

# Acta

# Balneologica

Published since 1905



JOURNAL OF THE POLISH  
BALNEOLOGY AND PHYSICAL  
MEDICINE ASSOCIATION

ISSN 2082 - 1867

2024 NOVEMBER-DECEMBER VOL. LXVI ISSUE 6 (184)

● HEALTH-RESORT MEDICINE ● PHYSICAL MEDICINE ● BIOCLIMATOLOGY

- Assessment of hand function in patients with systemic sclerosis based on physiotherapy examination after 2 years of rehabilitation
- Formation of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities
- Hydrogen sulphide and sulphide waters in the light of latest research reports
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Aluna Publishing

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ALUNA Publishing  
29 Z.M. Przesmyckiego St.  
05-510 Konstancin Jeziorna, Poland  
[www.actabalneologica.pl](http://www.actabalneologica.pl)

**PROJECT COORDINATOR:**

MEDDOM PRESS  
tel. 604-208-453  
[barbadom@wp.pl](mailto:barbadom@wp.pl)

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PHU Piotr Dobrzyński,  
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The journal is indexed in Web of Science – ESCI (IF 0.3), Index Copernicus, EBSCO,  
Ministry of Science and Higher Education and the Polish Medical Bibliography

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# Acta Balneologica

bimonthly journal

[www.actabalneologica.pl](http://www.actabalneologica.pl)

The journal „Acta Balneologica” is cofinanced under Contract No.RCN/SN/0715/2021/1 by the funds of the Ministry of Science and Higher Education

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# Peculiarities of stress disorders manifestation in armed conflict participants and directions of their social and psychological rehabilitation

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## ABSTRACT

**Aim:** The aim is to investigate the peculiarities of post-traumatic stress disorder (PTSD) in armed conflict participants and to substantiate the directions of their social and psychological rehabilitation.

**Materials and Methods:** The research involved 100 armed conflict participants of the russian-Ukrainian war of 2022-2024 (men aged 23 to 54). Research methods included bibliosemantic, medical and sociological (interviews, questionnaires), and statistical methods.

**Results:** It has been found that the majority of armed conflict participants (66%) have a high degree of PTSD manifestation, the main symptoms of which are headache (96.9%); sleep disturbance (69.7%); depression (74.2%); increased fatigue (62.1%); stomach cramps (59.1%); constant anxiety (68.2%); "paranoid" phenomena (45.5%); constant feeling of fear (71.2%); lack of self-confidence (65.2%); aggression (51.5%); substance abuse (30.3%); sense of guilt (27.3%); signs of hallucinatory experiences (24.2%); rage attacks (15.2%). The majority of soldiers (45%) avoid any talk about traumatic events and choose "avoidance" as a defense mechanism. The technology of social and psychological rehabilitation of armed conflict participants with PTSD manifestations has been substantiated, which has the aim, tasks, stages, methods, principles, and techniques.

**Conclusions:** It has been found that partnership and cooperation are key to implementing rehabilitation impact, which should involve the armed conflict participant himself in the recovery process. Individualization and consideration of each person's adaptive capacities, as well as the participation of commanders, medical personnel, psychologists, and fellow soldiers, are important elements of successful rehabilitation.

**KEY WORDS:** post-traumatic stress disorder (PTSD), stress, mental health, physical health, armed conflict participants, social and psychological rehabilitation

Acta Balneol. 2024;66(6):373-378. doi: 10.36740/ABAL202406101

## INTRODUCTION

War is not only about explosions, shelling, and sirens, but above all, it is a very strong pressure on the human psyche. The war in Ukraine has fundamentally disrupted the sense of security and led to stress, the psychological consequences of which can be dangerous for the healthy future of both military personnel and civilians. Traumatic experiences can lead to the development of post-traumatic stress disorder (PTSD) [1, 2]. This problem is especially acute for armed conflict participants.

According to scientists [3], many combatants may experience symptoms of depression, anxiety, or an acute reaction to combat stress or combat trauma, depressive reactions, and generalized anxiety disorder after their first stay in the combat zone. Many of them need the help of specialists – psychologists, psychiatrists, psychotherapists – as they are at a higher risk of developing PTSD. Experts say that between 20% and 40% of armed conflict participants need psychological help. Symptoms of acute trauma are

detected by 60-80% of soldiers who witnessed the deaths of their comrades-in-arms or civilians or saw the bodies of the dead [4]. Younger soldiers aged 18-24 who have symptoms of depression or have had problems with alcohol are at higher risk of developing mental health symptoms [5]. According to experts [6], more than 30% of participants in the russian-Ukrainian war have PTSD, and this trend is worsening. These are those who suffered combat trauma but did not seek psychological help for fear of being rejected for showing weakness or threatening their military career.

The relevance of studying the peculiarities of the manifestation of post-traumatic stress disorders in armed conflict participants and substantiating the directions of their social and psychological rehabilitation is due to the serious challenges that arise as a result of the mental and emotional consequences of war. Soldiers who have experienced stressful situations and traumatic events often face various difficulties in adapting to everyday life after returning from combat. PTSD can significantly affect

both the mental and physical health of armed conflict participants, family and team relationships, and their general condition [7, 8]. Research in the field of social and psychological rehabilitation of armed conflict participants with PTSD is important for developing effective strategies and interventions aimed at improving their mental and physical conditions and returning to a full life and harmonious integration into society.

## AIM

The aim is to investigate the peculiarities of post-traumatic stress disorder (PTSD) in armed conflict participants and to substantiate the directions of their social and psychological rehabilitation.

## MATERIALS AND METHODS

The research involved 100 armed conflict participants of the Russian-Ukrainian war of 2022-2024 (police officers of Kyiv and Lviv oblasts who were treated in the medical and psychological rehabilitation departments of the State Institution referred to as "Main Medical Center of the Ministry of Internal Affairs of Ukraine" and the Lviv Oblast Clinical Psychoneurological Hospital). The sample population included only men aged 23 to 54 years. The number of people who had been in the combat zone for 12 months or more was 65%; from 9 to 12 months – 19%; from 6 to 9 months – 10%; from 3 to 6 months – 5%; and up to 3 months – 1%. The study did not consider armed conflict participants' education, religious characteristics, income level, or political beliefs. The results were processed at the Department of Legal Psychology of the National Academy of Internal Affairs (NAIA, Kyiv, Ukraine) and Department of Theoretical Psychology and Department of Practical Psychology of the Lviv State University of Internal Affairs (LSUIA, Lviv, Ukraine).

Research methods included bibliosemantic, medical, sociological (interviews, questionnaires), and statistical methods. The bibliosemantic method was used to analyze scientific literature to determine the state of research on the problem raised in the article and ways to solve it. (22 sources from PubMed, Scopus, Web of Science, Index Copernicus and other databases were analyzed). Interviews with armed conflict participants were conducted orally to find out the consequences of the traumatic events they experienced during the war. The questionnaire method involved surveying soldiers using a questionnaire developed by the author's team. The questionnaire contains 30 questions, that are aimed at studying the signs of PTSD in armed conflict participants, the frequency of their manifestation, their severity at the psychological, physiological, and cognitive-analytical levels, and the prevailing types of reactions. The questionnaire was anonymous, which helped to increase the accuracy of the formulated conclusions. The questionnaire was assessed by the experts in this field (3 professor and 5 associate professors) and was approved by the Academic Council of NAIA (Protocol No. 4 dated 03.10.2022). Consent to voluntary participation in the survey was obtained from all respondents involved in the study. Data collection,

processing, and analysis were performed on a personal computer using MS Excel, a software package that can use statistical data processing methods. The procedure for organizing the study and the topic of the article were previously agreed with the committee on compliance with Academic Integrity and Ethics of the NAIA. Also this study followed the regulations of the World Medical Association Declaration of Helsinki. Informed consent was received from all participants who took part in this study.

## RESULTS

The results of the survey indicate that among the studied contingent, there are people with mild signs of PTSD (15%) and people with moderate signs (19%). The highest level of severity of PTSD symptoms was found in 66% of armed conflict participants. They have the highest severity of such symptoms as headaches (96.9%), sleep disturbances (69.7%), and depression (74.2%). Sleep disturbances include difficulty falling asleep, intermittent sleep, nightmares, and fear of falling asleep due to fear of repeating past events. The second most common is general anxiety, which manifests itself at the physiological level (increased fatigue (62.1%), backaches (54.5%), stomach cramps (59.1%), muscle pain (46.9%)), in the mental sphere (constant anxiety and concern (68.2%), "paranoid" phenomena (45.5%)) and in emotional experiences (constant feeling of fear (71.2%), self-doubt (65.2%), guilt complex (53.0%)). The third most common are high levels of aggression (51.5%) and unmotivated vigilance (43.9%). This aggression can be manifested as physical force, as well as mental, emotional, and verbal aggression. Soldiers displaying these signs of PTSD often pay excessive attention to potential dangers and are ready to react quickly to avoid risk. Other characteristic features of PTSD include substance and medication abuse (30.3%), intrusive memories, and a sense of guilt (27.3%). Signs of hallucinatory experiences were detected in 24.2% of the subjects, rage attacks are characteristic of 15.2% of the respondents, and drugs, especially alcohol, often cause them.

The analysis of the predominant types of reactions (avoidance, physiological excitability, or intervention) in armed conflict participants using the Traumatic Event Impact Assessment Scale showed that the dominant type of reaction is the "avoidance" defense mechanism, which was found in 45% of the subjects. Soldiers with this defense mechanism have a loss of interest in previously interesting things, feelings of detachment and alienation, apathy, and lack of plans for the future. The subjects with this mechanism are also characterized by impaired memory and concentration, increased aggressiveness, and unmotivated outbursts of anger, which often lead to rage attacks. They feel a need for isolation and a lack of interest in previous values. 33% of the study participants showed such a reaction as "interference." This defense mechanism was manifested by limited emotional involvement in the current situation, decreased interests, and a lack of prospects for the future. The subjects often experienced nightmares, obsessions, images, and thoughts related to the traumatic event. "Physiological excitability" was detected

in 22% of the study participants. Symptoms of this type of reaction to a traumatic event included difficulty falling asleep (insomnia), increased irritability, problems with concentration, outbursts of anger and explosive reactions, unmotivated tension, and readiness for a "flight response." For most armed conflict participants, this led to an increase in alcohol consumption, a decrease in the level of positive emotions, their "burnout," and "blockade."

It has been found that 56% of the soldiers assessed their general physiological condition as good, 25% – as satisfactory, and 19% – feel unsatisfactory and have significant physical health problems. In the area of functional indicators, the highest percentage of detected disorders is sleep problems – 41% (poor falling asleep, nightmares, intermittent sleep, periodic insomnia). Cardiovascular disorders are also prevalent, accounting for 28% (heart palpitations and unstable heart rhythm). In 14% of the respondents, autonomic system disorders (excessive sweating, dry mouth) were detected. The indicators of gastrointestinal disorders are lower – 11% (constipation, diarrhea, loss of appetite, nausea). The lowest percentage of functional disorders was detected in fighters with respiratory system disorders – 6% (shortness of breath, intermittent breathing).

Regarding the cognitive-analytical system, most disorders were found in attention: 25% of the subjects reported impaired concentration, switching, and distribution of attention. Impaired thinking functioning was recorded in 14% of the subjects, and impaired memory functioning was detected in 12%. The smallest percentage was in perception functioning – 6%.

The results of the survey indicate a high level of stress disorders among armed conflict participants, which requires appropriate social and psychological rehabilitation.

The social and psychological rehabilitation of armed conflict participants who have experienced prolonged trauma during the war is aimed at restoring lost internal and external resources. Since personal resources have the potential for psychological health and well-being, restoring these resources helps soldiers return to normal life as soon as possible. Therefore, based on the findings of many scientists and taking into account the results of our empirical research, we have substantiated a technology of psychotherapeutic assistance to overcome the manifestations of PTSD manifestation in armed conflict participants based on an integrative approach. This is a combination of different methods of psychotherapy, united by a systemically important element – a methodological platform and the corresponding generalized principles and procedures of the main areas of psychotherapy.

The purpose of the technology is to restore internal and external resources in armed conflict participants with PTSD manifestation who are undergoing inpatient rehabilitation. The objectives of the technology include conducting activities to reduce psychopathological syndromes, raising awareness of the impact of extreme stress and methods of processing traumatic experiences, mastering skills, and abilities to overcome the consequences of traumatic experiences, and raising awareness of the immediate environment.

The process of social and psychological rehabilitation includes three stages: initial (preparatory), psychological (main), and final. The initial stage aims to create a safe space for adaptation, stabilization, and restoration of the normal functioning of armed conflict participants. The psychological stage, which is the main one, uses specific approaches to work with trauma. Here, psychoeducation is conducted to normalize and explain the symptoms of PTSD. The final stage is the integration of experience, psychological support, and preparation for psychosocial adaptation. The technology is based on a person-centered approach that uses the interaction of crisis counseling and various areas of psychotherapy.

The main constructive models for overcoming psycho-traumatic symptoms include:

1. Cognitive coping – understanding of trauma, awareness of coping strategies and own capabilities; search and evaluation of resources that can be used to overcome psycho-traumatic symptoms.
2. Emotional coping – awareness and acceptance of one's feelings and emotions, permission to express them, mastering skills to control the dynamics of reactions; experiencing fear, anxiety, sadness, guilt, helplessness, anger, etc.
3. Behavioral coping – adjusting strategies of activity, activating certain forms of behavior, working with aggression, avoidance, disorganization.
4. Social and psychological coping – restoring interpersonal relationships.

The technology of restoring internal and external resources of armed conflict participants includes the following psychotechniques:

1. Techniques for reconstructing basic human resources (ways to increase the basic level of trust).
2. Techniques for managing the physical self (mastering stabilization and self-healing exercises; mastering relaxation exercises; autogenous training, meditation).
3. Techniques for processing traumatic experiences, including various emotional response techniques.
4. Techniques for reproducing resource states and positive images (pleasant memories; recalling situations where there was a sense of confidence, emotional uplift).
5. Self-regulation techniques (reducing arousal; breathing techniques).
6. Resource mobilization techniques (increasing motivation; imagination exercises; breathing; exercises for mental and sensory stimulation).
7. Techniques for working with the social atom (mobilization of external resources).
8. Suggestion techniques (positive suggestion, self-hypnosis). The key criteria for evaluating the effectiveness of using an integrative model of psychotherapy to treat PTSD manifestations in armed conflict participants include reducing the level of trauma symptoms, observing positive dynamics in planning for the future, increasing the level of self-regulation, and restoring personal integrity.



It is necessary to emphasize the close connection between mental and physical health. In this regard, paying attention to mental and physical health issues is essential as part of comprehensive medical and psychological services. The speed of recovery and return to full life after a traumatic experience depends on various factors, including the internal and external resources of the individual. Using these resources helps restore the ability to self-regulate and maintain psychological resilience in stressful situations. Herewith, it is important to consider various external factors, such as social support and stability in work and housing, as well as internal resources, including previous experience in overcoming difficulties and the characteristics of the nervous system.

## DISCUSSION

Both the army and civilians feel the effects of military conflict. The latter, who comprise most of the population, shape public opinion about the conflict. Their opinion is influenced by the uncompromising actions of the armed forces and the nature of military events. The very characteristics of the military conflict and the public reaction to it determine the further aggravation of PTSD in armed conflict participants, which can lead to maladjustment in civilian settings [9].

Maladjustment caused by PTSD is manifested in the behavior, activities, and communication of armed conflict participants. The main indicator of maladjustment in PTSD is a violation of social status. Research shows that armed conflict participants with PTSD are more likely to face difficulties in finding and keeping a job. They may experience instability in their professional life and change jobs more often [10]. Reduced social adaptability, in particular, can be manifested in a higher risk of alcoholism and drug addiction, as well as in manifestations of violence. Also, the possibility of auto-aggressive behavior, such as self-harm and suicide attempts, becomes significantly higher among those who experience PTSD. The maladjustment caused by PTSD leads to various forms of maladaptive behavior, which can lead to social problems and a deterioration in quality of life [11].

According to experts [12], armed conflict participants with a low level of social adaptation show significantly higher conflict and aggressiveness in relationships. The increase in the level of conflict in their behavior is determined mainly by subjective reasons. External conflicts can be a reflection of internal conflicts, which, in turn, arise due to a high level of frustration due to society's restrictions on meeting individual needs [13]. Many armed conflict participants have increased aggression or destructiveness of personality. Aggression occurs as a reaction to frustration, and every disappointment automatically leads to aggressive responses. Combat conditions can increase positive reinforcement of aggressive behavior directed against the enemy [14].

In general, PTSD affects people who have experienced traumatic events and is often expressed in high levels of conflict and aggression. It can cause social maladjustment and lead to antisocial and deviant behavior of servicemembers,

including suicide attempts. Such manifestations of PTSD become not only a personal problem for armed conflict participants but also a public issue, affecting public opinion and attitudes toward military operations in local conflicts.

The results of the analysis of scientific publications [15] identify groups of clinical and anamnestic factors that may be predictive for the development of PTSD during combat, during service, and after returning. Significant factors during the combat period include the degree of threat to life, the severity of losses, suddenness of the event, isolation from other people during the event, degree of environmental exposure, availability of protection against possible recurrence of the traumatic situation, moral conflicts related to the event, passive or active role during the traumatic event, immediate consequences of the event, duration of participation in combat, intensity of the traumatic situation (combat experience and severity of injuries). Significant factors for predicting PTSD after the combat period are changes in the system of relationships, the personal significance of combat experience and the ability to assimilate it, availability of social support, data on the most difficult period of adaptation to civilian life, changed attitudes toward the media covering combat, attitudes toward friends and people who did not fight, spending free time mostly alone, ideas about future life, low self-esteem of maturity and responsibility, health problems, the presence of acute feelings in situations of injustice and disrespectful attitude towards oneself, divergence of views formed during the war with generally accepted principles of modern society (desire for enrichment, corruption, loss of national dignity, decline in morality, etc.), distancing from society, and "combatant accentuation" [16].

The results of research by scientists [1] indicate that the presence of PTSD correlates with certain mental disorders that arise as a result of trauma or were present from the beginning. Among these disorders are anxiety neurosis, depression, a tendency to suicidal thoughts or attempts, medication, alcohol or drug dependence, psychosomatic disorders, and cardiovascular diseases. The study of data confirms that 50-100% of the patients who have PTSD have at least one of these comorbidities in their history, more often two or more [2].

