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ORIGINAL ARTICLE

The impact of stochastic resonance on the effectiveness of rehabilitation in patients after COVID-19

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ABSTRACT

Aim: The aim of this study was to assess the impact of therapy with the use of stochastic resonance on the results of rehabilitation in patients after COVID-19, based on the proprietary rehabilitation model.

Materials and Methods: The study included 120 patients after COVID-19, qualified for model C of pulmonary rehabilitation. The study group followed the rehabilitation program complemented with the Stochastic Resonance Therapy sessions (15 session over 3 weeks). The study assessed exercise tolerance (6MWT), strength and functional efficiency ('Sit-to-Stand' test), dyspnea level (Borg scale) and saturation.

Results: Both groups reported significant improvement in all parameters, however, SRT groups' results were statistically significantly better. Improvement in the results of 'Sit-to-Stand' test and dyspnea reduction were particularly noticeable.

Conclusions: 1. Stochastic resonance might be a valuable complement to rehabilitation after COVID-19 as it improves functional and pulmonary efficiency. 2. The results prove the need for more research into long-term efficiency of this method.

KEYWORDS: post-Acute COVID-19 syndrome, pulmonary rehabilitation, vibration

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INTRODUCTION

The pandemic of COVID-19 did not only reveal the limitations of contemporary medicine in terms of handling the acute stage of the disease, but it also showed the lack of standardized and effective methods of rehabilitation procedures in case of patients with long -term complications of the infection. Many of those patients, regardless of the severity of the course, experience chronic fatigue, reduced exercise tolerance, shortness of breath and a decline in overall physical performance, which considerably affect the quality of their life [1-7].

In response to these needs, a complex rehabilitation program was developed which aims to restore respiratory and physical function, improve quality of life and increase the independence of patients after COVID-19. Proprietary rehabilitation program designed by prof. Jan Szczegielniak includes patients' individual qualification and adjusting therapy to their current functional condition [8-10]. Key elements of the program include breathing exercises to improve ventilation and lung capacity, training to increase exercise tolerance, and elements of physiotherapy aimed at rebuilding muscle strength and improving motor coordination.

Due to a wide range of post-COVID symptoms, and the need to increase rehabilitation effectiveness, it is more and more common to look for latest therapy support methods. One of such promising methods, though not yet sufficiently discussed in literature, is Stochastic Resonance Therapy (SRT).

To date, there is no standardized methodology for its use in the rehabilitation for patients with the post-COVID syndrome in the context of balance disorders, muscle weakening or lowered physical activity [11-14].

This study attempts to assess the effectiveness of including SRT in the standard rehabilitation program for patients after COVID-19 to assess its impact on selected functional and respiratory parameters.

AIM

The aim of this study was to assess the impact of stochastic resonance (SRT) on the effectiveness of rehabilitation in patients after COVID-19 with the use of proprietary methodology of treatments within the rehabilitation program developed by J. Szczegielniak.

MATERIALS AND METHODS

The study was conducted between July 2022 and July 2023 in the group of patients treated in the pulmonary rehabilitation department of the MSWiA John Paul II Hospital in Glucholazy. The research group consisted of 120 patients, 56 females and 64 males (study group BA – 28 male, 32 female; control group KO – 36 male, 24 female) aged 50-75 years (study group: 65,2 ± 9,6; control group: 61,4 ± 11,1).

All patients underwent a 3-week pilot post COVID-19 pulmonary rehabilitation program, developed in accordance with current recommendations for rehabilitation for patients after SARS-CoV-2 infection [8, 9]. The program included rehabilitation models A, B, C, D and E differing in exercise intensity. Qualification for particular rehabilitation models was based on the results of the six-minute walk test (6MWT), assessment of overall physical condition, assessment of dyspnea and fatigue level on 10-point Borg scale, analysis of pulmonary ventilation function and assessment of arterial blood oxygen saturation (SpO_2) [8, 9].

All patients had had the SARS-CoV-2 infection and, at the time of qualification for therapy with the use of stochastic resonance, reported persistent symptoms typical of post-COVID syndrome including restricted functional efficiency in daily activities connected with mobility, such as standing up from chair or walking up stairs.

Both in the study group (BA) and the control group (KO), each patient had individually defined exercise load intensity. For both groups the rehabilitation program was designed for three weeks and was realised six times a week, in morning and afternoon sessions. It involved individual and group breathing exercises, general fitness training and aerobic training. Breathing exercises focused on pulmonary patterns re-education and techniques to improve breathing mechanics and relaxation with the use of biofeedback. General fitness training included elements of stretching, balance and coordination. Aerobic exercise involved cycloergometer training with the load of 60-80% of maximum heart rate. Depending on individual needs, the program could be complemented with additional treatment to support the recovery process. Detailed description of the program was presented in the separate article [8-10, 11-18].

In the study group (BA), additional therapy with the use of stochastic resonance (STR) was implemented. Therapy was conducted in compliance with the methodology considering patients' individual capabilities and adequately adjusted intensity and stimulation parameters (Table 1). The methodology allows for safe and progressive adjustment of vibration intensity, taking into account disorders typical of post-COVID syndrome, such as muscle weakness, balance and movement coordination [19-21].

The therapy followed the developed standard (Table 1) and, at the same time, was adjusted to the current condition of each patient.

In total, each research participant underwent 15 sessions with the use of stochastic resonance, conducted twice daily, morning and afternoon, for six days a week with a one-day break. Each session lasted 20 minutes and included breathing exercises combined with stochastic resonance technique carried out in an upright position. For every session, stimulation intensity and type were adjusted to particular rehabilitation model and patient's current clinical condition (Table 1).

The table presents a diagram of the application of stochastic resonance in individual rehabilitation models. It takes into account the basic parameters of therapy, such as intensity, duration of treatment, number of sessions per day, vibration frequency, and disturbance amplitude. The summary illustrates the diversity of methodology depending on the rehabilitation model and the level of patient load.

Functional efficiency was assessed in all patients, both in the study and control group, before and after physiotherapy. The analysis covered the assessment of overall physical condition, exercise tolerance, dyspnea level and arterial blood oxygen saturation (SpO_2).

Overall physical condition was assessed with the 30-second 'Sit-to-Stand' Test which is the component of the Fullerton test. The test allows to assess the strength of the lower limbs, dynamic balance and overall functional efficiency.

Exercise tolerance was measured with the use of the 6-minute walk test (6MWT) which allows for objective assessment of cardiorespiratory efficiency.

Perceived dyspnea level was assessed on the basis of the modified Borg scale (0-10), and saturation was measured with the use of pulse oximeter at rest and directly after the 6MWT.

To ensure homogeneity of the research group, the analysis included the patients from the C model of the rehabilitation.

Table 1. Stochastic resonance according to developed methodology

Parametr	Rehabilitation Model				
	A	B	C	D	E
Intensity	high	medium	low	very low	very low
Session time	20 min	20 min	20 min	15 min	15 min
No of sessions/day	2	2	2	1	1
Vibrations	8	8	6	4	4
Amplitude (interference)	5	5	5	4	3

Participant selection was conducted with the use of simple randomization method to guarantee objectivity and representativeness of the sample. Bioethics Committee of the State Higher Vocational School in Nysa, No. 1/2022, issued on 15 February 2022.

RESULTS

Arithmetic average and standard deviation were calculated for particular parameters. Obtained results were analysed within each group, comparing initial values and values recorded after the 3-week rehabilitation program. The Wilcoxon nonparametric test was used to assess the significance of differences. The comparison between groups was performed using the nonparametric Mann-Whitney U test.

All statistical analyses were performed using XLSTAT 2021.2.2 (Addinsoft) software on Mac computers. P values below 0.05 were considered statistically significant.

The analysis began with the Mann-Whitney U test to compare data before and after rehabilitation within each group (with Stochastic Resonance and without it). Next, the Mann-Whitney U test was used to compare data gathered after rehabilitation between the group with stochastic resonance treatment and the group which did not receive this treatment.

The study group, consisting of 60 patients, followed the rehabilitation according to the proprietary model complemented with Stochastic Resonance treatment.

In the 6-minute walk test, before rehabilitation, the average energy expenditure (MET) was 5.73 (ME: 5.64, standard deviation – SD: 1.18), and after rehabilitation it increased to 8.40 MET (ME: 8.35, SD: 1.27), which represents an increase of 2.67 MET.

In the Fullerton 'Sit-to-Stand' test, an average of 12.94 repetitions (ME: 12.75, SD: 2.24) was recorded before rehabilitation, and after rehabilitation this number increased to 15.16 repetitions (ME: 15.26, SD: 2.29), indicating an increase of 2.22 repetitions.

The assessment of dyspnea, measured on a 10-point Borg scale, showed an average of 3.55 (ME: 3.52, SD: 1.18) before rehabilitation, while after rehabilitation it dropped to 2.19 (ME: 2.13, SD: 1.12), which represents a decrease of 1.36 points.

Arterial blood oxygen saturation before rehabilitation averaged 93.23% (ME: 93.12, SD: 1.29), and reached 94.18% (ME: 94.11, SD: 1.24) after the rehabilitation process, indicating an improvement of 0.95 percentage points.

The control group, also consisting of 60 patients, followed proprietary rehabilitation model without the extra complementation in the form of Stochastic Resonance.

In the 6-minute walk test, before rehabilitation, the average MET was 5.68 (ME: 5.45, SD: 1.19), and after rehabilitation it increased to 7.19 MET (ME: 7.12, SD: 1.34), indicating an increase of 1.51 MET.

In the Fullerton 'Sit-to-Stand' test, a mean of 12.53 repetitions (ME: 12.43, SD: 2.15) was recorded before rehabilitation, and after rehabilitation the number increased to 13.85 repetitions (ME: 13.76, SD: 1.94), indicating an increase of 1.32 repetitions.

The dyspnea score, assessed on the 10-point Borg scale, indicated a mean of 3.57 (ME: 3.45, SD: 1.57) before rehabilitation, and decreased to a value of 2.78 (ME: 2.62, SD: 1.14) after rehabilitation, indicating a reduction of 0.79 points.

Arterial blood oxygen saturation before rehabilitation averaged 93.85% (ME: 93.72, SD: 1.84), and increased to 95.27% (ME: 95.12, SD: 1.65) after rehabilitation, indicating an improvement of 1.42 percentage points (Table 2).

WITHIN GROUP ANALYSIS

In the study group, a significant improvement was observed in the 6-minute walk test results after rehabilitation ($p<0.001$) which proves the effectiveness of the proprietary program with the use of Stochastic Resonance.

Similarly, the Fullerton test showed statistically significant improvement ($p<0.001$) which indicates increased ability to perform physical exercise after therapy based on Stochastic Resonance.

The results also showed a significant reduction in perceived dyspnea, assessed on the Borg scale ($p<0.001$) which might suggest reduced respiratory discomfort on completion of the program implementing this method.

Statistically significant increase in the level of saturation ($p<0.001$) points to improvement in respiratory function in patients in rehabilitation complemented with Stochastic Resonance.

After rehabilitation, the control group also reported statistically significant improvement in the results of the 6-minute walk test ($p<0.001$) which proves the effectiveness of the rehabilitation model used.

A statistically significant improvement in the number of repetitions in the Fullerton test ($p<0.001$) also indicates the benefits of the rehabilitation programme used in people who have had COVID-19. Similar to the group using Stochastic Resonance, a significant reduction in dyspnea assessed on the Borg scale ($p<0.001$) was observed in this group. A statistically significant increase in arterial oxygen saturation ($p<0.001$) may additionally indicate an improvement in respiratory function.

Both study group and control group recorded statistically significant changes after rehabilitation ($p<0.001$). These results indicate considerable improvement in physical efficiency in all study participants, regardless of the implementation of Stochastic Resonance. Both groups also showed significant improvement in the number of repetitions in the Fullerton test ($p<0.001$) which suggests increased ability to perform short-term, dynamic physical activity.

Statistically significant reduction in values on the Borg scale and improvement in saturation ($p<0.001$) in both groups indicate reduced perceived effort and respiratory discomfort after the rehabilitation program as well as respiratory function improvement (Table 2).

The table presents a comparison of rehabilitation effects between the group on therapy with stochastic resonance therapy (SRT) and the control group. Changes in exercise tolerance (6MWT), functional fitness (Fullerton test), dyspnea level, and blood oxygen saturation were taken into account. The results indicate a significantly higher improvement in all analyzed parameters in the SRT group compared to the control group.

ANALYSIS BETWEEN GROUPS

Particularly worth noting is the significantly greater improvement in the number of repetitions in the 'Sit-to-

Stand' test in the group which followed the Stochastic Resonance therapy ($p<0.001$), which may indicate a marked increase in the ability to perform dynamic physical effort, thereby improving functional performance.

Importantly, also the comparison of the results of the 6-minute walk test (MET) between group showed statistically significant differences ($p<0.001$), indicating a higher exercise tolerance increase in the group with SRT.

Significant differences in subjective perception of dyspnea assessed on the Borg scale ($p<0.001$) seem interesting, too. They might suggest that Stochastic Resonance might have further contributed to respiratory comfort improvement.

Moreover, statistically significant improvement in arterial blood oxygen saturation level ($p<0.05$) in this group might point to more effective support for respiratory system in patients following therapy with the use of Stochastic Resonance (Table 2, Fig. 1).

The graph shows a comparison of the effects of rehabilitation between the study group, in which stochastic resonance therapy (SRT) was used, and the control group. It illustrates the differences in the improvement of functional and respiratory parameters after completion of the therapeutic program. A clearly higher improvement in results is visible in the SRT group.

DISCUSSION

The analysis of therapy effectiveness focused on the assessment of functional capacity, exercise tolerance, dyspnea level and arterial blood oxygen saturation. In the group which was treated with SRT, a significantly greater increase in tested parameters was obtained in comparison with the control group which suggests that applying this method might increase the efficiency of the applied rehabilitation program. Particularly worth noting are the differences in MET values recorded in the 6-minute walk test and the number of repetitions in the Fullerton test, significantly higher in the group with SRT compared with the control group.

Similar observations were reported in other studies analysing the effectiveness of Stochastic Resonance in rehabilitation of neurological and geriatric patients [13, 20, 23]. Research to date has shown beneficial impact of SRT on balance, proprioception and overall functional efficiency, although its range was restricted to the population of older patients or patients with neurological deficits. The SRT mechanism is based on the use of random micro-vibrations of variable frequency and amplitude, which, according to the concept of Stochastic Resonance, stimulate the neuromuscular system to more effective activation and postural responses [16, 18, 24]. Such stimulation can promote the activation of balance reflexes, improve proprioception and coordination, which is particularly valuable in the rehabilitation of people after COVID-19, who often continue to experience difficulties with general motor skills [24-27].

