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ORIGINAL PAPER

Rehabilitation of patients with post-traumatic stress disorder by complementary methods

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ABSTRACT

Introduction. The article analyzes the relationship between stress, post-traumatic stress syndrome (PTSD) and changes in the functioning of the neuroendocrine system.

Aim. Development of a hypothesis and practical evaluation of its effectiveness based on the proposed rehabilitation protocols for patients with post-traumatic stress disorder resulting from psychoemotional stress, based on a multi-level multifactorial approach with the use of transcranial stimulation by pulse currents at the frequency of rhythms of the cerebral cortex, stimulation by light pulses at the frequencies of alpha, beta and theta rhythms of the cerebral cortex in combination with neuroacoustic correction of the neuroendocrine system.

Materials and methods. The study involved 36 men, combatants, aged 28-54 full years, who gave their written consent to participate in the study. In the course of the research at the first stage, a hypothesis was formed about possible options for multifactorial multilevel effects on the central nervous system in order to rehabilitate patients with PTSD.

Results. The implementation of the proposed solution is to increase the efficiency and reduce the time of rehabilitation of PTSD due to a multi-level multifactorial approach:

Conclusion. The results of the study revealed positive dynamics of clinical manifestations in both groups of patients. After analyzing the data obtained (assessment of the quality of life according to the SF-36 questionnaire), it was found that the protocol of rehabilitation of patients with post-traumatic stress disorder is based on the use of a multi-level approach that allows correction.

Keywords. post-traumatic stress disorder, stress-dependent diseases, transcranial electroneurostimulation, light pulse stimulation, neuroacoustic stimulation.

Introduction

According to WHO experts, "Stress is a state of anxiety or mental stress caused by a difficult situation. Stress is a natural reaction of a person, concentrating his attention on problems or threats that arise in everyday life. Everyone experiences a state of stress in relation to one event to varying degrees. However, our overall well-being largely depends on how we react to stress".¹

Any person is subject to stress, regardless of his position in society or material wealth. According to a study by the American Institute of Stress² in the United States, 90% of the adult population is under stress. Of these, 60% experience stress 1-2 times a week, 30% - almost every day and 15% are in a state of acute traumatic stress. At the initial visit to the doctor, in 90% of cases of non-communicable diseases, these are complaints of health disorders associated with symptoms based on psychoemotional tension or stress. Due to constant stress, almost 80% of patients in American clinics are diagnosed with psychoemotional stress, which often flows into mild depression or chronic (accumulated) fatigue. The economic losses of the United States alone from stress and rehabilitation of stress-dependent diseases in 2020-2022 exceeded \$ 410 billion.

Symptoms of stress-dependent diseases very often resemble manifestations of acquired immunodeficiency syndrome: decreased immunity, fatigue, insomnia, anxiety depression, weakness in the morning, "sand" in the eyes, frequent headaches, conflict, a tendency to psychological and social disorders.

Aim

The authors proposed and practically tested a protocol for the rehabilitation of patients with post-traumatic stress disorder (PTSD) resulting from psychoemotional stress, based on the combined use of transcranial stimulation with pulse currents at the frequency of rhythms of the cerebral cortex, light pulse stimulation and neuroacoustic correction of the neuroendocrine system.

Stress increases the likelihood of the occurrence and chronic course of psychosomatic stress-dependent diseases, including in the organs of the neuroendocrine and immune systems. In turn, the body's response to stress, being a stress factor that enhances immunosuppression.² The immune system participates in the stress response either as a functional system that carries out a specific response to stress, or is activated after the nervous and endocrine systems and participates in a non-specific stress response. In case of distress, the immune system, like the whole body, is exposed to damaging factors.³ On the other hand, the stress response of the

neuroendocrine system plays an important role in the formation of autoimmune pathology.^{4,5}

The trend of growth of stress-dependent diseases may lead in the near future to the emergence of a new type of pandemic "Stress syndrome of secondary immunodeficiency – SSSID".