According to scientists [17], the social and psychological rehabilitation of armed conflict participants, as part of the system of general rehabilitation, is an important area of improving their mental and physical condition and returning to a full life. Its goal is to restore, correct, or compensate for impaired cognitive functions, states, and personal and social status of people who have experienced mental trauma. Scientists [5, 10, 17-19] focus on social and psychological rehabilitation, the importance of which is determined by the participation in rehabilitation of medical workers, psychologists, and, above all, commanders and colleagues. This makes it important to maintain a healthy social and psychological climate in the units. Social rehabilitation is determined by the interaction of the injured person with the team, the presence of prerequisites for socially useful work, and the peculiarities of behavior during service

activities. The social factor aims to adjust the outlook and attitude to life and activate social ideals.

According to experts [13, 20], an effective impact on armed conflict participants in the rehabilitation framework can be carried out through psychotherapy, i.e., therapeutic influence on the human psyche with the help of psychological factors. It can be indirect, including measures aimed at creating positive conditions (rational organization of service activities and creation of a healthy social and psychological climate), or direct, including special techniques of verbal influence on the psyche [21]. Social and psychological rehabilitation, according to scientists [15, 22], also involves implementing hygiene measures, adherence to a clear daily routine, ensuring normal sleep, optimal motor activity, and rational nutrition.

## CONCLUSIONS

The features of PTSD manifestation in armed conflict participants have been studied, and it has been found that most of them (66%) have a high degree of PTSD manifestation and need additional medical and psychological examination and support. The main symptoms of PTSD manifestation are headaches (96.9%), sleep disturbances (69.7%), depression (74.2%), anxiety, which manifests itself at the physiological level (increased fatigue (62.1%), backaches (54.5%), stomach cramps (59.1%), muscle pain (46.9%)), in the mental sphere (constant anxiety and concern (68.2%), "paranoid" phenomena (45.5%) and in emotional experiences (constant feeling of fear (71.2%), self-doubt (65.2%), guilt complex (53.0%)), aggression (51.5%), unmotivated vigilance (43.9%), substance and drug abuse (30.3%), unforgotten memories and sense of guilt (27.3%), signs of hallucinatory experiences (24.2%), and rage attacks (15.2%).

The main predominant defense mechanisms have been identified, with the majority of armed conflict participants (45%) avoiding any talk about traumatic events and choosing "avoidance" as a defense mechanism. Armed

conflict participants do not want an "invasion" of their emotional sphere and do not get emotionally involved in others' situations. At the functional and cognitive-analytical levels, the main psychosomatic disorders of the armed conflict participants have been identified. The group of functional problems has the highest rates.

It has been found that most armed conflict participants can adapt to life in new conditions. However, the consequences of war leave their mark on everyone. Anyone who has participated in war comes out of it a different person and complete relief from PTSD is impossible. This syndrome tends not only not to disappear over time but also to become more pronounced, even against the background of general well-being. Improving the condition of armed conflict participants is possible only through a system of rehabilitation measures.

The technology of social and psychological rehabilitation of armed conflict participants with PTSD manifestations, which includes measures to reduce psychopathological syndromes, raise awareness of the impact of stress and methods of processing traumatic experience, master the skills and abilities to overcome the consequences of traumatic experience, as well as raising awareness of the immediate environment has been substantiated.

It has been found that partnership and cooperation are key to implementing rehabilitation interventions, which should involve the armed conflict participant in the recovery process. Individualization and consideration of each individual's adaptive capacities, as well as the participation of commanders, medical personnel, psychologists, and fellow soldiers, are important elements of successful rehabilitation. In addition, systematic monitoring and timely correction of the rehabilitation program are necessary to achieve effective results.

**Prospects for further research:** It is planned to test the effectiveness of armed conflict participants' social and psychological rehabilitation technology, as substantiated by the authors in practice.

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## CONFLICT OF INTEREST

The Authors declare no conflict of interest

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**RECEIVED:** 15.08.2024

**ACCEPTED:** 21.10.2024



# Assessment of hand function in patients with systemic sclerosis based on physiotherapy examination after 2 years of rehabilitation

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## ABSTRACT

**Aim:** To analyze the hand function of patients with systemic sclerosis treated at the Dermatology Clinic of PIM MSWiA after a 2-year individually tailored rehabilitation program. This program consisted of a set of manual exercises and self-massage of the upper limbs, performed at home and adapted to the patient's movement abilities.

**Materials and Methods:** The study group consisted of 55 patients aged 27 to 80 years (mean 56.4) with systemic sclerosis, who received cyclical rheological treatment at the Dermatology Clinic. For 2 years, the therapy was supported by individually tailored manual exercises and self-massage of the upper limbs. Before and after the therapy, the quality of hand grips and related independence in performing daily life activities were analyzed. The project was completed by 42 patients.

**Results:** The majority of the studied patients did not have any problems with the cylindrical grip (61.9% in the left hand and 59.5% in the right hand). If problems occurred, they were most often moderate (14.3% in the left hand and 11.9% in the right hand) or significant (19.0% in the left hand and 21.4% in the right hand).

**Conclusions:** The studies confirmed that the majority of patients did not experience any problems with cylindrical, hook, pulp, and pinch grips (both in the left and right hands). Moreover, the vast majority of patients had the same condition in both hands. If problems did occur, they were most often significant in both hands. All patients were independent and self-sufficient according to the Barthel scale and obtained the maximum number of points.

**KEY WORDS:** Systemic sclerosis, individual exercises, manual exercises, self-massage, hand grips, functional independence

Acta Balneol. 2024;66(6):379-385. doi: 10.36740/ABAL202406102

## INTRODUCTION

Independence in performing daily activities is crucial in planning the rehabilitation of a patient. The criteria for measuring the patient's functional efficiency and analyzing their results provide information on the effectiveness of treatment. Assessment scales are only constructive when they are clinically useful and scientifically reliable [1-3]. Katz's Activities of Daily Living and the Barthel Index are two of the oldest competing indicators of daily life activities [1-7]. They evaluate the patient's functioning in terms of the level of independence or dependence during certain activities required for daily life. The question is whether they provide a reliable picture of the quality of life for patients with SSc. The conducted studies utilized and compared classifications of human hand gripping abilities used in rheumatology with the number and quality of possible grips. Schlesinger identified 18 grips, including 4 basic ones. Taylor and Schwarz proposed 6 basic grips, while Cutkosky proposed 16. Napier introduced the classification scheme and division into power and precision grips [8-13].

## MATERIALS AND METHODS

For over 20 years, patients with systemic sclerosis, a chronic and progressive disease, have been treated at the Dermatology Clinic of PIM MSWiA. The Hospital's Bioethics Committee approved rehabilitation during the patient's stay in the Ward. Physiotherapy was based on individually

tailored exercises according to the measured grips: hook, cylindrical, pulp, and pinch. Among all types of complex gripping activities, four basic activities essential for human functioning are distinguished. The hook function ensures the hook grip, where the fingers are partially flexed relative to the hand. The ring function ensures the cylindrical grip, i.e., the fingers touching the hand or the thumb. The pincer function ensures the pulp grip, necessary for performing precise movements, formed by joining the pads of the thumb and index and middle fingers. The pincer function ensures the pinch grip, stronger than the previous one but less precise, formed by bringing the thumb to the side surface of the index finger. Precision grips require dexterity and a variety of movements performed by individual fingers. Objects are held between the pads of the fingers and thumb, ensuring their precise feeling [13]. Pen Grip and Holding a Mug with Both Hands by a Patient with Systemic Sclerosis (Fig. 1, 2). The International Classification of Functioning, Disability, and Health (ICF) issued by the World Health Organization in 2001 was used to determine the degree or extent of impairment. The overall classifier with a negative scale is used to determine the degree or extent of impairment. Broad percentage ranges include cases where scaled assessment tools or other quantitative measures for determining the extent of body function impairment are available. For example, the definitions "no impairment" or "extreme impairment" of body function may have an



**Fig. 1.** Pen grip by a patient with systemic sclerosis.

error margin below 5%. "Moderate impairment" reaches up to half the scale defining extreme impairment. Disability classification: 0 NO problem (none, absent, insignificant,...) 0-4% 1 SLIGHT problem (mild, small,...) 5-24% 2 MODERATE problem (medium, considerable,...) 25-49% 3 SEVERE problem (great, strong,...) 50-95% 4 EXTREME problem (total,...) 96-100% 8 not specified 9 not applicable.

Additionally, the Barthel Index was used to assess the patient's mobility. It determines which and to what extent the patient can perform activities independently, with assistance, or not at all. For each activity, points are awarded and summed up; the more points, the greater the patient's independence. Activities described in the Barthel Index

include eating, moving (e.g., from bed to chair), sitting, maintaining personal hygiene, using the toilet, moving (on flat surfaces), climbing and descending stairs, dressing and undressing, controlling stool/rectal sphincter, and controlling urine/bladder sphincter. The maximum score on the Barthel scale is 100 points. There are three assessment ranges: obtaining 0 to 20 points indicates total dependence, 20 to 80 points indicates that the patient needs some help, and a score between 80 to 100 points indicates that with minimal help, the patient can function independently. 0-20 points – patient's condition "very severe"; 21-85 points – patient's condition "moderately severe"; 86-100 points – patient's condition "mild." Scoring 40 points or fewer on the Barthel scale qualifies the patient for long-term care, meaning they require constant care [14-16].

Based on the obtained measurement results, individual self-massage and manual exercises were designed according to the patient's capabilities. It was recommended to perform upper limb massage twice a week for at least 10 minutes. The stroking technique started from the forearm, from the wrist to the elbow joint, the palmar and dorsal part of the hand from the fingers to the wrist joints, and then each finger separately from the distal part to the metacarpus. Movements were performed depending on the patient's capabilities with fingers, the dorsal and palmar part of the hand, and the forearm. Special attention was paid to the direction towards the heart during the massage. According to the learned movements, it was recommended to apply cream in the morning and evening after washing and cleaning the skin. Manual exercises performed after the massage involved gripping a cup with a diameter of at least 8 cm, and if it was not possible, the other hand was used for assistance. The next exercise involved turning the same cup from full supination to pronation in the wrist joint (from turning outward to turning inward). The third exercise involved precisely picking up matches, small coins, or other small objects and lifting them from the surface.

## RESULTS

The analysis of the measurement results confirmed that patients with systemic sclerosis have problems with the function related to the mobility of small hand joints. The initial study group consisted of 55 people, including 42



**Fig. 2.** Holding a mug with both hands by a patient with systemic sclerosis.

women and 13 men aged 27 to 80 (mean 56.4), with an average treatment duration of 8 years at the Dermatology Clinic. Ultimately, the project was completed by 42 people.

The majority of the studied patients did not have any problems with the cylindrical grip (61.9% in the left hand and 59.5% in the right hand). If problems occurred, they were most often moderate (14.3% in the left hand and 11.9% in the right hand) or significant (19.0% in the left hand and 21.4% in the right hand). The vast majority of patients had the same condition in both hands, i.e., the same result for the left and right hands. In 25 patients, there were no problems in either hand (score 0), while 8 patients had significant problems in both hands (score 3). Summary of Results – Cylindrical Grip (Fig. 3).

The majority of the studied patients did not have any problems with the hook grip (66.7% in the left hand and 64.3% in the right hand). If problems occurred, they were most often significant (16.7% in the left hand and 14.3% in the right hand). The vast majority of patients had the same condition in both hands, i.e., the same result for the left and right hands. In 27 patients, there were no problems

in either hand (score 0), while 7 patients had significant problems in both hands (score 3). Summary of Results – Hook Grip (Fig. 4).

The majority of the studied patients did not have any problems with the pulp grip (57.1% in the left hand and 54.8% in the right hand). If problems occurred, they were most often slight (11.9% in the left hand and 16.7% in the right hand) or significant (23.8% in the left hand and 21.4% in the right hand). The vast majority of patients had the same condition in both hands, i.e., the same result for the left and right hands. In 23 patients, there were no problems in either hand (score 0), while 10 patients had significant problems in both hands (score 3). Summary of Results – Tip Grip (Fig. 5).

The majority of the studied patients did not have any problems with the pinch grip (57.1% in the left hand and 54.8% in the right hand). If problems occurred, they were most often significant (21.4% in the left hand and 21.4% in the right hand).

The majority of patients had the same condition in both hands, i.e., the same result for the left and right hands.

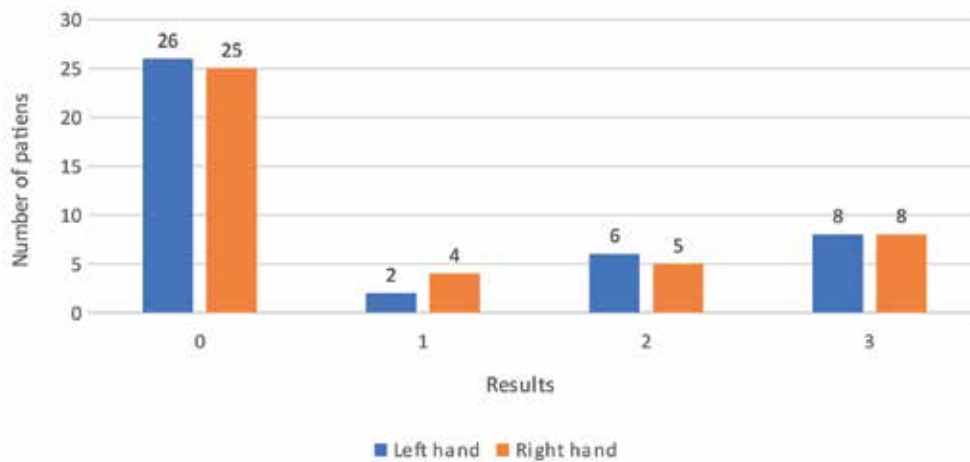


Fig. 3. Summary of results – cylindrical grip.

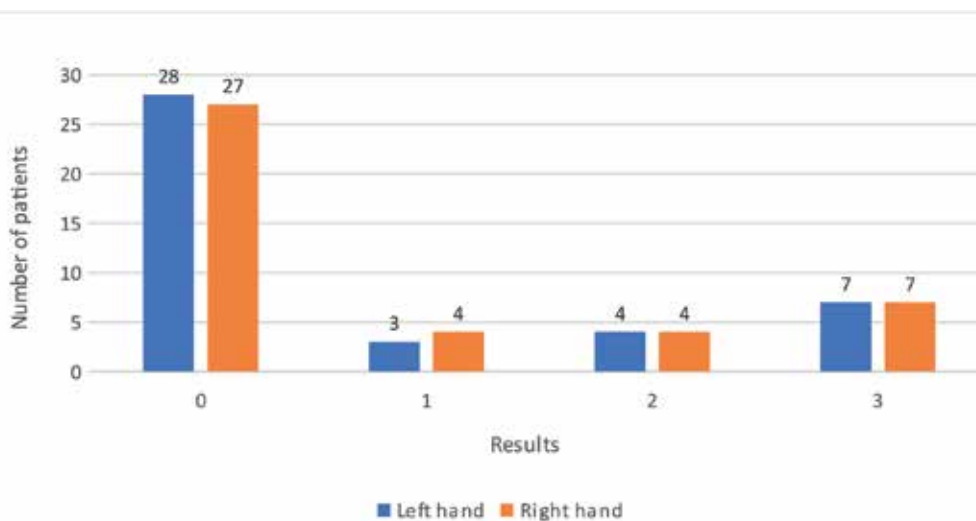
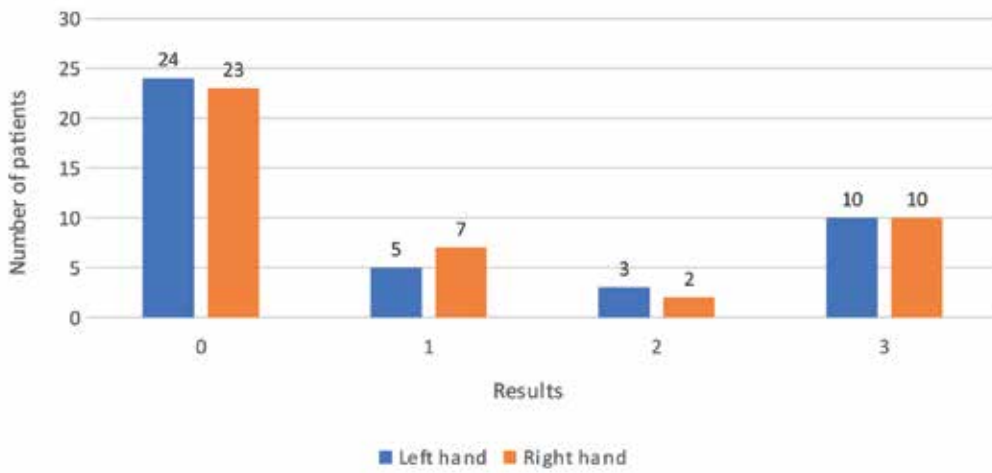
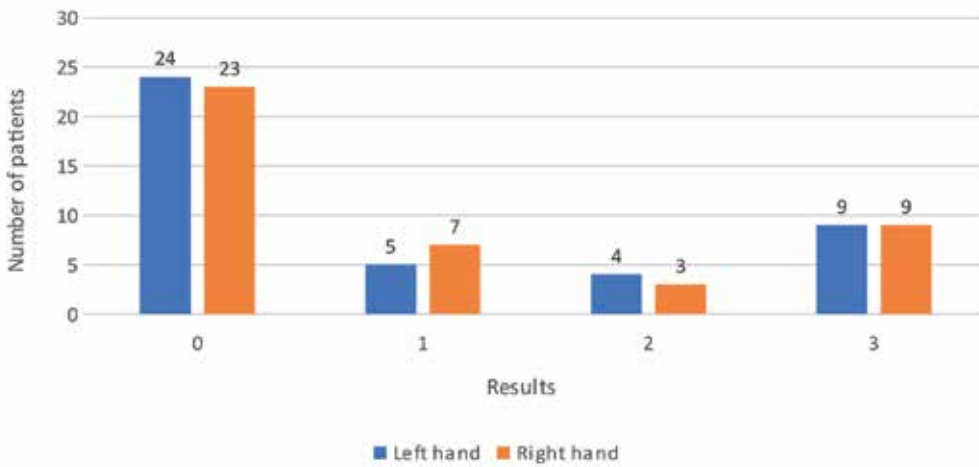


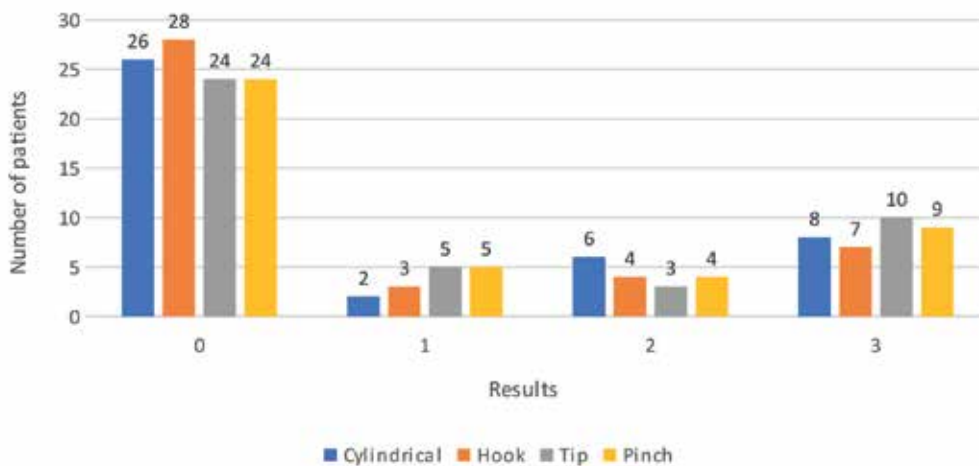
Fig. 4. Summary of results – hook grip.