Contrary to earlier reports, own research focused on patients with post-COVID syndrome and included the assessment of the impact of SRT therapy in the standardised rehabilitation model. Obtained results are in line with the previous observations which indicate the potential of the method. For the first time, however, its efficiency was shown in the context of improvement of not only exercise and functional parameters, but also dyspnea perception in this group of patients.

Application of SRT in the study group resulted in the significant improvement in both objective functional

Table 2. Effects of rehabilitation in study group and control group

Parameters	Before rehabilitation (average ± SD)	After rehabilitation (average ± SD)	Difference	p value (Wilcoxon)	p value (Mann-Whitney)
Test 6MWT (MET)					
Group with SRT	5.73±1.18	8.40±1.27	+2.67	p<0.001	p<0.001
Control group	5.68±1.19	7.19±1.34	+1.51	p<0.001	-
Fullerton test (no)					
Group with SRT	12.94±2.24	15.16±2.29	+2.22	p<0.001	p<0.001
Control group	12.53±2.15	13.85±1.94	+1.32	p<0.001	-
Dyspnea (0-10 pts)					
Group with SRT	3.55±1.18	2.19±1.12	-1.36	p<0.001	p<0.001
Control group	3.57±1.57	2.78±1.14	-0.79	p<0.001	-
Saturation (%)					
Group with SRT	93.23±1.29	94.18±1.24	+0.95	p<0.001	p<0.05
Control group	93.85±1.84	95.27±1.65	+1.42	p<0.001	-

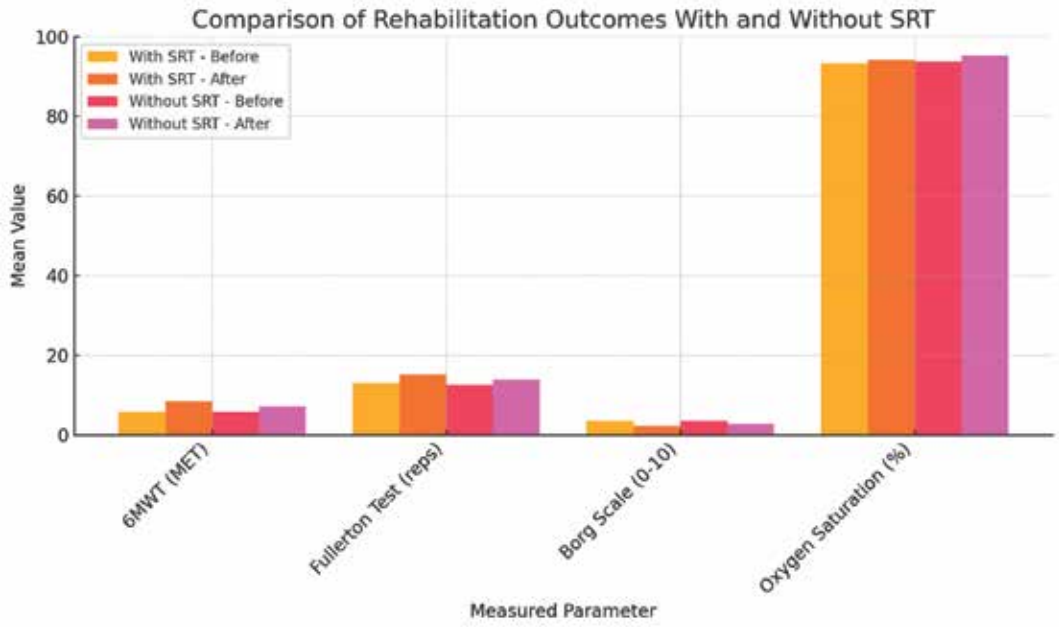

Fig. 1. Effects of rehabilitation in patients in study group and control group

parameters and the subjectively assessed respiratory comfort.

The conclusions drawn from the analysis are also confirmed by reports on the neuroplastic potential of stochastic stimulation in the context of restoring motor and respiratory functions [21, 24-27].

It may, therefore, be assumed that SRT does not only support the regeneration of physical fitness, but can also prevent or counteract the consolidation of incorrect movement patterns which deepen postural deficits in patient after COVID-19 leading to breathing mechanics dysfunctions.

Despite promising therapeutic effects, it is important to be aware of the limitations of the method. The literature describes cases of discomfort during SRT procedures, especially in patients with motion anxiety, sensory integration disorders or a tendency to dizziness. Applying this form of therapy requires therefore adequate verification and individualised adjustment of stimulation parameters, which was included in the analysed therapeutic program [22-28].

It is worth noting that this study, as one of the first, presents a detailed methodology of using SRT in patients after COVID-19, which might form the basis for the further standardisation of this form of therapy in clinical practice.

It is also important to note certain methodological limitations of this study. Although randomly selected, the sample included only patients qualified for the C model of the rehabilitation program. On the one hand, this increases the homogeneity of the study group, but on the other hand, it limits the possibility of generalising the results to the population of patients with more severe or milder forms of post-COVID syndrome. In the next stages of the study, comparative analysis of the impact of all rehabilitation models is planned to assess the relationship between SRT intensity and rehabilitation effectiveness in different patient groups.

The sustainability of the obtained effects is another important aspect requiring further analysis. Previous studies, including this one, have focused primarily on short-term results. There is a lack of data on the long-term benefits of Stochastic Resonance.

In conclusion, the results of the study indicate that Stochastic Resonance can be a valuable addition to the physiotherapy method used. Statistically significant, greater improvement in all analysed parameters in the group with SRT, justifies the need for further, more extensive research – both randomised and with a longer observation period – in order to more accurately assess the long-term effectiveness of this method.

Stochastic Resonance Therapy (SRT), as a method supporting a comprehensive rehabilitation program, has the potential to become an important component of future physiotherapy [29] standards in the treatment of patients after COVID-19, especially in the case of persistent functional deficits and respiratory disorders.

CONCLUSIONS

The use of Stochastic Resonance Therapy (SRT) as a supplement to the COVID-19 rehabilitation program contributed to a significant improvement in exercise tolerance and functional efficiency, as shown by a greater distance covered in the 6-minute walk test (6MWT) and a higher number of repetitions in the Fullerton 'Sit-to-Stand' test. The improvement in these parameters may indirectly indicate the beneficial effect of the therapy in improving lower limb muscle strength, postural control, and the ability to perform daily activities.

SRT therapy was also associated with a significant reduction in perceived dyspnea and improved arterial blood oxygen saturation, which may suggest a beneficial

effect of this method on subjectively assessed respiratory capacity and exercise tolerance in patients with post-COVID syndrome.

The greater improvement in functional parameters observed in the SRT group compared to the control group may indicate the effectiveness of the therapeutic methodology used, in which individually adjusted vibration stimuli with variable parameters could support the process of functional improvement, potentially through the activation of compensatory and adaptive mechanisms.

REFERENCES

1. Ponikowska I, Adamczyk P, Wojciechowski R, Jarosz K. Balneological treatment of patients with long COVID-19 syndrome in health-resort conditions. Acta Balneol. 2023;65(2):75-81. doi:10.36740/ABAL202302102.
2. Kiekens C, Boldrini P, Andreoli A et al. Rehabilitation and respiratory management in the acute and early post-acute phase. "Instant paper from the field" on rehabilitation answers to the Covid-19 emergency. Eur J Phys Rehabil Med. 2020;56(3):323-6. doi: 10.23736/S1973-9087.20.06305-4.
3. Barker-Davies RM, O'Sullivan O, Senaratne KPP, Baker P. The Stanford Hall consensus statement for post-COVID-19 rehabilitation. Br J Sports Med. 2020;54(16):949-59. doi: 10.1136/bjsports-2020-102596.
4. Vitacca M, Carone M, Clini E et al. Italian suggestions for pulmonary rehabilitation in COVID-19 patients recovering from acute respiratory failure: results of a Delphi process. Monaldi Arch Chest Dis. 2020;90(2). doi:10.4081/monaldi.2020.1444.
5. Curci C, Pisano F, Bonacci E et al. Early rehabilitation in post-acute COVID-19 patients: data from an Italian COVID-19 Rehabilitation Unit and proposal of a treatment protocol. Eur J Phys Rehabil Med. 2020;56(5):633-641. doi:10.23736/S1973-9087.20.06339-X.
6. Babliuk LA, Nesterak RV, Burba OS et al.Assessment of functional status and rehabilitation intervention in patients with coronavirus disease (COVID-19). Acta Balneol. 2022;64(6):529-533. doi: 10.36740/ABAL202206106.
7. Abo Elyazed TI, Alsharawy LA, Helmy NA., Abd El-Moneim AA. Effect of home-based pulmonary rehabilitation on exercise capacity in post COVID-19 patients: a randomized controlled trial. J NeuroEng Rehabil. 2024;21:40. doi:10.1186/s12984-024-01340-x.
8. Szczegielniak J, Bogacz K, Majorczyk E et al. Post-COVID-19 rehabilitation – a Polish pilot program. Med Pr. 2021;72(5):611-6. doi: 10.13075/mp.5893.01122.
9. Szczegielniak J, Bogacz K, Szczegielniak A, Łuniewski J. Proprietary model of qualification for in-hospital rehabilitation after COVID-19. Int J Environ Res Public Health. 2022;19(16):10450. doi:10.3390/ijerph191610450.
10. Bartczyk M, Suchanowski A, Woldańska-Okońska M. Efekty stosowania wibracji całego ciała w fizjoterapii – przegląd piśmiennictwa [The effects of whole-body vibration in physiotherapy – a review of the literature]. Acta Balneol. 2019;61(3):208-212. doi:10.36740/ABaI201903012. (Polish)
11. Stein J, Hughes R, D'Andrea S et al. Stochastic resonance stimulation for upper limb rehabilitation poststroke. Am J Phys Med Rehabil 2010;89(9):697-705. doi: 10.1097/PHM.0b013e3181ec9aa8.
12. Rogan S, de Bruin ED, Radlinger L et al. Effects of whole-body vibration on proxies of muscle strength in old adults: a systematic review and meta-analysis on the role of physical capacity level. Eur Rev Aging Phys Act 2015;12:12. doi: 10.1186/s11556-015-0158-3.
13. Rogan S, Hilfiker R, Schenk A, Vogler A. Effects of whole-body vibration with stochastic resonance on balance in persons with balance disability and falls history: a systematic review. Res Sports Med. 2014;22(3):294-313. doi: 10.1080/15438627.2014.919504.
14. Szczegielniak J, Majorczyk E, Bogacz K et al. A study on nonlinear estimation of submaximal effort tolerance based on the generalized MET concept and the 6MWT in pulmonary rehabilitation. PLoS One 2018;13(2). doi: 10.1371/journal.pone.0191875,
15. Benzi R, Sutera A, Vulpiani A. The mechanism of stochastic resonance. J Phys A 1981;14(11). doi: 10.1088/0305-4470/14/11/006.
16. White O, Babič J, Trenado C, Johannsen L. The promise of stochastic resonance in falls prevention. Front Physiol. 2019;9:1865. doi: 10.3389/fphys.2018.01865.
17. McDonnell MD, Abbott D. What is stochastic resonance? Definitions, misconceptions, debates, and its relevance to biology. PLoS Comput Biol. 2009;5(5). doi: 10.1371/journal.pcbi.1000348.
18. Rigoni I, Kirilov I, Marcolin G. Characterisation of the transient mechanical response and the electromyographical activation of lower leg muscles in whole body vibration training. Sci Rep. 2022;12(1):6642. doi:10.1038/s41598-022-10137-8.
19. Priplata AA, Niemi J, Salen M, et al. Noise-enhanced human balance control. Phys Rev Lett 2002;89(23):238101. doi: 10.1103/PhysRevLett.89.238101.
20. Mendez-Balbuena I, Manjarrez E, Schulte-Mönting J, et al. Improved sensorimotor performance via stochastic resonance: therapeutic implications for Parkinson's disease. PLoS One 2012;7(7). doi: 10.1371/journal.pone.0036270.
21. Bartczyk M, Suchanowski A, Woldańska-Okońska M. Stochastic resonance method in physiotherapy – a review of the literature. Wiad Lek. 2019;72(7):1364-70. doi: 10.36740/WLek201907132.
22. Sá-Caputo DC, Coelho-Oliveira AC, Pessanha-Freitas J et al. Whole-body vibration exercise: a possible intervention in the management of post COVID-19 complications? Appl Sci. 2021;11(12):5733. doi:10.3390/app11125733.
23. de Bruin ED, Baur H, Brülhart Y et al. Combining stochastic resonance vibration with exergaming for motor-cognitive training in long-term care. Front Med (Lausanne). 2020;7:507155. doi:10.3389/fmed.2020.507155.
24. Collins JJ, De Luca CJ. The effects of visual input on open-loop and closed-loop postural control mechanisms. Exp Brain Res. 1995;103(1):151-63. doi: 10.1007/BF00241327.
25. Zeldich D, Bou Jawde S, Herrmann J et al. Stabilizing breathing pattern using local mechanical vibrations: comparison of deterministic and stochastic stimulations in rodent models of apnea of prematurity. Biomed Eng Lett. 2021;11(4):383-392. doi:10.1007/s13534-021-00203-x.
26. Smith VC, Kelty-Stephen D, Qureshi Ahmad M et al. Stochastic resonance effects on apnea, bradycardia, and oxygenation: a randomized controlled trial. Pediatrics. 2015;136(6):e1561-e1568. doi:10.1542/peds.2015-1334.

27. Bloch-Salisbury E, Indic P, Bednarek F, Paydarfar D. Stabilizing immature breathing patterns of preterm infants using stochastic mechanosensory stimulation. J Appl Physiol (1985). 2009;107(4):1017-1027. doi:10.1152/japplphysiol.00058.2009.
28. Bartczyk M, Suchanowski A, Woldańska-Okońska M. Relations between vibratory stimulations and the variability of human motor skills. Acta Balneol. 2020;62(2):127-132. doi:10.36740/ABal202002110.
29. Ponikowska I, Kochański J.W.: (red). Wielka Księga Balneologii, Medycyny Fizykalnej i Uzdrowiskowej. Część ogólna [The Great Book of Balneology, Physical and Thermal Medicine. General Part]. Wyd. Aluna. Konstancin-Jeziorna. 2017. (Polish)

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Monitoring of wastewater in Vinnytsia Region of Ukraine for the content of the SARS-COV-2 virus genome

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ABSTRACT

Aim: The aim of the study was to determine the concentration of the SARS-CoV-2 virus genome in wastewater of the Vinnytsia region of Ukraine and analyze the results obtained.