Psychoemotional stress resulting from stress quite often (up to 15%) leads to the emergence of post-traumatic stress disorder.

One of the most common causes of the occurrence and development of PTSD are functional disorders of the hypothalamo-pituitary system (HPS), resulting from physiological or psychoemotional stress.

The peripheral branches of the stress system classically include: the hypothalamic-pituitary-adrenal system (HPAS), the sympathoadrenal system (SAS) and the parasympathetic nervous system (PNS).

In response to the psycho-emotional stress of the hypothalamic-pituitary-adrenal system, the SAS provides short-term protective reactions of the body. At the second stage, the function of the GGS itself increases, potentiating and supplementing the body's defense mechanisms. At the third stage, other departments of the endocrine system that produce somatotrophic hormone (STH), thyroid hormones T3, T4, parathyroid hormone, vasopressin, renin-angiotensin system participate in ensuring and maintaining the effects of CAC and HGS. SAS performs ergotropic restructuring of body functions. Under the influence of first SAS, and then glucocorticoids, STH and thyroid hormones, the following changes in metabolic processes occur: activation of glycogenolysis and then gluconeogenesis, which provides hyperglycemia; activation of lipolysis and an increase in the amount of free fatty acids; reduction of protein biosynthesis and an increase in protein breakdown, which leads to an increase in the concentration of amino acids, sodium and calcium in the blood due to osteolysis.^{6,7}

Schematically, this process can be represented in the form of a diagram shown in Fig. 1.

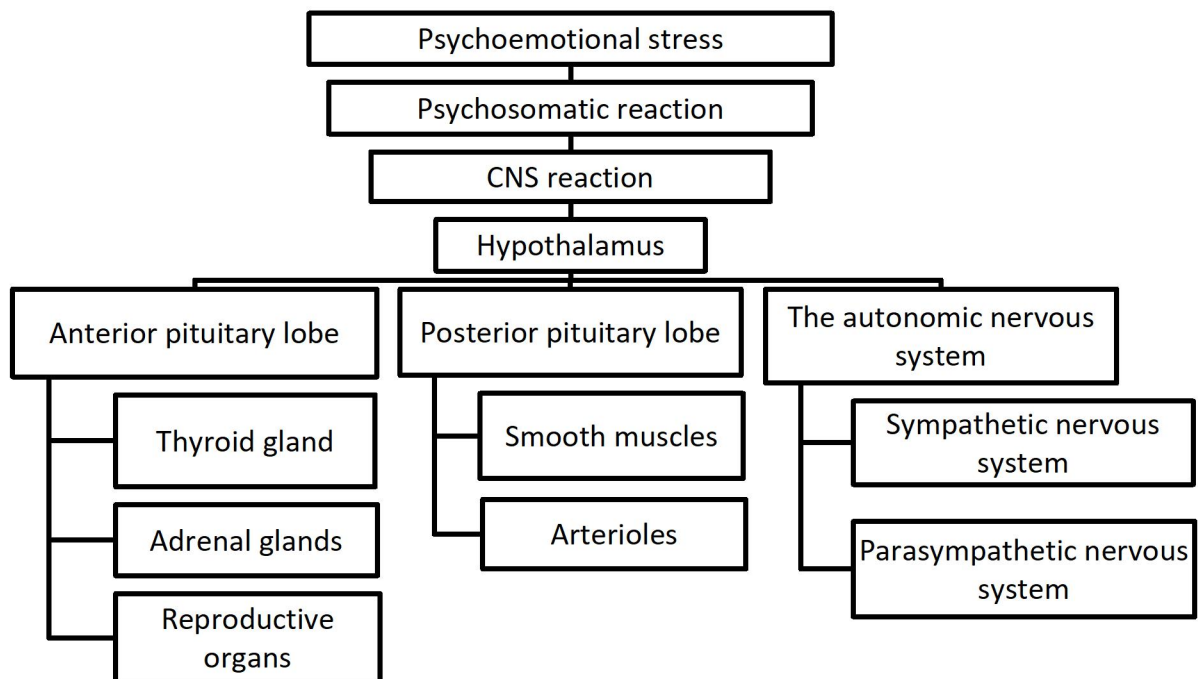


Fig. 1. Scheme of PTSD development.