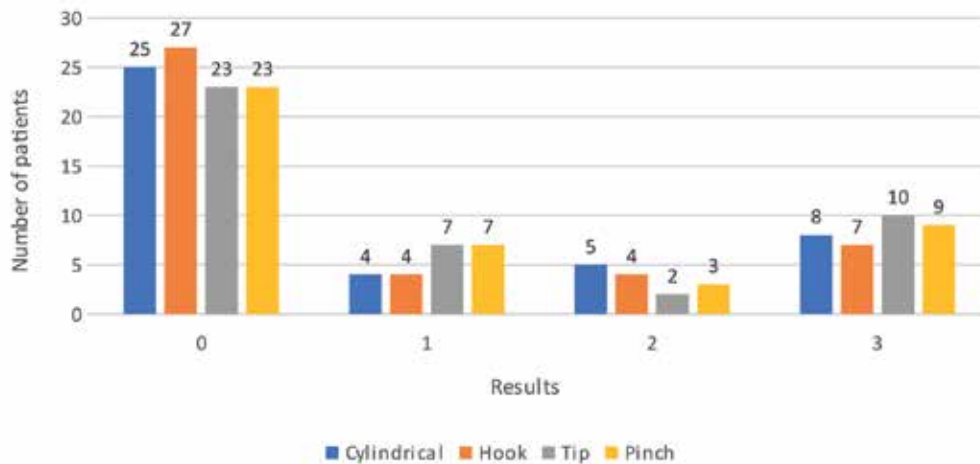
**Fig. 5.** Summary of results – tip grip.



**Fig. 6.** Summary of results – pinch grip.



**Fig. 7.** Summary of results – left hand.



**Fig. 8.** Summary of results – right hand.

In 23 patients, there were no problems in either hand (score 0), while 9 patients had significant problems in both hands (score 3). Summary of Results – Pinch Grip (Fig. 6).

Moreover, the evaluation of the Barthel scale showed that all patients were independent and self-sufficient. The minimum number of points was 95, and the maximum was 100. Such a result proves the high efficiency of the proposed exercises and rehabilitation measures.

The conducted studies confirmed that the majority of patients did not experience any problems with cylindrical, hook, pulp, and pinch grips (both in the left and right hands). Moreover, the vast majority of patients had the same condition in both hands, i.e., the same result for the left and right hands. If problems did occur, they were most often significant in both the left and right hands. All patients were independent and self-sufficient according to the Barthel scale and obtained the maximum number of points. Summary of results – left hand (Fig. 7). and summary of results – right hand (Fig. 8).

## DISCUSSION

The human hand has a complex anatomy. It serves gripping functions: both powerful and precise, and its dysfunctions significantly affect the quality of life of patients. Objective verification of existing symptoms by physiotherapists is based on scientific principles applied in clinical medicine and a biopsychosocial perspective, as outlined in the International Classification of Functioning, Disability, and Health (ICF). Equally important as the physiotherapeutic assessment of the range of motion limitations and subsequent therapeutic actions to restore expected values and indicators related to the musculoskeletal system is the assessment of the patient's ability to perform daily activities. Patient motivation and cooperation are also influenced by subjective factors; physiotherapists are well aware of the interdependencies between assessment and the treatment process, as the results of one determine the form of the other.

To develop a comprehensive treatment plan with the patient, the therapist conducts a detailed physical examination,

employs appropriate scales, identifies any limitations, and is aware of contraindications to the proposed treatment procedures. Significant impairment of hand function is common in systemic sclerosis (SSc). The grip used by a person with SSc may not conform to the patterns described and discussed in literature as normal. This has led to research using qualitative classification systems to study static grip patterns employed by hands affected by scleroderma, which could determine the relationship between hand impairment and changes in grip. Grip was observed in patients with scleroderma as they held a key, a coin, a glass, and a pot, documenting their grip patterns, including how they used their fingers to grasp objects, the surface area of their fingers in contact with the objects, and the positions of their finger joints. Greater differences in grip were noted with the coin, glass, and pot than with the key. The presence of pressure sores on the fingers indicated greater difficulties in holding the coin. The number of fingers with contractures correlated with the ability to hold all four objects.

Developing, testing, and disseminating rehabilitation interventions in SSc presents a challenge, especially as pain related to Raynaud's phenomenon often accompanies the condition [17-18]. The prevalence of this phenomenon in the general population is about 5%. Raynaud's syndrome (RS) was first described by the French physician Maurice Raynaud in 1862, characterized by a three-color change involving pallor (ischemic phase), cyanosis (deoxygenation phase), and erythema (reperfusion phase) triggered by cold or stress. Loss of hand functionality impacts patients' overall physical functions, health-related quality of life, and mental state [19]. The effectiveness of therapy significantly depends on the patient's engagement in the rehabilitation process, their individual needs, and the therapeutic methods used [20-24]. To increase treatment effectiveness, it is suggested that feasible procedures be performed at home, such as manual exercises or self-massage. The degree of hand deformity affects the limitations in the range of motion at specific joints; appropriate physiotherapy prevents and corrects deformities. In cases of severe disability, proper compensatory mechanisms are developed to facilitate daily



functioning. Physiotherapeutic analysis is comprehensive and also considers the maintenance of cardiovascular and respiratory system fitness.

Systemic sclerosis (SSc) is a disease that leads to the failure of multiple organs, and the resulting changes often cause pain, making it crucial to prepare the tissues for therapy, for example, through massage [17]. Patients can regain functionality through appropriately selected individual exercises that improve hand function. Internet networks have also been established to address this issue, where exercise programs aimed at improving hand function in patients with systemic sclerosis can be found (Scleroderma Patient-centered Intervention Network – SPIN) [25-26]. Unfortunately, not always do individually tailored exercises and physiotherapy treatments yield the expected results; surgical treatment may then be considered. There is a general reluctance towards surgical intervention due to the intrinsic ischemia of the disease and the potentially impaired healing capacity. In cases where weak but well-defined and stable periarticular vascular networks around the PIP and MCP joints are preserved, joint reconstruction with uncomplicated wound healing may prove effective for patients with scleroderma. While arthrodesis is generally recommended for severe flexion contractures of the interphalangeal joints, other surgical procedures such as arthroplasty, excision of painful calcinosis, and digital sympathectomy have been used sparingly, undoubtedly due to potentially hazardous conditions of soft tissues. The effectiveness of a precisely planned and skillfully performed operation in alleviating pain, preventing tissue loss, preserving function, and improving aesthetics is confirmed. For ischemic tissues in sclerodermic hands, a prerequisite for uncomplicated surgery is a tension-free wound, often requiring sensible shortening of the skeleton and healing by secondary intention [27-30]. The effectiveness

of ongoing rehabilitation depends on the presence of pain and numerous hard-to-heal wounds and ulcers. The motor disability of patients with scleroderma means that outpatient treatments offered where they live are often inaccessible to them. It is worthwhile to highlight and recommend the rich range of treatments available in health resorts and sanatoria. These facilities are prepared to accommodate individuals with disabilities, and an additional important element is the change of environment and the therapeutic effects of climate, which also impact the patient.

## CONCLUSIONS

The conducted research confirmed that patients suffering from scleroderma have problems with the small joints of the hands.

Based on the conducted research:

1. Most patients did not experience any issues with cylindrical, hook, tip, and pinch grips.
2. The condition of both hands is the same for most patients, i.e., there is the same result for the left and right hand.
3. When problems did occur, they were most often significant in both the left and right hand.
4. Regardless of the grip type, the distributions are very similar.
5. All patients, according to the Barthel scale, were independent and self-sufficient, achieving the maximum number of points.

Rehabilitation of the sclerodermic hand using exercises and massage allows for the maintenance of manual dexterity and preserves gripping ability, delaying deformative changes that occur during the course of the disease. It is recommended to utilize the physiotherapeutic and balneological resources that support treatment by reducing pain and healing numerous wounds.

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## CONFLICT OF INTEREST

The Authors declare no conflict of interest

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RECEIVED: 18.07.2024

ACCEPTED: 24.10.2024



# The role of dance movement therapy in the postoperative management of patients with lower limb fractures

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## ABSTRACT

**Aim:** To determine the effectiveness of dance movement therapy as part of a comprehensive rehabilitation program for patients who have undergone surgery for lower limb fractures.

**Materials and Methods:** The study involved 63 patients aged 27 to 59 with lower limb fractures, who were undergoing rehabilitation after surgery (osteosynthesis). A comparative analysis of motor activity in the knee and ankle joints was performed 8–10 weeks after surgery to assess the results of the rehabilitation treatment. Pain levels above 7 were considered a reason for temporary or complete cessation of group therapy sessions.

**Results:** After thorough study, processing and analysis of the data, two clinical groups of patients were distinguished based on the rehabilitation treatment methods applied. According to the KOOS, AOFAS, and VAS scales, the results in the art therapy group were significantly better. During the therapy course, gender-specific changes in pain sensations were identified. Subjective pain perception decreased by 1.49 points in women and by 1.84 points in men after completing the course of dance movement therapy.

**Conclusions:** The implementation of dance movement therapy measures in the group of patients after lower limb fractures requires dynamic adjustment, especially regarding the frequency and speed of performing individual tasks.

**KEY WORDS:** rehabilitation, art therapy, dance movement therapy, traumatology, osteosynthesis

Acta Balneol. 2024;66(6):386–391. doi: 10.36740/ABAL202406103

## INTRODUCTION

The full-scale war in Ukraine has provided significant impetus for the development of the rehabilitation care. Numerous combat injuries are driving the medical sector to train more specialists in physical and rehabilitation medicine (PRM), physical therapists, and occupational therapists, as well as to create reliable, highly qualified multidisciplinary teams and explore new methods and tools for rehabilitation. A great variety of novel techniques and training programs are emerging, aimed at helping military personnel return to normal life and recovering their psycho-emotional and physical states. Artistic forms and means are also coming to the aid, including areas such as painting, sand therapy, music therapy, dance movement therapy (DMT), drama therapy and others. Engaging in certain types of creativity has proven to be quite an effective method of improving the mental health of all segments of the population. However, the focus on physical correction remains underexplored [1, 2].

The close connection between the soul and the body was written about even in ancient times. Active educational efforts regarding the expression of emotions through dance movements were carried out by choreographers and studied by body-oriented therapists [3, 4].

Numerous studies confirm that the use of creative approaches in rehabilitation care of patients may not solve all problems, but it definitely accelerates recovery processes,

improves overall well-being, enhances the effectiveness of other rehabilitation methods and is appropriate for use in pathologies of any organ system [5, 6].

Scientific research shows that prolonged, rhythmic muscle activity with a well-chosen musical accompaniment, along with positive emotions, accelerates the reparative processes of the musculoskeletal system and can positively influence psychophysical processes [7].

Among the primary global objectives of dance movement therapy in the rehabilitation of trauma patients are the prevention of complications such as muscle atrophy, osteoarthritis, contractures and bedsores; increasing joint range of motion; and restoring the functionality of muscles and ligaments.

The choice of musical accompaniment plays a particularly important role. Music is an integral part of human life that contributes to spiritual development, emotional enrichment and aesthetic education. Referring back to the era of antiquity, an independent system of educating children through the influence of music on the young, not fully developed psyche was created.

A large number of scientific studies are dedicated to the rehabilitation of patients after fractures, including those treated surgically. Art therapy methods are mostly applied in cases of upper limb injuries. Functional deficiencies of the lower limbs are generally addressed through surgical or orthopedic methods [8–11].

No reliable data on the effectiveness of dance therapy in treating this category of patients have been found to date. Adhering to the basic rules of rehabilitation and the SMART goals principle is insufficiently supported by research regarding the principles of individualization, gradual learning of movements, dosage of physical activity, repetition frequency of the learned combination or movement, optimal execution speed, variety of dance steps, continuity in sessions, alternating movements for different body parts, and, if desired, combining with other art therapy methods [11].

## AIM

To determine the effectiveness of dance movement therapy as part of a comprehensive rehabilitation program for patients who have undergone surgery for lower limb fractures.

## MATERIALS AND METHODS

The study involved 63 patients with lower limb fractures, aged 27 to 59, who were undergoing post-operative rehabilitation care (osteosynthesis). The average age was  $40.7 \pm 8.3$  years. According to the WHO age classification, 63.5% (40) of the patients were young, while 36.5% (23) were middle-aged. In terms of gender distribution, females predominated (50.8% (32)), while males made up 49.2% (31). The average age of the female patients was  $40.6 \pm 6.2$  years, and for males, it was  $40.8 \pm 10.1$  years.

The cause of lower limb fractures in 71.4% (45) of the cases was low-energy trauma, such as falls from one's own height or twisting of the foot. In 28.6% (18), the fractures were caused by high-energy traumatic factors, such as road accidents, falls from heights or workplace injuries.

The distribution of bone injuries by anatomical region was as follows: diaphyseal fractures of the tibia or femur were diagnosed in 49.2% (31) of cases, and complex intra-articular fractures were found in 50.8% (32) of patients. Simple fractures were diagnosed in 39.7% (25) of patients, and complex comminuted fractures in 60.3% (38) of cases.

All patients underwent surgery using intramedullary or cortical metal fixators. For patients with diaphyseal fractures of the long tubular bones of the lower limbs, the chosen osteosynthesis method was antegrade locked intramedullary nailing, while patients with intra- or para-articular bone injuries underwent cortical osteosynthesis with compression plates with limited contact. In all cases, osteosynthesis was performed within the first seven days after the injury.

Femur fractures were diagnosed in 41.3% (26) of cases, tibia fractures in 41.3% (26) of cases, and ankle fractures in 17.4% (11) of patients. A detailed description of the fracture site and type based on gender is presented in Table 1.

In 49.2% (31) of cases, standard rehabilitation treatment protocols were applied during the postoperative period. In 50.8% (32) of patients, the typical rehabilitation measures were supplemented with the introduction of dance therapy, the intensity and specificity of which depended on the injured segment, the type of fracture and the type of metal fixators used during the bone osteosynthesis.

Standard rehabilitation measures included a set of active and passive movements in the knee and/or ankle joints. Passive movements were initiated in the early postoperative period, followed by the addition of active exercises.

Elements of art therapy, in the form of dance therapy, were applied in combination with standard rehabilitation protocols, provided the patients met the main selection criteria, namely the results of questionnaires completed by the PRM specialist (Table 2) and the orthopedic traumatologist who was part of the surgical team that performed the osteosynthesis on the specific patient (Table 3). Failure to meet at least one of the criteria resulted in the exclusion of dance-related rehabilitation measures from the rehabilitation protocol.

An undisputed factor in initiating this type of rehabilitation was the conscious consent of the patient for its implementation.

**Table 1.** Distribution of bone fractures of the lower limbs depending on gender

Gender	Femur		Tibia		Ankles, % (n)
	Diaphyseal area, % (n)	Intra-articular area, % (n)	Diaphyseal area, % (n)	Intra-articular area, % (n)	
Male	15.9 (10)	9.5 (6)	7.9 (5)	9.5 (6)	6.4 (4)
Female	7.9 (5)	7.9 (5)	15.9 (10)	7.9 (5)	11.2 (7)

**Table 2.** Criteria for dance therapy approval by the PRM specialist

	Approval	Prohibition
Ability to stand independently	Yes	No
Psychological consent	3-5 on the Likert scale	1-2 on the Likert scale
"Flamingo" test	>10 s	<10 s

**Table 3.** Criteria for dance therapy approval by the orthopedic traumatologist

	Approval	Prohibition
Pain syndrome	Below 7 on the VAS scale	Above 7 on the VAS scale
Permission for axial loading	Greater 50% of body weight	Lower 50% of body weight
Need for external fixation (cast, orthosis, external fixation device)	Optional or symptomatic	Mandatory

To evaluate the results of the rehabilitation treatment, a comparative analysis of the range of motion in the knee and ankle joints was conducted 8–10 weeks post-surgery. Additionally, to assess the severity of the pain syndrome, the Visual Analog Scale (VAS) was used. A pain level above 7 was a reason for the temporary or complete cessation of activities in the group.

The functional activity of the knee joint was assessed according to the Knee Injury and Osteoarthritis Outcome Score (KOOS). This scale consists of 42 items grouped into 5 separate subscales, with a scoring range from 0 to 100, where 0 indicates severe problems with knee joint mobility and 100 indicates no problems.

The assessment of ankle joint mobility was conducted using the American Orthopedic Foot and Ankle Society Ankle-Hindfoot Score (AOFAS), which combines the subjective experiences of the patient with objective examinations performed by the physician. This scale consists of 9 items forming 3 subscales, with a scoring range from 0 to 100, where 100 indicates no mobility impairments and 0 indicates severe mobility impairments in the ankle joint.

The processing of the obtained results was conducted according to the rules of medical and biological statistics and using licensed software Microsoft Office 2019.

According to the conclusions of the Ethics Commission of the PSMU, the paper meets the requirements of the Helsinki Commission. Patients assigned to the clinical groups participated with informed consent.

## RESULTS

After a thorough study, processing and analysis of the data, two clinical groups of patients were distinguished based on the rehabilitation treatment methods applied.

The first clinical group included 31 patients aged 27 to 59 years, whose rehabilitation treatment included standard rehabilitation measures with passive and active mobility of the knee and ankle joints. Among them, women predominated at 58.1% (18), while men made up 41.9% (13). The average age of patients in this clinical group was  $42.5 \pm 8.8$  years.

Femoral fractures were diagnosed in 45.2% (14) of cases, with diaphyseal fractures in 25.8% (8) and intra-articular fractures of the condyles in 19.2% (6) cases. Fractures of the leg bones were found in 41.9% (13) of patients, including diaphyseal injuries of the tibia and fibula in 25.8% (8) and intra-articular fractures of the tibial condyles in 16.1% (5). Intra-articular fractures of the ankle bones were diagnosed in 12.9% (4) of patients.