Materials and Methods: The study was conducted in two accredited laboratories (SE „Vinnytsia Regional Center for Disease Control and Prevention of the Ministry of Health of Ukraine" and the Hygiene and Ecology Institute of the O.O. Bogomolets National Medical University), covering the period 2023-2024 with a total of 518 samples. For statistical data processing, modern software packages were used: IBM SPSS StatisticsBase v.23, MedStat v.5.2 and Microsoft® Excel® for Microsoft 365 MSO.

Results: Showed that the virus is present almost year-round, demonstrating seasonal dependence. The highest concentration of SARS-CoV-2 Total (E/N) was recorded in December 2023 (413-18,756 copies/ml) and January 2024 (5-15,503 copies/ml), after which the level decreased. In June 2024, its concentration was minimal (2-56 copies/ml), and in the summer the virus was almost undetectable. Variant analysis showed that Delta (L452R) disappeared after mid-2023, and Omicron (E484A) had a stable dynamic, reaching a peak in March 2024 (795 copies/ml), but gradually decreasing. Detection of influenza A/B virus was limited, observed in five samples in 2023-2024.

Conclusions: The data obtained demonstrate the effectiveness of wastewater monitoring for tracking viral trends and confirm seasonal fluctuations of SARS-CoV-2. A decline in its spread after May 2024 may indicate effective control measures and changes in the circulation of the virus.

Keywords: SARS-CoV-2 virus, monitoring, wastewater

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INTRODUCTION

On March 12, 2020, the World Health Organization officially recognized the global epidemic situation caused by the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (a beta coronavirus identified in the second half of 2019) as a pandemic. The disease was named COVID-19 [1, 2].

Biosafety, bioethics, and biosecurity are not only relevant areas of modern scientific research, but also a vital necessity for the global health system. Particular attention is paid to the early detection and isolation of symptomatic patients, which, combined with diagnostics, tracking, and quarantine of contacts, is a key strategy for containing COVID-19, caused by the SARS-CoV-2 virus [3-5].

Cases of severe acute respiratory syndrome (SARS-CoV-2) caused by SARS-CoV-2 have been recorded in more than 170 countries around the world. Initially, infections were associated with travel to China, Italy, South Korea, and Iran, but cases have since been reported in many countries among people who had not traveled to these regions [6, 7]. Currently, COVID-19 is mostly spread through local transmission between patients, carriers, and contacts [8].

AIM

Determining the content of the SARS-COV-2 virus genome in wastewater of the Vinnytsia region of Ukraine and analyzing the results obtained.

MATERIALS AND METHODS

The experiment examined raw wastewater and sewage sludge for non-infectious RNA fragments of SARS-CoV-2 in Vinnytsia region. The research was conducted at the Vinnytsia Regional Center for Disease Control and Prevention of the Ministry of Health of Ukraine (EN ISO/IEC 17025:2019 accreditation) and the Institute of Hygiene and Ecology of the O.O. Bogomolets (accreditation DSTU EN ISO/IEC 17025:2019 (EN ISO/IEC 17025:2017, IDT; ISO/IEC 17025:2017, IDT). Samples were taken year-round in the period 2023-2024. A total of 518 samples were taken: 243 in 2023 and 275 in 2024.

Statistical processing of the results was carried out using the statistical software package IBM SPSS StatisticsBase v.23, MedStat v.5.2 (Copyright © 2003-2019) and Microsoft® Excel® for Microsoft 365 MSO (version 2305 build 16.0.16501.20074) (License ID: CWW_0071e48a-250c-4bdb-9013-b8daf357b5e9_b5685e92-c95d-4399-9b83-449d76a26fb6_79f3b2da2f9adcda29).

Table 1. The concentration of SARS-CoV-2

Sample no	Month and year of sampling	Maximum wastewater flow rate (m^3/s)	SARS-CoV-2 total (E/N) (virus concentration), copies/ml	Influenza A/B (quantification)	SARS-CoV-2 Delta variant (L452R) (number of positive samples)	SARS-CoV-2 Omicron variant (E484A) (virus concentration), copies/ml
1-9	03.2023	0.72	100-5867*	1	2	0-64*
10-33	04.2023	0.72	125-4530	5	0	10-108
34-60	05.2023	0.72	58-7163	0	0	5-1405
61-87	06.2023	0.72	68-1782	0	3	9-105
88-114	07.2023	0.72	8-1682	0	2	56-392
115-141	08.2023	0.70	17-1138	0	0	120**
142-165	09.2023	0,70	1-86	0	0	202-533
166-192	10.2023	0.72	4-274	0	0	45-862
193-219	11.2023	0.71	5-6025	0	0	17-1190
220-243	12.2023	0.70	413-18756	0	0	35-736
244-270	01.2024	0.72	5-15503	2	0	75-215
271-297	02.2024	0.69	11-467	2	0	54-805
298-321	03.2024	0.70	5-422	0	0	795
322-345	04.2024	0.70	16-2844	0	0	363
346-360	06.2024***	0.70	2-56	0	0	0
361-387	07.2024	0.70	9-154	0	0	0
388-388	08.2024	0.70	24-1136	0	0	0
415-441	09.2024	0.70	1-3210	0	0	0
442-468	10.2024	0.70	43-344	0	0	0
469-492	11.2024	0.70	33-464	0	0	0
493-516	12.2024	0.69	21-183	0	0	0

*Notes: * - the minimum and maximum values are given among positive samples for the specified month, **- one case for the specified month, *** - due to technical issues, sample collection and analysis were not carried out in May 2024.*

RESULTS

The assessment of the results obtained allowed us to establish general trends in the viral load. As a result of the studies conducted, it was found that SARS-CoV-2 is present in wastewater almost all year round. Its concentration levels have a certain seasonal dependence. The concentration of SARS-CoV-2 Total (E/N) varies significantly in the samples, reaching maximum values in December 2023 (413-18,756 copies/ml), which may indicate a seasonal increase in infection and spread of the virus in the environment (Table 1). In January 2024, a significant concentration of SARS-CoV-2 Total (E/N) (5-15,503 copies/ml) is also observed, after which the level stabilizes to lower values. The lowest indicators are recorded in June 2024, when the virus concentration drops to 2–56 copies/ml. In July-August 2023 and 2024, SARS-CoV-2 was practically absent in wastewater. 5 positive samples were detected in July and 10 positive samples in August 2023. Maximum 1158 copies per ml in August, but mostly in concentrations up to 50 copies/ml.

We also analyzed the presence of SARS-CoV-2 variants and found that the Delta (L452R) variant is observed in samples mainly in March-June 2023, after which it disappears, and Omicron (E484A) shows more stable dynamics, reaching a maximum value in March 2024 (795 copies/ml) and gradually decreasing over the following months.

In addition, the detection of influenza A/B virus in wastewater was carried out for comparison. Influenza A/B was observed in five samples, mainly in March, April 2023 and in January-February 2024. The largest number of positive samples was in April 2023 (5 positive samples).

It should be noted that during the study period, the wastewater flow rate: The maximum wastewater flow rate remained relatively stable, fluctuating slightly between 0.69 and 0.72 m^3/s during the observed period.

DISCUSSION

Our data suggest that SARS-CoV-2 E/N concentrations peaked in December 2023 and January 2024, indicating high levels of viral shedding during the winter months, consistent with typical seasonal patterns of infection. High viral loads in winter may indicate increased infections, possibly due to seasonal effects and indoor crowding.

According to [9], wastewater surveillance has been effective in detecting new variants before clinical cases spike. According to [10], similarly high concentrations of SARS-CoV-2 in wastewater during December 2023–January 2024 correspond to peaks in hospitalizations reported worldwide.

According to our data, since June 2024, both SARS-CoV-2 and its variants have shown a sharp decline in presence, indicating reduced community transmission. This correlates with [9, 10]: during the 28-day period from March 4 to 31, 2024, among countries consistently reporting these data for the current and past reporting periods, there was an overall decrease of 44% and 46% in new hospitalizations and new intensive care unit admissions, respectively.

Results of viral genome sequencing in wastewater from Vinnytsia region showed that the Omicron variant was dominant, while the Delta variant disappeared after mid-2023. The disappearance of Omicron after May 2024 may reflect effective control measures, a change in virus dynamics, or a decrease in sampling sensitivity.

Data [10, 11, 12] correlate with our results. The Delta variant was dominant in early 2023, but its presence decreased as Omicron took over. The results support the idea that newer variants spread faster, requiring rapid public health intervention.

According to [13], no major influenza outbreaks were detected, indicating a low level of transmission according to wastewater analysis. The lack of detection of the influenza A/B virus suggests limited spread through wastewater sources or lower prevalence in the controlled area. Which coincides with the data we obtained regarding isolated cases of influenza viruses being detected in wastewater from the studied region.

CONCLUSIONS

1. It is shown that the concentration of SARS-CoV-2 in wastewater of the Vinnytsia region of Ukraine exhibits traditional seasonal fluctuations with a peak in winter and a decrease in the summer period, which correlates with data published by WHO for other countries. The concentration of the virus fluctuated significantly, with noticeable peaks in December 2023 (413-18,756 copies/ml) and January 2024 (5-15,503 copies/ml), after which a downward trend was observed in the following months.
2. It was found that the Delta strain ceases to circulate, while Omicron remains the dominant variant, although its concentration decreases in 2024. The concentration of the Omicron variant was inconsistent, with notable peaks in March 2024 (795 copies/mL) and April 2024 (363 copies/mL), but its presence has declined to zero since June 2024.
3. Wastewater surveillance has been shown to be an important tool for the early detection of new variants.

REFERENCES

1. Coronavirus disease (COVID-19) pandemic. Emergencies. WHO. URL: https://www.who.int/europe/emergencies/situations/covid-19.
2. Novel coronavirus (COVID-19) open. Bulletin of the World Health Organization. WHO. URL: https://www.who.int/publications/journals/bulletin/covid-19.
3. Rutjes SA, Vennis IM, Wagner E et al. Biosafety and biosecurity challenges during the COVID-19 pandemic and beyond. Front Bioeng Biotechnol. 2023;11:1117316. doi: 10.3389/fbioe.2023.1117316.
4. Faust L, Zimmer AJ, Kohli M et al. SARS-CoV-2 testing in low- and middle-income countries: Availability and affordability in the private health sector. Microbes Infect. 2020;22:511-514. doi:10.1016/j.micinf.2020.10.005.
5. Antonenko AM, Borysenko AA, Omelchuk ST et al. Comparative hygienic assessment of the migration of active ingredients of pesticide preparations into soil and surface waters after application using innovative methods and the risk of their negative impact on humans when consuming contaminated water. Odeskyi Medychnyi Zhurnal [Internet]. 2023;2(183):84-87. doi: 10.32782/2226-2008-2023-2-15.
6. Hu H, Yan F, Zhu J et al. Intercontinental transmission and local demographic expansion of SARS-CoV-2. Epidemiol Infect. 2021;149:e94. doi: 10.1017/S0950268821000777.
7. Patel KP, Vunnam SR, Patel PA et al. Transmission of SARS-CoV-2: an update of current literature. Eur J Clin Microbiol Infect Dis. 2020;39(11):2005-2011. doi: 10.1007/s10096-020-03961-1.
8. Zhou L, Ayeh SK, Chidambaram V et al. Modes of transmission of SARS-CoV-2 and evidence for preventive behavioral interventions. BMC Infect Dis. 2021;21(1):496. doi: 10.1186/s12879-021-06222-4.
9. Wolfe M, Hughes B, Duong D et al. 2022. Detection of SARS-CoV-2 Variants Mu, Beta, Gamma, Lambda, Delta, Alpha, and Omicron in Wastewater Settled Solids Using Mutation-Specific Assays Is Associated with Regional Detection of Variants in Clinical Samples. Appl Environ Microbiol. 2022;88(8):e0004522. doi: 10.1128/aem.00045-22.
10. COVID-19 Epidemiological Update. Edition 166. Published 12 April 2024. URL: https://www.who.int/docs/default-source/coronaviruse/situation-reports/covid-19_epi_update_166.pdf?sfvrsn=e7fd0f6_1&download=true.
11. Madewell ZJ, Yang Y, Longini IM. et al. Rapid review and meta-analysis of serial intervals for SARS-CoV-2 Delta and Omicron variants. BMC Infect Dis. 2023;23(1):429. doi: 10.1186/s12879-023-08407-5.
12. Tan MW, Anelone AJ, Tay AT et al. Differences in virus and immune dynamics for SARS-CoV-2 Delta and Omicron infections by age and vaccination histories. BMC Infect Dis. 2024;24(1):654. doi: 10.1186/s12879-024-09572-x.
13. SURVEILLANCE REPORT. Seasonal influenza, 2023-2024. Annual Epidemiological Report for 2023. URL: https://www.ecdc.europa.eu/sites/default/files/documents/seasonal-influenza-annual-epidemiological-report-2023-2024.pdf.

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Comparative clinical efficacy and safety of Nd: YAG Laser (1064 nm) *versus* oral isotretinoin in the treatment of severe Acne Vulgaris

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ABSTRACT

Aim: This study aimed to compare the clinical efficacy, patient satisfaction, and safety of long-pulsed Nd:YAG laser therapy versus oral isotretinoin in patients with severe acne vulgaris.

Materials and Methods: A randomized clinical trial was conducted with 60 patients aged 18-40 years, equally divided into two groups (28 females and 2 males each). Group 1 received oral isotretinoin 0.5 mg/kg/day for 12 weeks. Group 2 underwent 12 sessions of Nd:YAG laser therapy performed once weekly over 12 weeks (1064 nm; fluence 15-50 J/cm^2, pulse duration 20-50 ms, spot size 6-9 mm, 4 Hz, with dynamic cooling). Clinical efficacy was evaluated using the Global Acne Grading System (GAGS) at baseline, week 6, and week 12. Patient satisfaction was measured using the Visual Analogue Scale (VAS, 10-point). Safety was assessed by monitoring adverse events throughout the study period.

Results: At baseline, demographic parameters and GAGS scores were comparable between groups (34.9±3.2 vs. 35.1±3.3; p=0.76). Both groups demonstrated significant improvement from baseline (p<0.001). The Nd:YAG laser group achieved greater reductions in GAGS at week 6 (19.8±2.8 vs. 22.4±3.0; p=0.04) and week 12 (12.1±2.5 vs. 15.3±2.7; p=0.02). VAS scores were higher in the laser group at week 6 (7.9±0.7 vs. 6.8±0.8; p=0.004) and week 12 (8.7±0.6 vs. 7.4±0.7; p<0.001). No serious adverse events occurred. The isotretinoin group mainly reported dryness (30%) and irritation (20%), whereas the laser group experienced transient erythema (25%) and mild edema (15%), both resolving spontaneously. No pigmentary changes or scarring were observed.

