use a retrospective analysis of interrelated parameters necessary for the performance of professional functions and indicators of neuropsychological stability. The study of additional parameters of the psychological state will allow to reduce the influence of the "human factor" on the risks of creating or untimely correction of emergency situations.

Keywords: *professionally important qualities, nuclear terrorism, hostages, performance of professional functions, neuropsychological stability, NPP control panel operators.*

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INTRODUCTION

Nuclear energy provides approximately 10% of the energy needs of the OECD countries (Organization for Economic Co-operation and Development) and about 1% of the world's energy needs [1, p. 7]. For 50 years, global energy demand has

increased approximately 2.4 times: from 254 EJ in 1973 to 606 EJ in 2019. In Ukraine, 15 blocks of 4 Nuclear Power Plants (NPP) produce approximately 53.5% of electricity (which amounted to 76,203 GWh in 2020) [2; 3]. The nuclear terrorism of the russian federation at NPP in Ukraine during the last six months [4] constantly draws the attention of scientists and society to the possible scenarios and consequences of radiation accidents.

It is known that even in peacetime, the "human factor" is responsible for 40–50% of emergency situations at NPPs, when personnel make incorrect, untimely, illogical decisions that lead to the failure of technological processes of energy production, unscheduled equipment shutdowns. Another 50–60% of accidents occur due to natural disasters and the technical condition of equipment. In particular, aging, when instead of replacing the equipment with a new one, its service life is extended [5; 6]. Often the effect of the "human" and technical factors is negatively combined.

The use of Ukrainian nuclear power plants as a "nuclear shield" for russian terrorists endangered the lives and health of not only the personnel of the Chernobyl and Zaporizhzhya NPPs, but also 410,000 people in the 50-kilometer zones around the plants, who will have to be evacuated in the event of a nuclear incident. At Zaporizhzhya NPP captured by the russians, station personnel are being held hostage, subjected to intimidation and abuse. The plant and its satellite city of Energodar are constantly under fire, russian military equipment and ammunition are located on the territory of the station [7; 8]. The work of the station personnel under pressure naturally increases the risk of erroneous actions during reactor operation control, which, in turn, increases the risks of a nuclear accident [9].

The aim of the study was to determine additional parameters for monitoring the state of health and psychological state of NPP control panel operators in the conditions of the seizure of the station by terrorists.

Materials and methods

The bibliosemantic method and the system analysis method according to E.P. Golubkov (1975) [10], with minimal detailing of research stages (problem formulation; research; analysis; preliminary judgment; confirmation; final judgment; implementation of the decision) were used for the research. To determine the range of professionally important qualities that have the greatest influence on the decision-making of NPP control panel operators, 14 psychological experts who specialize in working in extreme conditions and have at least 10 years of work experience been involved. The assessment was carried out during the seminar by filling in a specially developed questionnaire after expert instruction by the participants of the research group. The method of expert evaluations was combined with the statistical method. To determine the list of investigated qualities, the separation of professions, scaling and balancing methods were used.

An analysis of the psychological examination cards (psychograms) and professiograms of NPP control panel operators who received a license for professional activity in Ukraine or improved their qualifications within the period of 2017–2020 was conducted. For the purposes of scientific research, 124 profiles are provided anonymously. Based on the profiles data, the distribution of the types of temperament of the operators, the quality of the performance of professional tasks while working on the simulators of the Zaporizhzhya NPP in simulated training extreme situations, and the neuropsychological stability according to the types of temperament of the operators, and the predominant types of psychological reactions according to the subjective and objective indicators in response to significant stressful situations. For the analysis, extreme situations were chosen, which, according to the experts, are comparable in terms of force and vectors of influence to situations associated with being in captivity [11–15], and cause both adaptive and maladaptive reactions. Statistica 10 and MS Excel LTSC programs were used for statistical processing of the results. A result of $p<0.05$ was considered statistically significant.

In order to correctly compare the results of training at the NPP training center with the real working conditions of operators held captive by russian terrorists, we chose simulated training situations of the maximum level of complexity. We considered a *high level* of *performance of professional functions* of NPP control panel operators in extreme conditions to be the ability to flawlessly perform his duties in regulating the emergency situation and to cooperate effectively with other NPP employees. We considered the *average level* to be a few errors that do not affect the performance of professional tasks with the simultaneous ability to see and partially correct one's errors. We considered a *low level* of professional performance to be a significant number of mistakes that do not critically affect the situation, but do not correct it, with the simultaneous inability to critically evaluate and correct one's mistakes.

We considered a *high level* of *neuropsychological stability* to be the operator's ability to maintain emotional balance, indicators of attention, speed of information perception and memory for error-free performance of their functional duties (score 5–6). We considered the *average level* of neuropsychological stability to be a partial decrease in indicators of attention, speed of information perception and memory, necessary for performing professional tasks without significant errors that could affect the result of anti-crisis actions, with the ability to quickly restore a state of emotional balance (7–13 points). We considered a *low level* of neuropsychological resistance to significant stress to be a short-term significant decrease in attention indicators, the speed of information perception and memory, which can lead to incapacity due to stupor or chaotic panic actions, with a gradual independent return to a functional state (14–29 points). It should also be noted that the persons with an unsatisfactory level of neuropsychological stability (29–33 and more points) are not allowed to work as NPP control panels operators even during professional selection.

Research results and their discussion

Ukraine belongs to the group of countries in which the share of nuclear energy in the total volume of electricity production will only increase [16]. Even the accident at the Chornobyl NPP in 1986 did not affect this vector of energy development. Therefore, it is urgent for Ukraine to improve the rules of work safety and process management at NPPs, including those related to the "human factor".

Major accidents at NPPs (*table 1*) made adjustments to the rules of personnel selection, control of their health and psychological state, the training system, changed approaches to the safety of nuclear energy production, and even prompted the transition from LWGR (Light Water Graphite Reactors – such were, for example, at the Chornobyl NPP) to PWR (Pressurized Water Reactor – the most common type in the world). Material and technical support of NPP by means of fire extinguishing, radiometric control, physical protection of personnel from the effects of radiation, and their improvement is mandatory [17]. Instead of the experiments like Chornobyl (it was conducted in the interests of the country's energy sector, but led to catastrophic consequences), computer experimental models using artificial intelligence are used [18].

The analysis of large accidents data confirms that accidents are caused by the combined action of unsuccessful technological solutions, imperfect design of the main NPP elements, lack of necessary equipment, and erroneous actions of personnel (both those actions that lead to the accident and actions during the accident). In open scientific sources, there is practically no data on the health and psychological state of NPP control panel operators and other personnel who overcame emergency events. For example, about those employees of the Chornobyl NPP who survived their stay at the station and in the exclusion zone of the occupiers (9 employees died, 5 were kidnapped). The occupiers themselves, having looted the property of the station (including dosimeters and fire extinguishers), were exposed to radiation. Their actions at the station threatened a radiation accident, and in connection with this, in April 2022, the Ministry of Health of Ukraine approved Methodological recommendations for actions in nuclear damage zones [22]. Also in August 2022, reports appeared in the mass media about the possible exposure of russian military personnel at the Zaporizhzhya NPP, after which the Ministry of Health of Ukraine reminded the population of recommendations for iodine prophylaxis in the event of a radiation accident [23].

The overall outcome of accidents is affected by the number and severity of errors. On average, a NPP unit operator makes 1–2 mistakes for every 100 operations [5]. An increase in the number of errors leads to: 1) inconsistency of the requirements with the capabilities of the specialist; 2) uncertainty of possible ways to solve problems; 3) uniformity and monotony of activity; 4) nervous tension from individual responsibility and work in frequent extreme situations. Up to 30% of emergency shutdowns of NPP units occur due to personnel errors, which are only partially compensated by the capabilities of protective systems, computer programs with elements of artificial intelligence, knowledge and the ability to use the results of analysis of previous accidents, which are reflected in emergency protocols.

The effectiveness of energy system operators is affected by [5]:

1) level of education, experience and training, duration of work load, somatic health (so, for example, the analysis of the heart rhythm makes it possible to make a forecast of the operator's behavior in emergency situations;

2) condition, in particular, wear and tear, of the equipment being serviced;

3) availability of motivation, level of purposefulness and self-control;

Table 1. Data on some large accidents at Nuclear Power Plants around the world

The place of the accident	Kyshtym, Southern Urals, RSFSR, USSR	Windscale, England	Three Mile Island, Pennsylvania, USA [19; 20]	Chernobyl, Ukrainian SSR, USSR	Fukushima, Japan [21]
The date	29 Sep 1957	10 Oct 1957	29 Mar 1979	26 Apr 1986	11 Mar 2011
Evaluation of the level of the event on the scale INES* (risk to the environment)	6 (serious accident)	5 (accident with wider consequences)	5 (accident with wider consequences)	7 (major accident)	7 (major accident)
The cause of the accident and radiation contamination	Equipment failure, failure to repair within a year, personnel errors during an accident. Explosion of radioactive waste storage.	Lack of control and measuring devices, staff errors. Burning graphite, uranium.	Technical malfunctions, violations of repair and operational procedures, erroneous actions of personnel during an accident. Melting of components of the active zone of the reactor.	Low level of technological culture of personnel and management in the field of energetics. A failed electrical experiment. Staff mistakes during the accident.	Earthquake, tsunami, erroneous actions of personnel during an accident.
Emissions of radionuclides (radioactivity)	Iodine-131 basic, 20 thousand Cu (740 TBq), including 54 Ku from Strontium.	Iodine-131 basic, 20 thousand Cu (740 TBq), including 20 Ku from Strontium.	The radioactivity of the gases released into the air ranged from 2.5 to 13 million Cu (92.5–481 thousand TBq).	1,000 thousand Cu, including ~150 thousand Cu from Iodine-131.	Iodine-131 – $1.5 \cdot 10^{17}$ Bq, Cesium-137 – $1.2 \cdot 10^{16}$ Bq
Pollution area, km^2	15,000	500	1,000	160,000	The entire territory of the country and sea water areas.
Evacuated, thousands of people	10–12	No evacuation was carried out.	144 (left their homes on their own). No evacuation was carried out.	1,200	200
Died, persons	200	30 (the data is doubtful: underestimated)	0	31 (information is incomplete)	1 person 15 people were injured.
Sick, thousands of people	9–10	1,000	30 (increased risk of cancer for 20 years)	200–600	6 cases of induced cancer

Note: *INES (International Nuclear Event Scale) – international scale of nuclear events, developed by the International Atomic Energy Agency in 1988 to assess NPP accidents with radiation emissions.

4) relations with colleagues, level of conflict, ability to work in a team;

5) individual psychological qualities (sensory, mnemonic, intellectual and motor). In particular, the following features of the character affect the quality of work: decisiveness, absent-mindedness, nervousness, the level of possible formation of fear and underestimation of danger, reduced attention, stress resistance (equilibrium);

6) in emergency situations, the level of theoretical training, education and practical skills is significant.

The activity of a human operator is evaluated with the help of numerous tests, the construction of professiograms and psychograms [24]. The professional profile assesses readiness for emergency actions, for making complex decisions and the accuracy of their implementation; psychodrama

determines cognitive qualities (attention, memory, imagery and analytical thinking), communicative qualities (culture of behavior and language), emotional qualities (restraint, honesty, compassion, readiness to make decisions), willpower qualities (stress resistance, endurance, concentration and etc.).

Health control of NPP control panel operators is regulated by the Law of Ukraine "On the Use of Nuclear Energy and Radiation Safety" [25], but it does not take into account the situations of work under pressure and when there is a threat to life. Professional selection takes into account the researched data of sensorimotor reactions, assessment of attention and the speed of its switching, stress and fatigue resistance, ability to make decisions in emergency situations. In addition to professional selection, the operator needs constant health control, which determines admission to work. For peacetime, there are recommendations for improving procedures for monitoring the physiological state of NPP control panel operators who have been under the influence of severe stress for a certain time (in order to prevent cardiovascular crises) [26]. The level of fatigue, work of the heart, organs of vision and hearing, coordination of movement, absence of alcohol and drugs in the blood, absence of acute diseases and the period of exacerbation of chronic diseases, increase in body temperature above subfebrile, impaired consciousness, memory, attention, adequacy of perception in space, time, his personality, absence of hallucinations are subjects of control.

Only licensed specialists with appropriate education, work experience [27], who have undergone special psychological training [28], simulator training and passed the licensing exam are allowed to work at the control panel of the NPP unit. The specialty of NPP control panel operator must correspond to the list of the industry standard [29]. Only operators who have passed a daily medical examination with an assessment of their psychological state are allowed to work [30]. The state of physical health of the staff is checked during employment, periodic and daily medical examinations.

It is expected that a NPP control panel operator should have [31; 32] such professionally important qualities as: responsibility; honesty; the ability to quickly make the right decisions; adherence to principles; discipline; sense of duty; organization; stability of attention; high speed of attention switching; high speed of a simple sensorimotor reaction; well-developed short-term and long-term memory; the ability to qualitatively assess time intervals; strong will; analytical and communicative abilities; highly developed deductive thinking; operational thinking; reaction speed; physical and mental endurance; initiative. These professionally important qualities are formed in the process of professional education and training, professional orientation and candidate selection according to the requirements for the profession, adaptation to professional activity, actual activity, professional improvement, attestation (as a stage of training and professional development), rehabilitation after burnout, long-term somatic illness or psychological breakdown.

In the conditions of work at the captured Zaporizhzhya NPP, we predicted an increase in the influence of the "human factor" on making wrong decisions and committing wrong actions in the event of accidents. Therefore, in an expert way, with the involvement of 14 expert psychologists we limited the range of professionally important qualities that have the greatest impact on the effectiveness of the professional activity of NPP control panel operators to the following: information processing speed; stability and distribution of attention; accuracy of perception; decision-making in a difficult situation, under conditions of obstacles; resistance to stress, monotony; physical endurance; efficiency; professional responsibility; stable professional orientation. The stability of attention to the main information has a strong influence on the reliability and accuracy of decisions made by operators. It is emphasized that the lack of time can distort the result of the activity, prevent the achievement of the goal, that is, professional reliability may not be fully realized in the activity.