The second clinical group consisted of 32 patients aged 27 to 53 years, whose rehabilitation treatment included a combination of standard rehabilitation methods and art therapy through the addition of dance movements to the treatment program. All patients met the requirements set by the PRM specialist and the orthopedic-traumatologist for implementing dance therapy. Among them, men predominated at 56.3% (18), while women made up 43.7% (14). The average age of patients in this clinical group was  $38.9 \pm 7.4$  years.

Femoral fractures were diagnosed in 37.5% (12) of cases, with diaphyseal injuries found in 21.9% (7) and intra-articular fractures of the femoral condyles in 15.6% (5). Leg bone fractures were observed in 40.6% (13) of cases, with diaphyseal fractures in 25% (8) and intra-articular fractures of the tibial condyles in 15.6% (5) cases. Fractures of the ankle bones were found in 21.9% (7) of patients.

Rehabilitation measures among patients in the first and second clinical groups began within the first two days after surgery and depended on the severity of the pain syndrome.

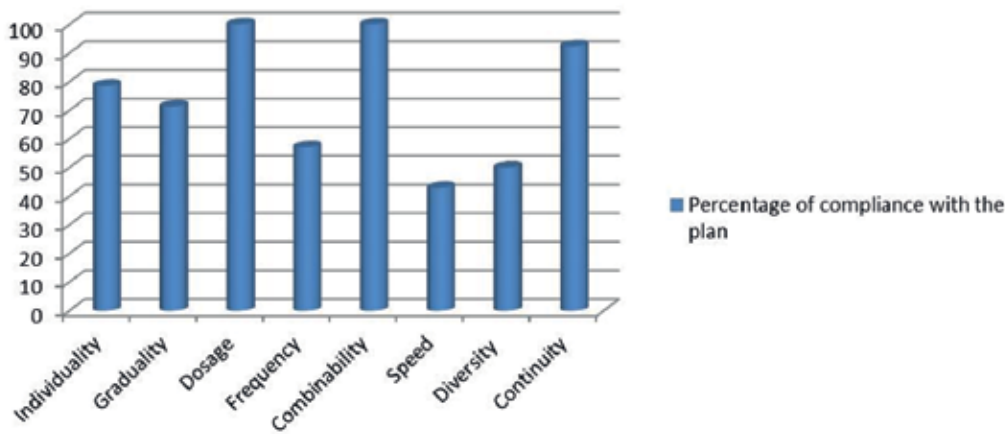
Among patients in the first clinical group, whose rehabilitation treatment included only standard schemes of rehabilitation care, the mobility scores for the knee joint according to the Knee Injury and Osteoarthritis Outcome Score ranged from 48 to 65 points, with an average of  $54.3 \pm 4.5$  points. The mobility scores for the ankle joint according to the American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Score (AOFAS) ranged from 63 to 78 points, with an average of  $68.2 \pm 3.6$  points.

Among patients in the second clinical group, whose rehabilitation treatment included a combination of standard schemes of rehabilitation care and dance therapy, the mobility scores for the knee joint (KOOS) ranged from 62 to 81 points, with an average of  $72.9 \pm 5.9$  points. The results of the assessment of mobility in the ankle joint among patients in this clinical group ranged from 69 to 85 points, with average values of  $78.7 \pm 5.2$  points.

The average functional activity scores for the knee joint among patients in the second clinical group, who performed dance therapy in combination with standard schemes of rehabilitation care, were by 18.6 points higher compared to patients in the first clinical group on the KOOS scale. This difference in average results is statistically significant ( $p < 0.01$ ).

The average functional activity scores for the ankle joint among patients in the second clinical group were by 10.5 points higher on the AOFAS scale compared to the patients

### Percentage of compliance with the plan



**Fig. 1.** Compliance of elements of the dance movement therapy with the plan.

in the first clinical group. This difference in average results is statistically significant ( $p \leq 0.01$ ).

Art therapy involving dance elements was based on the following key principles of execution:

1. Individual approach to selecting dance movements.
2. Variety of exercises.
3. Speed of performing dance therapy elements.
4. Gradual progression from simple to complex.
5. Diversity of dance movements and repetition frequency to ensure continuity in the rehabilitation process.

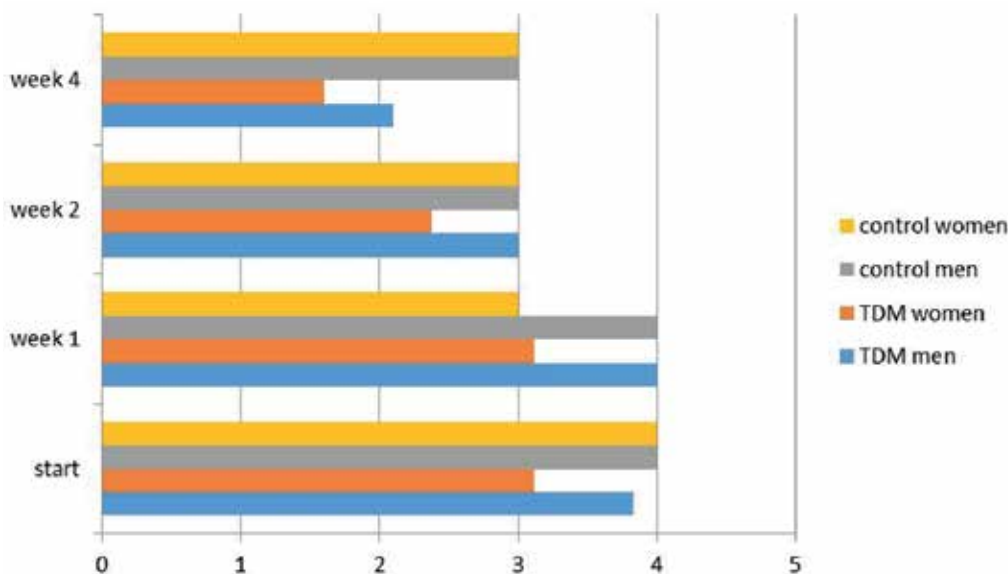
During the sessions, individual elements of the dance movement therapy program underwent significant adjustments (Fig. 1).

The resulting data showed the urgent need to pay attention to the frequency (42.9% of changes) and speed (57.1% of changes) of exercise performance. With an increase in

the number of participants in the therapeutic program, a change in the study indicators is anticipated depending on the detailing of clinical characteristics of the injury.

When determining the effectiveness indicators of the conducted treatment course, a four-week observation revealed certain gender differences. In this part of the study, similar data from patients who did not undergo the DMT course but were under the supervision of an orthopedic traumatologist during the same rehabilitation period (16 patients) were also analyzed (Fig. 2).

From week 1 of classes, a decrease in pain sensations was observed among women. This trend towards hypoalgesia was noted over the course of four weeks. In the group of men, more complaints on the increased intensity of the pain syndrome was established; however, they significantly decreased by the end of the week 4.



**Fig. 2.** Comparison of pain syndrome intensity at stages of rehabilitation care.

At the beginning of the DMT, the average pain intensity indicators in the area of the injured segment according to the VAS were  $3.12 \pm 1.55$  points among women, while among men, it was  $3.83 \pm 1.34$  points. After 7 days of classes, the average pain intensity values according to the same scale among women were  $3.12 \pm 0.93$  points, and among men, it was  $4.0 \pm 1.0$  points. An increase in pain sensations was observed among male patients, on average, by 0.17 points, which is related to gender sensory characteristics.

By the end of the week 2 of DMT classes, the pain intensity according to the VAS was  $2.37 \pm 0.99$  points among female patients, that was by 0.75 points lower compared to the beginning of the classes and 7 days after they were conducted. Among men, pain sensations according to the chosen scale were  $3.0 \pm 1.0$  points, achieving positive dynamics and a reduction in pain by 1.17 and 1.0 points, respectively.

At the end of week 4 of DMT classes, the average pain activity indicators localized in the area of the injured segments were  $1.63 \pm 0.99$  points among female patients, while among male patients, it was  $2.16 \pm 1.21$  points. The subjective pain sensations at the final assessment, according to the VAS, decreased by 1.49 points among women and by 1.84 points among men, compared to the beginning of the classes.

The reduction in the intake of various medications correlated primarily with the intensity of the pain syndrome. Data from the main group were compared with the control group, where significant differences were noted in the long-term postoperative period, regardless of gender (Fig. 3).

The overall attitude towards the relevance of the dance movement therapy course was positive among all respondents. The small number of observations at this stage does not provide grounds for forming clear recommendations for conducting a dance therapy course for all patients with limb injuries; however, it allows for the identification of scientific areas for further research.

## DISCUSSION

Adhering to classical rehabilitation program options and recommended general and local treatment protocols, dance movement therapy often does not catch the attention of most physicians. However, the recognized benefits of this treatment method for various forms of pathological states in the body have been confirmed by scientific research from scholars around the world, including Ukraine [2].

Drawing the attention of orthopedic traumatologists to the idea of combining standard therapeutic exercises with music and transforming traditional rehabilitation programs into those integrated with dance therapy will lead to faster patient improvement through the enrichment of positive emotions, thereby accelerating their recovery in the physical aspect due to a higher level of engagement in the process and increased motivation.

At this stage, the majority of works devoted to dance therapy after injuries specifically address psychological trauma [12]. Undoubtedly, this is a very important aspect of the overall recovery of the patient. Nevertheless, the limited reliable data on the effectiveness of dance therapy in the treatment of patients with musculoskeletal injuries does not allow for a full discussion regarding the management of principles such as individuality, gradual learning of movements, dosage of physical load, frequency of repetitions of learned combinations or movements, optimal execution speed, variety of dance steps, continuity in classes, alternation of movements for different body parts, and, if desired, combination with other art therapy methods.

## CONCLUSIONS

Dance movement therapy has defined effectiveness as part of the rehabilitation measures in the treatment of patients with lower limb fractures in the postoperative period.

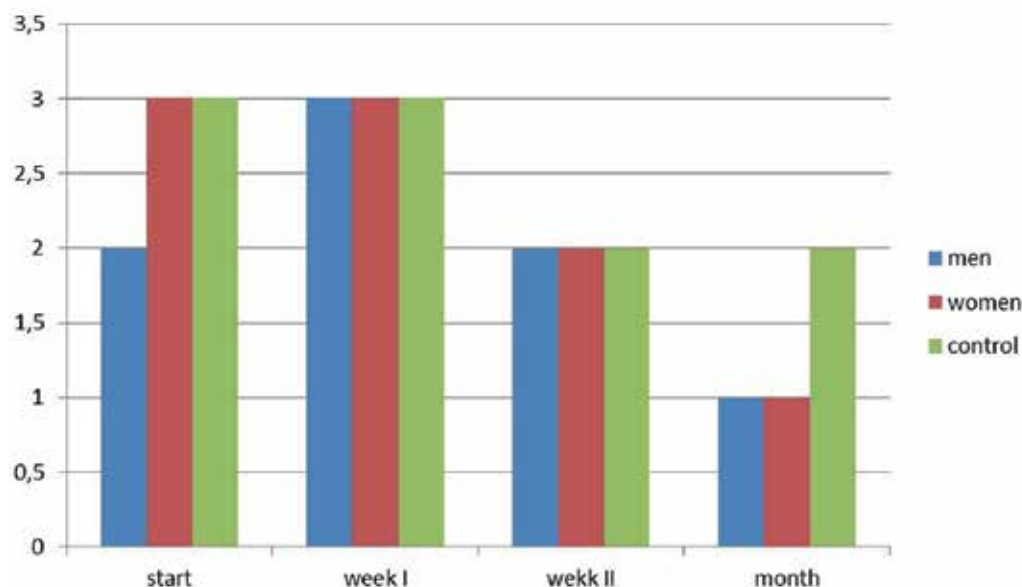


Fig. 3. Level of medication support during the DMT.

During the therapy course, gender-specific features of changes in pain sensations are observed. The subjective feeling of pain decreased by 1.49 points in women and by 1.84 points in men after the dance movement therapy course.

The implementation of dance movement therapy measures in the group of patients after lower limb fractures requires dynamic adjustment, especially regarding the frequency and speed of performing individual tasks.

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*The paper has been written within the scientific research work, made at the Department «Age aspects of step-by-step care for orthopedic and trauma patients with comorbid pathology». State registration No 0122U002528*

## CONFLICT OF INTEREST

The Authors declare no conflict of interest

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**A** – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article

RECEIVED: 01.09.2024

ACCEPTED: 05.11.2024





# Formation of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities

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## ABSTRACT

**Aim:** The aim of the study is to determine, substantiate and experimentally test the effectiveness of proposed didactic conditions for the formation of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities.

**Materials and Methods:** The program of the local pedagogical experiment was implemented through the realization of ascertaining (2022–2023) and formative (2023–2024) stages. Pedagogical experiment involved students in the specialty 227 Therapy and Rehabilitation, field of knowledge 22 Health care of the Poltava State Medical University (Ukraine).

**Results:** The analysis of the results of the formative experiment, during which students studied according to the implementation program in the system of professional training in a medical institution of higher education under specified didactic conditions, shows positive changes in the levels of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities.

**Conclusions:** The model proposed by the authors of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities improves the quality of education of occupational therapists and better prepares them for practical activities.

**KEY WORDS:** health, readiness, occupational therapists, rehabilitation technologies, professional activities, patients

Acta Balneol. 2024;66(6):392-399. doi: 10.36740/ABAL202406104

## INTRODUCTION

The modern system of higher medical education in Ukraine is characterized by a dynamic renewal of the educational space. One of the defining trends in modern higher medical education is the training of occupational therapists, able to perform their professional duties at a high level, provide rehabilitation care, carry out medical and diagnostic process using rehabilitation technologies in professional activities, to lay a solid foundation of health of the population, as well as capable to solve complex problems and problems in the field of health care in the specialty 227 Therapy and Rehabilitation in professional activities, to professional development, continuous professional self-development.

Theoretical analysis of scientific works, acquaintance with the results of scientific and practical experience of medical institutions of higher education on the outlined problem

allowed to identify a number of contradictions between: society's need for highly professional occupational therapists and the actual level of their training to perform professional duties in modern conditions; potential opportunities for training future occupational therapists to use modern rehabilitation technologies in professional activities in medical institutions of higher education and the lack of scientifically sound didactic conditions for this activities; requirements for the level of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities and the imperfection of traditional methods and technologies of its formation; the need to increase the level of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities and the lack of appropriate diagnostic tools to monitor this process [1-3].

## AIM

The aim of the study is to determine, substantiate and experimentally test the effectiveness of proposed didactic conditions for the formation of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities.

## MATERIALS AND METHODS

The program of the local pedagogical experiment was implemented through the realization of ascertaining (2022-2023) and formative (2023-2024) stages. They made it possible to state the state of the researched problem, to understand and formulate the purpose of the research, to outline the tasks of the experimental work, to clarify the theoretical foundations of the formation of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities.

The confirmatory stage of the pedagogical experiment provided for the diagnosis of the levels of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities to defined criteria. A package of complex tasks (tests, situational cases with tasks, the solving of which demonstrates the ability and skills to use modern rehabilitation technologies in the work of a occupational therapy) served as a diagnostic toolkit. In the conditions of distance learning, the forms of communication and interaction between the participants of the educational process also changed. They can be combined into two groups: asynchronous communication – e-mail correspondence, forwarding of educational materials, file sharing, video instructions, etc.; synchronous communication: chat – instant messaging, online counseling; video and audio communication – conversations, discussions online.

The formative stage of the experiment involved the implementation of the author's model of the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities was developed, consisting of methodological-target, implementation-technological and diagnostic-resultative blocks.

Pedagogical experiment involved students in the specialty 227 Therapy and Rehabilitation, field of knowledge 22 Health care of the Poltava State Medical University (Ukraine).

The hypothesis of the research was formulated, which lies in that the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities will be effective if following didactic conditions are implemented:

1. Actualization of the possibilities of the medical institution of higher education as an innovative environment for the study of modern rehabilitation technologies.
2. Introduction and use in the process of professional training of students of the workshop «Modern rehabilitation technologies».
3. Implementation of a resource-based approach in the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities.

4. Monitoring of the process of formation of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities is carried out using a set of criteria (motivational, cognitive, activity and self-education).

A set of following research methods was used to achieve the goal and to test the hypothesis:

- *theoretical* – analysis, synthesis, comparison, generalization and systematization of the obtained data in order to compare different views of scientists on the research problem, clarification of the concept of «readiness of future occupational therapists to use modern rehabilitation technologies in professional activities», determination of its structural components, clarification of methodological approaches that characterize the current state of training of future occupational therapists in the system of higher medical education, substantiation of didactic conditions; modelling – to build a model for monitoring the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities;
- *empirical*: (questionnaire, testing, conversation) – to diagnose the level of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities; pedagogical experiment – in order to check the effectiveness of didactic conditions and the model;
- *mathematical statistics* – combination of quantitative and qualitative analysis of the received empirical material using the Pearson's  $\chi^2$  test in order to justify the reliability of the obtained results, a graphical representation of the quantitative and qualitative analysis of the results of the pedagogical experiment.

## RESULTS

On the basis of the analysis of scientific literature and the practice of medical institutions of higher education, it was found that the problem of training future occupational therapists to use modern rehabilitation technologies in professional activities remained outside the scope of the study of scientists, which is an important component of the system of professional training of occupational therapists in medical institutions of higher education, and therefore, a guarantee of the future successful professional activity [4-6].

Based on the understanding of the scientific literature, the essence of the concept of «training of future occupational therapists in professional activities» was substantiated as a purposeful dynamic process of training students, aimed at forming the ability to apply the acquired knowledge, skills and abilities in working with a wide range of modern rehabilitation technologies for the treatment of diseases, as well as in establishing a constructive interaction with the patient as a subject of his own health care.

*Readiness of future occupational therapists in professional activities* is considered as a holistic personal dynamic formation acquired as a result of special training, which is characterized by the ability of the applicant in practice in real conditions

to demonstrate his knowledge of the principles of operation and use of various categories of modern rehabilitation technologies, and as a set of practical skills for working with it for the organization of the treatment and diagnostic process, and a focus on successfully mastering the latest modern rehabilitation technologies.

In the structure of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities, the following components were distinguished: *motivational, cognitive, activity and self-educational*.

*Motivational component* characterizes the student's interests, motives for mastering modern rehabilitation technologies, striving for professional growth and competitiveness in the market of medical services in the field of therapy and rehabilitation.

*Cognitive component* determines the set of fundamental knowledge that is necessary and sufficient for the use of rehabilitation technologies in the future professional activity of occupational therapists.

*Active component* reflects the set of abilities and skills to successfully implement their functional duties when providing rehabilitation care to patients and their families with the use of modern rehabilitation technologies in the future professional activity of future occupational therapists.