This material illustrates the systemic pathogenesis of PTSD. Accordingly, the restoration of this function should also be carried out on the basis of a systematic multilevel approach using methods of correction of the

psychological state (elimination of the stress factor), as well as restoration of the functions of the central nervous, hormonal and immune systems. According to the indications, it is additionally necessary to conduct cognitive motivational therapy.

The authors proposed and practically tested a method of rehabilitation of patients with post-traumatic stress disorder resulting from psychoemotional stress, based on the combined use of transcranial electroneurostimulation, light pulse and neuroacoustic stimulation of the brain, taking into account the selection of individual parameters of stimulation, taking into account the psychoemotional reaction of the patient to light pulse stimulation.

Materials and methods

Ethical approval

Verification of compliance with ethical standards in patients is carried out in accordance with the provisions of the Helsinki Declaration of 1975, revised and supplemented in 2002, and the directive of the National Committee on Research Ethics. The research protocol was approved by the Ethics Committee of Shupyk National Healthcare University of Ukraine (Protocol No. 07/12/19-1 of 07.12.2019). During the tests, informed consent was obtained from all participants and all measures were taken to ensure the anonymity of participants.

The study involved 36 men, combatants, aged 28-54 full years, who gave their written consent to participate in the study.

In the course of the work at the first stage, a hypothesis was formed of possible variants of multifactorial multilevel effects on the central nervous system in order to rehabilitate patients with PTSD. In the second stage, a protocol for the rehabilitation of patients of this group was developed and methods of empirical research were applied: assessment of the condition of a patient with post-traumatic stress disorder after performing transcranial stimulation with pulse currents at the frequency of rhythms of the cerebral cortex, stimulation with light pulses at the frequencies of alpha, beta and theta rhythms of the cerebral cortex, in combination with neuroacoustic correction of the neuroendocrine system based on a comparison of the results of patient's condition during treatment based on drug rehabilitation protocols and based on the proposed technology. The comparison was carried out on the basis of the SF-36 questionnaire, psychometric tables A.Beck and Spielberger-Khanin.

Participants

The object of clinical and physiological observation were patients undergoing rehabilitation (36 men aged 28-54 full years) with a diagnosis of PTSD and who gave written consent to participate in the study.

Design and procedure of the study

The authors conducted clinical observations of the rehabilitation of patients with post-traumatic stress disorder using a multilevel multifactorial approach based on the combined use of electroneurostimulation, light pulse and neuroacoustic stimulation⁸⁻¹¹ using three levels of exposure:

1. Correction of the psychological state based on improved communication between the right and left hemispheres of the brain using transcranial electroneurostimulation by bipolar impulses. To do this, the

electrodes of the ELITE-1 apparatus were installed on the projection of the temporal artery on the left and right sides. The pulse repetition frequency was 88 Hz, the pulse repetition frequency was 8.1 Hz,⁷ the pulse duration was 1 ms, the voltage amplitude was set in the range from 6 V to 20 V until a slight tingling appeared in one of the electrode overlay sites.

2. Correction of functioning of elements of the neuroendocrine system. The procedure was performed by light pulse stimulation using the WIT-MT "TARA" apparatus. Light pulse stimulation was performed at an individual therapeutic frequency in the visible range of the electromagnetic radiation spectrum.

Parameters of light pulse stimulation: In the device WIT-MT "TARA", the pulse repetition rate was selected individually according to the Samosyuk-Chukhraev method.⁷ In most patients, it was (8.0 ± 0.7) Hz. The power of the optical flow of the red spectrum (0.63 microns) was 30 MW, the power of the optical flow of the blue spectrum (0.45 microns) was 25 MW.