Conclusions: Both therapies were effective, but Nd:YAG laser demonstrated superior clinical outcomes, higher patient satisfaction, and fewer systemic side effects, supporting its role as a promising non-pharmacological option in the treatment of severe acne vulgaris.

KEYWORDS: severe acne, Nd:YAG laser, isotretinoin, GAGS, VAS

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INTRODUCTION

Acne vulgaris is one of the most prevalent chronic inflammatory skin disorders, affecting up to 80-85% of adolescents and young adults worldwide, with many cases persisting into adulthood [1]. Severe acne occurs in approximately 10-20% of patients, depending on population characteristics and diagnostic criteria [2]. While mild to moderate forms are often managed with topical treatments and antibiotics, severe acne poses a greater challenge due to its chronicity, development of nodules and cysts, and high risk of permanent scarring [3].

Beyond physical lesions, severe acne exerts profound psychosocial effects, including depression, anxiety, social isolation, and reduced quality of life. Its psychological burden is comparable to that of chronic systemic diseases such as diabetes or asthma [4]. These effects highlight the importance of timely and effective management to improve both skin condition and overall well-being.The etiology of acne is multifactorial, encompassing genetic, hormonal, environmental, and lifestyle factors. A positive family history significantly increases the likelihood of developing severe and persistent disease. Androgens stimulate sebaceous gland hypertrophy and excessive sebum production, both key drivers in lesion development. Moreover, high-glycemic diets, stress, and inappropriate cosmetic use may exacerbate symptoms and hinder treatment response [5]. Pathogenesis involves four interconnected processes: sebaceous hyperactivity, follicular hyperkeratinization, proliferation of Cutibacterium *acnes*, and a subsequent inflammatory immune response. Recent research emphasizes that acne should be regarded as a chronic inflammatory condition characterized by immune dysregulation and microbiome alterations rather than a simple infection. Oxidative stress and dysbiosis further contribute to its chronicity and severity [6-8].These insights have encouraged the development of physical treatment modalities such as the long-pulsed Nd:YAG laser (1064 nm), which penetrates deeply into the dermis, selectively targets sebaceous glands, reduces inflammation, and improves skin texture with minimal systemic exposure [9].Oral isotretinoin remains the gold standard for severe acne management. It reduces sebaceous gland size and activity, normalizes keratinization, and provides long-term remission [10]. However, isotretinoin therapy carries well-known risks, including mucocutaneous dryness, cheilitis, teratogenicity, dyslipidemia, and hepatic dysfunction [11]. These adverse effects necessitate strict monitoring and often lead to treatment discontinuation or contraindications. Consequently, interest in non-pharmacological alternatives

has grown, with Nd:YAG laser therapy emerging as a localized, safe, and effective substitute or adjunctive option [12]. Despite the widespread clinical use of both isotretinoin and Nd:YAG lasers, few high-quality randomized controlled trials have directly compared their outcomes in severe acne. Most available studies focus primarily on moderate cases or use lasers as adjunctive modalities.

AIM

The objective of this study was therefore to compare the clinical efficacy, patient satisfaction, and safety profile of long-pulsed Nd:YAG laser therapy versus oral isotretinoin to support evidence-based, individualized treatment strategies for severe acne vulgaris.

MATERIALS AND METHODS

This prospective, randomized, controlled clinical trial was conducted within the framework of the research project of Sumy State University, "Study of comorbidities of non-communicable diseases to ensure a healthy lifestyle and promote the well-being of the population of different age groups" (state registration number 0121U114163; 01.22-11.26), under a formal collaboration agreement with the Sumy Clinic of Laser Medicine and Sumy State University (Cooperation Agreement No. 62.14-01.16-21/n). Each participant was observed for a 12-week follow-up period from the time of enrollment. Prior to participation, all patients were thoroughly informed about the study objectives, procedures, potential risks, and expected benefits. Written informed consent was obtained from each participant before any study-related procedures were initiated, including permission to use anonymized clinical data and study results for scientific publication. All personal data were handled with strict confidentiality in accordance with applicable data-protection regulations. The study complied with the ethical principles outlined in the Declaration of Helsinki (World Medical Association, 2013 revision) and received ethical approval from the Local Bioethics Committee of Sumy State University (Protocol No. 1/09, September 8, 2025). A total of 60 patients with clinically confirmed severe acne vulgaris were enrolled and randomized into two equal groups (n=30 each). Each group had an identical gender distribution – 28 females (93.3%) and 2 males (6.7%) – and an age range of 18-40 years. Randomization was performed using a computer-generated sequence to ensure equal allocation and minimize selection bias. Inclusion criteria were: clinical diagnosis of severe acne vulgaris with a baseline Global Acne Grading System (GAGS) score ≥ 31, age between 18 and 40 years, absence of systemic acne treatment within the previous 3 months, willingness to comply with study procedures, and signed informed consent. Exclusion criteria included pregnancy or lactation, hypersensitivity to isotretinoin or laser treatment, severe systemic disease (e.g., uncontrolled diabetes, hepatic or renal dysfunction), use of systemic corticosteroids or immunosuppressants within the previous 3 months, active skin infection or dermatosis in the treatment area, and previous laser therapy within 6 months. Group 1 received oral isotretinoin at a dose of 0.5 mg/kg/day once daily with food for 12 weeks. Hepatic function was monitored by measuring ALT, AST, and bilirubin at baseline, week 6, and week 12. All baseline laboratory values were within normal limits. Female participants were instructed to use effective contraception throughout the treatment period. Group 2 underwent 12 sessions of long-pulsed Nd:YAG laser therapy (1064 nm) performed once weekly over 12 weeks. Treatments were conducted by dermatologists using the following parameters: fluence 15-50 J/cm^2, pulse duration 20-50 ms, spot size 6–9 mm, frequency 4 Hz, with dynamic cooling before and after each pulse. Parameters were individually adjusted, starting from the lower range and gradually increasing according to skin tolerance and clinical response. Each procedure lasted approximately 15-20 minutes. Participants were instructed to avoid direct sun exposure and apply broad-spectrum sunscreen throughout the study period. The primary efficacy endpoint was the change in GAGS score from baseline to weeks 6 and 12. Secondary endpoints included patient satisfaction assessed using a 10-point Visual Analogue Scale (VAS) at weeks 6 and 12, and safety evaluation by documenting all adverse events (type, frequency, and severity) as well as monitoring for post-inflammatory hyperpigmentation and scarring. In the isotretinoin group, special attention was paid to systemic and mucocutaneous side effects such as xerosis, cheilitis, photosensitivity, and laboratory abnormalities. In the laser group, local skin reactions – erythema, edema, and mild discomfort – were recorded. Data collection, correction, systematization, and statistical processing were performed using Microsoft Office Excel (Microsoft Office 365, Open Value Subscription Education Solutions V9144120). Continuous variables were expressed as mean±standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Between-group comparisons were conducted using the independent samples t-test for continuous data and the chi-square test for categorical data. A p-value<0.05 was considered statistically significant. Group 1 received oral isotretinoin (0.5 mg/kg/day) for 12 weeks, whereas Group 2 underwent twelve sessions of long-pulsed Nd:YAG laser therapy (1064 nm) performed once weekly during the same period. Both groups were evaluated at baseline, week 6, and week 12 to compare treatment efficacy, patient satisfaction, and safety outcomes.

RESULTS

A total of 60 patients were enrolled and completed the study, with no dropouts in either group. Each treatment arm included 30 participants, with an identical gender distribution of 28 females (93.3%) and 2 males (6.7%). The mean age was 29.4±6.1 years in the isotretinoin group and 29.8±5.9 years in the Nd:YAG group (p=0.87). Baseline demographic and clinical characteristics, including Global Acne Grading System (GAGS) scores, were comparable between groups (34.9±3.2 vs. 35.1±3.3; p=0.76), confirming successful randomization (Table 1).

At week 6, both groups demonstrated a statistically significant reduction in GAGS compared with baseline (p<0.001). Improvement was greater in the Nd:YAG group (19.8±2.8) than in the isotretinoin group (22.4±3.0; p=0.04).

By week 12, mean GAGS was significantly lower in the laser group (12.1±2.5) compared with the isotretinoin group (15.3±2.7; p=0.02), indicating superior efficacy of Nd:YAG therapy. These results are presented in Table 2 and illustrated in Figure 1, which shows the steeper decline in acne severity in the laser group.

Patient satisfaction, assessed by a 10-point Visual Analogue Scale (VAS), was consistently higher among

Table 1. Baseline demographic and clinical characteristics of study participants in the isotretinoin and Nd:YAG laser groups (n=60)

Variable	Isotretinoin Group (n = 30)	Laser Group (n = 30)	p-value
Age (years), mean±SD	29.4±6.1	29.8±5.9	0.87
Female, n (%)	28 (93.3%)	28 (93.3%)	1.00
Male, n (%)	2 (6.7%)	2 (6.7%)	1.00
Baseline GAGS score, mean ± SD	34.9±3.2	35.1±3.3	0.76

Notes: Both groups (n=30 each) were comparable in age, gender distribution, and baseline GAGS scores (p>0.05), confirming successful randomization

Table 2. Dynamics of Global Acne Grading System (GAGS) score reduction in the isotretinoin and Nd:YAG laser treatment groups over 12 weeks

Time point	Isotretinoin Group (mean ± SD)	Laser Group (mean ± SD)	p-value
Baseline	34.9±3.2	35.1±3.3	0.76
Week 6	22.4±3.0	19.8±2.8	0.04
Week 12	15.3±2.7	12.1±2.5	0.02

Notes: Both groups improved significantly over time (p<0.001), with the Nd:YAG laser group achieving lower mean scores at week 6 (p=0.04) and week 12 (p=0.02) compared to the isotretinoin group

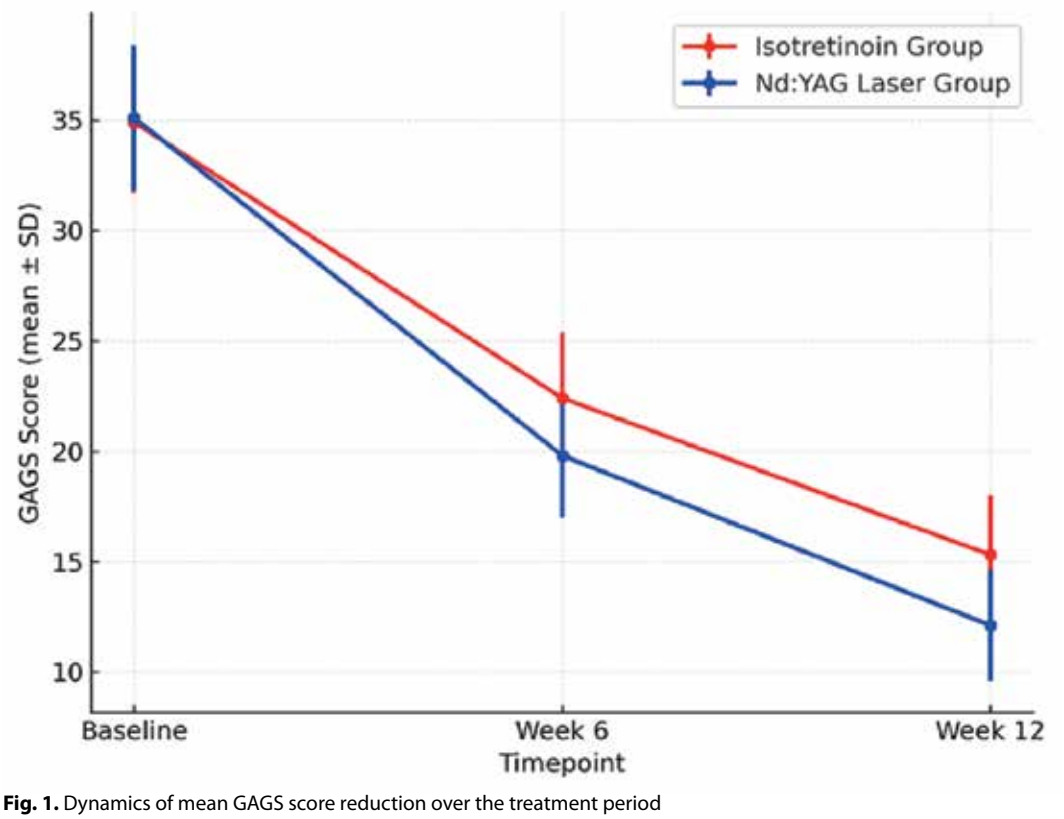

Fig. 1. Dynamics of mean GAGS score reduction over the treatment period

Notes: A progressive reduction was observed in both groups over time, with a more pronounced decrease in the Nd:YAG laser group compared to the isotretinoin group by week 12. Error bars represent standard deviation (SD)

patients receiving Nd:YAG therapy. At week 6, the mean VAS score was 7.9±0.7 in the laser group compared to 6.8±0.8 in the isotretinoin group (p=0.004). At week 12, satisfaction further increased to 8.7±0.6 in the laser group, while the isotretinoin group reached 7.4±0.7 (p<0.001). These data are shown in Table 3 and Figure 2.

No serious adverse events occurred during the study. In the isotretinoin group, dryness (30%) and skin irritation (20%) were the most common side effects. In the laser group, transient erythema (25%) and mild edema (15%) were observed, both resolving spontaneously within 48 hours. No cases of pigmentary alterations, scarring, or systemic complications were reported. These findings are summarized in Table 4 and illustrated in Figure 3.

Representative clinical photographs demonstrate the therapeutic outcomes. Figure 4 shows improvement in a patient treated with oral isotretinoin after 12 weeks, while Figure 5 highlights the marked clinical response achieved with Nd:YAG laser therapy, including visible reduction in inflammatory lesions and improvement in skin texture.