*Self-educational component* stands for the student's ability to carry out self-educational activities in the context of mastering the methods of modern rehabilitation technologies, the desire for self-education, self-development and self-control.

Based on a comprehensive study of the criteria and their indicators, three levels of readiness were differentiated: *low, medium and high*.

Didactic conditions were singled out in view of methodological approaches (competence-based, comprehensive, health-preserving and preventive, multidisciplinary, internationalization, prognostic, environmental, technological, resource-based) and principles (didactic: scientificity, accessibility, strength of knowledge, systematicity and consistency, clarity, practical focus of learning, awareness and activity of learning, individualization of training, control and correction of knowledge; specific: interactivity, parity, contextual learning, constructive communication, freedom of choice, informed perspective, continuous professional development).

*The first didactic condition* – actualization of the possibilities of a medical institution of higher education as an innovative environment for studying modern rehabilitation technologies – involves the search for implementation mechanisms for improving the spatial-objective, subject, axiological-semantic, informational and educational, substantive and procedural components of such an environment as an open system of opportunities and resources for development, self-development, support of students and scientific and pedagogical workers in the process of training future occupational therapists to use modern rehabilitation technologies in professional activities on the basis of pedagogical innovations.

During the implementation of this didactic condition, special attention was focused on the generation of innovative

flows in a medical institution of higher education (generating new productive ideas for the purpose of developing and implementing pedagogical innovations for the continuous improvement of the process of professional training of students); increasing the innovative potential of a medical institution of higher education (improvement of the educational process using material and technical, organizational and managerial, educational and developmental innovations, etc.); preservation of local, administrative innovations, traditional and innovative author's methods of teaching students; improvement of spatial-subject, subject, axiological-semantic, informational-educational, content and procedural components innovative educational environment of a medical institution of higher education. Taking into account the specific principles, a strategy for training future occupational therapists to use modern rehabilitation technologies in professional activities was proposed; creation of modern rehabilitation centers, training rooms «Occupational therapy office», author's pedagogical workshops of the type «Ergotherapy» as a permanent consultation center, which introduces original forms and methods of teaching future occupational therapists to work with modern rehabilitation technologies; development of special educational, methodical and informational resources that will ensure the traditional and remote educational process, is directly focused on the process of preparing future occupational therapists to use modern rehabilitation technologies in professional activities[7-9].

*The second didactic condition* – introduction and use in the process of professional training of students of the workshop «Modern rehabilitation technologies» – aimed at implementing the content of the workshop, the method of implementation of which can be disclosed in the following recommendations:

1. The development of tasks for the workshop should take into account didactic principles (scientificity, accessibility, solidity of knowledge, systematicity and consistency, clarity, practical orientation of learning, awareness and activity of learning, control and correction of knowledge) and specific principles of training future occupational therapists to use modern rehabilitation technologies in professional activities (interactivity, parity, contextual learning, constructive communication, freedom of choice, informed perspective, continuous professional development).
2. Guided by the principles of individualization of training, interactivity, freedom of choice, with the aim of providing free access to materials of the workshop, the online platform «Modern rehabilitation technologies» with digital content was developed and used.
3. The content of the workshop «Modern rehabilitation technologies» focuses on the model of the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities (motivational, cognitive, activity and self-educational components).
4. The use of a number of interactive teaching methods, which are aimed at the assimilation of future occupa-

tional therapists at the same time as classroom professionally oriented components of the work and the use of modern rehabilitation technologies in professional activities: simulation methods, business games, the consilium method, the case method, the incident method, take a position (own opinion), discussion during the discussion of patient treatment tactics, situational modeling, methods of using virtual and augmented reality, etc.

5. The teacher's activity in teaching the practical is characterized by the following features: the teacher guides the discussion of the problem presented in the practical tasks for the modules; the teacher organizes the independent activity of students in a simulated situation, which makes it possible to combine theoretical training with practical skills and abilities, apply the theoretical basis to solving practical situations that may arise in the real professional activity; the methods used and moderated by the teacher during the discussion of tasks should be interactive.
6. The result of work on practical tasks – formulating a practical solution to a problem or situation based on a deep and comprehensive analysis, evaluation of decision algorithms proposed by future occupational therapists, selection of the best option in the context of a task or problem, which requires the use of modern rehabilitation technologies in professional activities.

*The third didactic condition* – implementation of a resource-based approach in the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities – involves orientation to the principles of parity, contextual learning, freedom of choice, continuous professional development and individualization of learning.

This condition was implemented thanks to:

- organization of resource-based training in the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities as such an organization of training that takes into account the individual needs and capabilities of the future occupational therapists, is built on the principles of stimulating independent cognitive activity of students to master the skills of active transformation of the information environment, students' assimilation of knowledge in the field of rehabilitation and modern rehabilitation technologies in professional activities and promotes the development of a digitally and professionally competent personality, orientation towards professional formation, professional self-development of future occupational therapists by introducing elements of self-education into the educational process;
- careful planning of self-educational work of students in the context of forming their readiness to use modern rehabilitation technologies in professional activities of future occupational therapists (use of project technologies – individual projects, web quests);
- usage of future occupational therapists portfolio of readiness to use modern rehabilitation technologies in

professional activities as a method of recording, accumulating and evaluating the individual achievements of a student in a certain period of his educational, especially independent activity (during the implementation period of the workshop «Modern rehabilitation technologies», for the entire period of study at the medical institution of higher education);

- creation of a resource base for self-mastery of methods of using modern rehabilitation technologies in professional activities of a future occupational therapists.

*The fourth didactic condition* – monitoring of the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities is carried out using a set of criteria (motivational, cognitive, activity and self-educational) – involves conducting diagnostic procedures of studied readiness according to defined criteria and three levels (low, medium, high).

*Motivational criterion* expresses the degree of development of interests, motives for mastering modern rehabilitation technologies during training, the desire for professional growth and competitiveness in the market of medical services in the field of therapy and rehabilitation.

*Cognitive criterion* characterizes the set of fundamental knowledge that is necessary and sufficient for the use of modern rehabilitation technologies in the future professional activity of a future occupational therapists.

*Activity criterion* reflects the degree of development of abilities and skills to successfully implement their functional duties in providing rehabilitation care to patients and their families using modern rehabilitation technologies in the future professional activity of a occupational therapists.

*Self-education criterion* reflects the degree of development of skills to carry out self-educational activities in the context of mastering the methods of using modern rehabilitation technologies in the professional activity of a occupational therapists, desire for self-education, self-development and self-control.

The analysis of indicators of the level of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities made it possible to establish that: according to the *motivational criterion*, 20% of students demonstrated a high level of readiness, medium – 30.59%, low – 49.51%; according to the *cognitive criterion*, 8.24% of students demonstrated a high level of readiness, medium – 56.86%, low – 34.90%; according to the *activity criterion*, 4.31% of students demonstrated a high level of readiness, medium – 51.76%, low – 43.92%; according to the *self-education criterion*, 9.41% of students showed a high level of readiness, medium – 33.73%, low – 56.86%. Therefore, the results of the ascertainment stage of the experiment proved the insufficient level of readiness of the students, which determines the need to improve the process of preparing future occupational therapists to use modern rehabilitation technologies in professional activities by implementing certain didactic conditions.

Within the framework of the experiment, a monitoring model of the process of forming the readiness of future occupational therapists to use modern rehabilitation

technologies in professional activities was developed, consisting of *methodological-target, implementation-technological and diagnostic-resultative blocks* (Fig.1).

The *methodological-target block* of the model contains the goal, methodological approaches, didactic and specific principles of formation the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities as a basis for achieving the defined research goal.

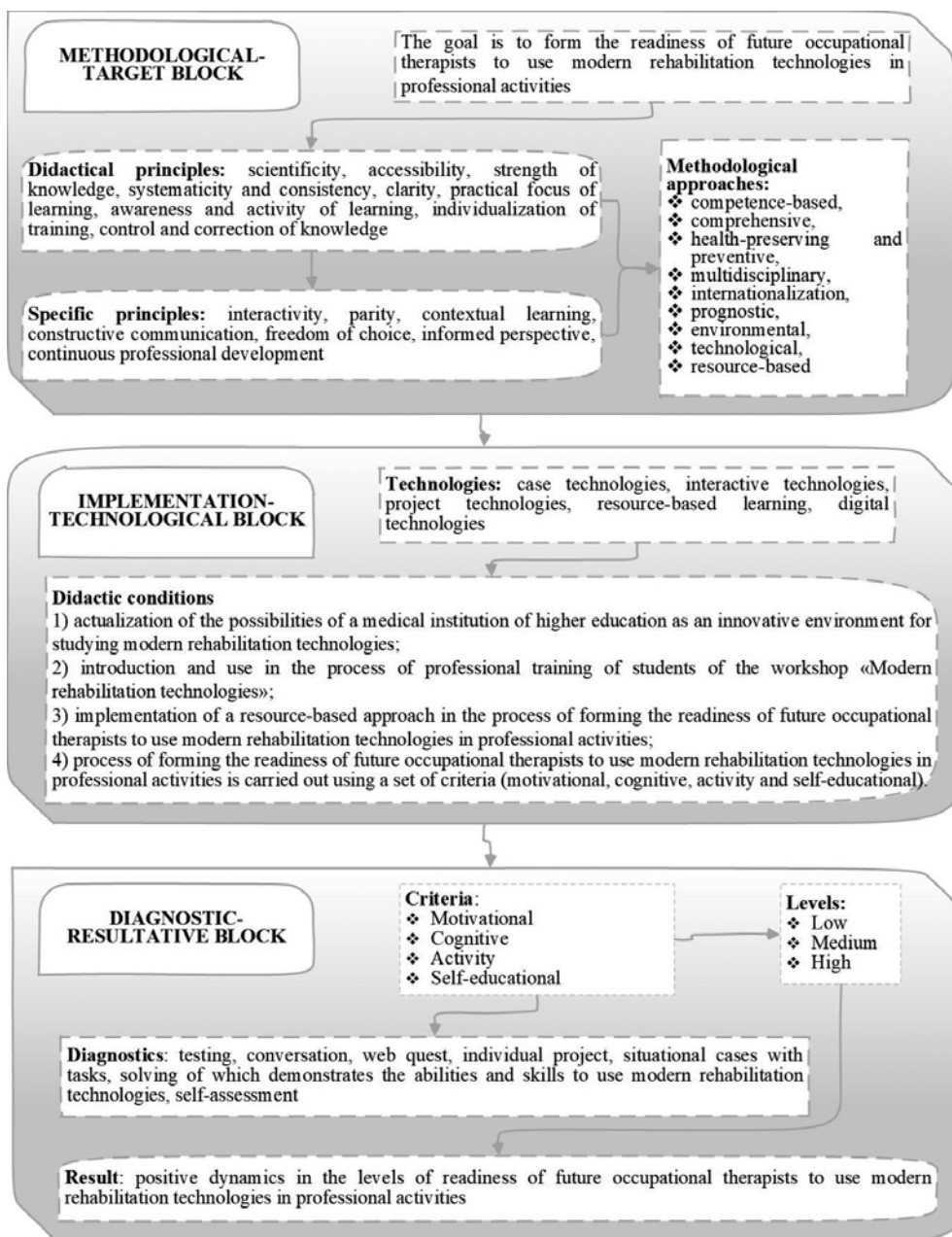
The *implementation-technological block* of the model reflects the didactic technologies that were used in the context of preparing students for the use of modern rehabilitation technologies of specified didactic conditions.

The *diagnostic-resultative block* is determined by the purpose of the study and the specifics of the content of

the study determined for conducting the experimental study. It highlights the criteria and levels of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities, diagnostic toolkit for its assessment, as well as the result, namely, the positive dynamics in the levels of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities.

The implementation of the model was ensured by the implementation of a complex of defined didactic conditions for the formation of the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities.

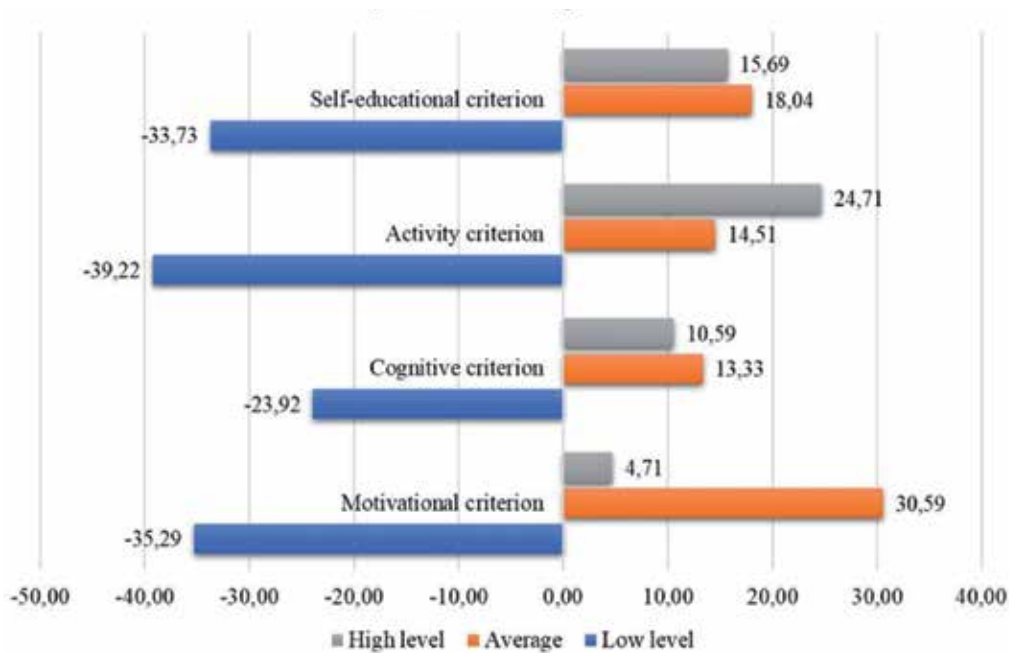
During the experiment, the importance and effectiveness of the strategy of preparing future occupational therapists



**Fig. 1.** Model of the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities.



**Fig. 2.** Electronic resource «Modern rehabilitation technologies».



**Fig. 3.** Dynamics of changes in the levels of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities (%).

to use modern rehabilitation technologies in professional activities was revealed in: annual work plan; study rooms «Occupational therapy office», author's pedagogical workshops of the type «Ergotherapy»; technical bases for practice; developed special educational, methodological and informational resources, which provided the traditional and remote educational process, focused directly on the process of training future occupational therapists to use modern rehabilitation technologies in professional activities

(educational and methodological support, electronic resource «Modern rehabilitation technologies» (Fig. 2).

The students also noted the effectiveness of involving practicing dentists in the pedagogical experiment; internship under the guidance of a practicing doctor of physical and rehabilitation medicine on the basis of clinics; conducting thematic master classes, digital technologies in the work of a doctor of physical and rehabilitation medicine; use of project technologies (individual projects such as «SWOT

analysis); use of the portfolio (webportfolio) of the future occupational therapists to use modern rehabilitation technologies in professional activities.

The analysis of the results of the formative experiment, during which students studied according to the implementation program in the system of professional training in a medical institution of higher education under specified didactic conditions, shows positive changes in the levels of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities. Thus, according to the *motivational criterion*, 24.71% of students demonstrated a high level of readiness, medium – 61.18%, low – 14.12%; according to the *cognitive criterion*, 18.82% of students demonstrated a high level of readiness, medium – 70.20%, low – 10.98%; according to the *activity criterion*, 29.02% of students demonstrated a high level of readiness, medium – 66.27%, low – 4.71%; according to the *self-education criterion*, 25.10% of students demonstrated a high level of readiness, medium – 51.76%, low – 23.14%.

A generalized characteristic of the dynamics of changes in the levels of readiness studied after the experiment is presented in Fig. 3.

The obtained results of the study testify to the effectiveness of the proposed model and didactic conditions for the formation of the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities, since the level of formation of indicators of students' readiness criteria acquired positive dynamics.

## DISCUSSION

In this regard, it is important to create didactic conditions for effective training of future occupational therapists in domestic medical institutions of higher education. A special role in this process belongs to the formation of the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities, as well as the problem of monitoring this process [10, 11].

Analysis of scientific and pedagogical literature shows that there is a powerful scientific arsenal of scientific works on the problems of professional training of future occupational therapists and formation of their professional competencies. However, there is a need to determine and justify the didactic conditions for the formation of the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities [12, 13].

In the course of scientific research it has been proven that the following didactic conditions are effective in forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities [14, 15]:

1. Actualization of the possibilities of a medical institution of higher education as an innovative environment for studying modern rehabilitation technologies.
2. Introduction and use in the process of professional training of students of the workshop «Modern rehabilitation technologies».
3. Implementation of a resource-based approach in the process of forming the readiness of future occupational

therapists to use modern rehabilitation technologies in professional activities.

4. Process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities is carried out using a set of criteria (motivational, cognitive, activity and self-educational).

## CONCLUSIONS

During the discussion it was noted that the proposed author's model is effective and innovative, because for the first time the didactic conditions for the formation of the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities have been defined, substantiated and implemented: actualization of the possibilities of a medical institution of higher education as an innovative environment for studying modern rehabilitation technologies; introduction and use in the process of professional training of students of the workshop «Modern rehabilitation technologies»; implementation of a resource-based approach in the process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities; process of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities is carried out using a set of criteria (motivational, cognitive, activity and self-educational); a model of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities was developed, consisting of *methodological-target, implementation-technological and diagnostic-resultative blocks*; the essence of the concept of «training of future occupational therapists to use modern rehabilitation technologies in professional activities» has been improved, «readiness of future occupational therapists to use modern rehabilitation technologies in professional activities», criteria (motivational, cognitive, activity, self-educational) and levels of readiness of future occupational therapists to use modern rehabilitation technologies in professional activities, diagnostic tools for assessing the level of this readiness.

The practical significance of the obtained results of the experiment was noted, which consists in the development of educational and methodological support for the implementation of didactic conditions of formation of the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities, in particular, the workshop «Modern rehabilitation technologies» and an online platform for its study with digital content, educational and methodological support, of the electronic resource «Modern rehabilitation technologies», criterion-diagnostic apparatus for assessing the level of readiness of the future occupational therapists to use modern rehabilitation technologies in professional activities.

The model proposed by the authors of forming the readiness of future occupational therapists to use modern rehabilitation technologies in professional activities improves the quality of education of occupational therapists and better prepares them for practical activities.