Similar conclusions were reached by other experts [24; 33]. Adequacy of information perception and limitation of its volume in normal working conditions depends on the influence of distracting factors (sound interference, poor visibility, etc.), for example, in the situation of searching for victims, assessing the location of an emergency situation. The power of the impact increases if the emergency event continues (fire continues, shelling) [34; 35]. The influence of these factors can be felt at the decision-making stage. But the psychological consequences of being in captivity can have the strongest impact. It is known [36] that prisoners feel helplessness, doom; are oppressed by the expectation of an indefinite improvement in their own situation. One fifth of them feel constant anxiety, every fourth – constant

fear for their life. Aggression and anger, or, conversely, depression and apathy are also possible.

Most professional tasks are characterized not only by significant physical, but also emotional tension [37]. The impact of this tension on reliability can be manifested in a decrease in professional orientation. The significance of the uncertainty factor, unpredictability of development of an emergency situation, the high probability of an emergency situation associated with a risk to one's own life or even a radiation incident, determine the importance of such a feature of activity as the ability to quickly and adequately make independent, non-standard decisions, to make changes in the activity process. The unpredictability of the situation causes difficulty in setting goals, determining priority tasks, and choosing adequate methods of their implementation. In extreme conditions, there are signs of behavioral disorganization, inhibition of stable skills, reduced work capacity, inadequate response to sharp stimuli, difficulty switching attention, narrowing and errors of perception, memory lapses, excessive impulsive actions or confusion and stupor, inability to focus on the main activity, easy distraction, decrease in mental stability and productivity of mental operations. The flexibility of behavioral reactions, which is characteristic of most specialists in normal working conditions, decreases. Complex coordinated team actions and even ordinary personal bodily movements, which are usually automatic in nature, are particularly affected. The influence of temperament and psychotype can amplify or smooth out these negative effects.

On the basis of expert evaluations, we obtained the data that the most qualitatively perform the professional tasks of individuals with a predominant sanguine type of temperament. To verify this belief of the majority of experts, we investigated the ability to perform professional functions, as well as a compared the levels of this ability with the levels of neuropsychological stability of operators. The percentage ratio of the quality of performance of professional functions according to the predominant types of temperament is presented in the *figure* (percentages are rounded to whole numbers).

We investigated the quality levels of the performance of professional tasks by operators while working on simulators of the Zaporizhzhya NPP according to their temperament types. The percentage ratio of the quality of the performance of professional functions and the relationship of the level of neuropsychological stability of the NPP operator according to the predominant types of temperament are shown in *Table 2*. The number of variants of the studied indicators corresponded to the pattern of normal distribution, the results were statistically significant ($p<0.05$).

Table 2. The relationship between the temperament type of control panel operators, the levels of professional functions performance quality and neuropsychological stability

Indicator	Level	Predominant types of temperament			
		Amount (percentages rounded to whole numbers), p<0.05			Total, persons
		Sanguines	Cholerics	Melancholics	
		89 (100%)	31 (100%)	4 (100%)	124
Professional functions performance	high	45 (51%)	-	-	45
	medium	34 (38%)	16 (53%)	-	50
	low	10 (11%)	15 (47%)	4(100%)	29
Neuro-psychological stability		high level of professional functions performance 45(100%), p<0.05			
	high	25 (58%)	-	-	25
	medium	16 (35%)	-	-	16
	low	4 (7%)	-	-	4
		medium level of professional functions performance 50 (100%), p<0.05			
	high	-	-	-	-
	medium	30 (78%)	6 (37%)	-	36
	low	4 (12%)	10 (63%)	-	14
		low level of professional functions performance 29 (100%), p<0.05			
	high	-	-	-	-
	medium	3 (30%)	-	1 (25%)	4
	low	7 (70%)	15 (100%)	3 (75%)	25
				Total	124

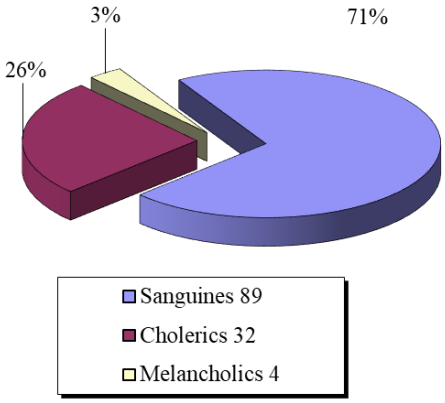

Fig. The ratio of temperament types of NPP control panel operators.

The result of the study confirmed the hypothesis that sanguine operators are better suited to act in extreme conditions. Thus, the ability to perform professional functions at high and medium levels was recorded in 79 sanguine operators (63.2% of the total number of examined), in 16 choleric operators (12.8%), and was not recorded in melancholic operators. The sample had an insufficient number of respondents to calculate the correlation coefficients. Also, high and medium levels of neuropsychological stability of operators were recorded in 74 sanguine operators (59.2% of the total number of examined), in 6 choleric operators (4.8%), and was not recorded in melancholic operators.

The outcome and consequences of an emergency situation depend on the operator's choice of decision. Mistakes caused by distracting his attention even for 30–50 seconds lead to accidents. Incorrect actions are possible in cases of insufficient qualification of operators, receiving inaccurate information by them, a special mental state (for example, the appearance of a "false alarm" – a reaction to a signal that does not exist). Some of the signals are processed at an unconscious level, in the case of making the right decision, it depends on the developed automatism. Excessive stress and fatigue cause a violation of the self-regulation of mental processes, which increases the frequency of errors.

Destructive reactions are possible in emergency situations on the part of operators with a weak nervous system, which is defined as tense, cowardly, inhibiting, aggressive-uncontrollable, fussy, focused on small things to the detriment of correct assessment [5]. The operators with a strong nervous system, on the contrary, demonstrate strong-willed, constructive and overcoming behavior, owing to which it is possible to correct the mistakes of "distracted", "frivolous", "weak-willed" colleagues and "stubborn", which allows control of an emergency situation. Such relations explain why the ability to work in a team (planning, division of functions, mutual assistance, mutual control) and unacceptable conflict relationships are important for a team of operators. Team behavior is determined by the presence of introverts and extroverts: introverts usually make compromises or step aside, extroverts are more constructive and look for practical solutions. Cooperation of these types of personalities in a team helps to control emergency situations more effectively [24].

Conclusions

1. In the conditions of the training center for NPP control panel operators, it was possible to create conditions that, in terms of stress, are comparable to the working conditions in captivity of the russian occupiers. Through an expert assessment, we identified a range of professionally important qualities that have the greatest impact on the effectiveness of the professional activity of NPP control panel operators, including: speed and accuracy of information perception; stability and distribution of attention; the ability to make decisions in difficult situations, under conditions of obstacles; resistance to stress, monotony; physical endurance; efficiency; professional responsibility; stable professional orientation.

2. Analysis of the psychological state of the operator of the NPP control panel, who performed official duties in extreme conditions with significant psycho-emotional stress caused by the presence of a real vital threat, allows us to assert that the influence of psychogenic factors of such a threat causes negative changes in the structure of personal characteristics and the mental state of employees. The research confirmed the hypothesis of a better ability to act effectively and without mistakes in extremes and the greatest neuropsychological stability in sanguine operators, slightly less in choleric operators and the least in melancholic operators. This conclusion allows us to recommend giving preference to applicants with a sanguine temperament when hiring (licensing) NPP control panel operators.

3. To analyze the psychological state of NPP control panel operators, we suggest using a retrospective analysis of the parameters necessary for the performance of professional functions and indicators of neuropsychological stability, which are related to each other. The study of additional

parameters of the psychological state will allow to reduce the influence of the "human factor" on the risks of creating or untimely correction of emergency situations on NPPs.

DECLARATIONS:

Statement of Ethics

The authors have no ethical conflicts to disclosure.

Consent for publication

All authors give their consent to publication.

Disclosure statement

The authors have no potential conflicts of interest to disclosure.

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SELECTION AND IMPROVEMENT OF THE METHOD AND TOOL FOR RESTORING THE ANATOMICAL INTEGRITY OF THE RETINA AFTER ITS DETACHMENT

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ABSTRACT

Introduction. Retinal detachment (RD) is a common pathological condition that without timely surgical treatment leads to vision loss. The patients with significant RD undergo one of three retreatment procedures: Pneumatic Retinopexy, Scleral Buckling, and/or Pars Plana Vitrectomy. Techniques and tools for these procedures have been developed, but the methods themselves still have a significant number of complications. A possible alternative to their further improvement may be a fundamentally new method of treatment, coagulation of the retina with high-frequency electric current (HFEC), for which significant improvement of the tool is still possible.

The purpose of the study was to determine a safer method of RD treating and to improve medical tools for restoring anatomical integrity and repositioning a detached retina under two conditions: firstly, obtaining a reliable chorioretinal adhesion, and secondly, minimizing the number of incidental effects of surgical intervention.

Materials and methods. The bibliosemantic method, the system analysis method, an experiment on laboratory animals (rabbits) with RD simulation and its coagulation by HFEC, tissue biopsy of operated animals after their euthanasia on the 7th day after surgery, and the production of histological micro-preparations were used.

Results. To fulfill the conditions for improving the method, a chorioretinal high-frequency electrocoagulation operation with suprachoroidal access, a modified EK-300M1 generator (Kyiv, Ukraine) with an electrode with a gold hemispherical tip of 25 gauge and electrical generation parameters of 66 kHz, 10–16 V, 0.1 A was proposed, which causes chorioretinal adhesion in the place where the electrode is used. The method of calculating the parameters of heat transfer from the electrocoagulation tool to the tissues and fluids of the eye was selected: it was proposed to use the Fourier-Kirchhoff and Newton-Richmann equations. Destructive phenomena in the retina from the thermal effect of tissue coagulation in the form of the destruction of rods, cones, the development of cysts, the loss of bipolar, amacrine, horizontal and ganglion cells were noted. Atrophic changes in the retina were minimal at a voltage of 10–12 V.

Conclusions. The problem of improving the methods of restoring the anatomical position of the retinal layers has been relevant for many decades, but it does not lead to a significant reduction in the number of complications. The proposed method and tool for its application causes the creation of a reliable chorioretinal adhesion in a short period of time after surgical intervention with minimal thermal tissue damage. The use of the method of chorioretinal high-frequency electrocoagulation with suprachoroidal access is recommended in conditions of urgent restoration of vision, but not recommended for the prevention of retinal detachment in retinopathies.

Keywords: *retinal detachment, chorioretinal adhesion, high-frequency electrocoagulation, suprachoroidal access.*

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INTRODUCTION

During military operations in Ukraine, the frequency of traumatic eye injuries increased approximately 6 times compared to peacetime. Traumatic eye injuries account for 13–16% of all combat injuries, which is associated with modern types of weapons used on the battlefield [1–3]. The largest number of nonpenetrating eye injuries

is caused by the blast wave, which damages the brain together with the eyes. Military damage to the eyes is more often bilateral, while in peacetime – unilateral. A frequent consequence of closed eye injuries during wartime is extensive traction retinal detachments (in peacetime, traction detachments are mainly the result of retinopathies). The number of such injuries increases in direct proportion to the increase in the number of head injuries [4; 5]. Similar observations were previously published regarding the injuries of servicemen during the USSR war in Afghanistan [6; 7].

Rhegmatogenous retinal detachment (RRD) is widespread and associated with a high risk of visual impairment without treatment [8]. Its frequency in peacetime is approximately 1 case per 10,000 population [9; 10], the general prognosis of treatment with timely and successful surgical intervention reaches 95% of vision recovery [11]. Surgical methods of RRD treating are first and foremost – Scleral Buckling (SB), Pars Plana Vitrectomy (PPV), a combined PPV/SB, and Pneumatic Retinopexy [12]. PPV is the most common general option, and in young phakic patients it is SB.

There is a need and conditions for the creation of new methods of treatment of retinal detachment (RD) associated with legislative circumstances, an increase in the number of eye injuries in wartime, a high RD rate in peacetime, a known number of complications of existing treatment methods and the development of modern technologies that allow improving methods treatment and tools [13].

The purpose of the study was to determine a safer method of treatment of retinal detachments and to select parameters for instruments developed or used for this purpose in ophthalmology, from the point of view of minimizing the number of incidental effects and complications of operations and simultaneously achieving reliable indicators of patients' vision recovery.

Materials and methods

At the first stage of the investgation, literature sources (monographs and articles) available for study on PubMed, Medline, EMedicine, UpToDate and Cochrane Library were subjected to analysis; with reference checking in DiseasesDB, OMIM (Online Mendelian Inheritance in Man) and MeSH. The analysis of the received information was carried out according to the principle of system analysis according to the scheme "study – synthesis – primary hypothesis – hypothesis testing – improvement – determining future prospects", with minimal detailing of the steps. Circumstances for determining the relevance of the research are determined by the conditions of peacetime, strengthened by the consequences of military operations.

At the second stage of the research, technical achievements in conducting operations to eliminate RD using existing microsurgical instruments were analyzed and a proprietary method and a tool developed for it were proposed. The obtained result is projected on the hypothetical practice of an ophthalmologist during the treatment of RD within the stage of "improvement" of the system analysis method. To test the research hypothesis, we turned to the results of our own research on laboratory animals (rabbits), which were simulated RD, which was eliminated with the help of high-frequency electric current for the coagulation using a modified EK-300M1 generator (Kyiv, Ukraine) with a frequency of 66 kHz generation, with voltages in the range of 10–16 V, current strength of 0.1 A and with an electrode with a gold hemispherical tip of 25 gauge. Description of the experiment with animals was not the purpose of our research. It is only important to note that the conditions of its conduct did not violate the ethical principles of experiments with laboratory animals, and the results were statistically reliable, with an estimate of $p<0.05\%$ according to the Student's t-test. To evaluate the results of using retinopexy with HFEC, selective photomicrographs of the biopsy of the eye of rabbits 7 days after the surgical intervention were used. The results are compared with literature data of similar experiments using laser- and cryopexy.

Results and discussion

Legislative prerequisites for the creation of new methods of treatment of RD in Ukraine are reliable, and are represented by a number of Orders of the Ministry of Health of Ukraine and clinical protocols for providing ophthalmic care to the population.

The Order of the Ministry of Health of Ukraine No.372 on May 14, 2013 "On the system of ophthalmological care for the population of Ukraine" states the need to provide 24-hour emergency care for eye injuries (art. 2.2.12); conducting scientific research on topical issues of diagnosis and treatment of eye diseases and visual impairments (art. 2.2.19); development and implementation of the latest forms and methods of treatment of eye diseases (art. 2.2.23). Treatment of retinal breaks and detachments is recommended to be carried out both in laser offices and in laser centers of specialized ophthalmic care (Appendix 3) [14].