DISCUSSION

This randomized controlled clinical trial provides important insights into comparing long-pulsed Nd:YAG laser therapy with oral isotretinoin for the treatment of severe acne vulgaris. Acne vulgaris is a chronic inflammatory condition with a multifactorial pathogenesis involving hormonal imbalance, sebaceous gland hyperactivity, follicular hyperkeratinization, bacterial colonization, and immune dysregulation [13,14]. Oral isotretinoin remains the gold standard for severe acne because it acts on multiple pathogenic mechanisms simultaneously [15]. However, its systemic adverse effects, including teratogenicity, hepatotoxicity, and dyslipidemia, as well as the need for strict laboratory monitoring, limit its use in certain populations [16]. These challenges have increased interest in non-pharmacological options such as laser therapy, which offers localized treatment with minimal systemic risk [17]. In this study, both groups achieved significant clinical improvement over 12 weeks. Baseline demographic and clinical characteristics were comparable between

Table 3. Patient satisfaction scores assessed by Visual Analogue Scale (VAS) at week 6 and week 12 in the isotretinoin and Nd:YAG laser groups

Time point	Isotretinoin Group (mean ± SD)	Laser Group (mean ± SD)	p-value
Week 6	6.8±0.8	7.9±0.7	0.004
Week 12	7.4±0.7	8.7±0.6	<0.001

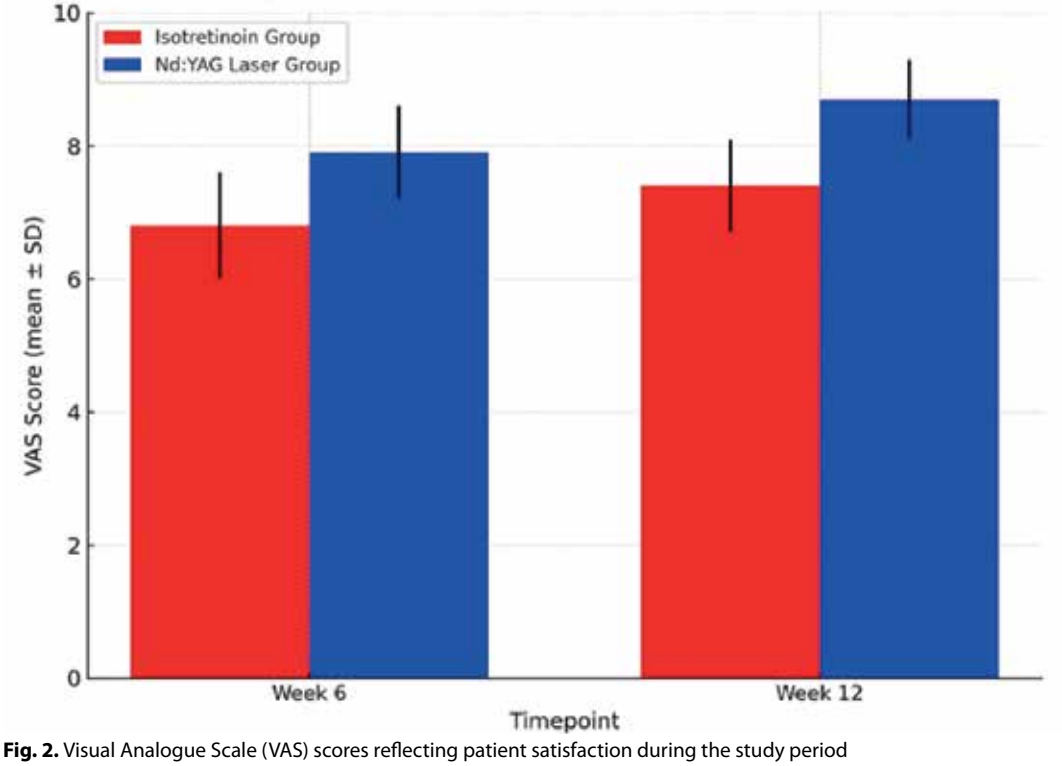

Fig. 2. Visual Analogue Scale (VAS) scores reflecting patient satisfaction during the study period

Notes: The Nd:YAG laser group demonstrated significantly higher satisfaction compared to the isotretinoin group at both time points, indicating superior patient-perceived outcomes. Error bars represent standard deviation (SD)

Table 4. Comparative analysis of adverse events in the isotretinoin and laser treatment groups

Adverse Events	Isotretinoin Group (n=30)	Laser Group (n=30)
Dryness	12 (30%)	0 (0%)
Skin irritation	6(20%)	0 (0%)
Transient erythema	0 (0%)	8 (25%)
Mild edema	0 (0%)	5 (15%)
Pigmentary changes	0 (0%)	0 (0%)
Scarring	0 (0%)	0 (0%)

Notes: The isotretinoin group mainly experienced dryness (30%) and skin irritation (20%), while the Nd:YAG laser group showed transient erythema (25%) and mild edema (15%). No pigmentary changes, scarring, or serious adverse events were reported in either group

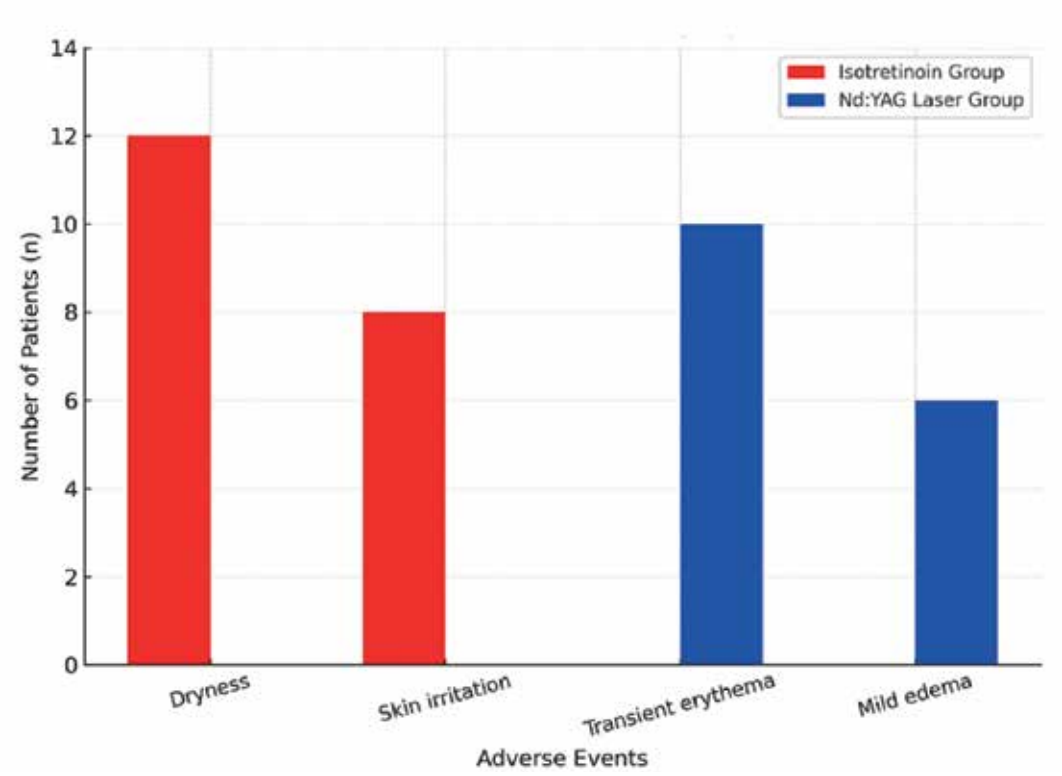

Fig. 3. Comparative incidence of adverse events between isotretinoin and Nd:YAG laser groups

Notes: The isotretinoin group exhibited a higher frequency of dryness and skin irritation, whereas the Nd:YAG laser group primarily demonstrated transient erythema and mild edema. No pigmentary changes or scarring were reported in either group, indicating a favorable safety profile of the laser treatment compared to isotretinoin.

groups, confirming proper randomization ($p>0.05$) (Table 1). However, the Nd:YAG group demonstrated superior outcomes, with faster and more pronounced reductions in acne severity measured by the Global Acne Grading System (GAGS). By week 12, mean GAGS scores decreased by 65.5% in the laser group compared to 56.1% in the isotretinoin group ($p<0.05$) (Table 2). This difference was statistically significant and visible as early as week 6, highlighting the rapid clinical response achieved with Nd:YAG therapy. The reduction trend over time is illustrated in Figure 1, which clearly shows a steeper decline in GAGS scores for the laser group. These findings are consistent with previous reports demonstrating the effectiveness of 1064 nm Nd:YAG laser in reducing inflammatory lesions and improving overall acne severity [18-20].The superior outcomes of laser therapy can be attributed to its mechanism of action. The 1064 nm wavelength penetrates deeply into the dermis, targeting sebaceous glands and perifollicular vasculature while sparing the epidermis [21]. Through selective photothermolysis, it induces controlled thermal damage to sebaceous glands, reducing sebum production, disrupting the environment favorable for *Cutibacterium acnes*, and modulating the local inflammatory response [22, 23]. Additionally, thermal stimulation promotes dermal remodeling, leading to improvements in skin texture and scarring, which are particularly important for patients

Fig. 4. Patient from the 1st group before and after a 12-weeks course of oral isotretinoin therapy, showing a marked reduction in inflammatory acne lesions and visible improvement in overall skin appearance

Fig. 5. Patient from the 2nd group before and after a 12-weeks course of Nd:YAG laser therapy, showing substantial improvement with a marked reduction in inflammatory acne lesions and enhanced overall skin texture

with severe acne [24]. Patients satisfaction was another key outcome. VAS scores were significantly higher in the laser group at both week 6 and week 12 ($p<0.05$) (Table 3). By week 12, the mean VAS score was 8.7±0.6 compared to 7.4±0.7 in the isotretinoin group. These differences are further illustrated in Figure 2, which shows a clear upward trend in satisfaction among laser-treated patients. This aligns with previous studies showing that non-invasive laser therapies provide rapid visible improvements and minimal downtime, factors that strongly influence patient-reported outcomes [25, 26]. The absence of systemic side effects likely contributed to better adherence and overall patient experience in the laser group. The safety profile also differed between the two groups. In the isotretinoin group, the most common side effects were mucocutaneous dryness (30%) and skin irritation (20%) (Table 4, Figure 3), consistent with known isotretinoin-related reactions [27]. These adverse effects, although manageable, may reduce compliance and negatively affect quality of life. Moreover, isotretinoin treatment requires regular laboratory monitoring and strict contraceptive measures due to its teratogenic potential. In contrast, the laser group experienced only mild, transient local reactions such as erythema (25%) and edema (15%), which resolved spontaneously within 48 hours without medical intervention. Notably, no cases of pigmentary changes, scarring, or systemic

effects were observed, confirming previous reports of the high safety profile of Nd:YAG therapy [28].To further illustrate these results, representative clinical photographs demonstrate the therapeutic effects of both treatments. Figure 4 shows a patient before and after 12 weeks of oral isotretinoin therapy, revealing a marked reduction of inflammatory lesions and visible improvement in overall skin appearance. Figure 5 depicts a patient treated with Nd:YAG laser, demonstrating substantial improvement with a significant reduction in acne lesions and enhanced skin texture [29]. These images visually reinforce the quantitative findings reported in Tables 2, 3, and 4. T hese findings have important clinical implications. While isotretinoin remains indispensable for certain severe cases, Nd:YAG laser therapy offers a localized, targeted treatment with a favorable risk-benefit profile. It is particularly valuable for patients who cannot tolerate systemic drugs or who refuse them due to side-effect concerns. Furthermore, combining Nd:YAG laser with topical or systemic agents could maximize treatment outcomes and reduce the psychological distress associated with severe acne [30].The study design had several strengths, including balanced demographics, equal group sizes, and standardized treatment protocols, which improve reliability. There were no dropouts, demonstrating that both interventions were well-tolerated. However, some limitations should be acknowledged. The 12-week follow-up allowed evaluation of short-term efficacy and safety but not long-term remission or recurrence rates. Future research should include extended follow-up periods to assess durability and relapse prevention. Larger, multicenter studies would improve generalizability, and adding a combination therapy group would provide insights into optimizing treatment protocols. From a mechanistic perspective, isotretinoin exerts a systemic effect, shrinking sebaceous glands, normalizing keratinization, and reducing inflammation throughout the body. In contrast, Nd:YAG laser acts locally, selectively targeting sebaceous glands and perifollicular structures without systemic exposure. This explains the minimal side effects observed in the laser group and highlights its role as a safer alternative for carefully selected patients.

CONCLUSIONS

This randomized controlled trial demonstrated that both oral isotretinoin and long-pulsed Nd:YAG laser therapy significantly improved clinical outcomes in patients with severe acne vulgaris over a 12-week period. Notably, the Nd:YAG laser group achieved superior reductions in Global Acne Grading System (GAGS) scores, higher patient satisfaction, and a faster clinical response compared to isotretinoin.

Nd:YAG laser therapy showed an excellent safety profile, with only mild and transient local reactions, while isotretinoin was associated with systemic mucocutaneous side effects requiring laboratory monitoring and strict contraceptive measures. These results suggest that Nd:YAG laser therapy can serve as an effective and well-tolerated alternative for patients who are unable or unwilling to undergo systemic treatment, particularly when rapid improvement and minimal systemic risk are desired.

While these findings are promising, the study was limited by its 12-week follow-up period, which did not assess long-term remission or relapse rates. Future multicenter trials with extended follow-up and larger patient populations are warranted to further validate these findings and to explore the role of combination therapy strategies integrating laser treatment with topical or systemic agents in the comprehensive management of severe acne vulgaris.

REFERENCES

1. Heng AHS, Chew FT. Systematic review of the epidemiology of acne vulgaris. Sci Rep. 2020;10(1):5754. doi: doi:10.1038/s41598-020-62715-3.
2. Sudha M. A clinico-epidemiological study of acne vulgaris conducted at a tertiary care hospital, Tamil Nadu. MedPulse Int J Med. 2021;19:133-138. doi:10.26611/102119311.
3. Layton AM, Ravenscroft J. Adolescent acne vulgaris: current and emerging treatments. Lancet Child Adolesc Health. 2023;7(3):175-186. doi:10.1016/S2352-4642(22)00314-5.
4. El Kazzi T, Shahine M, Salameh P. Effect of severity of acne on the mental health of Lebanese patients with acne: findings from an online survey. BMC Psychol. 2025;13:502. doi:10.1186/s40359-025-02808-8.
5. Telkkälä A, Sinikumpu S-P, Huilaja L. Etiology of adult female acne: Systematic review. Health Sci Rep. 2024;7(8):e70697. doi: doi:10.1002/hsr2.70697.
6. Xu W, Xu J, Huang D, et al. Acne vulgaris: advances in pathogenesis and prevention strategies. Eur J Clin Microbiol Infect Dis. 2025;44:515-532. doi:10.1007/s10096-024-04984-8.
7. Kim HJ, Kim YH. Exploring acne treatments: from pathophysiological mechanisms to emerging therapies. Int J Mol Sci. 2024;25(10):5302-5336. doi:10.3390/ijms2510530.
8. Salinas AB. Acne vulgaris: role of the immune system. Int J Dermatol. 2021;60(3):326-333. doi:10.1111/ijd.15415.
9. Jia X, et al. Evaluation of the Safety and Efficacy of a fractional picosecond 1064 nm laser for Post-acne Erythema in Adult Chinese patients. Skin Res Technol. 2023;29(1):e13274. doi:10.1111/srt.13274.
10. El-Ghareeb MI, Kandeel AH, Khayrullah NM. Efficacy and safety of combined oral isotretinoin and desloratadine vs. isotretinoin alone in acne vulgaris: a comparative study. Arch Dermatol Res. 2025;317:689. doi:10.1007/s00403-025-04145-7.
11. Soutou B, Sleiman J, Tomb R, et al. Prevalence of adverse events varies with the different oral isotretinoin brands in acne treatment: a retrospective observational study. Arch Dermatol Res. 2023;315:1533-1539. doi:10.1007/s00403-023-02532-6.