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## CONFLICT OF INTEREST

The Authors declare no conflict of interest

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**A** – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article

RECEIVED: 25.06.2024

ACCEPTED: 05.10.2024





## REVIEW ARTICLE

## Hydrogen sulphide and sulphide waters in the light of latest research reports

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### ABSTRACT

For over 100 years healing properties, therapeutic use and effect mechanism of sulphide and hydrogen sulphide waters have been researched. In recent time, especially during the pandemic, interest in sulphide waters has greatly increased. Many research papers have been published showing new, previously unknown, therapeutic effects and indications for use. In this article authors present new research results, which supplement and broaden current knowledge regarding sulphide and hydrogen sulphide waters. Proving an important physiological role of endogenous hydrogen sulphide (H<sub>2</sub>S) effect as signaling gas was an exceptionally important discovery. In this aspect hydrogen sulphide is now classified among other, earlier known signaling gases – nitrous oxide (NO) and carbon monoxide (CO). H<sub>2</sub>S is created within the organism in enzymatic and non-enzymatic process. It is synthesized in blood vessel endothelium, cerebral tissue, liver, pancreas and gastrointestinal tract. Modern laboratory technology allows determining blood H<sub>2</sub>S level. This allows proving that in case of many diseases (such as diabetes, Parkinson's disease, brain stroke or dementia) the concentration of H<sub>2</sub>S in serum is decreased. This led to the concept of supplementing hydrogen sulphide contained in mineral waters. Aside of earlier known effects of hydrogen sulphide and sulphide waters, the following new ones have been found in recent time: antioxidant, anti-inflammatory, cardio-protective, neuroprotective, metabolic and endocrine.

In recent decade many new research results have emerged, proving that hydrogen sulphide and sulphide waters can be used therapeutically in wider way than before.

**KEY WORDS:** H<sub>2</sub>S and sulphide waters, new effect mechanisms, balneology

Acta Balneol. 2024;66(6):400-403. doi: 10.36740/ABAL202406105

### INTRODUCTION

Hydrogen sulphide (H<sub>2</sub>S) is colorless gas just smelling of rotten eggs. It is lipophilic, well soluble in water, highly toxic. In water 2/3 of gas volume undergoes hydrolysis breaking down into H<sup>+</sup>, HS<sup>-</sup> ions and 2H<sub>2</sub>S<sub>2</sub>, while 1/3 of volume is undissociated. HS<sup>-</sup> i HS<sub>2</sub> anions have strong oxygenating properties, especially in presence of metals. In water with acidic reaction sulphur is present mainly in H<sub>2</sub>S form, with pH 6,5-7,5. In hydrogen sulphide and sulphide waters there are other sulphur compounds aside H<sub>2</sub>S, such as: sulphides, sulphates, trisulphates, colloidal sulphur and other mineral components [1].

Antioxidant effect of hydrogen sulphide and sulphide waters is based on decreasing production of free oxygen radicals and stimulating the activity of antioxidant enzymes. Anti-inflammatory effect results mainly from decreasing the activity of pro-inflammatory cytokines such as IL-2, gamma interferon and TNF-α. Cardio-protective effect of sulphide waters has been proven – hydrogen sulphide they contain acts two-way. On one side, as gas alone, it has vasodilation effect. On the other, non-directly, as signaling gas it stimulates nitrous oxide synthesis which

increases tissue blood supply. Clinical tests have proven that hydrogen sulphide and sulphide waters decrease heart ischemia, influence vessel re-perfusion and stimulate NO secretion. H<sub>2</sub>S has proven positive angiogenetic influence on patients with diabetes, nephropathy and retinopathy. Improvement was expressed by positive influence on endothelium function. In recent years neuroprotective effect of hydrogen sulphide and sulphide waters has been determined. Decreased secretion of hydrogen sulphide has been diagnosed in case of many neurodegenerative diseases, where negative effect of endothelium function triggers disease onset. Stimulating endogenous H<sub>2</sub>S synthesis by its supplementation may have neuroprotective influence. Moreover in recent years, during the pandemic time, immunomodulatory effect has been proven – sulphide waters increase the immunity to virus infections. Many research papers conclude that such waters have anti-inflammatory effect as they stimulate immunological system by decreasing the level of pro-inflammatory cytokines, slowing apoptosis and facilitating phagocytic activity of white blood cells. Sulphide waters have also endocrine and metabolic effect. It has been proven that under the

influence of sulphide waters: the insulin resistance is reduced, fat tissue lipolysis is controlled, adipokine secretion in fat tissue is stimulated, blood cholesterol level is decreased and plasma fibrinolytic activity is facilitated.

## REVIEW AND DISCUSSION

### OCCURRENCE OF HYDROGEN SULPHIDE IN NATURE AND HUMAN ORGANISM (EGZOGENIC AND ENDOGENIC GAS)

In nature  $H_2S$  occurs in volcanic air, natural gas, gypsum rock, mineral waters. In decks of earth elemental sulphur occurs, which is created as a result of reducing gypsum rock calcium sulphate by bacteria.

In the last decade there has been an important and interesting discovery regarding physiological and pathophysiological role of endogenous hydrogen sulphide. It has been determined that  $H_2S$  is created within organism as signaling gas, beside nitrous oxide (NO) and carbon monoxide (CO). These gas transmitters are created within organism in the same cells and organs, and present similar biological action, yet based on different mechanisms [2]. Signaling gasses present the following biological action: vasodilation, angiogenic, antioxidant, anti- or pro-inflammatory and action protective for various organs.  $H_2S$  transmittance through cell membranes, therefore hydrogen sulphide possible influence on metabolic processes, is an important discovery. These discoveries open new ways for research and therapeutic use of hydrogen sulphide and sulphide waters. The above-mentioned signaling gasses are endogenic transmitters, capable of transmitting chemical signals and evoking various effects within human organism. There are various correlations between transmitters. Nitrous oxide may activate hydrogen sulphide synthesis within endothelium. Hydrogen sulphide triggers nitrous oxide secretion, but under certain conditions it may also inhibit its synthesis [3]. Beside physiological effect of nitrous oxide as transmitter, which is known since long ago, it has been proven that also carbon monoxide can act as transmitter. This gas is produced within organism as a result of aerobic heme decomposition by heme oxygenase enzyme. Carbon monoxide has modulatory effect on  $H_2S$  biosynthesis [4].

Within the organism  $H_2S$  is produced by three enzymes: CSE, CBS and 3 MTS. It can be also created in non-enzymatic way from organic or non-organic polysaccharides (in this way  $H_2S$  is created in garlic). Occurrence of hypoxia stimulates  $H_2S$  synthesis. Within the organism hydrogen sulphide occurs in blood-flow with concentration of 1-160  $\mu M$  (micromol) and in tissues. Higher concentration is in cerebral tissue (50-160  $\mu M$ ). Sulphur in blood has the form of polysulphides, in tissues – hydrogen sulphide and colloidal sulphur.  $H_2S$  in blood occurs in free form, dissociated form or bonded to hemoglobin as sulfhemoglobin. Free from is eliminated through lungs. Main elimination way is through kidneys in form of sulphates. Within tissues  $H_2S$  bonds with oxygen. Hydrogen sulphide is mainly synthesized in blood vessel endothelium, pancreas beta-cells and liver [5].  $H_2S$  in gas form occurs also in gastrointestinal tract, produced as a result of bacteria influencing protein [6].

We therefore see how important endogenic hydrogen sulphide is for organism. This is where the concept of balneological supplementation originates. It utilizes sulphide and hydrogen sulphide water treatment, in the form of bathing, drinking or irrigation. After hydrogen sulphide has been discovered as endogenic gas it was predicted that some day medicaments containing sulphur compounds and utilizing the benefits of valuable hydrogen sulphide effect will be available. Currently medication from ACE-1 group is available for hypertension treatment, such as *Zofenopril*, which contains sulfhydryl group. This group is catalytic for releasing hydrogen sulphide from vascular endothelium by activating CBS/SCE enzymes. Thanks to increased  $H_2S$  and nitrous oxide secretion in endothelium, vasodilation and decrease in blood pressure are achieved. Results of new research regarding the key role of hydrogen sulphide within human organism change the perception of sulphide and hydrogen sulphide waters. New mechanisms of hydrogen sulphide effect allow for broadening the healing use of sulphide and hydrogen sulphide waters.

Treatment with the use of sulphide and hydrogen sulphide waters has been described in numerous textbooks, such as *Wielka Księga Balneologii, Medycyny Fizycznej i Uzdrawiskowej*, edited by I. Ponikowska. In the chapter regarding sulphide and hydrogen sulphide waters Prof. Kochański gathered all the information concerning sulphide and hydrogen sulphide waters effect and their therapeutic use, based on then current knowledge [1]. Since that time much research has been done, allowing for better understanding the effect mechanism and practical application of such waters. Since not long ago we know of important role of endogenic  $H_2S$  in physiological and pathophysiological aspect within human organism, which greatly broadens the possibilities of using endogenic gas, therein sulphide and hydrogen sulphide waters.

### EFFECT MECHANISM OF HYDROGEN SULPHIDE AND SULPHIDE WATERS, WITH REGARD TO $H_2S$ TRANSMISSION PROPERTIES

Hydrogen sulphide has been the subject of research for 300 years, but this research focused mainly on gas toxicity. Since about 100 years ago research aims at medical use of hydrogen sulphide and sulphide waters [4]. Interest in hydrogen sulphide and sulphide waters has greatly increased over the last years, especially during COVID-19 pandemic. Many new research results emerged, indicating immunomodulatory effect of  $H_2S$  on immune system [7].

Hydrogen sulphide and sulphide waters are prominent in balneotherapy. Waters with relatively high  $H_2S$  and HS-concentration occur in 4 Polish resorts: Solec Zdrój, Busko Zdrój, Swoszowice and Horyniec (Table 1). Wełnin-Malinowe spring in Solec Zdrój needs noticing, with concentration of over 850 mg/l  $H_2S$  and HS-, this being the highest sulphur compound concentration in Poland, and possibly in Europe. Apart from that there are several Polish resorts with lower  $H_2S$  concentration (1,36-5,93 mg/l): Wieniec Zdrój, Wapienne, Przerzeczyn and Wysowa. According to international classification waters classified as sulphide need

to contain at least 1 mg of sulphur determined iodometrically. According to guidelines of Polskie Towarzystwo Balneologii i Medycyny Fizycznej (Polish Society of Balneology and Physical Medicine) sulphide waters should contain no less than 10 mg of divalent sulphur per liter. In sulphide waters sulphur occurs in various forms, such as: hydrogen sulphide, thiosulphates, sulphates and colloidal sulphur. Sulphides and sulphates are partially oxygenated by bacteria, producing sulphuric acid ( $H_2SO_4$ ). Apart from sulphur compound these waters also contain: sodium, potassium, chloride, iodide, calcium, magnesium, ferrous ions, selenium, phosphorus and other substances. *In vitro* and *in vivo* tests have proven the following healing effect of sulphide and hydrogen sulphide waters: oxidoreductive, anti-inflammatory, antibacterial, anti-fungal, cardio-protective, neuroprotective, immunological, osteogenetic and metabolic.

#### ANTIOXIDANT EFFECT

Sulphide and hydrogen sulphide waters have antioxidant effect achieved by reducing secretion of free oxygen radicals and facilitating the activity of antioxidant enzymes (8). Research has proven increased superoxide dismutase (SOD), MDA, GSH and CRP among patients with rheumatoid arthritis subjected to sulphide water baths. During treatment based on drinking sulphide waters antioxidant and metabolic effect has been proven (9). Hydrogen sulphide has proven antioxidant effect and protective effect on blood vessels, which lead to slowing down atherosclerosis process [10, 11].

#### ANTI-INFLAMMATORY EFFECT OF SULPHIDE WATERS

Anti-inflammatory action of hydrogen sulphide is well researched [12]. Main anti-inflammatory effect of sulphide and hydrogen sulphide waters is based on significantly slowing down the activity of pro-inflammatory cytokines, such as IL-2, gamma interferon, *TNF- $\alpha$*  and metalloprotease [13, 14]. It has been proven that sulphur compounds contained in healing water inhibit CD4 T lymphocytes responsible for production of pro-inflammatory cytokines, eventually leading to reducing their level [15]. Other authors have also confirmed decreased level of IL-1, *TNF- $\alpha$* , IL-12 and IL-23 pro-inflammatory cytokines among patients taking sulphide and hydrogen sulphide water baths [16, 17].

#### ANTIBACTERIAL AND ANTI-FUNGAL EFFECT

Hydrogen sulphide easily permeates the skin, many times more intensively than oxygen [18]. During single bath organism absorbs 50-60 mg of sulphur. Positive effect of sulphur compounds in case of skin diseases has been

researched long time ago. Highly concentrated sulphur compounds have keratolytic effect on skin, while lower concentration acts keratoplastically [1, 12]. Moreover it has been proven that sulphur compounds have bactericidal and fungicidal effect [15].

#### CARDIO-PROTECTIVE EFFECT

It is scientifically well-proven that the effect of sulphide waters influence cardio-vascular system by vasodilation and angiogenetic mechanism. Increased supplementation of  $H_2S$  to organism facilitates nitrous oxide secretion, which triggers vasodilation. We therefore observe two possible vasodilation effect mechanisms – of hydrogen sulphide itself and through nitrous oxide [19]. In clinical research Ping HoChen et. al. have determined that sulphide waters reduce myocardial ischemia by metabolic effect, re-perfusion and triggering nitrous oxide synthesis. Cardio-protective and angiogenetic effects have been proven by Salloum et. al. in 2015 [20]. Other research has proven that  $H_2S$  improves endothelium function among diabetic patients with nephropathy, retinopathy and cardiopathy. It has been also determined that oxidative stress among those patients has been reduced [21]. In other papers it has been shown that patients who have undergone sulphide water baths had increased concentration of blood hemoglobin and red blood cell count [8]. Apart from that, other cardiological research has proven anti-arrhythmic effect of hydrogen sulphide, which is attributed by the authors to its influence on potassium, calcium and chloride channels of cell membranes [10].

#### NEUROPROTECTIVE EFFECT OF SULPHIDE WATERS

There are many new research results regarding neuroprotective effect of sulphide waters available. These prove that decreased level of endogenous hydrogen sulphide, frequently alongside reduced carbon monoxide level, is observed in case of many neurodegenerative diseases such as Parkinson's disease, brain stroke and dementia. The consequence of decreased  $H_2S$  synthesis within brain is endothelium dysfunction, promoting development of neurodegenerative diseases such as ischemic brain stroke [22-24]. It can be therefore concluded that supplementation of sulphur compounds in the form of balneological treatment may improve nervous system functioning, therein cognitive functions [25]. Neuroprotective effect of  $H_2S$  is related to anti-inflammatory and anti-stress effect and facilitating cerebral tissue oxygenation [22, 26]. Another article shows that  $H_2S$  enhances cerebral tissue micro-circulation, which results in better central nervous system functioning [27].

**Table 1.** Resorts in Poland with sulphide waters

	Resort	$H_2S$ and HS- level in mg/l	Mineralization %
1.	Solec Zdrój (Wetlin-Malinowe spring)	850.0	3.65%
2.	Busko Zdrój	86.0	1.23 – 1.40
3.	Swoszowice	68.0	0.26 – 0.28
4.	Horyniec	28.0	0.06 – 0.08

### IMMUNOMODULATORY EFFECT OF SULPHIDE WATERS

During COVID-19 pandemic many papers have been published regarding hydrogen sulphide and sulphide waters effecting immune system [7, 18, 29]. It is known that endogenous H<sub>2</sub>S enhances proliferation and increases the activity of T-lymphocytes [30]. Meta-analysis by Masiero et. al. presented many documented research results in the field of balneological treatment effecting immune system [7]. Rinaldi et. al. have proven that HS<sup>-</sup> ions administered orally facilitate short-term life of neutrophils creating anti-inflammatory effect. Another effect observed by the authors is leukocyte apoptosis inhibition [29]. Other papers describe facilitating phagocyte activity of granulocytes and macrophages, reduction of PGE<sub>2</sub> prostaglandins and pro-inflammatory cytokines [12, 17]. Yang et. al. have proven that hydrogen sulphide regulates the function of mesenchymal T stem cells [31].

### OSTEOGENETIC EFFECT OF SULPHIDE WATERS

Sulphur compounds participate in creating cartilage, nail and hair growth – these are effects known since long time ago, but new research has been done. It has proven that exogenous H<sub>2</sub>S supplementation has positive effect on osteogenesis in bone implants and osteoarthritis [32]. Authors of this thesis have proven anti-inflammatory and anti-catabolic effect in chondrocytes influenced by H<sub>2</sub>S. It has also been shown that hydrogen sulphide prevents bone mass loss, which is particularly important in osteoporosis. H<sub>2</sub>S plays major role chondrocyte activity – reducing inflammation by increasing IL-16 and inhibiting inflammatory prostaglandins [13] along with stimulating osteogenetic process [33].

### METABOLIC AND ENDOCRINE EFFECT OF HYDROGEN SULPHIDE AND SULPHIDE WATERS

It has been proven that diabetic patients have decreased hydrogen sulphide blood level, which may indicate the need of supplementing this gas [25]. It has been shown that H<sub>2</sub>S presents metabolic and endocrine effect – inhibits insulin secretion by activating ATP-dependent potassium channels. This facilitates glucose uptake by tissues [34]. Thanks to these effects insulin resistance, very common among diabetic and obese patients, can be inhibited. Moreover, hydrogen sulphide stimulates glucogenesis

and increases glucagon storage within liver. H<sub>2</sub>S as signaling gas influences growth hormone and pancreatic hormones secretion [35]. Many authors have determined that hydrogen sulphide and sulphide waters stimulate pituitary-adrenal axis, this way increasing the secretion of ACTH and cortisol [7]. Moreover H<sub>2</sub>S has regulatory effect on lipolysis in adipose tissue and stimulates adipokine secretion [36]. Earlier research has proven that therapy utilizing drinking sulphide waters causes decrease in total cholesterol level, LDL fraction and triglycerides. Plasma fibrinolytic activity increases and platelet aggregation decreases [37]. Decreasing cholesterol level and inhibiting development of atherosclerosis has been confirmed by many authors [5, 11]. Slowing down atherosclerotic process under the influence of sulphide waters may be based on different mechanism than decreasing cholesterol level.

Gheibi et. al. have proven that H<sub>2</sub>S stimulates estrogen receptors, therefore increasing H<sub>2</sub>S synthesis in liver and vascular endothelium – blood vessels are effected in this indirect way, organs are better oxygenated and atherosclerosis is eventually inhibited [34]. Moreover it has been proven that H<sub>2</sub>S inhibits the renin-angiotensin system function in kidneys [34]. Bakaliuk et. al. have determined the positive effect of sulphide and hydrogen sulphide baths on patients with diabetic polyneuropathy. After 8 sulphide baths a significant increase in sensing touch, temperature and vibration has been observed. Authors relate these therapeutic effects with hydrogen sulphide improving adaptive, protective and regenerative abilities of the organism [38].