The morphological features of RD and adhesion as a result of its treatment have been studied long enough, which explains the large number of references to literary sources about the original studies of 1970–2000 years. During this time, considerable data has been accumulated on various methods of retinopexy, their reliability and safety. These data have been repeatedly verified in various studies, including those related to oncology, which will not be the subject of our study. Only research results with a high level of evidence were taken into account.

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Thus, the authors of a Cochrane review (Znaor L. et al., 2019) [15] based on an analysis of 10 studies in European countries, India, Iran, Japan and Mexico, which included 1307 patients, concluded that PPV compared to SB less often leads to repeated RD, with the exception of iatrogenic and cataract progression cases, but has the same result in terms of visual recovery. The authors of another Cochrane review (Sena D.F. et al., 2021) [16] based on the analysis of the results of studies conducted in Ireland, the USA and Italy, which included 274 participants (276 eyes), concluded that SB can be more or less equally effective compared to pneumatic retinopexy (PR) in terms of reliability of chorioretinal adhesion and reduction of the risk of re-detachment. However, the use of SB resulted in more myopic progression, which was interpreted as a sign of cataract development.

Approaches to the treatment of patients with RD in Ukraine have been developed and established in numerous medical care protocols. Ukraine is on the path of implementing international medical care protocols into medical practice, which replace the previous outdated ones. These protocols regulate the stages of diagnosis, treatment, recovery after operations [17; 18].

At the outpatient and inpatient stages of providing ophthalmic care for RD (code of the International Classification of Diseases X revision – H33, XI revision – 9B73) the following examinations are recommended: general ophthalmological examinations; binocular reverse ophthalmoscopy of the periphery of both eyes; biomicroscopy with a Goldmann lens of the retina and vitreous body; surgical treatment with and without vitrectomy. The average duration of treatment until the recovery of normal vision and working capacity is 20 days [19]. However, the use of modern methods of restoring the functional state of a detached retina makes it possible to improve vision by 2–3 times immediately after surgery (for example, from 20% to 40–60%).

The choice of the method of restoring the integrity of the retina and its adhesion to the underlying tissues largely depends on the nature of the retinal damage: a fixed retinal rupture without detachment, detachment without a rupture, or detachment combined with a rupture. So, rhegmatogenous detachment most often means its lifting, moving during eye movements, wrinkling. If there is a retinal rupture, it has a valvular or holey appearance, the detachment can reach the dentate line (ora serrata). Anterior detachment is accompanied by hemorrhage into the vitreous body, pigment cells are found in the anterior part. Posterior detachment is often accompanied by a decrease in intraocular pressure, and the detached retina forms wrinkles.

In the case of *traction detachment*, the retina can be stationary, with a smooth surface that is either convex or concave, and the detachment itself rarely extends to the serrated edge. In retinopathies, there are fibrous bands in the vitreous body, which separate the retina from the pigment epithelium. This requires little effort, because there are no anatomical structures that connect these tissues: the intraocular fluid and the vitreous body press these layers together [20]. However, both of these RD types are subject to urgent surgery. If the detachment is spread to the area of the macula, the operation must be done in the first 2 days to vision saving.

Another widespread RD pathogenetic type is exudative, which is most often associated with an oncological process. In the case of retinal tumors without metastases and enlarged lymph nodes, organ-saving operations are possible by means of diathermocoagulation, photocoagulation, or cryocoagulation. The treatment period is 7–10 days, recovery of working capacity lasts 4–6 weeks. But the main goal of treatment in such cases is to preserve the eye and prevent tumor metastasis, and only in the second place is to eliminate complaints about visual impairment and restore visual acuity.

Exudative detachment can regress on its own after elimination of its immediate cause [21].

Retinal ruptures require surgical intervention (using laser or cryoprocedures, scleroplasty, etc.) within 2–3 days from the onset of the incident. A month after the operation, the patient recovers his work capacity, he should limit physical activity for up to three months. The duration of sanatorium-resort treatment is 18–24 days on an average.

To eliminate RD, it is necessary to remove the accumulated subretinal fluid, bring the retina closer to the choroid, perform retinopexy with the formation of a chorioretinal adhesion, which will not allow fluid to accumulate in the subretinal space again. The strength of the chorioretinal adhesion is affected by the type of retinopexy (cryopexy, diathermy, laser photocoagulation, electrocoagulation of biological tissues). At the current stage, transciliary vitrectomy can be performed with gas or silicone oil tamponade and without the use of vitreous substitutes.

Retinal adhesion is influenced not only by the choice of surgical intervention method and the chosen instrument, but also by some humoral factors. For example, oxygenation and the state of collagen metabolism [22].

Each of the retinopexy methods has its own disadvantages: cryopexy leads to the formation of intracellular ice crystals, diffuse atrophy of the retinal pigment epithelium and damage to small vessels, a decrease in the layer of photoreceptor cells and the formation of chorioretinal adhesions [23–28]. When using a laser, its light energy is mainly absorbed by the cells of the pigment epithelium and transmitted to the neighboring tissues. Overheating leads to the destruction of photoreceptors, choriocapillaries, the formation of scars that fix the retina too firmly [29–32]. The photosensory layer also thins, and ganglion cells are strongly irritated, strong adhesion does not occur in the first days, but only on the fourth day, and gains strength in only three weeks. At the same time, the effect does not depend on the type of the laser.

Jaccoma E.H. et al. (1985) established [33] that cryocoagulation and photocoagulation with an argon laser destroy the hematoretinal barrier, which can be the cause of proliferative vitreoretinopathy. In addition, the risk of recurrence of RD when using laser and cryoretinopexy reaches approximately 10% [34], mainly due to insufficient retinopexy, proliferative vitreoretinopathy or a new retinal rupture. Long-term formation of reliable adhesion requires long-term tamponade with oil, air, or gas, which is uncomfortable for the patient and increases the risk of cataracts, scars, and atrophy of the optic nerve [35; 36].

The use of laser- or cryoretinopexy in patients with horseshoe retinal ruptures reduces the risk of secondary RD from 30% to 1%. But for coagulation the retina with a laser, its intensity is regulated from 100 to 500 mW, depending on the pigmentation of the fundus, the presence and severity of cataracts. The damage to the neurolayer of the retina by excess thermal energy cannot be reduced so far. As well as the damaging effect of cryoretinopexy.

Other methods of treatment associated with tamponade have many complications. Thus, to ensure chorioretinal adhesion in RRD, viscoelastic material is injected into the suprachoroidal space. The patient's retina is leveled with an air bubble or a heavy perfluorocarbon liquid that leaves intravitreal air in the eye for a long time, a bubble of SF6 or C3F8 gas, or silicone oil. The procedure is called SupraChoroidal Buckling (SCB). Antaki F. et al. reported complications of the procedure in the form of bleeding in 23% of cases with the predominant location of the detachment zone in the lower quadrants of the eye. In 4%, combined subretinal and suprachoroidal hemorrhage was recorded against the background of tuberculosis. And although 50% of the patients experienced an improvement in vision as a result of the procedure, 67% experienced re-detachment [37]. The authors concluded that the procedure needs additional safety testing and improvement to reduce the number of complications.

Other common RD treatment methods listed at the beginning of the article have a defined sequence of use in most cases of significant detachment. Thus, PR leads to successful attachment of the retina in approximately 70% to 80% of cases after one procedure, therefore, in cases of failure, patients undergo SB as a second step. Of those patients who undergo SB, 80–90% are successful in reattachment of the retina. Others undergo vitrectomy.

In 2012, Umanets N.N. et al. proposed to use high-frequency electrowelding of biological tissues for the formation of a chorioretinal adhesion endovitreally [38]. The method turned out to be the fastest for obtaining a strong chorioretinal adhesion: it was stronger already an hour after coagulation, but also strong a month after coagulation [39; 40]. The method demonstrated less retinal damage and eliminated the need for prolonged tamponade. In my own research, the method was developed in the form of the use of an electrocoagulation tool

with a gold hemispherical tip of 25 gauge, connected to a modified EK-300M1 generator (Kyiv, Ukraine) (*Fig. 1*) with the following electrical generation parameters: frequency 66 kHz, voltage 10–16 V, current 0.1 A [41]. The selection of parameters of the new tool is the result of long-term research and modeling of thermal processes in the tool and tissues of laboratory animals with the aim of creating a reliable chorioretinal adhesion in a short time after surgical intervention with minimal thermal tissue damage.

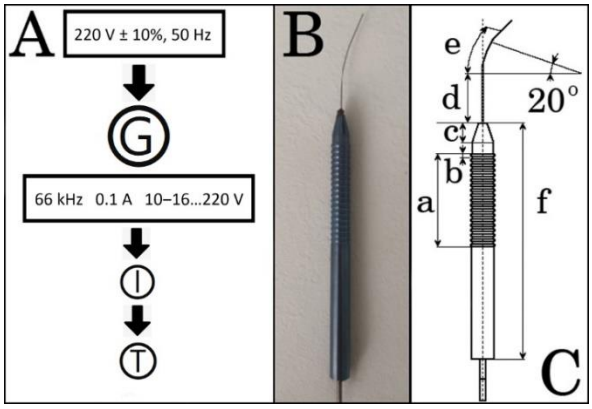

Fig. 1. Equipment for high-frequency electrocoagulation of the retina:

A – conversion of electric current:
(G – Generator, I – Instrument (B, C), T – Tissues);
B – electrode with a 25-gauge hemispherical tip (diameter 0.5 mm);
C – drawing of the electrode with dimensions (rounded to whole values):
a – 37 mm, b – 2 mm, c – 8 mm, d – 20 mm,
e – 18 mm, f – 95 mm.

SolidWorks, Abaqus, etc. software are used to model thermal processes in the electrocoagulation tool. [42; 43]. During the simulation, coagulation temperature, mechanical load on tissues, coagulation time and voltage are taken into account. When calculating heat transfer parameters, the Fourier-Kirchhoff equations were used for moving media (eye fluids), and the Newton-Richmann law was used for the external environment/tissue boundary:

$$-\lambda \frac{dt}{dx} = \varepsilon\sigma(T_T^4 - T_C^4), \qquad (1)$$

where λ – thermal conductivity coefficient (W/m × degree);
σ – thermal conductivity (W/degree).

When the coagulation tool affects tissues, taking into account the processes of melting and hardening, the formula describes the heat transformation for the boundary between the solid and liquid phases of the eye:

$$-\lambda \frac{dt}{dx} = r \times \rho \frac{d\varepsilon}{d\tau} + q_{\text{P}}, \qquad (2)$$

where r – latent specific heat of the phase transformation;
$d\varepsilon/d\tau$ – speed of movement of the two-phase boundary;
ρ – density of the body part;
ε – thickness of the solid part of the body normal to the two-phase boundary;
q_P – heat flow from the liquid phase to the two-phase boundary.

According to Nikolsky O.I. and Sheremet O.P. [44, p. 10], equation (2) in relative parameters has the form:

$$-\frac{d\theta}{d\eta} = K \frac{d\xi}{dF_o} + \delta_L, \qquad (3)$$

where $\left(\xi = \frac{\varepsilon}{\tilde{x}}\right)$ – relative thickness of the solid phase (dense tissues);

$\delta_L = \frac{q_{\text{P}}\tilde{x}}{\lambda \cdot (t_{max} - t_{min})}$ – dimensionless heat flow;

$F_o = \frac{a\tau}{\tilde{x}^2}$ – Fourier criterion;

$K = \frac{r}{c \cdot (t_{max} - t_{min})}$ – physico-chemical transformation (or crystallization) criterion;
r – latent specific heat of phase transformation.

The use of high-frequency electrocoagulation of the retina with suprachoroidal access and a tool with our chosen parameters in an experiment on animals [41] showed high adhesion in the area of application of the electrode, rapid (within an hour) formation of a strong adhesion, which further strengthened over time. Meanwhile, the destruction of rods and cones, the development of cysts, the loss of bipolar, amacrine, horizontal and ganglion cells (*Fig. 2*), damage and migration of choroidal melanocytes occurred in the retina. Characteristic changes in the form of thinning (degeneration) of the retina were observed for 30 days. A reliable adhesion appeared within an hour after surgery and gained strength during the day. Calculation of tissue heat transfer by formula (3) allowed us to choose a voltage range from 10 to 16 V, in which the electric current caused minimal

exudation during acute retinal necrosis and left the vitreous body intact. Atrophic changes in the retina were minimal at a voltage of 10–12 V.

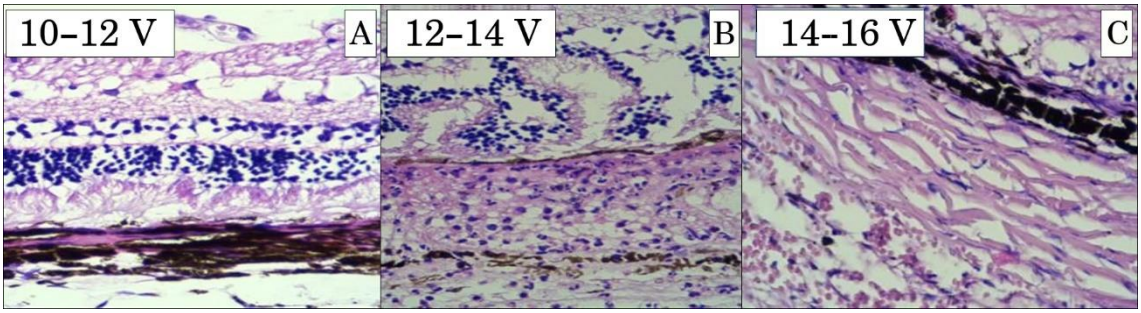

Fig. 2. Morphology of the chorioretinal adhesion in the rabbit's eye at 7 day, when using a voltage of 10–12 V (A), 12–14 V (B) and 14–16 V (C). *Hematoxylin-eosin, ×400*

An important achievement of the use of the HFEC for choreoretinal coagulation was the rapid production of chorioretinal adhesion. Its strength one hour after surgery was similar to strength when using laser coagulation after a similar retinal detachment one week after surgery [35]. At the same time, adhesion strength gradually increased, more so during the first week after surgery, and equaled the strength after laser retinopexy one month after surgery. Direct tissue coagulation time was also reduced by approximately 27%.