12. Ip A, Muller I, Geraghty AWA, McNiven A, Little P, Santer M. Young people's perceptions of acne and acne treatments: secondary analysis of qualitative interview data. Br J Dermatol. 2020;183(2):349-56. doi:10.1111/bjd.18684.
13. He S, Wang Y, Wang J, Tang L, Yang L, Ye F. Isotretinoin combined laser/light-based treatments versus isotretinoin alone for the treatment of acne vulgaris: a meta-analysis. J Cosmet Dermatol. 2024;24(1):e16639. doi: 10.1111/jocd.16639.
14. Vasam M, Korutla S, Bohara RA. Acne vulgaris: a review of the pathophysiology, treatment, and recent nanotechnology based advances. Biochem Biophys Rep. 2023; 36:101578. doi:10.1016/j.bbrep.2023.101578.
15. Costa CS, Bagatin E, Martimbianco ALC, da Silva EMK, et al. Oral isotretinoin for acne. Cochrane Database Syst Rev. 2018;11(11):CD009435. doi:10.1002/14651858.CD009435.pub2.
16. Kapała J, Lewandowska J, Placek W, Owczarczyk-Saczonek A. Adverse events in isotretinoin therapy: a single-arm meta-analysis. Int J Environ Res Public Health. 2022;19(11):6463. doi: 10.3390/ijerph19116463.
17. Jean-Pierre P, Tordjman L, Ghodasara A, et al. Emerging lasers and light-based therapies in the management of acne: a review. Lasers Med Sci. 2024;39:245. doi:10.1007/s10103-024-04196-8.
18. Paichitrojjana A, Paichitrojjana A. Oral isotretinoin and its uses in dermatology: a review. Drug Des Devel Ther. 2023;17:2573-91. doi: 10.2147/DDDT.S427530.
19. Albalat W, Ehab R, AbouHadeed MH, et al. Combined low-dose isotretinoin and long-pulsed nd: YAG laser in the treatment of post-acne erythema. Arch Dermatol Res. 2024;316:359. doi:10.1007/s00403-024-03143-5.
20. Santer M, Burden-Teh E, Ravenscroft J. Managing acne vulgaris: an update. Drug Ther Bull. 2024;62(1):6-10. doi: 10.1136/dtb.2023.000051.
21. Gold MH, Goldberg DJ, Nestor MS. Current treatments of acne: Medications, lights, lasers, and a novel 650-μs 1064-nm Nd: YAG laser. J Cosmet Dermatol. 2017;16(3):303–318. doi:10.1111/jocd.12367.
22. Li MK, Liu C, Hsu JTS. The use of lasers and light devices in acne management: an update. Am J Clin Dermatol. 2021;22(6):785–800. doi:10.1007/s40257-021-00624-5.
23. Mohammadi M. Cutibacterium acnes bacteriophage therapy: exploring a new frontier in acne vulgaris treatment. Arch Dermatol Res. 2025;317:84. doi:10.1007/s00403-024-03585-x.
24. Zhou C, Yao M, Chen W, et al. Treatment of erythematous acne scars using 595-nm pulsed dye laser combined with 1565-nm ResurFX nonablative fractional laser. J Cosmet Dermatol. 2024;6:2015-2021. doi:10.1111/jocd.16235.
25. Reynolds RV, Yeung H, Cheng CE, Cook-Bolden F, Desai SR, Druby KM, et al. Guidelines of care for the management of acne vulgaris. J Am Acad Dermatol. 2024 May;90(5):1000.e11-1000.e30. doi:10.1016/j.jaad.2023.12.017.
26. Ibrahim SM, Farag A, Hegazy R, Mongy M, Shalaby S, Kamel MM. Combined low-dose isotretinoin and pulsed dye laser versus standard-dose isotretinoin in the treatment of inflammatory acne. Lasers Surg Med. 2020;52(10):965-972. doi:10.1002/lsm.23356.
27. Brzezinski P, Borowska K, Chiriac A, Smigielski J. Adverse effects of isotretinoin: A large, retrospective review. Dermatol Ther. 2017;30(4):e12483. doi:10.1111/dth.12483.
28. Xue H, Ye D, Huang S, He S, Li Y, Liu J, et al. Efficacy and safety of low-dose oral isotretinoin monotherapy versus combined therapy with picosecond laser for the treatment of acne scars in Asian population. Lasers Surg Med. 2023;55(5):527-36. doi:10.1002/lsm.23646.
29. Nast A, Dréno B, Bettoli V, Bukvic Mokos Z, Degitz K, et al. European evidence-based (S3) guideline for the treatment of acne – update 2016 – short version. J Eur Acad Dermatol Venereol. 2016;30(8):1261-1268. doi:10.1111/jdv.13776.
30. Handler MZ, Bloom BS, Goldberg DJ. Energy-based devices in treatment of acne vulgaris. Dermatol Surg. 2016;42(5):573-585. doi:10.1097/DSS.0000000000000715.

CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Effectiveness of Lee Silverman voice therapy – big on body movements in Parkinson Disease – a pilot study

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ABSTRACT

Aim: This pilot study evaluates the effectiveness of the Lee Silverman Voice Treatment – BIG in improving body movements in individuals with Parkinson's disease compared to general exercise therapy.

Methods and Materials: A pilot study was conducted with 34 participants diagnosed with mild to moderate Parkinson's disease. Patients were randomly assigned to two groups: Group A (Lee Silverman Voice Treatment – BIG) and Group B (general exercise therapy). Each group underwent a 4-week intervention, with two sessions per day, four days per week. The Unified Parkinson Disease Rating Scale – Part III was used to assess motor function pre- and post-intervention. Data analysis was performed using SPSS Version 27.

Results: Both interventions significantly improved Unified Parkinson's Disease Rating Scale – Part III scores ($p<0.05$). However, Group A demonstrated a greater reduction in motor impairment (pre-test: 51.29±1.213, post-test: 48.88±2.619) compared to Group B (pre-test: 51.65±1.272, post-test: 50.59±1.502).

Conclusion: Lee Silverman Voice Treatment – BIG effectively enhances Healthy movement amplitude and mobility in people with Parkinson's disease, showing superior improvements over general exercise therapy. This study suggests Lee Silverman Voice Treatment – BIG as a preferred rehabilitation strategy for managing Parkinson's disease related motor disabilities.

KEYWORDS: general exercise, Parkinson disease, pilot study, health, disabilities

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INTRODUCTION

The term Parkinson disease was first used in 1817 by James Parkinson. Neurological conditions like Parkinson's disease are common. Over time, both motor and non-motor function are affected by this degenerative disease [1]. Between 2004 and 2023, Parkinson's disease prevalence climbed significantly and rapidly; worldwide, the condition affects more than 3.81 out of every 1,000 people [2]. Young onset Parkinson disease (YOPD) occurs before or around age 40, while late onset Parkinson disease (LOPD) occurs after or around age 70. However, males were more likely than women to develop Parkinson disease overall, with an average age of 64-66 years [3]. Parkinson's disease non-motor symptoms include hallucinations, illusions, delusions, attention deficit disorder, despair, apathy, anxiety, and anhedonia, according to neuropsychiatric Repetitive conduct, obsessional behaviour, and dementia Autonomic dysfunction, including bladder issues, sleep disorders, confusion, delirium, and orthostatic hypotension. Pain, paraesthesia, and olfactory disruption are sensory complaints [4]. Bradykinesia, stiffness, tremor (including resting tremors), and postural instability are all signs of Parkinson's disease [5]. Parkinson disease vocal motor effect is marked by monotony in loudness and pitch, decreased stress, fluctuating rate, inaccurate consonants, and a harsh, breathy voice that manifests as dysarthria [6]. The causes and consequences of Parkinson's disease involves The neuroinflammation caused by microglia and astrocytes starts the cell destruction in the substantia nigra. The nigrostriatal pathway degenerates and the brain's dopamine reserves are depleted when dopaminergic neurons in the substantia nigra are destroyed. In the corpus striatum, this leads to an imbalance between excitatory (acetylcholine) and inhibitory (dopamine) neurotransmitters. The excessive excitatory impulses of acetylcholine are not inhibited by the lowered dopamine levels, resulting in motor symptoms such bradykinesia (slowness of movement), stiffness, and tremors. Moreover, postural instability and trouble starting and regulating voluntary motions are caused by damage of the extrapyramidal pathways, which regulate complex bodily movements. The motor control systems of the brain are significantly impacted by this series of neurodegenerative events, which results in the hallmark symptoms of Parkinson's disease, including trouble balancing and coordinating movements. The motor dysfunctions linked to the illness are supported by both neuronal loss and this neurochemical imbalance [7].

Parkinson's disease is commonly characterized by resting tremors, tiny, cramped handwriting (micrographia), modest walking problems (hypokinesia), and a progressive slowing of motions (bradykinesia). These symptoms intensify as the disease progresses, resulting in festination (hurried, shuffling steps), involuntary movements (dyskinesia), an inability to start movement (akinesia), markedly decreased movement (marked hypokinesia), and difficulties with posture

and balance, which make daily tasks more challenging. In 1985, Lee Silverman created the voice therapy BIG, also known as LSVT-BIG [8]. Parkinson's disease patients are trained to execute large-amplitude whole-body movements as part of the LSVT-BIG program. By increasing the pace and amplitude of their functional duties, this approach promotes larger movements for better mobility and everyday life activities this emphasis on practice [9]. Parkinson's disease patients are trained to execute large-amplitude full body movements as part of the LSVT-BIG program. By encouraging larger motions for better mobility and everyday life activities, this approach seeks to increase the speed and amplitude of their functional duties. In order to compensate for the disease's restricted movement patterns, the emphasis is on performing exaggerated motions [10]. The main purpose of the study is to examine the effectiveness of Lee Silverman Voice Treatment – BIG (LSVT-BIG) on improving motor function in comparing with general mobility exercise on Parkinson's patients assessing UPDRS-III scale.

AIM

The aim of this pilot study is to evaluate the effectiveness of Lee Silverman Voice Treatment – BIG in improving body movements in individuals with Parkinson's disease compared to general exercise therapy.

METHODS AND MATERIALS

This study was approved by Institutional Scientific Review Board Approval no: 415/07/2024/ISRB/UGSR/SCPT conducted at Saveetha Hospital, Chennai, India, from the first week to the fourth week of December 2024. A total of 34 patients were included based on the inclusion criteria, and the sample size was selected according to the rule of thumb method. All subjects provided informed consent before being randomly assigned to two groups of 17 patients each. Group A received the LSVT-BIG protocol, while Group B received general exercise therapy. Demographic data were collected from each participant before treatment (Table 1).

The inclusion criteria consisted of patients diagnosed with Parkinson's disease with a UPDRS-III score ranging from 0 to 32 (mild) and 33 to 58 (moderate), aged between 40 to 80 years, including both male and female participants. Patients with motor symptoms such as bradykinesia, hypokinesia, rigidity, and postural instability who had not received LSVT-BIG training in the past six months were considered eligible. Exclusion criteria included severe Parkinson's disease (UPDRS-III score of 59 to 132), other neurological disorders such as stroke or multiple sclerosis, uncontrolled cardiovascular, respiratory, or musculoskeletal conditions, recent surgery, or participation in other therapies.

The Intervention for Group A involved the Lee Silverman Voice Treatment – BIG (LSVT-BIG) protocol, which included various exercises. Floor to Ceiling Reach instructed patients to stand tall and reach their arms upward as high as possible before bending down to reach toward the floor. Side-to-Side Stepping required patients to take a big step to the right while swinging their arms, return to the centre, and then step big to the left. High-Knee Marching involved marching in place with exaggerated knee lifts and arm swings for 30 seconds. BIG Steps & Turns instructed patients to walk forward with large steps, turn in an exaggerated manner, and walk back using big steps. Seated BIG Arm Swings required patients to sit in a chair, rest their arms, and raise one arm high while keeping the other low, switching arms in a big, exaggerated motion [8].

The Intervention for Group B underwent general exercise therapy, which included Sit-to-Stand Exercise, where patients sat in a sturdy chair with feet flat on the floor, leaned slightly forward, pushed through their legs to stand up, then slowly lowered back down. Step-Ups required stepping onto a sturdy platform with one foot, bringing the other foot up, stepping down, and repeating for each leg. Reaching & Grasping involved standing and reaching for an object on a high shelf, grasping it firmly, bringing it down slowly, placing it back, and repeating. Weight Shifting & Turning included standing with feet shoulder-width apart, transferring weight from side to side, lifting

Table 1. Demographic data

Gender	Male	20
	Female	14
Age	40-50	12
	51-60	9
	61-70	7
	71-80	6
Comorbidities	Diabetes mellitus	3
	Hypertension	5
	Thyroid	0
Body Mass Index	16.5 to 18.5 (Underweight)	4
	19.5 to 24.9 (Normal weight)	22
	25 to 29.9 (Overweight)	8

Table 2. Study protocol

LVST-BIG				
Exercise	Weeks	Session	Sets	Reps
Floor to Ceiling Reach	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
Side-to-Side Stepping	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
High-Knee Marching	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
BIG Steps & Turns	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
Seated BIG Arm Swings	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
General exercise therapy				
Sit-to-Stand Exercise	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
Step-Ups	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
Reaching & Grasping	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
Weight Shifting & Turning	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20
Heel-to-Toe Walking (Tandem Walk)	Week 1	2	2	15
	Week 2	2	2	15
	Week 3	2	3	15
	Week 4	2	3	15-20

one foot slightly, and performing controlled 180-degree and 360-degree turns. Heel-to-Toe Walking (Tandem Walk) instructed patients to walk in a straight line, placing one foot directly in front of the other while using a wall or support if needed, for ten steps forward and backward. Core Activation & Stability exercises included seated or standing leg lifts, gentle side bends to improve flexibility, and seated torso twists to enhance rotational ability [11]. Study protocol is mentioned in Table 2.