### CONCLUSIONS

This article focuses on presenting information regarding newly-researched mechanisms and supplementing current knowledge. Even the latest balneological textbooks lack the information regarding anti-inflammatory effect mechanism of sulphide and hydrogen sulphide waters. Currently it is known that these waters influence inflammatory and anti-inflammatory cytokines and oxidative stress, therein oxygen free radicals and antioxidant enzyme system. Current knowledge also concerns cardio-protective and neuroprotective effect of these waters. Apart from that we have learnt many new aspects of immunological effect of sulphide and hydrogen sulphide waters. Previous research

**Table 2.** What new have we learned about hydrogen sulphide and hydrogen sulphide/sulphide waters

Supplement to textbook knowledge	New knowledge, not included in existing textbooks
Understanding anti-inflammatory effect mechanisms	Role, physiological and patophysiological effect of endogenous hydrogen sulphide as signaling gas
Metabolic and endocrine effect	Cardio-protective effect
	Neuroprotective effect
	Antioxidant effect
	Immunological effect

Abbreviation list: H<sub>2</sub>S – hydrogen sulphide, NO – nitrous oxide, CO – carbon monoxide, H<sup>+</sup> – hydrogen, CSE – cystathionine beta-synthase, CBS – cystathionine synthase, 3 MTS – 3 mercaptopiruvate cystathionine sulphotransferase

results concerned mainly the influence on total cholesterol blood level. Several years ago information was published concerning endogenous hydrogen sulphide synthesis and its role in proper functioning of many human organs. Knowledge regarding not only therapeutic effects, but also the effect mechanisms of hydrogen sulphide on human organism has been greatly broadened (Table 2). New knowledge

should trigger correcting current indications for sulphide and hydrogen sulphide waters treatment, especially adding cardiological, neurological and immunological indications. Enriching knowledge about significant physiological role of hydrogen sulphide and about the effect mechanisms of hydrogen sulphide and sulphide waters does also open new possibilities of clinical research.

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#### CONFLICT OF INTEREST

The Authors declare no conflict of interest

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**RECEIVED:** 16.07.2024

**ACCEPTED:** 10.10.2024



## REVIEW ARTICLE

# Balneological and rehabilitative aspects of thermal treatment for patients with Parkinson's disease

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## ABSTRACT

Parkinson's disease is one of the most common neurodegenerative disorders, characterized by the progressive impairment of motor functions and the occurrence of non-motor symptoms. Despite the effectiveness of pharmacological treatment in the early stages of the disease, advanced stages are associated with a reduced effectiveness of medications and the intensification of symptoms such as balance disturbances, tremors, and muscle rigidity. The aim of the article is to present the role of physical rehabilitation and occupational therapy as important components of comprehensive treatment for Parkinson's disease.

The article discusses the significance of physical exercises tailored to the individual needs of patients, taking into account the different stages of the disease. The effectiveness of manual therapy, movement exercises, and artistic activities, such as sculpture and drawing, in alleviating motor symptoms and improving well-being is emphasized. The potential of modern technologies, such as virtual reality, in the rehabilitation of patients is also discussed, indicating both the benefits and limitations of these methods.

The presented research findings suggest that regular and long-term rehabilitation can improve the quality of life for patients and reduce the risk of complications associated with movement limitations. The authors emphasize the need for further research in order to develop more comprehensive guidelines for rehabilitation therapy in Parkinson's disease.

**KEY WORDS:** Parkinson's disease, rehabilitation, nordic walking

Acta Balneol. 2024;66(6):406-409. doi: 10.36740/ABAL202406106

## INTRODUCTION

Parkinson's disease is the second most common neurodegenerative disorder, affecting approximately 10 million people worldwide. Over time, it leads to significant disability, not only cognitive but also motor [1]. The early stages of the disease are characterized by a good response to dopaminergic medications; however, as the disease progresses, their effectiveness decreases. The progressive loss of neural cells and the expansion of damage to other brain areas lead to the advanced stage.

In this stage, medication response persists but is inconsistent, with delays in drug action, peak-dose dyskinesias, muscle cramps, and "freezing" episodes. These symptoms are accompanied by balance problems and an increased tendency to fall. Managing the advanced phase of Parkinson's disease, characterized by motor fluctuations and dyskinesias, presents significant challenges. Additionally, a range of non-motor symptoms emerges, worsening the disease course. These symptoms can be particularly difficult to treat and often require a reduction in the doses of medications that enhance motor function [2, 3].

For this reason, physical therapy is essential. Although motor rehabilitation cannot halt the progression of the disease, it plays a vital role in maintaining the patient's ability to function normally in society. Regular physical

activity improves mobility in patients with Parkinson's disease, thereby preventing falls and reducing muscle pain associated with Parkinsonian rigidity. As a result, it can delay the onset of disability. Therefore, motor rehabilitation should begin early in the treatment process [4-6].

## STUDY DESIGN

The article is based on a literature review of physical rehabilitation and occupational therapy in the treatment of Parkinson's disease (PD). The analyzed sources include scientific publications available in databases such as PubMed, Scopus, and Web of Science, published between 2000 and 2024.

## INCLUSION AND EXCLUSION CRITERIA

The analysis included original studies, reviews, and meta-analyses focused on the effectiveness of physical rehabilitation, occupational therapy, balneotherapy, and modern technologies in PD therapy. Studies involving only pediatric populations, neurodegenerative diseases other than PD, and publications without peer review were excluded.

## LITERATURE SEARCH PROCESS

The search was conducted using keywords such as «Parkinson's disease,» «rehabilitation,» «occupational therapy,»

«physical therapy,» «virtual reality,» «balneotherapy,» and «Nordic walking.» Articles in both Polish and English were included.

#### ETHICS

The literature review relied exclusively on already published data, eliminating the need for ethical committee approval.

#### LIMITATIONS

The identified limitations stem from the heterogeneity of the studied groups and the rehabilitation methods applied. Variations in observation periods and sample sizes across the analyzed studies complicate the generalization of findings.

### REVIEW AND DISCUSSION

Rehabilitation should be tailored to the individual needs of the patient, taking into account the stage of the disease and the predominant symptoms. Based on studies guidelines for movement therapy have been developed depending on the phase of Parkinson's disease (PD) [7, 8]. In stages 1 to 2.5 on the Hoehn and Yahr scale, which represent the early stage of the disease, patients have no significant motor limitations. At this stage, the primary goals are to prevent inactivity, minimize fear of falling, and maintain physical fitness (aerobic capacity, muscle strength, and joint mobility) through exercises focused on balance and movement dynamics. In stages 2 to 4, motor limitations develop, leading to balance disorders and an increased risk of falls. Functional exercises with dual tasking simultaneously performing two motor tasks or a motor and cognitive task are particularly important. In stage 5, the advanced stage, patients rely on wheelchairs or are bedridden. Here, the goal of physical therapy is to maintain vital functions and prevent complications such as bedsores or contractures. The involvement of a caregiver is essential [7-9].

Another critical aspect of rehabilitation is the regularity of physical exercises and manual therapy. Studies confirm that artistic activities, such as sculpting, alleviate PD symptoms [10]. Regular physical exercises support motor skills by reducing symptoms like rigidity and coordination difficulties. Artistic activities improve mood, reduce anxiety, and stimulate fine motor skills. The most significant improvement was observed in groups combining physical exercises with manual activities, highlighting the importance of comprehensive therapy for PD patients [10]. Consistency and long-term therapy are crucial for maintaining results. During the COVID-19 pandemic, home exercise programs for PD patients were developed due to isolation. Studies documented modest improvements in motor function, quality of life, walking speed, balance, and reduced fear of falling when exercises lasted at least 8 weeks and included no fewer than 30 training sessions [11].

In another study, exercises for knee flexor and extensor muscles on an isokinetic testing device demonstrated significant improvements in lower limb mobility after two months, potentially reducing the risk of falls and related complications [12]. Any form of physical activity helps alleviate PD symptoms. One study [13] found that dance,

walking, and balance training had moderate effects on motor functions. Strength, resistance, and water training had smaller effects, while stretching had uncertain effects. However, water training significantly improved quality of life. The study emphasized the importance of physical exercise for PD patients, with the type of exercise playing a secondary role [13].

Patients in the early stages of PD have a high chance of symptom alleviation through full-body physical activities, such as karate. Improvements in walking, reduced tremors, and better coordination were reported [14]. In some cases, no motor improvements were observed after therapy, although patients reported better well-being [15].

Modern technologies like virtual reality (VR) offer new opportunities in PD rehabilitation. VR provides immersive environments that support motor processes and balance through multisensory stimulation and neuroplasticity promotion. Studies indicate VR can improve motor functions [16]. Personalized therapy with VR is safe for patients at risk of falls [17, 18]. However, VR faces challenges such as high equipment costs and therapist training requirements. Additionally, small sample sizes in studies limit generalizability, and long-term research is lacking. Efforts to reduce costs, increase accessibility, and integrate VR with simpler platforms are essential for its widespread adoption in clinical practice. VR holds the potential to become an integral part of PD therapy, complementing traditional methods, particularly in improving motor skills, balance, and quality of life. Key steps include increasing technology accessibility and conducting further research on long-term effectiveness. Motor rehabilitation for patients with Parkinson's disease can provide short-term but highly significant effects, particularly improving patients' balance and stability, which contributes to a reduced risk of falls. Movement therapy should be tailored individually to the patient, taking into account their functional status, disease stage, and specific needs. Personalized therapy enhances treatment effectiveness and reduces symptoms [19, 20].

Balneotherapy, which uses natural mineral resources like therapeutic waters, is a complementary therapy for PD. These treatments can alleviate muscle rigidity, reduce pain, and improve overall motor performance. Additionally, they positively impact mental well-being, supporting a comprehensive rehabilitation approach. Studies suggest that thermal therapy positively influences certain aspects of quality of life in PD patients, particularly psychological well-being. The absence of adverse effects confirmed the safety of thermal treatments. However, the benefits were short-lived, with no significant effects observed after 20 weeks of follow-up. Regular repetition of thermal therapies two or three times a year may sustain benefits. Currently, there is a lack of research evaluating the efficacy of thermal therapy in PD treatment [21].

Further studies highlight the potential of water therapy for managing cardiovascular stress in controlled conditions. Exercises in thermal water provide effective rehabilitation and improve the quality of life and mental well-being in PD patients [22, 23]. Comprehensive rehabilitation combining



multiple methods better mitigates PD motor and non-motor symptoms, reducing anxiety and improving psychological well-being [10].

Nordic walking (NW) combines physical activity with minimal joint strain, making it particularly beneficial for older individuals and those with mobility issues. NW engages multiple muscle groups, improving cardiovascular fitness and strengthening postural muscles, leading to better body stabilization and reduced fall risk. It also enhances coordination and balance, crucial for neurological rehabilitation. However, proper technique is necessary to avoid injuries. Accessibility may be limited due to equipment costs and the need for training. Weather conditions can also hinder regular practice, affecting therapeutic outcomes. Studies show NW's positive impact on PD symptoms, particularly gait improvement and quality of life, although no major clinical changes in motor functions were observed [24, 25].

Cryotherapy involves short-term exposure to low temperatures, reducing inflammation, pain, and muscle tension. It supports regenerative processes, improves blood and lymph circulation, and reduces swelling, making it useful in post-injury rehabilitation and treating rheumatic diseases. Promising results have been observed in using

cryotherapy for PD patients [26, 27]. Cryotherapy chambers improve circulation, potentially enhancing gait and range of motion. Its antioxidant effects may prevent or delay dementia in PD. However, further studies are needed to confirm its effectiveness.

## CONCLUSIONS

Rehabilitative treatment in Parkinson's disease requires an interdisciplinary approach, incorporating physiotherapy, occupational therapy, balneology, psychological support, and the use of virtual reality. Rehabilitation plays a key role in the comprehensive management of Parkinson's disease, contributing to improved motor functions, quality of life, and reduced caregiver burden. Combining various methods, such as physiotherapy, alternative therapies, and assistive technologies, allows for better customization of therapy to individual patient needs.

Further research into the use of modern technologies in rehabilitation may help optimize its effectiveness. The findings of studies on rehabilitation programs are inconclusive, underscoring the need for additional research to confirm the impact of rehabilitation on improving quality of life in Parkinson's disease and to develop comprehensive guidelines.

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#### CONFLICT OF INTEREST

The Authors declare no conflict of interest

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**RECEIVED:** 12.08.2024

**ACCEPTED:** 10.11.2024



## CASE STUDY

## Guillain-Barre syndrome or only a peripheral nervous system disease? Case Report

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### ABSTRACT

Acute Motor Sensory Axonal Neuropathy (AMSAN) is a variation of Guillain-Barre syndrome (GBS). It is characterized by a severe clinical course generating, in up to 20% of patients, permanent neurological deficits.

We are presenting a case of a 45-year-old female patient with a severe clinical course, with a diagnosis of AMSAN with record high protein values in the cerebrospinal fluid. A week prior to the hospital admission, the patient was treated for upper respiratory tract infection. Two days prior to hospitalization, she began to experience ascending paraesthesia in the region of lower extremities. A nerve-conduction study showed extension of latency or absence of the F wave. Irregularities in the form of short ictal discharges were also observed in the ECG tracings. From the fourth day of hospitalization, the patient's neurological condition began to deteriorate progressing towards flaccid quadriplegia with cranial nerves involvement and symptoms of 'vegetative storm'. Following three-week hospitalization and treatment instituted, the overall and neurological condition of the patient began to stabilize and gradually improve. The patient was transferred to rehabilitation units where she spent a total of 12 months. Home rehabilitation was completed at two years from the development of the disease with full restoration of mobility.

The described course of the disease with ECG changes is but another single report confirming that CBS is not only and solely a disease of the peripheral nervous system.

**KEY WORDS:** Guillain-Barre syndrome, axonal neuropathy, flaccid quadriplegia, cranial nerves involvement, high protein in CSF

Acta Balneol. 2024;66(6):410-414. doi: 10.36740/ABAL202406107

### INTRODUCTION

The first GBS description dates back to 1859 and was presented by Landry. In 1916, Guillain and Barre provided a detailed description of the syndrome with characteristic albuminocytologic dissociation in the cerebrospinal fluid. In 1949, Haymarker and Kernohan described morphological changes in GBS pointing to the oedema of the roots, myelinoclasia and presence of inflammatory cells [9, 10]. In 1986, Feasby described the axonal form [11]. The incidence of GBS is estimated at 2.6-2.8% [1]. The disease is characterized by the appearance of symmetrical flaccid paresis of upper and lower extremities, muscles of the trunk, with areflexia revealed on neurological examination. Deficits of muscle power are usually preceded by paraesthesia localized distally in the region of upper and lower extremities. What can be observed in the course of the syndrome are involvement of cranial nerves and symptoms of irritation of spinal roots. In over 70% of cases, the development of the disease is preceded by infection, immunization, surgery or another disease [1].

### FORMS OF GBS

The classic form of GBS involves *acute inflammatory demyelinating polyneuropathy* (AIDP), with usually fully reversible demyelinating changes within the nerve fibres of the peripheral nervous system. There are also variants with axonal damage to nerve fibres. The latter include:

- AMAM (*Acute Motor Axonal Neuropathy*) and AMSAN (*Acute Motor and Sensory Axonal Neuropathy*) reported in 5% of GBS in Europe and the USA while in up to 30-47% of the population of South America, China and Japan [2, 12]. What is observed in these rare forms is the presence in the cerebrospinal fluid of gangliosides antibodies: antiGMI, antiGD1a, antiGalNAC-GD1a, antiGD1b [2]. A number of variants has also been distinguished:
- pharyngeal-cervical-brachial variant of GBS, with antiGT1a and antiGT1b present [1, 2]
- paraparetic variant of GBS,
- Miller-Fischer variant with characteristic antiGQ1b [1, 2],
- acute autonomic neuropathy.

## PATHOGENESIS

40-70% of GBS cases are preceded by infection [12]. *Campylobacter jejuni* and *cytomegalovirus* (CMV) are the most commonly identified infections preceding CBS, in particular AMAN [12]. The pathogenesis of CBS is seen in the similarity of the structure of gangliosides and lipooligosaccharide of *Campylobacter jejuni* [9]. The antigen mimicry is believed to be responsible for conditioning the appearance of the cellular and humoral response of the immune system oriented against the host's own tissues [9].

In 1969, Asbury described damaging-nerve-fibres lymphocytes, activated t-lymphocytes recognizing autoantigen-MHC II [10]. A certain role is also played by CAM and MMP. T-lymphocytes activate macrophages. What follows is the production of cytokines, toxic mediators of the inflammatory condition, antibodies permeating the damaged blood-nerve barrier. Antibodies against myelin components - gangliosides, P2 protein, galactocerebrosides, sulfatides are produced [10]. Epitopes connected with nerve conduction (places with insufficient blood-nerve barrier) are blocked, the cascade of the complement, MAC - (C5b-C9) is activated. The inflammatory reaction is extinguished through the mediation of macrophages causing the induction of the apoptosis of lymphocytes and anti-inflammatory cytokines: IL - 10, TGF-  $\beta$ . What is also reported is high production of TNF $\alpha$  and IFN $\gamma$  (IL -12, IL - 18) by mononuclear cells of peripheral blood in the progression phase, declining in the recovery phase (IL-10). Pathological processes proceed 'locally'. TNF $\alpha$  is present in 30% of CBS patients. Strong activation of the components of the C3d complement was confirmed. The cerebrospinal fluid of CBS patients was found to contain small peptides <3kDa [13].

## CLINICAL COURSE OF AMSAN

### ACCRUAL PHASE

In the course of the first days following the appearance of symptoms, for approximately a month, neurological deficits tend to accrue and symptoms of deficits become visible. They are often accompanied by pain in the thoracic and lumbosacral regions. In 5% of patients, neck stiffness and occasionally congestive shield can be reported. In ca. 30% of patients, cranial nerves become involved [12]. In 30% of cases, autonomic, vegetative storm-like symptoms can be seen, with high values of arterial tension and pulse as well as excessive, profuse sweating. As many as 30% of patients manifest respiratory insufficiency [1] and 3-5% die [1].

### PLATEAU PHASE

The phase of the stabilization of the neurological condition tends to last up to 14 days in the course of which no new deficits appear on neurological examination.

### RECOVERY PHASE

The phase of recovery to a full functional condition is usually long, lasting from 6 to 14 months and requires intensive, holistic rehabilitation of the patient. Unfortunately, in as many as 1/5 of the patients, permanent neurological deficits persist as confirmed by neurological examination.