The success of the intervention put before us an additional question about the possibility of using high-frequency coagulation with a preventive purpose, and not only for urgent restoration of vision. For this purpose, we turned to the Cochrane Library.

The use of surgical interventions with a preventive purpose, when there are only risks of repulsion, cannot be considered safe in view of the lack of reliable evidence for such a statement [45]. Instead, early identification of retinal ruptures and prompt treatment is advisable, which protects against additional and repeated RDs and significant vision loss. This conclusion of the author of the Cochrane review Wilkinson C.P. (2001–2014), originally obtained for the methods of laser- and cryopexy of the retina, is also valid for its high-frequency electrocoagulation (HFEC). However, for patients with a giant retinal rupture in the paired eye, prophylactic treatment may be appropriate.

It is also known [46–49] that RD can be a complication of cataract surgery and is associated with the use of fluoroquinolones. Therefore, without preventive coagulation of the retina, these patients should still be given additional attention in the form of preventive examinations.

Conclusions

Chorioretinal high-frequency electrocoagulation with suprachoroidal access, an electrode with a 25-gauge gold hemispherical tip and electrical generation parameters of 66 kHz, 10–16 V, 0.1 A, which causes chorioretinal adhesion in a place of electrode application, is the operation of choice for traction and rhegmatogenous retinal detachments. As a result of surgical intervention, a strong chorioretinal adhesion occurs within an hour, which reduces the time of surgical intervention, minimizes the risks of repeated detachment, and cancels the need for eye tamponade. In terms of adhesion quality, the method is superior to laser and cryoretinopexy. The use of the method is appropriate in conditions of urgent restoration of vision, but inappropriate for the prevention of retinal detachment in retinopathies.

The optimal voltage parameters, according to the results of morphological studies of laboratory animals' tissues, are 10–12 V, which reduces the damaging current on the retina. The effect of electrocoagulation causes minimal exudation during acute retinal necrosis and leaves the vitreous body intact.

The proposed operative method and the tool improved for this purpose correspond to modern Ukrainian clinical protocols for the treatment of retinal detachment.

DECLARATIONS:

Disclosure Statement

The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

Data Transparency

The data can be requested from the authors.

Statement of Ethics

The authors have no ethical conflicts to disclosure.

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All authors give their consent to publication.

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AN INTEGRATED MODEL OF PSYCHOTHERAPEUTIC SUPPORT IN THE SYSTEM OF THERAPY FOR COVID-19 PATIENTS

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Abstract

Introduction. To date, it has been already established that COVID-19 has a negative impact not only on the physical condition, but also on the mental health of the population in every country of the world. Many people have a fear of coronavirus, which is usually associated with the possible risk of infection, the lack of pathogenetic treatment, unpredictable course of the disease, as well as total uncertainty. All of the above causes negative psychological reactions. according to a scientific review published by the World Health Organization, global prevalence of anxiety and depression increased by a quarter of a percent in the first year of the COVID-19 pandemic.
The **aim** of the study was to develop an integrated model of psychotherapeutic support for patients with COVID-19.

Materials and Methods: a comprehensive clinical-psychopathological and psychodiagnostic examination of 125 patients with COVID-19 and non-psychotic mental disorders, of both sexes, with an average age of 36.0±3.4 years, was conducted.

Results. The findngs of the clinical-psychopathological study suggest that the clinical picture of non-psychotic mental disorders in the examined patients is represented by astheno-neurotic, anxious, depressive and cognitive syndromes. The psychotherapeutic program included individual and group psychotherapy and psychoeducation. An important component of the psychotherapeutic support program was psychoeducation aimed at developing an adequate system of ideas about the neurotoxic impact and consequences of COVID-19, understanding the main psychopathological syndromes caused by the disease, involving patients in active participation in treatment, and teaching methods of overcoming immersion in the disease.

Conclusions. The analysis of the clinical findings of using the developed program showed a positive dynamic of the emotional state, a decrease in the expressiveness of anxiety-depressive symptoms, a positive transformation of coping strategies, the transition of non-constructive types of attitudes to the disease into adaptive, constructive ones, and an increase in the quality of life.

Keywords: *psychotherapy, treatment, comprehensive approach, mental disorders*.

INTRODUCTION

The COVID-19 pandemic is one of the largest global crises that humanity has faced in the recent decades. It has serious negative consequences for both human health and health care systems, the economy and society [1; 2].

Similar to other coronaviruses, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), exhibits neurotropism. Systemic inflammation, as well as neuroinflammatory changes, are caused by a massive increase in pro-inflammatory cytokines, neuroglial reactivity, altered neurochemical profile, and pathological remodeling of neuronal networks. These organic changes, which occur together with external stressors caused by experiences of staying in intensive care units, fear of a pandemic and social restrictions, financial and economic problems, contribute to development of psychological and pathopsychological disorders [3; 4].

To date, it has been established that COVID-19 has an unfavorable impact on mental and emotional well-being of population around the world. The fear of coronavirus, associated with the possible risk of infection, the unpredictable course of the disease, the lack of pathogenetic treatment and

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total uncertainty, causes negative psychological reactions. According to a scientific review published by the World Health Organization, worldwide prevalence of depression and anxiety rose by 25% for the first year of COVID-19 pandemic [5; 6].

At present, there is a need for development of personalized programs for pathogenetically based therapy and rehabilitation of persons who have suffered from COVID-19. Modern medical care strategies define six goals on the way to improving the quality of treatment and rehabilitation of patients: safety, efficiency, patient-orientation, timeliness, rationality, impartiality of care. At the same time, it is psychotherapy and medical-psychological rehabilitation that are extremely important and complementary therapeutic strategies [7; 8].

Pandemic of coronavirus disease significantly affects the psychological state and disrupts the mental balance of various population groups around the world, which is confirmed by a number of empirical studies. Timely and effective psychological and psychotherapeutic help during this special period is urgently needed. Inevitable changes due to the pandemic situation generate a challenge to create relevant modifications of psychological and psychotherapeutic support. The major challenge of these modifications is highly preserve stability of the treatment environment and continuation of necessary patient's assistance in such strenuous conditions as quarantine [9–11].

The aim of the study was to develop an integrated model of psychotherapeutic support for patients with COVID-19.

Material & Methods

In order to achieve the goal, a comprehensive clinical-psychopathological and psychodiagnostic examination was conducted in 125 patients with non-psychotic mental disorders and COVID-19. The examinees were of both genders (57 males and 68 females) and had a mean age of 36.0±3.4 years. Informed consent for participation in a scientific study and compliance with the principles of bioethics and deontology was obtained. Mathematical and statistical processing of the study results was performed using specialized software packages (Statistica 6.0, MS Excel) using the Student's t-test methodology.

The following psychodiagnostic methods were also used for the research: the Hospital Anxiety and Depression Scale, the "Methods of Coping Behavior" method (Lazarus R., Folkman S., adapted by Kryukova T., 2002), the questionnaire "Type of attitude towards the disease" (Mendelevych V.D., 2005), "The Integral Quality of Life Scale" (Mezzich et al., 1999, modified by Maruta N.O., 2004).

During the clinical-psychopathological examination, it is planned that the clinical picture of non-psychotic mental disorders in the examined patients will be manifested in depressive, anxious, astheno-neurotic and cognitive syndromes. The following psychotherapeutic interventions in various combinations will be used for these syndromes.

The method of biosuggestive therapy (by Strazhny O., 1996; patented on 2019) [12] is a simple psychotherapeutic technique aimed at ridding a person of mental disorders, restoring psychological comfort and well-being. This method includes a combination of verbal and non-verbal suggestion techniques in a light trance state. The use of the prefix "bio" in the name indicates that not only suggestion is used, but also other influences: the contact of the therapist's palm with the client, a certain tone of voice, in the situation of group therapy – induction of the client by group members.

With the help of art therapy, the most disturbing aspects of life are sublimated into the outside world. One of the important advantages of art therapy is that art allows you to reconstruct a conflict-traumatic situation in a hidden symbolic form and find its solution.

Mindfulness, which is also called the practice of self-awareness or the practice of attentiveness, is a meditation technique, the essence of which is to return your attention to what is happening "here and now", to make each action conscious instead of thinking about thousands of things at once.

The purpose of stress resistance training is to develop it by making patients aware of their position in life, forming effective communication skills in the process of communication, acquiring self-control skills and constructive expression of negative impulses in behavior.

Body-oriented psychotherapy is one of the directions of modern psychotherapy, which is based on the principle of stabilizing emotional state through work with the body and allows you to reunite feelings, bodily sensations and thoughts, restore lost relationships between them.

An important component of the psychotherapeutic support program is psychoeducation aimed at forming an adequate system of ideas about the neurotoxic impact and consequences of COVID-19,

understanding the main psychopathological syndromes caused by the disease, involving patients in active participation in treatment and teaching methods of overcoming immersion in the disease.

In the course of the study, an integrative model of psychoeducational work was used, which included: informational training, training of interpersonal interaction, improvement of compliance, problem-oriented discussions. A separate training was dedicated to providing information directly about COVID-19, clarifying meaning of the term pandemic, need to follow the rules that all people without exception must comply with during the quarantine period.

Results & Discussion

The findings of the clinical psychopathological study indicated that clinical presentation of non-psychotic mental disorders in the subjects is showed in depressive (29.1% of the examined), anxious (33.4% of the examined), astheno-neurotic (24.2% of the examined) and cognitive (13.3% of the examined) syndromes.

In consideration of the data collected during the comprehensive examination of pathopsychological, psychological and clinical psychopathological features of patients with COVID-19 was developed an integrated model of psychotherapeutic support for such patients, which includes psychotherapy and psychoeducation.

The psychotherapeutic program included individual and group psychotherapy and psychoeducation.

Cognitive behavioral therapy, biosuggestive therapy, art therapy, mindfulness technique were used for depressive syndrome. Duration of psychotherapy was 4–8 weeks.

In a case of an anxious syndrome cognitive-behavioral therapy, biosuggestive therapy, stress resistance training were used. Psychotherapy lasted for 4–8 weeks.

Cognitive-behavioral therapy, biosuggestive therapy, body-oriented psychotherapy, art therapy for astheno-neurotic syndrome treatment were used. Duration of psychotherapy was 3–6 weeks.

Cognitive-behavioral therapy and cognitive training were used for cognitive syndrome. Psychotherapy lasted for10–12 weeks.

Cognitive-behavioral therapy was aimed at correcting behavioral forms of response, realizing own life values and changing one's life path based on these values, accepting full responsibility for own choices.

The analysis of clinical results of the use of the developed program showed a positive dynamic of the emotional state, a decrease in the expressiveness of anxiety-depressive symptoms (68.3% of the examined patients) such scores were obtained due to the Hospital Anxiety and Depression Scale, before and after therapy; a positive transformation of coping strategies (59.8%) such scores were obtained due to the "Methods of Coping Behavior" method (Lazarus R., Folkman S., adapted by Kryukova T., 2002) method before and after therapy; transition of non-constructive types of relationship to the disease into adaptive, constructive ones (61.4%) such scores were obtained due to the questionnaire "Type of attitude towards the disease" (Mendelevych V.D., 2005) before and after therapy of the; improvement of the quality of life (64.7%) such scores were obtained through "The Integral Quality of Life Scale" (Mezzich et al., 1999, modified by Maruta N.O., 2004) before and after therapy.

Unfortunately, there is currently no description of psychotherapeutic interventions for patients with psycho-emotional disorders who have suffered from COVID-19. Of course, there is a large number of separate studies that relate to psychotherapy of psycho-emotional disorders without taking into account somatic and infectious diseases. The article by Corpas J. et al. views various types of psychotherapeutic interventions for psycho-emotional disorders [13; 14].

Conclusions

An integrated model of psychotherapeutic support for patients with COVID-19 showed a positive dynamic of the emotional state, a decrease in the expressiveness of anxiety-depressive symptoms, positive transformation of coping strategies, transition of non-constructive types of relationship to the disease into adaptive, constructive ones, improvement of the quality of life.

DECLARATIONS:

Statement of Ethics

The authors have no ethical conflicts to disclosure.

Consent for publication

All authors give their consent to publication.

Disclosure statement

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Data Transparency

The data can be requested from the authors.

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CLINICAL AND PSYCHOPATHOLOGICAL ANALYSIS OF EMOTIONAL AND COGNITIVE DISORDERS IN PATIENTS WITH TYPE II DIABETES

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Abstract

The psycho-emotional state has the most significant effect on the clinical picture and course of diabetes of any type. According to many researchers, it is known that patients with diabetes suffer from depression almost three times more often than patients without it. When the patient has symptoms of depression, his emotional state is disturbed, which quite often leads to the patient's refusal of the prescribed necessary treatment, and eventually decompensation of the somatic state occurs. In turn, it causes new episodes of depression, which requires the use of psychotropic drugs and psychotherapy. A comprehensive clinical-psychopathological and psychodiagnostic examination of 82 patients with type II diabetes of moderate and severe forms was conducted. The average duration of diabetes was (7.9±5.2) years. Emotional disorders are represented by anxious, depressive, astheno-hypochondriac, hysteroform variants of psychopathological symptoms. Cognitive dysfunction is a frequent complication of type II diabetes. It is associated with both the age-related aspect of the disease and the pathological dysmetabolic cascade that forms basis of the pathogenesis of diabetic encephalopathy development. Cognitive decline in type II diabetes has a mixed (vascular-degenerative) nature and is characterized by complaints of decreased working capacity, and is marked by a decrease in memory, auditory-speech and visual modalities, slowing of thinking, decreased concentration of attention, absent-mindedness, inability to focus on performance of a certain task for a long time. The analysis of cognitive functions using the MMSE method showed that the examined patients had mild or moderate cognitive impairments in the form of a decrease in verbal memory, a decrease in the speed of calculation operations, difficulty in orientation, and a decrease in indicators of the perceptual-gnostic sphere.

Keywords: *cognitive disorders, emotional disorders, metabolic disorders, depression.*

Diabetes mellitus is one of the most widespread human diseases. Prevalence of diabetes in the world has a significant tendency to increase. A comparison of the prevalence of diabetes shows that in developed countries a significant increase in diabetes is predicted for 2030 in people older than 65 years; at the same time, developing countries are characterized by an increase in the number of diabetes patients aged 45–64. Today, there are 371 million people with diabetes in the world, and by 2025, 552 million people with diabetes are expected. Epidemiological studies of diabetes mellitus in Ukraine demonstrate a constant increase in the number of patients. In various countries of the world, the number of patients with diabetes mellitus is (4–7) % of the total population [1; 2].