The outcome measure was assessed using the Unified Parkinson's Disease Rating Scale – Part III (UPDRS-III), which was measured during the first week and after four weeks of intervention. This scale consists of 12 components, each scored from 0 to 4, where 0 indicates the absence of impairment and 4 indicates severe impairment. The total score ranges from 0 to 132, categorizing motor impairment as mild (0-32), moderate (33-58), and severe (59-132) [12]. For data analysis, SPSS version 27 was used to analyse all collected data. Age and Sex distribution of samples were illustrated in Table 3.

RESULTS

A Wilcoxon signed-rank test was conducted to evaluate the within-group changes in motor performance, as measured by UPDRS-III, following the 4-week intervention period. In Group A, individuals underwent LSVT-BIG therapy administered four times per week. The results demonstrated a statistically significant reduction in UPDRS-III scores from pre- to post-intervention ($Z=-3.471$, $p<0.001$), indicating a meaningful improvement in motor symptoms among participants who received LSVT-BIG.

Similarly, Group B, which received general exercise therapy at the same frequency (four sessions per week), also showed a significant improvement in UPDRS-III scores ($Z=-3.286$, $p=0.001$). Although both therapeutic approaches yielded positive outcomes, the descriptive data and statistical trend indicate that the improvement observed in Group A was comparatively greater, suggesting that LSVT-BIG may offer superior motor benefits over general exercise within the same treatment duration (Table 4).

Between-group comparisons were performed using the Mann–Whitney U test to determine whether the magnitude of improvement differed significantly between the two interventions. As shown in Table 5, the pre-test analysis revealed no significant difference between Group A and Group B ($U=122.00$, $p=0.424$), confirming that both groups were statistically comparable at baseline, with similar levels of motor impairment. This supports the internal validity of the intervention effects observed post-treatment.

In contrast, the post-test comparison demonstrated a statistically significant difference between the groups ($U=77.50$, $p=0.019$), indicating that the type of intervention had a meaningful impact on post-intervention motor performance. Participants in Group A showed a greater

Table 3. Age and Sex distribution of samples

Age	Group A			Group B		
	Male	Female	Total	Male	Female	Total
40-50	4	2	6	4	2	6
51-60	3	2	5	3	1	4
61-70	2	2	4	2	1	3
71-80	1	1	2	1	3	4
Total	10	7	17	10	7	17

Table 4. Comparison of UPDRS-III within Group A & Group B

Group	Pre-Test Mean±SD	Post-Test Mean±SD	Z-Value	P-value
Group A (N=17)	51.29±1.213	48.88±2.619	-3.471	<0.001
Group B (N=17)	51.65±1.272	50.59±1.502	-3.286	0.001

Table 5. Difference between Pre & Post test of both group

Tests	Mean±SD	Z value	W	U	P-value	R-value
Pre-test	50.47±1.237	-0.799	275.000	122.00	0.424	0.137
Post-test	49.74±2.247	-2.349	230.500	77.500	0.019	0.402

reduction in UPDRS-III scores when compared to those in Group B, further supporting the enhanced efficacy of LSVT-BIG therapy for improving functional motor outcomes in Parkinson's disease.

Effect size calculations provided additional insight into the magnitude of these findings. The pre-test effect size (r=0.137) was small, aligning with the non-significant baseline difference. Conversely, the post-test effect size (r=0.402) represented a moderate to large effect, reinforcing the clinical relevance of the between-group differences. Collectively, these findings highlight that although both interventions were beneficial, LSVT-BIG produced a clinically superior and statistically stronger improvement in motor performance compared to general exercise therapy.

DISCUSSION

The results indicate that both intervention groups showed a statistically significant reduction in UPDRS-III scores after a four-week treatment. The findings support LSVT-BIG's effectiveness in improving motor function in Parkinson's disease patients. Studies states that impacts of LSVT® BIG on Tremor, stiffness, bradykinesia (slow movement), and postural instability and gait disorder (PIGD) are the four primary motor symptoms of Parkinson's disease (PD) are still not fully clear. However, this study found that LSVT® BIG led to significant improvements in overall motor function, particularly in bradykinesia and PIGD. While tremor and rigidity showed a trend toward improvement, these changes were not statistically significant. According to these results, LSVT® BIG could be a useful treatment for certain PD symptoms, while alternative treatment modalities might be required for others. This study's improvement in the overall MDS-UPDRS Part III score is consistent with earlier findings. For example, Ueno et al., 2017 found that patients with PD at Hoehn and Yahr (HY) stages II-III experienced significant improvements in motor function after completing LSVT® BIG. Their study reported a decrease in the UPDRS Part III score from a median of 12.5 to 8.5, reinforcing the effectiveness of this therapy. Comparing scores for the four major motor symptoms allows us to better understand LSVT® BIG's impact. LSVT® BIG aims to help PD patients recognize when their movements are smaller than normal and train them to correct this by increasing movement size. This helps counteract bradykinesia, which is characterized by slow or small movements and delayed movement initiation [13]. Research by Flood et al., 2020 found that LSVT® BIG significantly improved walking speed, stride length, and functional movement tests (such as the 10-meter walk test and the timed up-and-go test) in patients with PD at HY stages I-III. PIGD, which includes balance and gait difficulties, is particularly challenging to treat with dopaminergic medications alone [14]. Studies by Walsh et al., 2020 showed that LSVT® BIG significantly improved walking ability, balance (measured by the Berg Balance Scale), and functional gait assessments in patients with PD at HY stages II-IV. These findings highlight LSVT® BIG's potential benefits for postural stability and mobility. However, tremor and rigidity did not show statistically significant improvements in this study. This suggests that these symptoms may require a combination of LSVT® BIG with other treatments, such as deep brain stimulation (DBS) and dopaminergic medications. Previous research has shown that DBS is particularly effective in reducing tremors and rigidity [15] and studies by Wong et al., 2020 found that combining DBS with medication provides even greater symptom relief than medication alone [16]. Iwai et al., 2024 Studies states reveals the theory that people with Parkinson's disease experience altered sensorimotor integration. Additionally, our results suggest that LSVT BIG helps retrain proprioceptive processing, allowing patients to better perceive and adjust their movements. However, further research with larger participant groups and controlled study designs ideally using a crossover study would be necessary to confirm these results [17-22]. Peterka et al., 2020 study is the first to suggest a potential physiological mechanism behind an amplitude-based, symptom-specific behavioural intervention like LSVT BIG. Beyond this therapy our findings may also inspire future research into how other treatment approaches impact proprioceptive function in Patient with Parkinson disease [18, 23, 24].Parkinson's disease is a neurological disorder that affects millions of people worldwide. It is primarily caused by the progressive loss of dopamine in the brain, leading to challenges in motor function and cognitive abilities. Unfortunately, there is currently no cure for PD – only treatments that help manage symptoms or slow disease progression. While medication is commonly used, Physician may hesitate to prescribe it for two reasons. First, many PD medications have significant side effects. Second, over time, the body becomes accustomed to the medication, reducing its effectiveness. As a result, healthcare professionals are increasingly turning to non-invasive physical therapy. One promising therapy is LSVT BIG, a treatment designed to help PD patients improve movement amplitude. Research has consistently shown that LSVT BIG is effective in enhancing mobility and quality of life. Given its benefits, all individuals with Parkinson's disease should have access to this treatment [11].

In the present study although both groups showed significant within-group improvements, between-group analysis indicated a greater improvement in the LSVT-BIG group compared to the general exercise group. The observed effect size was small at baseline (r=0.137) and large post-intervention (r=0.402), suggesting a meaningful enhancement in motor function following LSVT-BIG therapy.

LIMITATION

The limitations of the study that need to be taken into consideration. The study may only assess the short-term effects of LSVT BIG, making it difficult to determine the long-term benefits or limitations of the therapy. Another factor to consider is the dependence on therapist expertise, as the effectiveness of LSVT BIG may vary based on the skill and experience of the therapist delivering the treatment. If the therapist is not adequately trained, the outcomes may be less favourable. Furthermore, cultural and socioeconomic

factors may not be accounted for in the study, which could influence the effectiveness of LSVT BIG and limit the applicability of the results to diverse populations.

RECOMMENDATION

To improve the study, several key recommendations should be considered. First, recruiting a larger sample size would enhance the generalizability of the findings, allowing for more reliable conclusions. Additionally, comparing the effectiveness of LSVT BIG with other movement therapies, such as physical therapy or occupational therapy, would provide a clearer understanding of its relative benefits. Another important area of focus is assessing the impact of LSVT BIG on quality of life and daily functioning in individuals with PD, as this would offer valuable insights into its practical benefits. Lastly, utilizing neuroimaging techniques to investigate the neural mechanisms behind LSVT BIG's effects on body movements could provide a deeper understanding of how the therapy influences brain function and motor control.

CONCLUSION

Both LSVT-BIG and general exercise therapy produced significant motor improvements in individuals with Parkinson's disease. However, LSVT-BIG showed greater improvement than general exercise, suggesting it may be considered a first-line rehabilitation approach for enhancing motor performance.Additionally, no adverse events were reported during the intervention period, indicating that LSVT-BIG is a safe rehabilitation option for Parkinson's patients.

REFERENCES

1. Hayes MT. Parkinson's Disease and Parkinsonism. Am J Med. 2019;132(7):802-7. doi: 10.1016/j.amjmed.2019.03.001.
2. Zhu J, Cui Y, Zhang J et al. Temporal trends in the prevalence of Parkinson's disease from 1980 to 2023: a systematic review and meta-analysis. Lancet Healthy Longev. 2024;5(7):e464-79. doi: 10.1016/s2666-7568(24)00094-1.
3. Wickremaratchi MM, Ben-Shlomo Y, Morris HR. The effect of onset age on the clinical features of Parkinson's disease. Eur J Neurol. 2009;16(4):450-6. doi: 10.1111/j.1468-1331.2008.02514.x.
4. Chaudhuri KR, Healy DG, Schapira AH. Non-motor symptoms of Parkinson's disease: diagnosis and management. Lancet Neurol. 2006;5(3):235-45. doi: 10.1016/s1474-4422(06)70373-8.
5. Xia R, Mao ZH. Progression of motor symptoms in Parkinson's disease. Neurosci Bull. 2012;28(1):39-48. doi: 10.1007/s12264-012-1050-z.
6. Holmes RJ, Oates JM, Phyland DJ, Hughes AJ. Voice characteristics in the progression of Parkinson's disease. Int J Lang Commun Disord. 2000;35(3):407-18. doi: 10.1080/136828200410654.
7. Sayyaed A, Saraswat N, Vyawahare N, Kulkarni A. A detailed review of pathophysiology, epidemiology, cellular and molecular pathways involved in the development and prognosis of Parkinson's disease with insights into screening models. Bulletin of the National Research Centre/Bulletin of the National Research Center. 2023;47(1). doi: 10.1186/s42269-023-01047-4.
8. Fox C, Ebersbach G, Ramig L, Sapir S. LSVT LOUD and LSVT BIG: Behavioral Treatment Programs for Speech and Body Movement in Parkinson Disease. Parkinson S Disease . 2012;2012:1-12. doi: 10.1155/2012/391946.
9. Farley BG, Koshland GF. Training BIG to move faster: the application of the speed–amplitude relation as a rehabilitation strategy for people with Parkinson's disease. Exp Brain Res. 2005;167(3):462-7. doi: 10.1007/s00221-005-0179-7.
10. Janssens J, Malfroid K, Nyffeler T et al. Application of LSVT BIG Intervention to address GAIT, balance, bed mobility, and dexterity in people with Parkinson Disease: a case series. Phys Thera. 2014;94(7):1014–23. doi: 10.2522/ptj.20130232.
11. Hayek ME, Lopes JLMLJ, LeLaurin JHet al. Type, timing, frequency, and durability of outcome of physical therapy for Parkinson disease. JAMA Network Open. 2023;6(7):e2324860. doi: 10.1001/jamanetworkopen.2023.24860.
12. Hentz JG, Mehta SH, Shill HA et al. Simplified conversion method for unified Parkinson's disease rating scale motor examinations. Mov Disord. 2015;30(14):1967-70. doi: 10.1002/mds.26435.
13. Ueno T, Sasaki M, Nishijima H et al. LSVT-BIG Improves UPDRS III Scores at 4 Weeks in Parkinson's Disease Patients with Wearing Off: A Prospective, Open--Label Study. Parkinsons Dis. 2017;2017:1-4. doi: 10.1155/2017/813014.
14. Flood MW, O'Callaghan BPF, Diamond P et al. Quantitative clinical assessment of motor function during and following LSVT-BIG® therapy. J Neuroeng Rehabil. 2020;17(1). doi: 10.1186/s12984-020-00729-8.
15. Walsh SF, Balster C, Chandler A et al. LSVT BIG® and long-term retention of functional gains in individuals with Parkinson's disease. Physiother Theory Pract. 202;38(5):629-36. doi: 10.1080/09593985.2020.1780655.
16. Hacker ML, DeLong MR, Turchan M et al. Effects of deep brain stimulation on rest tremor progression in early stage Parkinson disease. Neurology. 2018;91(5). doi: 10.1212/wnl.0000000000005903.
17. Sivalingam AM, Sureshkumar DD, Pandurangan V. Cerebellar pathology in forensic and clinical neuroscience. Ageing Res Rev. 2025;106(102697):102697. doi: 10.1016/j.arr.2025.102697.
18. Iwai M, Koyama S, Takeda K et al. Effect of Lee Silverman Voice Treatment® BIG on the major motor symptoms in patients with moderate Parkinson's disease: an observational study. Journal of Gerontology and Geriatrics. 2024;72(2):76-82. doi: 10.36150/2499-6564-n711.
19. Peterka M, Odorfer T, Schwab M et al. LSVT-BIG therapy in Parkinson's disease: physiological evidence for proprioceptive recalibration. BMC Neurol. 2020;20(1). doi: 10.1186/s12883-020-01858-2.

20. Balaji T, Ramalingam V, Santhana Lakshmi S. Comparing the effects of post-isometric relaxation and hold-relax technique for cervicogenic headache among computer users. Neurol Asia. 2025;30(1):157-63. doi: 10.54029/2025tmx.
21. Hemalatha S, Nimalan P, Farhana M, Jeberson J. Effect of Toe Walking Exercises and Intrinsic Foot Muscle Exercises for Individuals With Flat Foot: A Comparative Study. Muscles Ligaments & Tendons Journal (MLTJ). 2024;14(4).
22. Kuliński W, Mróz J, Iwaniszczuk A. Physical therapy in Parkinson disease: clinical aspects. Acta Balneol. 2025;67(4):293-295. doi: 10.36740/ABAL202504109
23. Khubetova I. Complex rehabilitation of patients with Parkinson's disease. Acta Balneol. 2023;65(1):11-4. doi: 10.36740/abal202301102.
24. M K, Josyula S, S JA, M N, J H, J V et al. Comparative analysis of high-intensity interval training and traditional rehabilitation programs for accelerated recovery from musculoskeletal injuries. J Back Musculoskelet Rehabil. 2024;37(2):437-43. doi: 10.3233/BMR-230146.