3. Correction of the hippocampus, amygdala and hypothalamic-pituitary system by neuroacoustic stimulation in combination with cognitive psychotherapy using the device WIT-MT "TARA".

Binaural stimulation was performed at a frequency of 80 Hz for the left channel. The frequency of the right channel was determined as the sum of the frequency of the left channel and the individual therapeutic frequency obtained as a result of the study. The determination of the individual therapeutic frequency was carried out by the Samosyuk-Chukhraev method.⁷ In all patients who participated in the study, it was (8.0 ± 0.7) Hz. Additionally, an audio file with elements of cognitively motivated psychotherapy or relaxing music was played.

Rehabilitation using combined exposure at all 3 levels was carried out for 20 minutes, the rehabilitation course was 12 procedures, the procedures were carried out 3 times a week.

A group of 36 patients aged (37 ± 8) years with an established diagnosis of PTSD lasting more than 6 months and who gave written consent to participate in clinical observations was selected for clinical trials. The study participants were randomly divided into 2 groups of 18 patients. The studies were conducted in a certified medical center of Ukraine's Ministry of Internal Affairs.

In the first (control) group, drug treatment was carried out according to an approved protocol with additional cognitively motivated psychological correction.

In the second group, treatment was carried out according to the method proposed by the authors using multilevel multifactorial exposure at three levels.

As a result of rehabilitation carried out on the basis of the protocol approved by the Ministry of Health of Ukraine (control group), 18 patients successfully underwent rehabilitation within 4 weeks.

As a result of rehabilitation according to the protocol proposed by the authors (the second group), 18 patients underwent successful rehabilitation within 4 weeks.

The clinical observation model included an assessment of the level of depression and an assessment of the quality of life according to the extended SF-36 questionnaire,⁷ in which an assessment of the level of depression and sleep quality was additionally introduced.

Statistical analysis

Statistical processing was carried out using the software package "Microsoft Excell" and "Statistica 6.4 StatSoft Inc" (Tulsa, Oklahoma, USA).

The results of statistical processing of the results are shown in Fig. 2 and Fig. 3.

Results

The result of the implementation of the protocol of rehabilitation of patients proposed by the authors is to increase the effectiveness and reduce the time of social adaptation of PTSD patients due to the multilevel approach of the multifactorial approach:

1. Correction of the psychological state based on improving the connection between the right and left hemispheres of the brain using transcranial electroneurostimulation by bipolar impulses at the frequency of rhythms of the cerebral cortex.

2. Correction of the rhythms of the elements of the neuroendocrine system by the method of light pulse stimulation at an individually selected frequency of modulation of the optical flow by the Samosyuk-Chukhraev method, providing a state of relaxation of the patient.

3. Assessment of the quality of life of patients (SF-36) who participated in the study:

3.1. Physical functioning (FF) – at the beginning of rehabilitation in the first group there were 58 points, in the second – 59 points. After rehabilitation measures in the first group, this indicator was 63 points, in the second group - 75 points.

3.2. Role-based functioning due to physical condition (Role-Physical Functioning – RP) – at the beginning of rehabilitation in the first group was 56 points, in the second – 58 points. After rehabilitation in the first group, this indicator was 67 points, in the second group 81 points.

3.3. General Health (General Health – GH) – assessment of the patient's health at the time and after the rehabilitation measures. At the time of the start of rehabilitation, the general health of patients was estimated at 44 and 47 points, respectively, after the rehabilitation course, the assessment of the general health, according to the study participants, was 62 points in the first group and 82 points in the second group. The lower the score on this scale, the lower the health assessment.