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Mental disorders in diabetes mellitus, depending on the contingent of examined patients, are found in (1.3–100.0) % of cases. Patients with diabetes are people with a chronic disease who, for the most part, can react sharply to their disease and its treatment. Such reactions are due to the awareness of the chronic nature of the disease with long-term, acute, progressive complications and the need for constant treatment. Diagnosing of diabetes is shocking for most patients and their families. As a result, psycho-emotional disturbances may occur [3; 4].

Psycho-emotional state is one of the most significant factors that affects clinical picture and nature of the course of diabetes. It is known that patients with diabetes suffer from depression almost three times more often than patients without it. With depression, emotional state is disturbed, which frequently leads to the patient’s refusal from prescribed necessary treatment, and over time, decompensation of the somatic state occurs. In turn, it causes new episodes of depression,

which requires psychotropic drugs prescription and psychotherapy [5; 6].

Nowdays, type II diabetes mellitus is considered the most important nosological cause of cognitive decline. In a number of studies, it was established that hyperglycemia and the duration of diabetes are associated with cognitive impairment, while the prevalence of mild cognitive impairment in the presence of type II diabetes is 20% in men and 18% in women over 60 years age [7; 8].

The above facts determined the relevance of this research, which purpose is to conduct a clinical-psychopathological analysis of emotional and cognitive disorders in patients with type II diabetes.

In order to achieve this goal, in compliance with the principles of bioethics and deontology, psychodiagnostic and clinical-psychopathological examination were conducted for 82 patients with type II diabetes mellitus of medium (84.1%) and severe (15.9%) degree of severity. The average duration of diabetes was (7.9±5.2) years.

Clinical-psychopathological research data indicate emotional and cognitive disorders in the examined patients.

Emotional disorders were represented by the following variants of psychopathological symptoms: 43.4% – anxious variant, 26.6% – depressive variant, 19.8% – asthenic hypochondriacal variant, 10.2% – hysteroform variant.

In the case of an anxious variant, there was a predominance of a general anxious mood background, unmotivated anxiety, a feeling of internal tension with the inability to relax, fussiness, motor restlessness, hyperesthesia, various kinds of fears and apprehensions, sleep disturbances.

The depressive variant was characterized by a low mood, feelings of longing, sadness; narrowing of interests, thoughts about own inferiority, ideas of self-blame and self-destruction, psychomotor retardation. Feelings of the hopelessness of own life, loss of the meaning of further existence, concentration of attention on the state of somatic discomfort, feelings of helplessness, doctor dependency were observed.

In the asthenic hypochondriacal variant, there is reduced activity and hypobulia, feeling of complete exhaustion with general inhibition, apathy, inactivity, indifference and focusing on the state of somatic discomfort, slowing of the pace of thinking, narrowing of associative processes.

The hysteroform variant was characterized by demonstrativeness, irritability, impatience, a tendency to paroxysmal affective reactions, focusing on the state of somatic discomfort, which was facilitated by vegetative paroxysms, more often of the cardiovascular type (a heavy feeling of pressure and tightness in the chest).

The conducted psychodiagnostic research revealed an increase in the level of situational ([55.7±6.1] points) and personal anxiety ([54.5±6.4] points) according to the Spielberger-Khanin Scale. 65.8% of examined patients had a mild, 11.5% moderate depressive episode and 56.1% of examined patients had mild, 40.3% moderate anxiety episodes according to the Hamilton Anxiety Rating Scale (HAM-A).

The personal profile of patients with diabetes was characterized by emotional lability, irritability, depression, isolation, and reduced sociability.

The study of the level of general asthenia according to the Scale of Self-Assesment of Asthenic State (SAS) showed an increase in score of general asthenia to (85.6±7.9) points, which corresponded to moderately expressed asthenia, which was formed due to damage to the neurons of the deep parts of the brain under conditions of diabetes.

Cognitive dysfunction was a frequent complication of type II diabetes, which is associated with both the age-related aspect of the disease and the pathological dysmetabolic cascade that forms basis for pathogenesis of diabetic encephalopathy development. Decreased cognitive functions in type II diabetes had a mixed (vascular-degenerative) nature and were characterized by complaints of reduced working capacity (85.6% of the examined), decreased memory of the auditory-speech and visual modalities (66.9% of the examined), slowing of thinking (58.3%), decreased concentration (71.3%), absent-mindedness (51.1%), inability to focus on a certain task for a long time (44.6%).

The analysis of cognitive functions using the MMSE method showed that examined patients had mild ([51.2±1.5]%) or moderate ([49.8± ±1.4]%) cognitive impairment in a state of decrease in verbal memory ([39.8 ±1.3]%), decrease in the speed of counting operations ([42.1±1.4)%, difficulty in orientation ([42.2±1.4]%), decrease in indicators of the perceptual-gnostic sphere ([39.8±1.3]%).

Evaluation of data of the correction (Bourdon) test showed a decrease in ability to concentrate, increase in fatigue, and a decrease in load tolerance. Maximum concentration on average for the group was noted in the second minute of the study, from the 4th minute a reaction of fatigue was noted. Simultaneously, 62.2% of subjects had

a "work-in period" – the largest number of errors was observed in the 1st minute of examination, the smallest – in the 3d minute. A further elevation in the number of mistakes is up to 6 minutes of the examination specified a decreasing attention span and brain tiredness.

Conducting a test for memorizing 10 words in 59.8% of the examined patients was revealed a decrease in the ability to concentrate attention, auditory perception and memorization, as well as a deterioration of working memory.

Based on the data obtained during the research, a complex program of comprehensive therapy of cognitive and emotional disorders of patients with type II diabetes was developed, including psychopharmacotherapy, psychotherapy and cognitive training.

Conclusions

This research indicated in patients with type II diabetes, mild cognitive impairment with emotional disorders, like anxious, depressive, asthenic hypochondriacal and hysteroform variants of symptoms. The results of a complex program of comprehensive therapy of cognitive and emotional disorders of patients with type II diabetes showed a positive dynamic of the emotional state, working capacity, concentration, ability to focus an memorize current events. So, its significantly improved of the quality of life.

In the future, it is planned to study younger patients with type I diabetes.

DECLARATIONS:

Disclosure statement

The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

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COMPREHENSIVE PROGRAM OF PSYCHOTHERAPEUTIC SUPPORT OF COMBATANTS WITH ALCOHOL ADDICTION

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Abstract

Introduction. The combatants develop anxious alertness, the perception of the environment as potentially dangerous, the impulsive response increases, and the personality structure is affected. All this leads to a change in behavior and, most often, to alcoholization of this demographic group.

Materials and methods. To achieve this goal, we examined 96 men who were treated in the psychiatry and narcology clinic of the Military Medical Clinical Center of the Northern Region. According to the diagnostic criteria of ICD-10, they suffered from alcohol dependence: 31.9% of respondents – alcohol abstinence, 22.6% – abstinence in conditions precluding use, 29.2% – constant use, 16.3 % – occasional use. The treatment group (patients who took part in rehabilitation program) included 56 people. The control group consisted of 40 people who received standard treatment regulated in the hospital. The style of alcohol abuse with a high degree of reliability correlated with the issues of danger to physical, psychological and mental health. Dangerous alcohol consumption was found in 55.2% of the participants, a high probability of alcohol dependence was found in 44.8% of respondents.

Results. The clinical picture of alcohol dependence was characterized by loss of situational control, palimpsests, dysphoria, affective reactions, anxiety and depressive disorders and asthenic manifestations. Against the background of the use of the developed comprehensive program of psychotherapeutic support in 45.1% of the members of the main group and 32.6% of control group patients demonstrated coping strategies aimed at addressing the challenges; 31.4% and 22.4% of the treatment and control groups, respectively, demonstrated coping strategies aimed at emotions; in 15.9% and 32.6% of patients coping strategies were designed to avoid stress; in 6.7% and 12.4% in the above mentioned groups respectively – coping strategies aimed at the distraction.

Conclusions. As a result of the implementation of the comprehensive program of psychotherapeutic support for combatants with alcohol addiction, it is expected that the quality of medical care for combatants will improve.

Keywords: *psychotherapy, comprehensive treatment, combatants, alcoholism.*

INTRODUCTION

Improving the effectiveness of diagnosis, treatment, prevention, medical and social rehabilitation of patients with alcohol dependence is one of the significant issues of modern psychiatry and narcology [1]. The modern period of our country's development is characterized by a large number of destructive and socially determined stress factors. As a result, there is a significant increase in the long-term stress load under which people live in Ukraine [2; 3].

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This creates a number of unfavorable factors for increasing level of psychoactive substance use, especially, alcohol [4]. Modern studies of alcohol addiction are devoted to updating the concept of psychological and social rehabilitation of patients, their social reintegration and improving their's quality of life [5; 6]. As a result, the search for new psychotherapeutic approaches to the treatment of alcohol dependence and the development of effective schemes that meet modern standards of treatment is increasing [7].

Combatants are a special part of the population. They have always had special social and psychological consequences of participation in military conflicts. It is known that there are numerous factors of violations of adaptation of combatants in civilian life. These can be violations in the sphere

of interpersonal relations (aggression, conflicts), or they can manifest themselves in deviant behavior. According to statistics, up to 50% of combatants exposed to combat stress suffer from Post Traumatic Stress Disorder (PTSD) [8; 9].

The combatants develop anxious alertness, the perception of the environment as potentially dangerous, the impulsive response increases, and the personality structure is affected. All this leads to a change in behavior and, most often, to alcoholization of this demographic group [10; 11].

The aim of our research was to develop the comprehensive program of psychotherapeutic support for combatants with alcohol addiction.

Materials and methods

To achieve the goal, 96 men were examined, who were treated at the psychiatric and narcological departments of the Military Medical Clinical Center of the Northern Region. According to the diagnostic criteria of ICD-10, they suffered from alcohol dependence: 31.9% of respondents – alcohol abstinence, 22.6% – abstinence in conditions precluding use, 29.2% – constant use, 16.3 % – occasional use.

All patients received psychopharmacotherapy regulated in accordance with the standards of the Ministry of Health of Ukraine.

The main group (patients who took part in rehabilitation program) included 56 people. The control group consisted of 40 people who received standard treatment regulated in the hospital.

The following examination methods were used: anamnestic, clinical-psychopathological, psychodiagnostic and statistical.

Results and discussion

According to the results of the study, among the interviewed patients there was a predominance of people who constantly abused alcohol, the average score on the AUDIT test was 4.0, which indicated the presence of serious alcohol disturbances. Alcohol consumption style is highly reliably correlated with physical, psychological, and mental health hazards. Dangerous alcohol use was detected in 55.2% of subjects, a high probability of alcohol addiction – in 44.8% of respondents.

The clinical picture of alcohol addiction was characterized by a loss of situational control, palimpsests, dysphoria, affective reactions, anxiety-depressive disorders and asthenic manifestations.

In 40.2% of the patients, intoxication dominated with dysphoric-explosive component, in 35.1% of patients had anxiety-depressive component; in 24.7% of patients was aggressive component of intoxication.

For the combatants, the main motive for alcohol abuse was to "relieve combat stress", "numb the pain", "get rid of important military memories", the desire to use alcohol to level negative emotional experiences (tension, anxiety, fear, sadness).

As the analysis of the severity of traumatic stress has shown, 31.4% of the patients have a complete manifestation of stress disorder, an obvious manifestation of 39.5%, and a partial manifestation of 29.1% of patients. The data obtained indicate an extremely high strength of combat stress as a risk factor for the development of an addiction syndrome in servicemen both at the time of exposure and in the future

The study of the styles of stress-overcoming behavior made it possible to ascertain the predominance of non-constructive forms of behavior in the surveyed combatants: in 51.4% of patients with alcohol dependence coping strategies were noted focused on avoidance, in 33.3% – on distraction, in 10.3% – on emotions, 5.0% – on solving problems. 67.5% of respondents demonstrated a very high level and 29.8% demonstrated elevated levels of social frustration.

Patients of the main group received complex treatment with the use of pharmacotherapy, psychotherapy and psychoeducation. Its main strategy is a comprehensive impact on the cognitive, emotional, psychological and physiological, behavioral and social features of alcohol addiction.

Pharmacotherapy was aimed at suppressing the pathological craving for alcohol, maintaining remission, and correcting emotional disorders.

The psychotherapeutic complex included the use of the program "12 steps. New life", trauma-focused cognitive-behavioral therapy, desensitization and processing of emotional trauma with eye movements, personality-oriented psychotherapy, art therapy and psychoeducation.

Trauma-focused cognitive-behavioral therapy is a short-term intervention designed to reduce symptoms associated with a traumatic event. It is aimed at working with negative emotions, physical reactions and any other difficulties associated with a traumatic experience.

Eye Movement Desensitization and Reprocessing therapy (EMDR) is aimed at alleviating the experiences caused by traumatic memories.

Person-centered psychotherapy is aimed at the patient's understanding of cause-and-effect relationships and the relationship between his personality and the disease, the formation of an adequate assessment of a psychotraumatic situation and

finding ways to overcome it. Drawing techniques aimed at harmonizing the emotional state and constructive actions taking into account the specifics of psycho-traumatic circumstances were used during the art therapy.

The main tasks in conducting mental and educational classes were filling the knowledge gaps related to narcology among the patients and their families; reducing levels of stigmatization and self-stigmatization in patients and their family members; teaching patients the skills of coping with the disease; correction of patients' social positions changed by alcohol dependence; counteracting the possibility of disease recurrence.

A comprehensive program of psychotherapeutic support included social skills training, stress resistance, learning skills to overcome acute stress because of the specificity of combat trauma.

Approbation of the proposed comprehensive program of psychotherapeutic support for combatants with alcohol addiction proved its high effectiveness. Analysis of clinical results of the developed system indicated that in the main group according to the AUDIT test 65.3% of respondents found alcohol consumption relatively safe (or stopped drinking alcohol completely), 23.1% considered alcohol consumption risky. Among the surveyed control group, 55.1% of the surveyed had dangerous alcohol consumption, and 25.8% had a high probability of alcohol dependence.