## TREATMENT

Given the dynamics of neurological changes, every CBS patient needs to be hospitalized in a neurological ward or in an intensive care ward. In the case of a mild course, observation of the patient is only recommended. In the case of a moderate or severe course, administration of 5 doses of intravenous immunoglobulin -IVIg of 0.4g/kg BW/d (a total of 2g/kg BW) is recommended [1]. An alternative method of treatment, of equal importance, consists in the application of plasmaferesis, plasma exchange, (PE) [1]. It has been proved that four PE procedures work better than two. In severe courses, six procedures were applied consisting in the purification of 50 ml of plasma/kg BW/48h.

Complementary therapy includes anticoagulant prophylaxis, treatment of pain, chronic fatigue syndrome and depression. Properly conducted physical therapy is of enormous importance [1].

## PROGNOSIS

Immunomodulating treatment shortens the duration of the acute phase of the disease, yet, it is of no importance for the final neurological deficit. Prognosis depends on the type of damage (demyelinating or axonal) and intensity of deficits revealed on neurological examination. 70-80% of patients complete rehabilitation without neurological deficits, 20-23% show permanent symptoms of neurological deficits. Mortality rate is estimated at ca. 3% [1]. In 5-10% of patients, a course with recurrences is observed.

## CONTROVERSIES

Literature presents more and more information on the CBS forms proceeding with symptoms of CNS damage, as it was in the case of our patient where we observed transient disturbances in ECG tracings.

Another controversy to be noted in literature concerns the symptomology of the so called 'vegetative storm' period in the aspect of confirming the death of brain stem. In many countries, the above has led to the novelization of the criteria for the qualification of transplant donors: it is necessary to exclude CBS before moving on to the protocol of declaring brain death [14].

## CASE REPORT

A female aged 45, hitherto healthy, not treated for chronic diseases, physically active, IT specialist by profession. Two days prior to hospital admission, she began to experience ascending paraesthesia localized in the region of lower extremities. It was accompanied by persistent headache.

She reported in hospital for gait deterioration and increasing paraesthesia in both upper and lower extremities. Six days prior to hospital admission, she was treated with amoxicillin with clavulanic acid (2x1g) for upper respiratory tract infection. Case history was non-contributory as regards nicotine (-), vaccinations over the past few weeks (-) and surgeries (-). Family history: father died from brain stroke, mother due to renal cancer.

## COURSE OF TREATMENT

## DAY 0

Neurological examination made on the patient's admission to hospital revealed only one deviation from normal – very weak tendon reflexes within upper and lower extremities. Basic examinations: peripheral blood count, coagulation profile, renal parameters, electrolytes, glycemia, CPK, urinalysis – within normal limits. Elevated CRP – 10mg/l, (n.0 – 0.5 mg/l). Chest X-ray – no irregularities. Lumbar puncture was performed – cerebrospinal fluid was within normal limits on general examination – watery, transparent, cytosis – 1/ul, protein – 33.3 mg/dl, protein reactions – negative.

## DAY 1-3

The patient reports periodical diplopia on looking downwards, without evident disturbances in the mobility of eyeballs; additionally, slight symmetric paresis (spinal) of upper and lower extremities was observed (MRC 4/5). On EMG - decline in the frequency of occurrence of F wave within the scope of the median nerve, no other abnormalities. On brain MRI – slight vasogenic changes in both hemispheres, massive inflammation of the sphenoid sinus, On EEG – abnormal tracings – generalized changes in the form of short paroxysmal discharges (Fig. 1).

## DAY 4-9

Further rapid accrual of upper and lower extremities paresis with areflexia, persisting diplopia of the picture seen, vegetative symptoms: tachycardia, increase in arterial hypertension, profuse sweating. On repeated lumbar puncture, cerebrospinal fluid: protein-207mg/dl, cytosis-2/ul, Pandy's and Nonne-Apelt's reactions

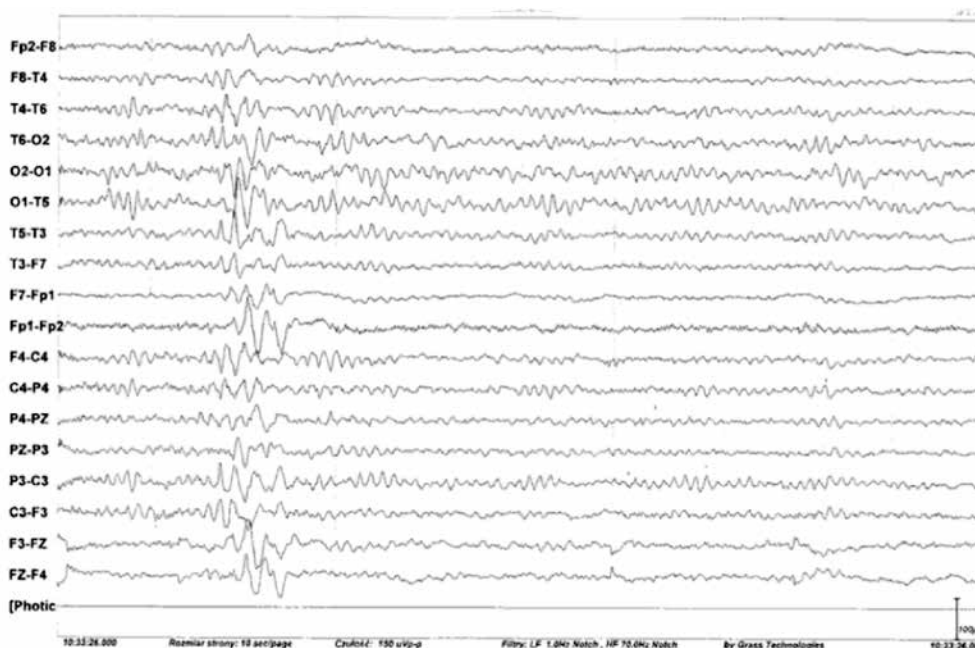
positive. Diagnosis: CBS, Treatment with human immunoglobulin was initiated: dose 0.4g/kg BW/d for 5 days. Due to pain localized in the frontal area, a laryngological consultation was requested and treatment with Clindamycin 2x600mg orally was instituted. Physical rehabilitation was commenced.

## DAY 10

Paresis increased to flaccid quadriplegia. Cerebrospinal fluid: slightly yellowish, transparent, on general examination: protein – 536 mg/dl, cytosis – 3, Nonne-Apelt reaction (-), Pandy's reaction (+). Blood serum and cerebrospinal fluid were collected for examination towards the presence of anti-GM1 antibodies. Given the AMSAN diagnosis, diagnostics was extended towards: HIV, HCY, HBV, SLE, sarcoidosis, boreliosis, HSV, EBV, CMV, *Mycoplasma pneumoniae*. Markers were collected towards paraneoplastic syndromes (-), antibodies against *Campylobacter jejuni* were collected (-).

On subsequent days of hospitalization, the patient's general condition remained stable, with improvement observed in the patient's neurological condition. Withdrawal of peripheral paresis of the left VII nerve and slight improvement in the power of postural muscles were observed. The patient was good at stabilizing the head and the trunk, could sit in an armchair. On examination of the cerebrospinal fluid: slight decline in the protein level to 474 mg/dl, cytosis – m4/ul, oligoclonal bands (-), Index IgG < 0.7, serology for *Borrelia burgdorferi* and other infections – negative results in blood and cerebrospinal fluid. The patient was transferred to the Rehabilitation Ward.

The patient was rehabilitated in several in-patient centres for a total period of 12 months and next, for subsequent 2 years, had regular home rehabilitation. At present, the patient can move



**Fig.1.** Abnormal EEG tracings on the first days of hospitalization – short paroxysmal discharges visible.

efficiently on her own, slight short muscles atrophies of both hands are noticeable. The patient resumed professional work. Check-up EEG tracings obtained a year from the development of the disease - tracings within normal limits.

## DISCUSSION

Literature provides single case reports of CBS with clinical symptoms and imaging examinations findings indicating the presence of accompanying processes taking place within the central nervous system. The descriptions concern, first and foremost, the appearance of the Reversible Cerebral Vasoconstriction Syndrome (RCVS) [3]. RCVS is a syndrome characterized by temporary disturbances in the normal tension of the walls of brain vessels resulting in the development of a constriction of cerebral arterial vessels [8], subsiding, usually, within 12 weeks [8]. The leading clinical symptom of RCVS is a sudden appearance of acute headache [8]. In 25 to 33% of patients, the course of RCVS can include complications such as Posterior Reversible Encephalopathy Syndrome (PRES), ischaemic brain stroke, subarachnoid haemorrhage (SAH) and epileptic seizures [8]. Literature has so far given descriptions of 28 cases of the coexistence of GBS and PRES [3]. PRES is a syndrome of clinical symptoms embracing headaches, disturbances of consciousness, epileptic seizures, disturbances of vision with the presence of MRI changes of vasogenic oedema character localized in the region of the white matter of the brain, PRES symptoms usually withdraw on their own without producing permanent deficits. The first description of PRES comes from 1996 [8]. Though numerous PRES cases can be found described in literature, its aetiology is not yet fully known. What predisposes to its development

are: arterial hypertension, eclampsia, infection, uraemia, porphyria [8].

The majority of researchers seek the aetiology of PRES in CBS accompanying disturbances within the nervous autonomic system translating into changes in the arterial vessels tension and their diameter as well as endothelial dysfunctions [3, 5-7]. Certain correlations have also been observed between the development of RCVS and treatment with intravenous immunoglobulin infusions [4]. So far, 4 cases of RCVS in the course of GBS have been described. All of them concerned patients treated with IVIg iv [3, 5, 6]. However, in two situations, RCVS symptoms appeared yet before the administration of IVIg iv. IT cannot be excluded that IVIg iv may trigger RCVS. Literature indicates that the development of vegetative system damage is more common in AIDP than in axonal forms [3]. Part of the authors postulate more frequent occurrence of PRES in women to be potentially due to the higher propensity of women to develop symptoms of dysautonomia in GBS [8].

## CONCLUSIONS

In our patient, we did not observe constriction of the cerebral arterial vessels in vascular options MRI TOF, neither did we observe focal changes within brain tissue. The patient has long suffered from bad headaches as well as showed vegetative symptoms: high values of arterial tensions and pulse demanding treatment, excessive sweating. Also, periodically, during the attack of the disease, significant irregularities were observed in the EEG tracings which seems to make our patient's case confirm that in CBS certain pathological processes are going on within the CNS which do require further research into the phenomena.

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#### CONFLICT OF INTEREST

The Authors declare no conflict of interest

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**RECEIVED:** 16.08.2024

**ACCEPTED:** 03.11.2024



## IN MEMORY

## HENRYK PAWLAK (1944-2023), M. A. ON THE FIRST ANNIVERSARY OF HIS PASSING

On November 23, 2023, Henryk Pawlak, M.A. in Physical Education, passed away.

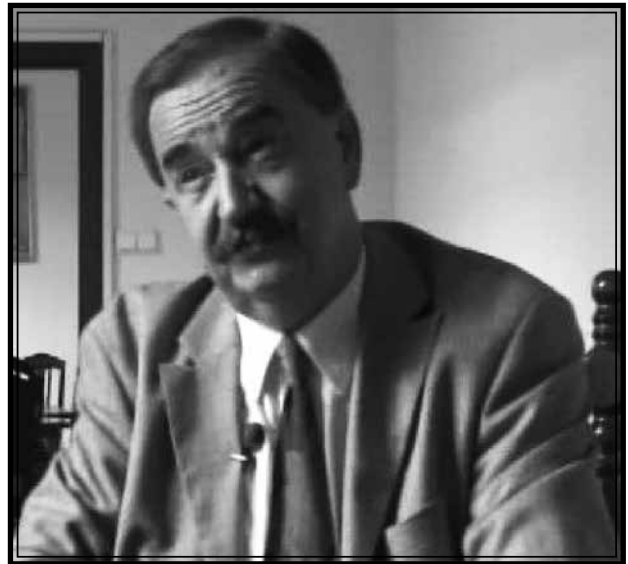
Born on February 12, 1944 in Wrocław, a graduate of the Faculty of Physiotherapy of the Medical Vocational Study and the Faculty of Physiotherapy Academy of Physical Education in Wrocław - an outstanding specialist in medical rehabilitation, specialist in medical massage. He completed his professional internships at the Institute of Balneoclimatology in Poznań and in many clinics of the Medical Academy (later the Piast Silesian Medical University) in Wrocław. He was particularly professionally and scientifically associated with the Clinic of Internal Medicine and Allergology, the Department and Chair of Family Medicine and the Department of Gerontology. He lectured at the National Medical Massage Collegium at the Higher School of Business and Health Sciences in Łódź.

He was, among others, a long-time teacher of therapeutic massage and vocational subjects, director of the Ludwik Hirszfeld's Medical Vocational Study in Wrocław, National Methodologist in the field of physiotherapy. He worked closely with Dr. Jadwiga Winklerowa - a pioneer of physiotherapy and balneoclimatology in Lower Silesia, a specialist in rheumatology. He co-created a biological regeneration program for the Polish Football Association (mountain team in 1974), the Polish Speedway Association and the Polish Track Cycling Association. He founded the Polish Committee of the Convention on the Rights of the Child, of which he became honorary dean, and the Foundation for the Children of the Breslau Fortress (Festung Breslau), whose aim is to study the fate of Polish, German, Jewish, French, Italian, Russian and Hungarian children born there and to help them. He created a center for physically and mentally disabled children in Kadłub in the Opole province, and was the driving force behind the establishment of the Opole Rehabilitation Center in Korfantów, also in the Opole region.

He acted as an active speaker and organizer of numerous conferences and symposia, author of textbooks, publications, various types of studies and television programs.

For his contribution to the development and popularization of massage in Poland, he was awarded a statuette by the Chapter of the Conference of Massage Therapists.

He devoted the last decades to working at the Good Brothers Fathers's Medical Massage Clinic in Wrocław,



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where, in addition to his professional work, he was the substantive and methodological supervisor of the team. It was here that I had the honor to be His student and then his collaborator. It's lucky that fate put Master Henryk Pawlak on my path.

Organizationally perfect, almost throughout his professional career; he was always himself. Delicate, especially sensitive to the suffering and helplessness of disabled people, with a predilection for sick children. He had endless amounts of kindness for people. He restored hope and smiles. Besides, Sam was always smiling, he could make people around him smile too. He gained authority through palpable kindness and easy accessibility.

We remember Henryk Pawlak, M.A. on the first anniversary of his passing.

You won't greet me with "hello Przemek!" anymore. Today I can only reply, "Goodbye, Master!" For me it is a great gift that our paths intertwined. Thank you, Master, for the years we spent together. I regret very much that I will no longer be able to benefit from the vastness of your skills, your deep knowledge, your personality.

**Przemysław Rejman, M.A**



# Wielka Księga Balneologii, Medycyny Fizykalnej i Uzdrowiskowej

**Tom I**  
Część  
ogólna

**Tom II**  
Część  
kliniczna

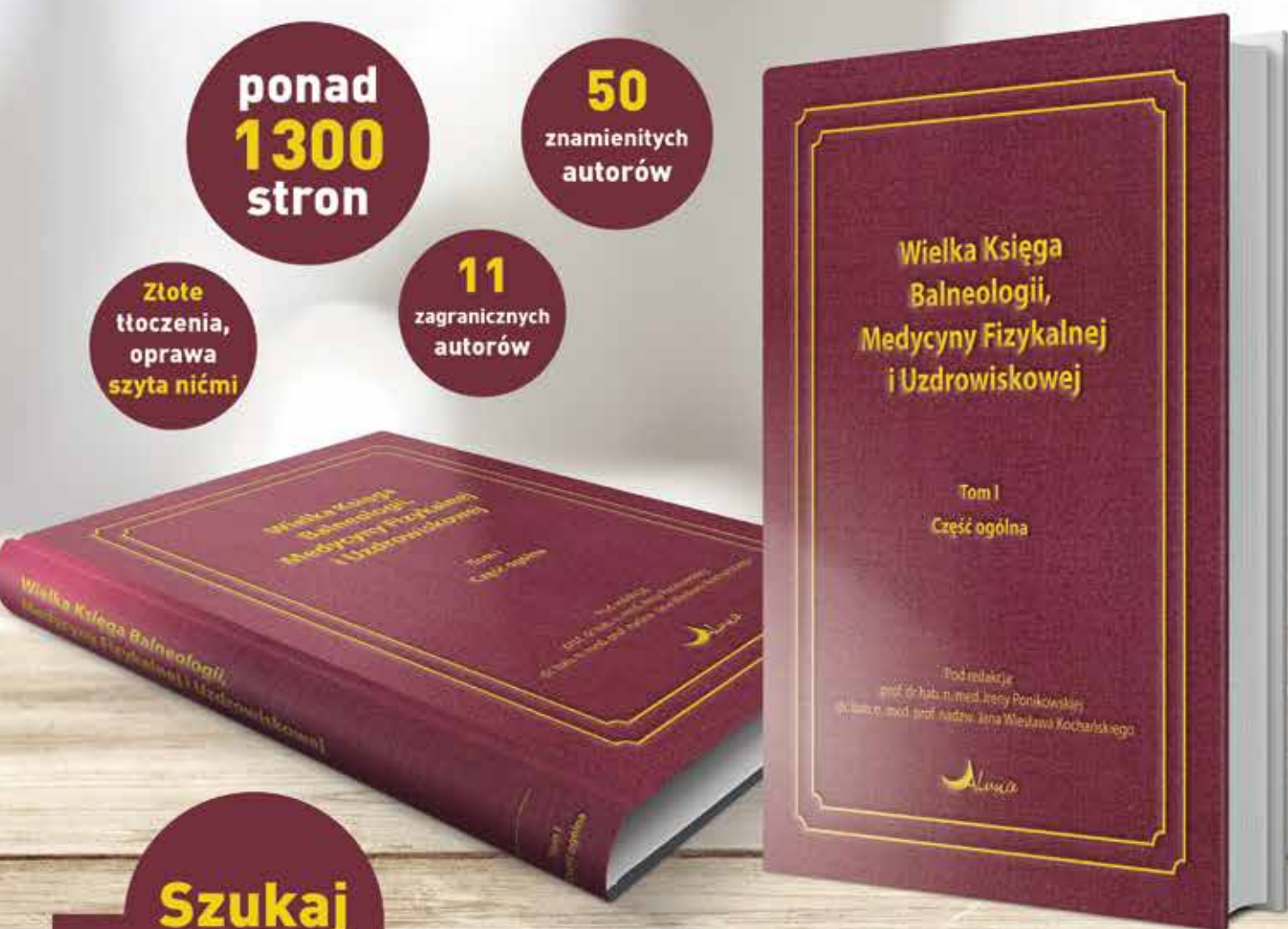
Pod redakcją:  
prof. dr hab. n. med. Ireny Ponikowskiej  
dr. hab. n. med. prof. nadzw. Jana Wiesława Kocharńskiego

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