3.4. Vital activity (Vitality – VT) implies a feeling of full strength and energy or, conversely, fatigue. Before the rehabilitation measures, the general condition of the patients' vital activity was estimated at 43 and 44 points, respectively, after the rehabilitation course, the subjective assessment of vital activity, according to the study participants, was 75 points in the first group and 89 points in the second group. Low scores indicate a decrease in vital activity.

3.5. Social Functioning (Social Functioning - SF), is determined by the degree to which a physical or emotional state restricts social activity (communication). Before rehabilitation, the social functioning of patients was assessed at 53 points, after the rehabilitation course, the assessment of social functioning, according to the study participants, was 64 points in the first group and 82 points in the second group. Low scores indicate a significant restriction of social contacts, a decrease in the level of communication due to the deterioration of psychological and emotional state.

3.6. Role-based functioning due to emotional state (role-emotional - RE) involves an assessment of the degree to which the emotional state interferes with the performance of work or other daily activities (including time-consuming, reduces the amount of work, reduces its quality, etc.). Before the rehabilitation measures, the role-based functioning of patients was assessed at the level of 42 and 41 accordingly, after the rehabilitation course, the assessment of role functioning, according to the study participants, was 57 points in the first group and 79 points. points in the second group. Low indicators on this scale are interpreted as a restriction on the

performance of daily work, due to the deterioration of the emotional state.

3.7. Mental health (Mental Health — MOH), characterizes the mood of depression, anxiety, a general indicator of positive emotions. Before rehabilitation, the mental health of patients was assessed at 41 and 42 points, respectively, after the rehabilitation course, the assessment of mental health, according to the study participants, was 71 points in the first group and 85 points in the second group. Low indicators indicate the presence of depressive, anxious experiences, mental disorders.

4. All the patients who participated in the study had an improvement in mood after the procedures, a decrease in the level of depression and anxiety according to the psychometric tables of A.Beck and Spielberger-Khanin, respectively. There were no negative effects after the procedures in patients. All patients were happy to take part in the testing and subsequent discussion of their psychological problems. The patients of the second group were the most active. Almost all patients wanted to participate in psychosomatic correction. Individual selection of the parameters of light pulse stimulation caused an additional positive reaction in almost all patients of the 2nd group. The results of determining the psychological state of patients are presented in Fig. 2 and Fig. 3.

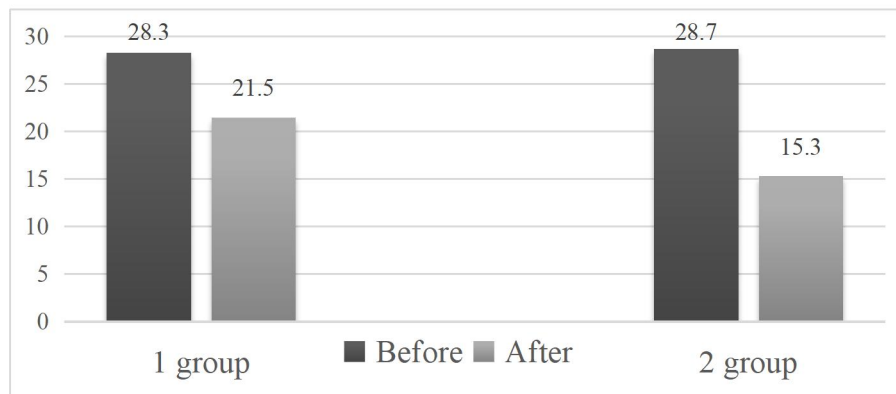


Fig. 2. Changes in the level of depression in patients of groups 1 and 2 (on the scale of A. Beck)