So, 77.6% of the surveyed in the treatment group formed a perception of their own dependent condition and understanding of the need for therapeutic work.

An analysis of the duration and quality of remission revealed (after 6 months): 70.1% of those surveyed in the main group showed complete remission of alcohol dependence compared to 41.5% of patients in the control group; incomplete remission – in 26.2% and 49.1% of respondents in the main and the control groups respectively; persistent alcohol abuse – in 3.7% and 9.4% of the main and the control groups respectively.

Against the background of the use of the developed comprehensive program of psychotherapeutic support in 45.1% of the members of the main group and 32.6% of control group patients demonstrated coping strategies aimed at addressing the challenges; 31.4% and 22.4% of the treatment and control groups, respectively, demonstrated coping strategies aimed at emotions; in 15.9% and 32.6% of patients coping strategies were designed to avoid stress; in 6.7% and 12.4% in the above mentioned groups respectively – coping strategies aimed at the distraction.

Conclusions

As a result of the implementation of the comprehensive program of psychotherapeutic support for combatants with alcohol addiction, it is expected that the quality of medical care for combatants will improve.

DECLARATIONS:

Disclosure statement

The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

Data Transparency

The data can be requested from the authors.

Statement of Ethics

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STUDY OF THE DIFFERENCES IN THE GAIT PARAMETERS OF HEALTHY AND DISEASED LIMBS IN PATIENTS WITH KNEE OSTEOARTHRITIS

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Abstract

Knee osteoarthritis is a prevalent condition that affects millions of people worldwide. It is a degenerative disease that occurs when the protective cartilage in the knee joint wears down over time, leading to pain, stiffness, and swelling in the knee. The actuality of knee osteoarthritis lies in its high prevalence, significant healthcare costs, and impact on quality of life. The article presents the results of the study of the difference in gait parameters of healthy and diseased limbs in patients with knee osteoarthritis. Twenty patients were examined. The diagnosis of knee osteoarthritis was established according to the criteria of the American College of Rheumatology. Gait parameters were studied using the GAITRite® system. The following parameters were studied: Temporal Definitions (Step Time, Gait Cycle Time, Single Support, Initial Double Support, Stance); Spatial Parameters and Definitions (Step Length, Stride Length, H-H Base of Support, Toe In / Toe Out). Among the investigated indicators, two demonstrated reliable differences between healthy and diseased limbs. It was found that Step Time for diseased limb was statistically significantly greater than for the opposite limb. At the same time, the foot support time of the healthy limb and, accordingly, the Initial Double Support indicator statistically significantly exceeded the similar indicators for the diseased limb. Summarizing the results of epy study, it can be stated that patients with knee osteoarthritis have a gait disorder in the form of asymmetric steps. Thus, the time of support on the foot decreases, and accordingly, the time of transferring the foot of the diseased limb increases. Changes in the diseased limb are also reflected in the opposite, healthy limb. An effort to increase the speed of movement during the examination causes an increase in movement on a relatively healthy limb in the form of an increase in the length of the step and a reduction in the time of transfer of the foot of the diseased limb.

Keywords: *knee joint; osteoarthritis; gait parameters; GAITRite*.

INTRODUCTION

Knee osteoarthritis is a prevalent condition that affects millions of people worldwide. It is a degenerative disease that occurs when the protective cartilage in the knee joint wears down over time, leading to pain, stiffness, and swelling in the knee [1]. The actuality of knee osteoarthritis lies in its high prevalence, significant healthcare costs, and impact on quality of life [2; 3].

According to scientific literature, knee osteoarthritis is one of the leading causes of disability worldwide, with an estimated 10% of men and 18% of women aged over 60 years being affected by the condition [4]. In the United States, it is estimated that over 14 million people have symptomatic knee osteoarthritis, and this number is expected to increase due to an aging population and rising obesity rates [5].

The epidemiology of knee osteoarthritis is complex, with several risk factors playing a role in its development [6]. These risk factors include age, obesity, genetics, joint injury, and repetitive knee use. Women are also more likely than men to develop knee osteoarthritis, although the reasons for this gender difference are not fully understood.

In terms of treatment, there is currently no cure for knee osteoarthritis, and treatment options focus on managing symptoms and improving function [7]. These options include non-pharmacologic interventions such as exercise, weight loss, and physical therapy, as well as pharmacologic

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such as nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroid injections. In severe cases, surgical interventions such as knee replacement may be necessary.

Taking into account the changes in the functional state of the limb affected by knee osteoarthritis, it is interesting from both a scientific and a practical point of view to study the gait characteristics of such patients.

The aim of the study was to study the differences in gait parameters of healthy and diseased limbs in patients with knee osteoarthritis.

Materials and Methods

The study was conducted in accordance with the main provisions of the Helsinki Declaration of the World Medical Association on the ethical principles of scientific medical research involving human subjects (2000) and the order of the Ministry of Health of Ukraine No.281 dated November 1, 2000. The research protocol was approved by the biomedical ethics committee of National Pirogov Memorial Medical University, Vinnytsya.

The study was conducted on the basis of the Department of Traumatology and Orthopedics and the Department of Neurology with Neurosurgery of National Pirogov Memorial Medical University, Vinnytsya.

As part of the study, 20 patients with knee osteoarthritis were examined. The age of the patients was (62.3±9.1) years.

The diagnosis of knee osteoarthritis was established according to the criteria of the American College of Rheumatology [8].

Gait parameters were studied using the GAITRite® system (CIR Systems Inc., USA) [9].

Due to the peculiarities of our study, we selected the parameters of the GAITRite® system, which allow us to compare the function of healthy and diseased limbs [9]:

1. Temporal Definitions (Step Time, Gait Cycle Time, Single Support, Initial Double Support, Stance);

2. Spatial Parameters and Definitions (Step Length, Stride Length, H-H Base of Support, Toe In / Toe Out).

"Step Time – it is the time elapsed from first contact of one foot to first contact of the opposite foot (sec)" [9].

"Gait Cycle Time – it is the elapsed time between the first contacts of two consecutive footfalls of the same foot (sec)" [9].

"Single Support – it is the time elapsed between the Last Contact of the current footfall to the First Contact of the next footfall of the same foot. It is measured in seconds (sec) and expressed as a percent (%) of the Gait Cycle time of the same foot" [9].

"Initial Double Support – it occurs from heel contact of one footfall to toe-off of the opposite footfall. It is measured in seconds (sec) and also expressed as a percent (%) of the Gait Cycle time for the same foot" [9].

"Stance – it is the time elapsed between the First Contact and the Last Contact of two consecutive footfalls on the same foot. It is presented as a percentage (%) of the Gait Cycle time" [9].

"Step Length – it is measured along the length of the walkway, from the heel center of the current footprint to the heel center of the previous footprint on the opposite foot (cm) " [9].

"Stride Length – it is measured on the line of progression between the heel points of two consecutive footprints of the same foot – left to left, right to right (cm)" [9].

"H-H Base of Support – it is the vertical distance from heel center of one footprint to the line of progression formed by two footprints of the opposite foot (cm)" [9].

"Toe In / Toe Out – it is the angle between the line of progression and the midline of the footprint (degrees)" [9].

The obtained data of instrumental studies were processed statistically using the IBM SPSS Statistics 20.0 application program package. The mean (M) and standard deviation (SD) were calculated. Comparison of parameters of contralateral limbs was performed using the T-test method for repeated measurements.

Results and Discussion

Levels of studied Temporal Definitions and Spatial Parameters and Definitions of healthy and diseased limbs in patients with knee osteoarthritis are presented on the *Fig. 1* and *Fig. 2*.

According to the data of the statistical analysis, it was found that the time of transferring the diseased foot (Step Time) in patients with knee osteoarthritis was statistically significantly ($p=0.044$) greater than the time of transferring the opposite limb, i.e. the support was carried out on the foot of the healthier limb.

In patients, an increase in the duration of the step (Gait Cycle Time) of the healthy limb was noted, in comparison with the duration of the step of the diseased limb. However, due to the significant spread of the parameter (from 0.95 s to 1.82 s), the differences were not statistically significant ($p=0.362$). As for the Single Support parameter, it was also demonstrated that there were no differences ($p=0.941$) between the diseased and healthy limbs.

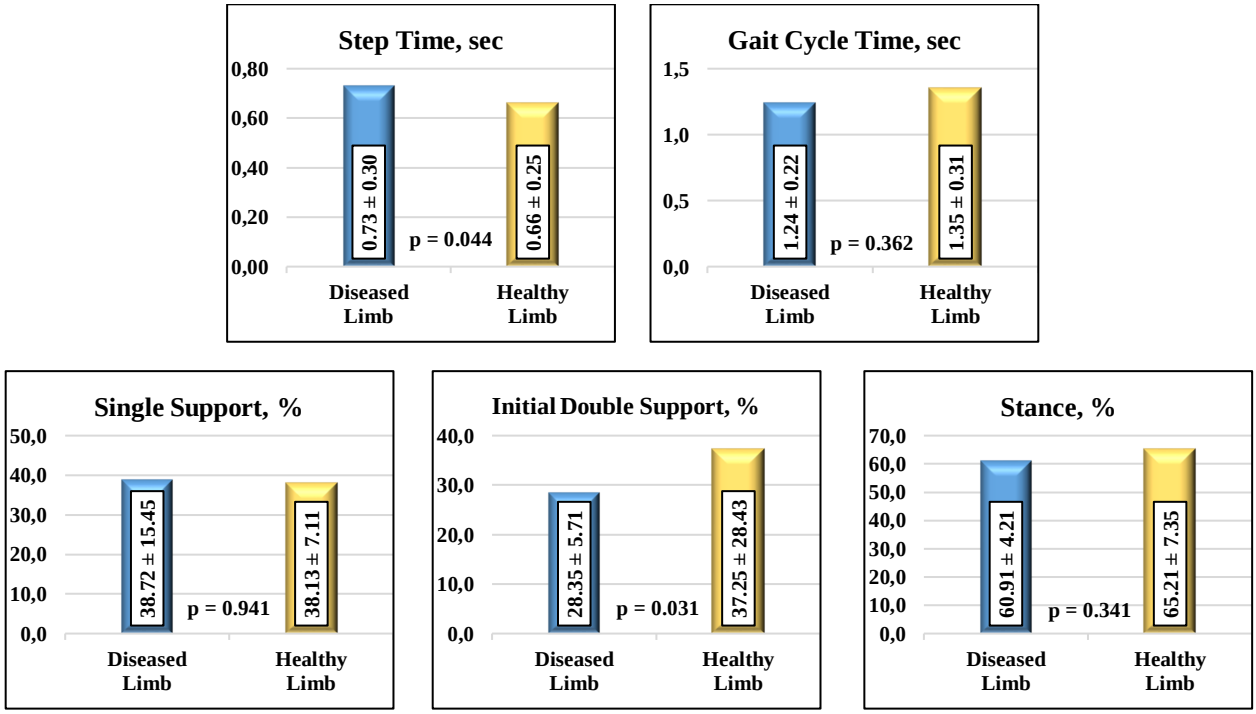

Fig. 1. Levels of studied Temporal Definitions of healthy and diseased limbs in patients with knee osteoarthritis.

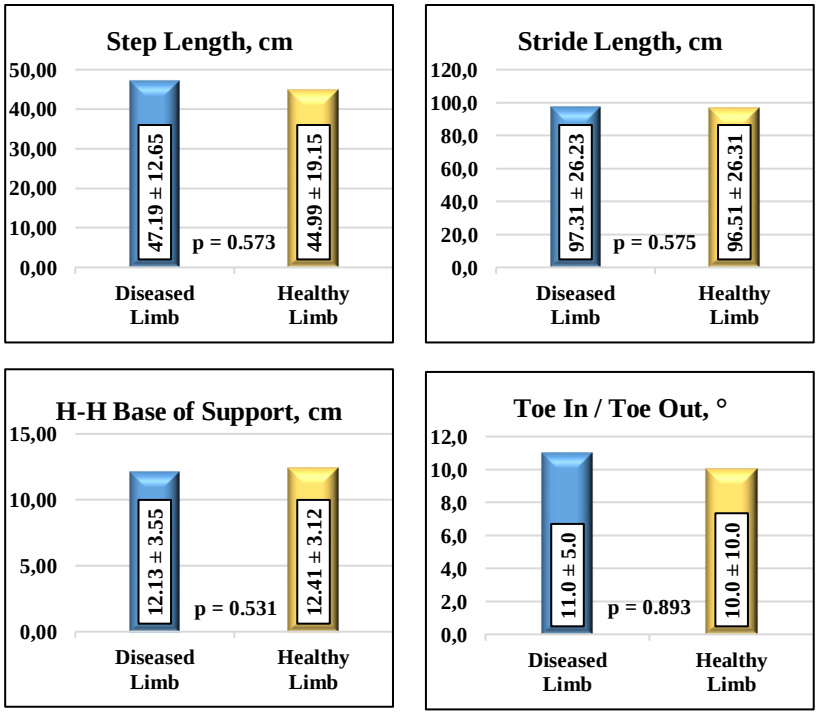

Fig. 2. Levels of studied Spatial Parameters and Definitions of healthy and diseased limbs in patients with knee osteoarthritis.

At the same time, statistical analysis showed that in patients with knee osteoarthritis, the foot support time of the healthy limb and, accordingly, the Initial Double Support indicator statistically significantly (p=0.031) exceeded the similar indicators for the diseased limb.

The study of the Stance indicator revealed that the studied contingent had a noticeable, although

statistically unreliable (p=0.341) decrease in support on the foot of the affected limb. This parameter is indicative due to its ability to determine the supportability of the feet. A decrease in the duration of support on the foot may indicate the presence of discomfort or pain syndrome.

In patients with knee osteoarthritis, although a slight increase in the length of the short step (Step Length) of the diseased limb by (2.11±8.89) cm was noted in comparison with the opposite healthy limb, however, the statistical significance of the differences could not be proven (p=0.573).

A similar picture was observed when studying the Stride Length parameter. In patients it was noted an increase in this indicator by (2.02±8.77) cm for the diseased limb, compared to the healthy one, but these differences were not statistically significant (p=0.575).

Statistical analysis of the parameter H-H Base of Support, or the width of the support, showed that the patients had no difference in the width of the support for both limbs, that is, its symmetry, as evidenced by the absence of statistically significant differences (p=0.531).

In patients with knee osteoarthritis, the foot is turned, mostly outward, which can be explained by additional adaptation to maintain balance while leaning on the limb. Thus, according to the results of the study of the Toe In / Toe Out indicator, the examined patients showed an increased angle of outward turning of the foot to an average of 10°, and this applied to both the diseased and healthy limbs. At the same time, the statistical significance of the differences was not observed (p=0.893).

Gait disorders refer to any deviation from normal gait that affects a person's ability to walk smoothly and efficiently [10; 11]. People with knee osteoarthritis often exhibit a slow, stiff, and uneven gait, which may be due to the different conditions that accompanies the disease.

Gait disorders can have a significant impact on a person's life, leading to reduced levels of physical activity, reduced functionality, and an increased risk of falls and fractures [2; 12; 13]. Some studies have shown that people with knee osteoarthritis and gait disorders are at higher risk of falls that can lead to serious injury. In addition to the physical consequences, gait disturbances can also affect a person's psychological health, causing anxiety, depression, and leading to social isolation.

Gait problems in knee osteoarthritis can be caused by several factors, including pain, joint stiffness, muscle weakness, and joint instability [14–17].

Pain is the most common cause of gait disturbance in knee osteoarthritis [14]. As the cartilage that cushions the knee joint wears out, the bones rub against each other, causing pain and inflammation. Pain can make it difficult for people with knee osteoarthritis to walk normally, resulting in a protective gait that includes slower walking and smaller steps to reduce stress on the knee joint. This gait pattern, also known as antalgic gait, can result in an uneven and stiff gait that can place additional stress on other joints such as the hip and ankle [18].

Joint stiffness is another important factor that may contribute to the development of gait disturbances in knee osteoarthritis [15]. As the disease progresses, the ligaments and muscles around the knee joint weaken, making it difficult to maintain proper position and balance. Stiffness in the knee joint can lead to reduced range of motion, making it difficult to bend the knee and lift the foot. This can result in a slow and shuffling gait with limited ability to lift the foot and push off the ground.

Muscle weakness is another factor contributing to the development of gait disturbances in knee osteoarthritis [16]. As the condition of the knee joint deteriorates, the muscles surrounding the joint may become weak and atrophy. This can lead to reduced muscle strength, making it difficult to maintain body weight and maintain proper gait mechanics. Weakness in the quadriceps is especially common in people with knee osteoarthritis and can lead to difficulty with activities such as climbing stairs and rising from a sitting position.

Joint instability is also an important cause of gait disturbance in knee osteoarthritis [17]. As the disease progresses, the ligaments and muscles around the knee joint weaken, making it difficult to maintain proper position and balance. This can lead to a wobbly, unsteady gait, which can increase the risk of falls and injury. Joint instability can also cause the knee joint to twist or deform, making proper movement difficult.

Summarizing the literature data and results of our study, it can be stated that patients with knee osteoarthritis have a gait disorder in the form of asymmetric steps. Thus, the time of support on the foot decreases, and accordingly, the time of transferring the foot of the diseased limb increases. Changes in the diseased limb are also reflected in the opposite, healthy limb. An effort to increase the speed of movement during the examination causes an increase in movement on a relatively

healthy limb in the form of an increase in the length of the step and a reduction in the time of transfer of the foot of the diseased limb.

Conclusion

In patients with knee osteoarthritis, there is a gait disorder in the form of asymmetry of steps, which is manifested by a decrease in the time of support on the foot, and accordingly, an increase in the time of transfer of the foot of the diseased limb.

In the future, a comparative study of gait parameters before and after knee arthroplasty in patients with knee osteoarthritis is planned.

DECLARATIONS:

Disclosure Statement

The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

Data Transparency

The data can be requested from the authors.

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STUDY OF THE EFFECTIVENESS OF THE EXPERIMENTAL MODEL OF IMMOBILIZATION CONTRACTURES IN RATS

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Abstract

Immobilization contractures are a common complication that can arise following prolonged immobilization of a joint or limb. They occur due to a combination of factors, including muscle atrophy, joint stiffness, and tissue adhesions. The aim of the study was to study the effectiveness of the experimental model of immobilization contractures in rats. The experimental study was conducted on 21 non-linear white male rats aged 6 months. We used 4-week plaster immobilization to evaluate the severity of changes in the knee joints of experimental rats. The immobilization and post-immobilization period in our study lasted 4 weeks each. Every week, the angles of extension and flexion, range of motion and severity of contracture were measured. During the period of immobilization, there was a progressive impairment of the function of the immobilized knee joints of all experimental animals. Thus, at the end of the 4th week of immobilization, the limits of flexion and extension on the immobilized limb gained high statistical significance in comparison with both the opposite intact limb and with 1st week of immobilization. In the post-immobilization period (from the 5th to the 8th week of the study), a progressive recovery of the studied indicators was observed. The indicators of extension and flexion of the limbs after immobilization were significantly differed from the initial values, but were also significantly better than the values at the end of the immobilization period. As for the range of motion, this indicator for both limbs was significantly higher than the values at 4th week of the study, but was also significantly lower than the initial values. Limitation of movements after immobilization was statistically significant both when compared with the opposite limb and when compared with baseline and 4th week of immobilization data. Experimental model of 4-weeks plaster immobilization of the knee joint allows to create a persistent pronounced limitation of movements and can be used for further study of various methods of prevention and treatment of immobilization contractures.

Keywords: *knee joint; immobilization contractures; experiment; rats*.

INTRODUCTION

Immobilization contractures are a common complication that can arise following prolonged immobilization of a joint or limb [1]. They can arise following a range of injuries, including fractures, dislocations, and soft tissue injuries. Immobilization contractures can occur when a joint or limb is immobilized for an extended period, such as in a cast or brace, or as a result of prolonged bed rest. They occur due to a combination of factors, including muscle atrophy, joint stiffness, and tissue adhesions [2].

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It is essential to understand the relevance of this problem, both for patients and for the broader healthcare system. Immobilization contractures can be a significant problem for patients, as they can result in pain, limited range of motion, and reduced function [3; 4]. The severity of this condition can vary, with some patients experiencing only mild stiffness, while others may have severe, debilitating contractures that require surgical intervention [2].

Also it can have a substantial impact on quality of life of patients [5]. They can result in chronic pain, reduced mobility, and a decreased ability to perform daily activities. Immobilization contractures can also have a significant psychological impact, as patients may feel frustrated, anxious, or depressed due to their reduced function and mobility [6].

From a healthcare system perspective, immobilization contractures can be costly to manage.

Such patients may require multiple interventions, including physical therapy, occupational therapy, and sometimes surgical procedures, all of which can be expensive. Moreover, it can result in prolonged hospital stays, which can further increase healthcare costs [7].

Preventing immobilization contractures is crucial to minimizing their impact on patients and the healthcare system. Early mobilization, physical therapy, and range-of-motion exercises can all help prevent the development of this complication [1; 8].

The need to solve this problem dictates the search for an adequate animal model of immobilization contractures, which would be closest in terms of conditions and results to that observed in patients.

One of such models, in our opinion, could be plaster immobilization.

The aim of the study was to study the effectiveness of the experimental model of immobilization contractures in rats.

Materials and Methods

All experiments were performed in accordance with the "Regulations on the use of animals in biomedical experiments" with the permission of the Bioethics Committee and in accordance with Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes". The study protocol was approved by the Committee on Bioethics, National Pirogov Memorial Medical University, Vinnytsya, Ukraine.

The experimental study was conducted on 21 non-linear white male rats aged 6 months. Before immobilization, the angle of extension and flexion of the knee joint was measured for all animals. Immobilization of the hind limb at an angle of 140° was performed by applying a plaster bandage under anesthesia.

To determine the amount of movement in animals, the immobilization bandage was removed once a week, the skin condition was examined and, if necessary, treated with an antiseptic. Markers were placed on the hip, knee and hock joints. To determine the bending angle, the hind limb was maximally bent. To determine the extension, a weight of 50 grams was tied to the hock joint.

The animals were photographed and the angle between the markers on the pictures was measured. A similar procedure was performed for the opposite limb. After the measurements were completed, the immobilization bandage was re-

applied. Measurements were taken at 1-week intervals during the 4 weeks of immobilization and 4 weeks after the end of immobilization.

The range of motion was determined based on these measurements of the extension and flexion angles. Joint contracture was calculated as the difference between the determined range of motion and the range of motion before the start of the experiment for each animal individually.

The obtained data of instrumental studies were processed statistically using the IBM SPSS Statistics 20.0 application program package (USA). The mean (M) and standard deviation (SD) were calculated. Comparison of parameters of contralateral limbs was performed using the T-test method for repeated measurements.

Results and Discussion

The values of the angles of bending and extension, as well as the volume of movements in the knee joints of experimental animals are graphically shown in *Figures 1–3*.

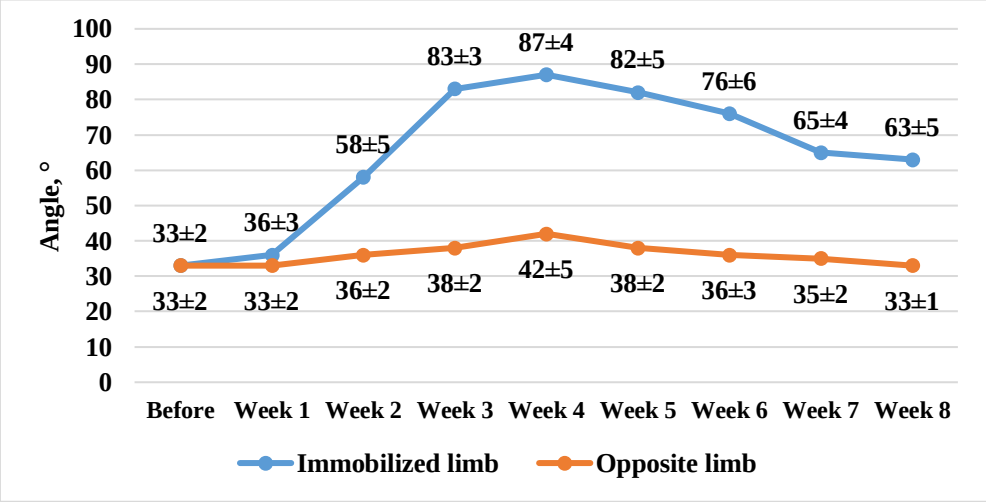

Fig. 1. The value of the angles of maximum extension in the knee joint of experimental animals.

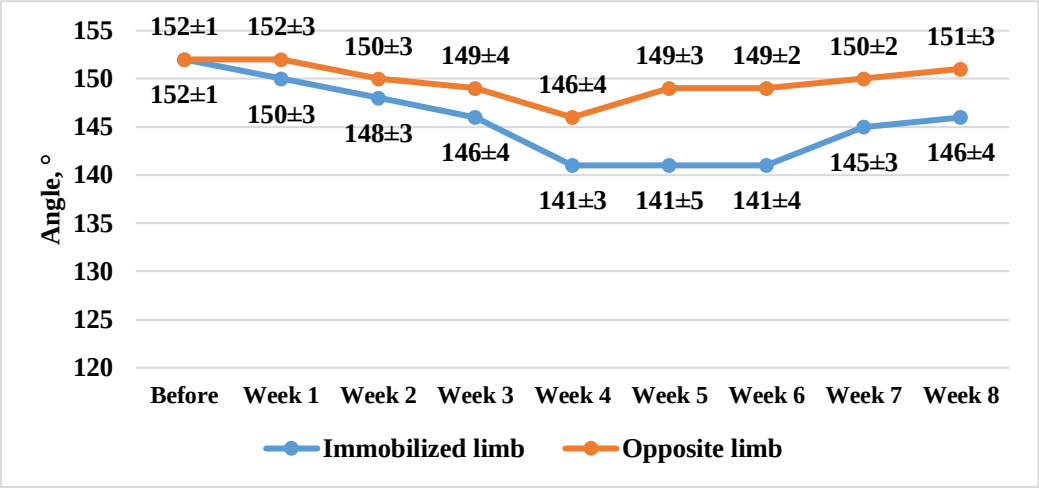

Fig. 2. The value of the angles of maximum flexion in the knee joint of experimental animals.

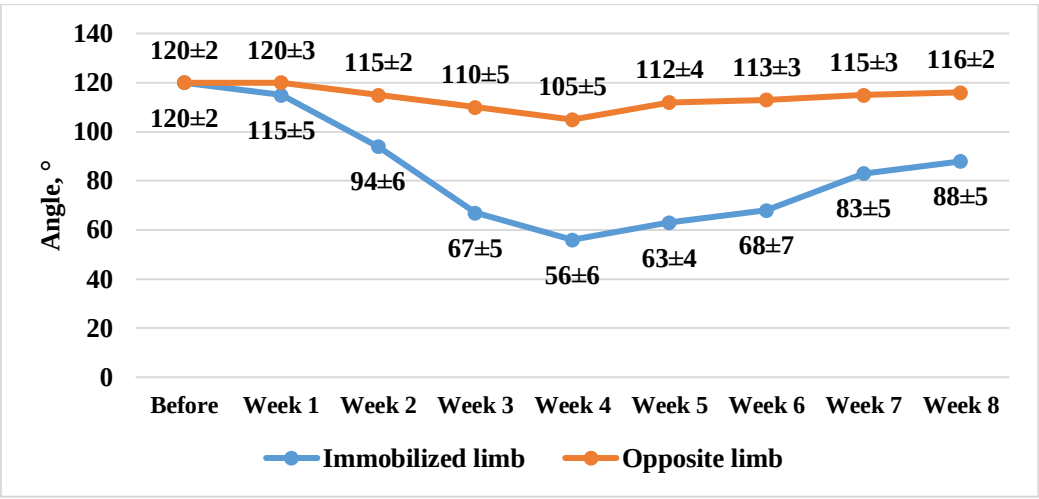

Fig. 3. The volume of movements in the knee joint of experimental animals.

Before the start of the experiment, the range of motion in the knee joint was measured in rats. The results of the statistical analysis showed that all the studied indicators were the same for both knee joints in each of the experimental rats.