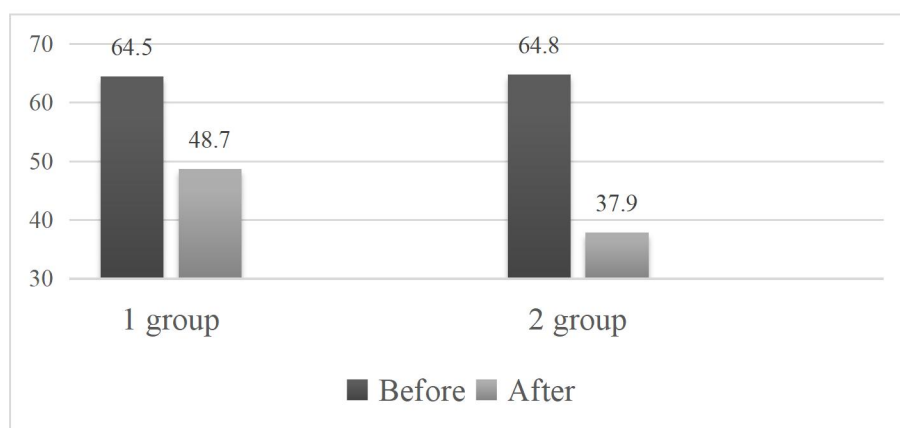


Fig. 3. Changes in the level of anxiety in patients of groups 1 and 2 (on the Spielberger-Hanin scale)

Discussion

In the process of planning and conducting the study, the authors hypothesized a systemic reaction of the

body to a severe stress state, respectively, and the approach to the treatment of this type of disease should be systemic or multilevel. With this in mind, the authors proposed simultaneous transcranial electroneurostimulation of the cerebral cortex by pulsed current at the frequency of rhythms of the cerebral cortex, based on improving the relationship between the right and left hemispheres of the brain, light pulse stimulation of visual analyzers at individually selected optical flow modulation frequencies (alpha, beta and theta rhythms of the cerebral cortex), providing a state of relaxation the patient, in combination with neuroacoustic correction of the state of the hippocampus, amygdala and hypotolamo-pituitary system.^{12,13}

Almost all patients of the second group already after 2-3 procedures felt a significant improvement in their condition, a decrease in the acuity of visual and sound hallucinations, an increase in the period between the onset of seizures. Most of them have improved their relationship in the family and their social adaptation has improved, and the process of falling asleep and sleep phases has improved. All patients were happy to visit the medical office for medical procedures and expressed a desire to undergo a second course of rehabilitation according to the protocols developed by the authors.¹⁴

However, the small number of patients who participated in the studies and the lack of analysis of long-term results do not yet allow us to talk about the widespread implementation of the proposed protocol for the rehabilitation of PTSD patients for mass implementation. The authors suggest conducting more extensive studies in the near future and analyzing the long-term results of rehabilitation.¹⁵

The article presents a comprehensive approach to rehabilitating patients with post-traumatic stress disorder (PTSD) resulting from psychoemotional stress. This approach combines transcranial electroneurostimulation, light pulse stimulation, and neuroacoustic stimulation. The study involved 36 male combatants aged 28-54 years, and the results were evaluated based on changes in their psychological state, quality of life, depression levels, and anxiety levels. Here is a discussion of the key points raised in the article:

Multifactorial Approach to PTSD: The study recognizes the multifaceted nature of PTSD and the need for a multilevel approach to address its various aspects. By combining different techniques, the authors aim to provide comprehensive rehabilitation.

Transcranial Electroneurostimulation: This technique targets the connection between the right and left hemispheres of the brain. Improved brain hemisphere communication can potentially help patients better manage stress and emotional responses. However, the article lacks detailed information on the specific mechanisms involved in this process.

Light Pulse Stimulation: The use of light pulses at specific frequencies is an interesting approach to relaxation and stress reduction. The article mentions individualized selection of stimulation parameters, which suggests a tailored treatment approach. However, it would be helpful to include more information on how these parameters are determined and their physiological effects.

Neuroacoustic Stimulation: This technique aims to correct the functioning of the hippocampus, amygdala, and hypothalamo-pituitary system. These brain regions are known to be involved in the stress response. While the article mentions neuroacoustic stimulation, it does not provide details on the methodology or specific frequencies used.