At the end of 1st week, flexion ($p=0.024$) and extension ($p=0.010$) limitations of the immobilized limb reached a statistically significant level compared to the contralateral intact limb. The total range of motion of the immobilized limb ranged from 106° to 120° and was statistically significantly ($p=0.002$) different from the values for the intact limb. Contracture during 1st week of the experiment averaged 5° (from 0° to 13°). Moreover, a slight restriction of the range of motion was observed in both knee joints. In comparison with the control values before the beginning of the experiment, there were statistically significant changes in the angle of extension ($p=0.041$), the angle of flexion ($p=0.040$) and the total range of motion ($p=0.011$) of the immobilized joint. At the same time, no significant changes were observed in the opposite knee joint ($p>0.05$).

In general, during the period of immobilization, there was a progressive impairment of the function of the immobilized knee joints of all experimental animals. Thus, at the end of the 4th week of immobilization, the limits of flexion ($p<0.001$) and extension ($p<0.001$) on the immobilized limb gained even greater statistical significance in comparison with both the opposite intact limb and with 1st week of immobilization. A similar tendency was demonstrated by indicators of the volume of movements in the joint. The total range of motion of the immobilized limb ranged from 41° to 67°, for the intact limb – from 93° to 111°. At the same time, the differences were statistically significant ($p<0.001$). Also, statistically

significantly ($p<0.001$), these indicators differed from the indicators before the beginning of the study. Contracture on the 4th week of the experiment was (63±7)° for the immobilized limb and (17±6)° for the intact limb. Movement limitation was statistically significant ($p<0.001$) both when compared between opposite limbs and when compared with baseline data.

In the post-immobilization period (from the 5th to the 8th week of the study), a progressive recovery of the studied indicators was observed both for the immobilized limb and for the intact limb.

Thus, the indicators of extension and flexion of the limbs after immobilization, although significantly ($p<0.001$) differed from the initial values, but were also significantly ($p<0.001$) better than the values at the end of the immobilization period. Indicators of extension and flexion of intact limbs were not significantly different from the initial values ($p>0.05$). As for the range of motion, this indicator for both limbs was significantly ($p<<0.001$) higher than the values at 4th week of the study, but was also significantly lower ($p<0.001$ and $p=0.015$ for immobilized and intact limbs, respectively) than the initial values. Overall range of motion ranged from 79° to 92° for immobilized limbs and from 112° to 120° for intact limbs. The contracture at the 8th week of the experiment was (33±5)° for the immobilized limb and (4±3)° for the intact limb. Limitation of movements after immobilization was statistically significant ($p<0.001$) both when compared with the opposite limb and when compared with baseline and 4th week data. Limitation of movements of intact limbs was significantly ($p<0.001$) lower than the indicators at the 4th week of the study and was not significantly different ($p>0.05$) from the initial data.

The data obtained during the study coincide with the results of other researchers. Thus, in the work of Chimoto et al. [9] immobilization of the knee joints in rats using an internal fixator in a flexion position of 150° was performed. The aim of the study was to develop an animal model of joint contracture to further investigate the progression of arthrogenic limitation of motion after immobilization. The study demonstrated a rapid progression of joint contracture up to 8 weeks. Although our experiment lasted only 4 weeks, we observed the progression of the contracture every week. Similar trends were demonstrated by other authors, in particular Kojima et al. [10].

Regarding the restoration of range of motion after immobilization, according to Trudel et al. [11] complete recovery of joint movements after 30 days of immobilization does not occur even on the 8th week of the post-immobilization period. At the same time, Sato et al. [12] reported a 32-week period required for full movement recovery after joint fixation in rats.

In general, the experimental model of plaster immobilization of the knee joint tested by us allows to create a persistent pronounced limitation of movements and can be used for further study of various methods of prevention and treatment of immobilization contractures.

Conclusion

Experimental model of 4-weeks plaster immobilization of the knee joint allows to create a persistent pronounced limitation of movements and can be used for further study of various methods of prevention and treatment of immobilization contractures.

In the future, it is planned to study various modes of vibration therapy for prevention and treatment of immobilization contractures in the experiment.

DECLARATIONS:

Disclosure Statement

The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

Data Transparency

The data can be requested from the authors.

Statement of Ethics

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Consent for publication

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MUTUAL INFLUENCE OF DIGITAL, LINGUISTIC AND VALEOLOGICAL COMPETENCIES IN HEALTH-SAVING ENVIRONMENT OF HIGHER EDUCATION

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Abstract

Introduction. In the context of distance learning in the sphere of valeology, the significance of university students' gaining computer literacy and English skills can hardly be overestimated. Therefore, it is relevant to organize an integrative learning format within valeological education based on parallel forming both digital and linguistic competencies of students in order to increase the efficiency of training.

Purpose of the study is to analyze the mutual influence of digital, linguistic and valeological competences in the health-saving environment of higher education of Ukraine.

Methods. The system analysis and bibliosemantic methods underlie the research.

Results. Inconsistencies in understanding the content of the studied competencies, which affect the methods of their forming and the evaluation of the learning outcomes, have been identified. Values and levels of formation of digital and linguistic competences in the European Union have been determined. The essence of valeological competence and proposals on the assessment of the levels of this competence formation has been disclosed by the group of Kharkiv researchers. The common characteristics of the assessment of the levels of forming the competences under study have been detected.

Conclusions. It has been ascertained that digital and linguistic competences are necessary for forming university students' valeological competence. The research has proved that gaining utmost effectiveness to that end is enabled through the realization of synergetic principles.

Keywords: *health-saving higher education, valeological competence, digital competence, linguistic competence, university students, distance learning, synergy in joint competences formation.*

INTRODUCTION

Modern higher education in Ukraine is undergoing a severe test due to the COVID-19 pandemic and the armed conflict on its territory. The forced transition from classroom to distance and mixed learning, as well as from distance synchronous to distance asynchronous learning requires all participants of the educational process to be fluent in modern digital technologies [1]. The ability to teach and study effectively in the digital space in modern competence-based education makes up the digital competence [2]. Digital competence is also defined as the expertise in using digital tools and the legal suitability of the specialist for a certain position which excludes doing without digital literacy. Digital competence is also one of the key competences for lifelong learning [3].

It is also difficult to imagine modern education without foreign language training. The complex of knowledge in vocabulary and the ability to apply it in productive (oral and written speech) and receptive (reading and listening) types of speech activity; capability for operating language tools, which requires knowledge of such language elements as phonetic peculiarities; specific character of forming and differential features of grammatical forms and constructions; preparedness and ability to select and understand relevant information from foreign-language texts with the help of key words, descriptors and concepts we define as the linguistic competence. The integrative nature and adaptivity of the virtual information

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environment are largely determined by multilingualism [4]. It is obvious that English is the most widely used language in Ukraine and all over the world. The English-language information space is an important source of knowledge and at the same time an environment for international learning, self-education, and the functioning of digital educational platforms [5]. English is one of six working languages of the United Nations (UN) and the international language of medicine [6; 7], although at the beginning of the 20th century, English, German and French were used equally in medicine [8].

The Ukrainian higher education system is still being reformed. it is relevant to mention that transformation processes were significantly boosted in 2014 when the country totally set a course for a gradual integration in the European and world community [9]. In the context of reforms, the trends in the development of digital and linguistic competences of university students and teachers, the use of the English language for teaching foreign students and constructing a health-saving educational environment remain unchanged [9–11]. New effective methods of forming the valeological competence are being actively searched for [12–18].

Despite the fact that a number of researchers point to the relevance of gaining parallelism of the vectors of forming health-saving and digital competences along with language and digital ones [19–21], up to now there are no works devoted to the concept of simultaneous development of digital, linguistic and valeological competencies in Ukrainian higher education.

Purpose of the study is to analyze the mutual influence of digital, linguistic and valeological competences in the health-saving higher education of Ukraine.

Materials & methods

The research has been carried out using the bibliosemantic method and the method of system analysis. Research papers presented in PubMed and Google Academia, declarations and regulations of the UN, the European Union (EU) and Ukraine have served as research materials for our study.

Results & discussion

The competence-based approach in education has a distinctive feature, namely the understanding of the same competence can be different depending on the area of education (humanitarian or technical, medical or non-medical). This mostly concerns competencies that are not defined in regulatory documents. For example, in the sphere of non-pedagogical sciences, the notion "pedagogical competence" is sometimes narrowed down to the ability to teach is [22], whereas, in fact, this concept means a systemic unity of pedagogical knowledge, experience and personal features of the teacher that enables execution of effective educational activities. Approximately the same thing one can witness in non-medical higher education, when the valeological competence is regarded as a derivative from the medical competence [23]. In view of this, it is relevant to distinguish this competence from other key competences of the medical university graduate, namely diagnostic, curative and preventive ones [24; 25].

According to the Digital Competence Framework for Citizens (DigComp) the digital competence is defined as "confident, critical and responsible use and interaction with digital technologies for learning, professional activity and participation in social life" [3; 26] and since 2006 this competence has been on the list of eight key competences. Digital competence includes knowledge (regarding digital etiquette, copyright, licensing policies data, information and digital content, environmental safety, the impact of digital technologies on human health) and skills (concerning information retrieval, digital content search, communication by means of digital technologies, creating digital content, programming, protecting devices, digital content and personal data from network threats, identifying needs and technical solutions to problems). Environmental protection includes the issue of safe disposing computer equipment. The aforementioned framework is a reference point for bringing Ukrainian legislation in compliance with the EU standards in terms of digitalization.

In the context of our research it is relevant to state that forming the linguistic competence should be realized with due regard for the EU policy of multilingualism, which dates back to the second half of the 20th century, when there was encouraged mastering languages, prompted linguistic diversity in the society, developed a multilingual economy, ensured access to the European legislation and information in various European languages, provided conditions for migrants' intercultural dialogue and labor mobility, etc. In view of this in the course of Ukraine's integration process in the EU, at the national level a broad scientific discussion on unifying the concept of multilingual education is being held.

At present the valeological competence is being formed within distance learning, which is based on digital technologies and skills. And although some authors evaluate distance learning positively [27] (as it is carried out at any time convenient for the student, is flexible and cheap, provides access to a large amount of educational information), others, on the contrary, point out the disadvantages of distance learning compared to the classroom format [28], and especially the weak points of distance asynchronous learning [29]. However, a high level of digital and linguistic competence in any learning environment can improve the process of forming the valeological competence, because teaching valeological disciplines [30–32] is based on the use of digital platforms for distance learning, which facilitate holding web-conferences, making online surveys, watching video materials, working with Ukrainian and English professional terminology in terms of compiling an appropriate glossary, etc.

There are various definitions of the competencies under our study. It is clear that to a certain extent the selection of training methods and correct definition of their essence both the methods forming these competences and the effectiveness of the outcomes of their forming depends on the correct understanding of their essence. We regard the health-saving competence (or the valeological competence) as the ability to lead a healthy lifestyle, practice safe behavior patterns and provide emergency aid in critical situations [33]. Taking into account the fact that the list Ukrainian higher education standards contains a number of health care issues [35], we believe that the valeological competence is mandatory for the graduate of any university in Ukraine. The term "valeological competence" is more typical of scientific-pedagogical literature, whereas in educational standards and other regulatory legal acts of Ukraine, the notion "health-saving competence" is used. The translation of this concept into English also adds variability to the issue of trying to unify this phenomenon (*health saving, health protection, health preserving*) [11; 13; 24; 35]. Health-saving competence is often considered in combination with the ecological competence, and as a component of "ecological-valeological culture" [36; 37]. The spectrum of the concepts of "linguistic culture" and "digital culture" is also broader than the one of the corresponding competencies [38–40]. But the very concept of culture of the university graduate, which must be formed in the course of his/her academic training, raises fewer questions than the list of competencies that must be formed in accordance with education standards. Regardless of whether we are talking about general-, professional-, or corporate culture, its three components – digital, linguistic and valeological ones – look like intuitively understandable parts of a single whole.

A number of interdisciplinary studies on health education also suggest that, ultimately, competence must become a part of the general and professional culture. However, unlike research in the linguistic and digital fields [41], there is still no unified understanding of the content of the valeological competence [13]. So, for example, the concept of multilingualism in Ukrainian scientific space gradually changed to "bilingualism", and after that to the "linguistic competence". Speeding up a similar process of the valeological competence crystallization can be gained through the evaluation of its effectiveness by following the model of assessing the efficiency of forming linguistic and digital competences in accordance with the criteria adopted not only in the EU, but also throughout the world (*Table*): as for foreign languages – according to the standards of the Common European Framework of Reference (CEFR) [43] and in terms of digital capabilities [44, p. 87] there are 6 levels of competence mastery (A1, A2, B1, B2, C1, and C2).

The levels of valeological competence formation are suggested to be determined in accordance with Bloom's taxonomy [44; 45]. It reflects the ability of the individual with formed competences to solve professional and everyday problems at six levels, namely "to remember", "to understand", "to apply", "to analyze", "to evaluate", and "to create". It should be mentioned the important common feature of this scale and the ones of the formation levels of linguistic and digital competences, lies in integration of each previous

Table. Levels of forming linguistic and digital competences according to the EU standards

Competence	Level of competence formation					
	A1	A2	B1	B2	C1	C2
Linguistic, CEFR	Beginner	Elementary	Intermediate	Upper-Intermediate	Advanced	Proficiency
Digital	Newcomer	Explorer	Integrator	Expert	Leader	Pioneer

level in each subsequent one. Another common feature is the definition of the minimum required level in accordance with the conditions for further application of the competence. In view of this, for instance, in some countries, a foreign language proficiency at the C1 level is the minimum required one for admission to a PhD postgraduate course, and B2 – for admission to a master's degree program. Similarly, it is suggested that it is acceptable to achieve the valeological competence formation at the levels of "to analyze" and "to evaluate" for bachelors, and "to create" – for master's degree students.

We have also detected the following regularity: forming any special competence within distance learning format is impossible without a formed digital competence, and is less effective without a sufficient level of linguistic competence formation. In course of studying valeological disciplines, due to working in a digital environment and completing tasks on creating a glossary of professional terms, digital and linguistic competences are being formed in parallel.

Conclusions

Thus, digital and linguistic competences are necessary for forming valeological competence within studying valeological disciplines at the universities of Ukraine. Forming valeological competence is the duty of any university to comply with the requirements of educational standards. Digital, linguistic and valeological competences mutually and synergistically affect each other in the course of studying valeological disciplines, and are also an important part of the professional and general culture of the university graduate.

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The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

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