Study Participants: The study involved a relatively small sample size of 36 participants. For broader applicability and generalization of results, larger-scale studies would be necessary. Additionally, information on the demographics and PTSD severity of the participants would be valuable.

Comparative Analysis: The article compares the outcomes of the proposed rehabilitation protocol with a control group that received drug treatment and psychological correction. It reports positive changes in the quality of life, depression levels, and anxiety levels in the group undergoing the proposed protocol.

Long-Term Effects: The article mentions the need for further research and long-term analysis of rehabilitation outcomes. Understanding the durability of the observed improvements is crucial for assessing the effectiveness of the proposed protocol.

Ethical Considerations: The study emphasizes the importance of obtaining informed consent from participants and ensuring ethical standards are met. This is a crucial aspect of research involving human subjects.

Recommendations: The authors recommend further extensive studies and the potential use of their protocol in specialized centers. While the results are promising, it's essential to validate the findings through larger-scale research before widespread implementation.

Conclusions

The results of the study revealed positive dynamics of clinical manifestations in both groups of patients. After analyzing the data obtained (assessment of the quality of life according to the modified SF-36 table), it was found that the protocol of rehabilitation of patients with post-traumatic stress disorder proposed by the authors based on the application of a multilevel multifactorial approach allows for correction:

1. Psychological state based on improved communication between the right and left hemispheres of the brain using transcranial electrostimulation by bipolar impulses.
2. The work of elements of the neuroendocrine system.
3. Hippocampus, amygdala and hypothalamo-pituitary system by neuroacoustic stimulation.
4. According to the results of a study of psychological testing using psychometric tables, A.Beck and Spielberger-Khanin showed a decrease in the average level of depression after the procedures in the first group by 7.8 ± 1.1 points, the level of anxiety by 15.8 ± 1.7 , in the second group by 18.1 ± 1.7 and 26.8 ± 0.4 , respectively. Additionally, it should be noted that the patients of the second group were more interested in conducting a repeat course.
5. The technology proposed by the authors can be recommended for conducting extended studies on the rehabilitation of patients with PTSD with the possibility of its use in specialized centers and at all stages of the rehabilitation of patients with PTSD.

In conclusion, the article presents an innovative approach to rehabilitating patients with PTSD, incorporating various stimulation techniques to address different aspects of the disorder. While the preliminary results are encouraging, further research and analysis are needed to confirm the long-term effectiveness and safety of this protocol. Additionally, more details on the specific methodologies used for each stimulation technique would enhance the article's comprehensibility and usefulness to the scientific community.

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Declarations

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Author contributions

Conceptualization, I.P.; Methodology, I.P., O.V.; Software, I.P. and W.Z.; Validation, I.P. and W.Z.; Formal analysis, I.P. and W.Z.; Consequence, V.F., H.K., I.B., O.V., I.K., O.L. and T.S.; Resources, WZ; Data curation, I.P. and W.Z.; Writing – preparation of the original draft, I.P. and W.Z.; Writing – reviewing and editing, I.P., O.V. and W.Z.; Visualization, I.P. and W.Z.; Supervision, I.P. and W.Z.; Project Administration, I.P. and W.Z.; Attraction of financing, V.F., H.K., I.B., O.V., I.K., O.L. and T.S.

Conflicts of interest

The authors declare that there is no conflict of interest.

Data availability

The data sets used and/or analyzed in the course of the conducted research are available to the corresponding author upon reasonable request.

Ethics approval

The research protocol was approved by the Ethics Committee of Shupyk National Healthcare University of Ukraine (Protocol No. 07/12/19-1 of 07.12.2019).

In the process of rehabilitation, the optimal terms of rehabilitation were determined on the basis of the protocols proposed by the authors – 12 procedures with a frequency of 3 times a week. The total rehabilitation time in both groups was 14 days. All patients who participated in the study were asked to undergo a second examination and a course of procedures after 2 months.

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