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Restoration of students' somatic health in the aquatic environment

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ABSTRACT

Aim: The aim is to experimentally test the effect of aqua fitness training sessions on the restoration of students' somatic health during their studies under martial law.

Materials and Methods: The research involved 126 female students, aged 17-21, divided into two groups: 62 in the experimental group (EG) and 64 in the control group (CG). The students of the EG participated in aqua fitness, while the students of the CG participated in dance aerobics. Research methods: analysis and generalization of literary sources, medical and biological methods, statistical methods. The level of somatic health was investigated using the method developed by H. Apanasenko.

Results: A more pronounced positive dynamics of somatic health indicators in the EG students, compared to the CG, was revealed during their studies under martial law. In the EG, the increase in somatic health level was 14.5 % ($p \leq 0.01$), whereas in the CG, it was 7.3 % ($p > 0.05$). At the end of the research, the level of somatic health in the EG students was significantly better than in the CG ($p \leq 0.05$), indicating a positive effect of the training sessions in the aquatic environment.

Conclusions: Significant improvement of morphofunctional indices and somatic health level in the EG students during the research period prove that exercises in the aquatic environment improve metabolism and reduce body weight, normalize the cardiovascular system, enhance respiratory function, and body resistance to colds, which confirms the sustainable health effect of aqua fitness training sessions

KEYWORDS: female students, somatic health, aquatic environment, water, aqua fitness

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INTRODUCTION

At the current stage of its development, Ukraine is among the countries in the European region with unsatisfactory health indicators and low life expectancy, which is a national concern [1]. According to recent statistics, only about 10% of students at higher educational institutions (HEIs) can be considered practically healthy [2]. This is due to the lack of health culture in society, including among students, low civic awareness regarding their health and the health of others, the prevalence of unhealthy behavioral factors associated with lifestyle, and high levels of stress [3].

It should be understood that a new quality of education and preservation of the health of the younger generation can only be achieved through the use of various means of physical education aimed at forming students' health-preserving behavior. In recent years, the peculiarities of studying of modern Ukrainian students have been characterized by a decrease in motor activity and an increased level of stress against the background of intensification of the educational process in the conditions of distance learning associated with quarantine restrictions and martial law, which leads to a deterioration in the somatic health of students [4-6]. The sedentary lifestyle, irrational diet, non-compliance with the daily routine, constant psycho-emotional stress, and low health culture characteristic of modern students lead to an increase in the number of young people with poor somatic health.

Rationally organized motor activity, which arouses interest and has a comprehensive health effect, has the potential to positively impact students' somatic health through pedagogical means. Studies show that physical exercises with a health and recreational orientation, particularly various types of wellness fitness, are in special demand among female students, which allows for increasing the overall working capacity and functional capabilities of the body, as well as the development of motor skills in various motor modes of active recreation. One type of wellness fitness is aqua fitness. Scientists have proven

that physical exercises in the aquatic environment have no special contraindications for use, as they enhance the effect of physical activity on the body of those who exercise due to the hydrodynamic properties of water, which allow them to play the role of a multifunctional simulator [7].

In practice, individual aqua-fitness programs are formed by synthesizing exercises from swimming, gymnastics, athletics, calisthenics, stretching, dance, and aerobics, among others, used in the aquatic environment [8, 9]. This variation in motor load intensity makes it accessible to students of different motor fitness levels. At the same time, it is essential to investigate the effectiveness of aqua fitness training sessions in restoring the somatic health of female students under martial law.

AIM

The aim is to experimentally test the effect of aqua fitness training sessions on the restoration of students' somatic health during their studies under martial law.

MATERIALS AND METHODS

PARTICIPANTS

The research was conducted in 2023-2024 and involved 1st- and 2nd-year students of the Ukrainian State Dragomanov University (Kyiv, Ukraine), comprising 126 girls aged 17-20 years. The experimental (EG) and control (CG) groups, each consisting of 62 and 64 individuals, respectively, were formed. The EG students participated in our aqua-fitness program, which included various motor exercises in water and provided a targeted effect on the body's functional capabilities and different muscle groups, with a reduced load on the joints. The female students of the CG were engaged in the sports clubs, mainly focusing on wellness and fitness through dance aerobics. Training sessions lasted 1 hour and were held three times a week. The selection of female students into groups was carried out solely at their request, with no specific selection process in place. At the beginning of the research, the homogeneity of all indicators for the EG and the CG was determined, and the absence of a significant difference between the indicators of the EG and the CG ($p \geq 0.05$) was revealed.

RESEARCH METHODS

Include the analysis and generalization of literary sources, as well as medical and biological methods, and statistical methods. The analysis and generalization of literary sources were employed to substantiate the theoretical problem. The medical and biological methods allowed us to assess the level of somatic health of female students. For this purpose, the methodology of Professor H. Apanasenko was employed. This methodology is based on the biological consistent pattern of a certain threshold of the biosystem's energy potential (body reserves), above which people generally do not have endogenous risk factors or chronic somatic diseases. Below this threshold (when reserve capacities are exhausted), endogenous risk factors first act, and then chronic somatic diseases develop. The methodology takes into account the following primary data: height, body weight, hand strength, vital capacity of the lungs (VC), blood pressure, and heart rate (HR) at rest, as well as after standard exercise. Based on the obtained indicators, morphofunctional indices (body mass index (BMI), vital index (VI), strength index (SI), Robinson index (RI), and Martine-Kushelevsky index (MKI)) and the general somatic health level (SHL) were calculated [10]. The level of students' somatic health was assessed in points according to the following gradation: I – low level (3 points or less), II – below average (4-6 points), III – average (7-11 points), IV – above average (12-15 points), V – high (16-18 points). The study of somatic health indicators was conducted at the beginning (September) and end (May) of the 2023-2024 academic year.

STATISTICAL ANALYSIS

Statistical methods enabled us to analyze the results both qualitatively and quantitatively and present them in a tabular format. Using the Shapiro-Wilk W test, we found that the distributions of the EG and the CG were normal. This allowed us to assess the reliability of the results using Student's t-test. The reliability of the difference was set at $p \leq 0.05$. All statistical analyses were performed using SPSS software. The results were presented as $X \pm m$, where X is the arithmetic mean and m is the standard error of the arithmetic mean.

ETHICAL STANDARDS OF THE RESEARCH

The process of research implementation is built following the requirements of scientific ethics. The Academic Ethics Commission of the Ukrainian State Dragomanov University approved the research. The pedagogical experiment was open, and its participants were informed about the aim and tasks of the research, and they voluntarily participated in it.

RESULTS

Based on the measurements of 126 female students at the beginning of the research, we calculated their morphofunctional indices, which collectively allowed us to assess their level of somatic health. As a result, it was determined that the majority of female students have a level of health below average (56.3%), while 13.5% of female students have a low level of somatic health. The number of girls with an average level of health is 28.6%, while only 1.6% of female students have an above-average level of somatic health. No high level of somatic health was found among the studied female students. The obtained results indicate that the general level of health among female students is in the range from low to below average, which suggests the expediency of using modern means of physical education to restore and improve the somatic health of female students at HEIs. To this end, we offered female students optional health training sessions, from which they could choose: aqua fitness or dance aerobics.

Each individual training session of any type of physical education and recreation activity traditionally includes preparatory, main, and final parts. The preparatory part of the aqua fitness training session included warm-ups, i.e., sets of general developmental exercises to warm

up the muscles, and took about 15 minutes. The water temperature in the pool was about 7-8°C below human body temperature, so the water seemed cold at first. The primary tasks of the preparatory part of the aqua fitness training session were to adapt the body to the water environment's temperature, create a positive emotional mood, and prepare the muscles for the main load. The main content of the preparatory part of the training session consisted of the following exercises: vigorous movements with a short lever arm, running, breathing exercises, types of walking with arm movements, isolated and complex movements of the arms, legs with the development of the main joints (ankle, knee, hip, spine, shoulder girdle, elbow joints), as well as exercises for individual muscle groups from local to regional (toe stands with different positions and arm movements; half-squats, lunges, dips, body movements forward, to the sides and backward (with the back leading), elements of classical aerobics) performed with musical accompaniment within the intensity range of 50-60 beats per minute, as well as aqua stretching.

The objectives of the main part are to improve somatic health indicators, to foster interest in the training, and to alleviate students' nervous and emotional stress. The main part of the training session, which lasted up to 30 minutes, was conducted in shallow (1.4 m) and deep (1.8 m) water, utilizing specialized equipment, including flexible sticks, armbands, foam boards, and vests. The main part of the training session included walking (50-150 beats per minute), running, jumping with high amplitude (up to 115 beats per minute), movements of the arms, body, legs in aqua jogging, aqua dance, aqua power (aqua building), aqua aerobics, aqua boxing modes. An essential part of the training session is the use of water games. Throughout the training session, the correct body position and coordinated breathing were monitored. The intensity of movements was increased gradually to prevent fluctuations in blood pressure. Changing directions of movement should be smooth to avoid the loss of balance. The side of the pool should be used as a support.

Stretching exercises were performed before and after the main part of the training session. In the preparatory part of the training session, stretching creates opportunities to warm up the muscles, which helps prevent injury. In the final part, the use of stretching promotes muscle elasticity. In the final part of the training session (lasting up to 15 minutes), we employed distance swimming, hydro-relaxation, slow-motion compositions, and muscle relaxation exercises.

The effectiveness of addressing health problems was determined by the dynamics of objective indicators of physical health among female students during their physical education. At the end of the academic year, the somatic health indicators of the female students were assessed, their dynamics were evaluated, and the reliability of the difference between the two groups of female students was determined.

Assessment of the somatic health of the EG and CG female students at the end of the academic year yielded the following results (Table 1).

The analysis of the results showed that during the research, the BMI improved in girls from the EG and the CG (by 5.3% and 2.2%, respectively). Still, the increase in the BMI was statistically significant only in the EG female students, with a difference of 1.2 kg/m^2 ($p \leq 0.001$). At the end of the research, the BMI of the EG female students was also significantly higher than that of the CG female students by 0.6 kg/m^2 ($p \leq 0.05$). The study of the dynamics of the VI in female students during the academic year gives the right to assert that this indicator also improved in

Table 1. Dynamics of somatic health indicators of female students of the EG (n = 62) and the CG (n = 64) during the academic year (X ± m), points

Indicators of somatic health	Groups	Research stages		The difference, %	Reliability of the difference	
		Beginning	End		t	p
BMI, kg/m^2	EG	22.7±0.19	21.5±0.18*	5.3	4.58	≤0.001
	CG	22.6±0.20	22.1±0.19	2.2	1.81	>0.05
VI, ml/kg	EG	41.2±0.71	45.4±0.68***	9.3	4.27	≤0.001
	CG	40.3±0.66	41.6±0.64	3.2	1.41	>0.05
SI, %	EG	43.5±0.57	46.3±0.53	6.1	3.61	≤0.01
	CG	42.3±0.51	45.8±0.49	7.6	4.95	≤0.001
RI, c. u.	EG	95.6±0.52	91.1±0.47**	4.7	6.42	≤0.001
	CG	95.3±0.50	93.5±0.46	1.9	2.65	≤0.001
MKI, s	EG	131.1±2.78	122.1±2.69	6.9	2.33	≤0.05
	CG	129.6±2.65	125.0±2.57	3.6	1.25	>0.05
SHL, points	EG	6.5±0.24	7.6±0.21*	14.5	3.45	≤0.01
	CG	6.4±0.22	6.9±0.19	7.3	1.72	>0.05

*Notes: X – arithmetic mean, m – error of the arithmetic mean, t – Student's t-test, p – statistical significance indicator, *, **, *** – reliability of the difference between the EG and the CG at the end of the research at the level of p ≤ 0.05, p ≤ 0.01, p ≤ 0.001.*

female students of both groups, but a significant increase is observed only in the EG female students (by 6.2 ml/kg (9.3%) at p≤0.001); in the CG the increase is 1.3 ml/kg (3.2%) at p>0.05. At the end of the research, the VI of the EG female students was significantly higher than that of the CG female students by 3.8 ml/kg (p≤0.001). The increase in the SI during the academic year was positive and statistically significant for both student groups. In the EG, the improvement in the SI was 6.1% (p≤0.01), and in the CG, it was 7.6% (p≤0.001). Additionally, no significant difference was found between the EG and the CG at the end of the research (p>0.05). Studying the increase in the RI during the research period, we found a significant difference between the initial and final values in female students from both groups. However, more pronounced changes in cardiovascular system indicators were observed in female students who trained in the aquatic environment. Thus, the improvement in the RI for the EG female students is 4.5 c. u. (4.7%) at p≤0.001, and in the CG – 1.8 c. u. (1.9%) at p≤0.05. At the end of the research, the female students in the EG had a significantly better RI than the students in the CG by 4.2 c. u. (p≤0.01). The examination of the MKI in the EG and the CG female students shows a positive dynamics of indicators in both groups. However, in the EG female students, this indicator significantly improved by 9 seconds (6.9%) at p≤0.05, whereas in the CG female students, the increase was statistically insignificant, amounting to 4.6 seconds (3.6%) at p>0.05. The significant improvement in morphofunctional indices among female students of the EG during aqua fitness training confirms that water exercises enhance metabolism, reduce body weight, normalize the cardiovascular system, improve respiratory function, and increase the body's resistance to colds. This demonstrates that the use of aqua fitness has a sustainable health impact and confirms the feasibility of its implementation in the physical education process for female students at HEIs.

The analysis of the SHL in female students at the end of the academic year showed positive dynamics in the female students of both groups, but in the EG female students the increase is 1.1 points (14.5%) at p≤0.01, and in the CG – 0.5 points (7.3 %) at p>0.05. That is, the increase in somatic health indicators among female students who systematically engaged in aqua fitness exercises was more pronounced compared to those in the control group. At the end of the research, the SHL of the EG female students was significantly better than that of the CG by 0.5 points (p≤0.05). Moreover, at the end of the academic year, the EG female students' SHL corresponded to the average level, whereas the CG's remained at a below-average level. This allows us to assert that training sessions in the aquatic environment contribute to the restoration and improvement of the somatic health of female students at HEIs.

DISCUSSION

According to statistics, recent years in Ukraine have been marked by ongoing negative trends in key population indicators of vital activity, particularly among children and young people. For example, there is an increase in the incidence rate for all classes of diseases, and primary morbidity tends to increase in most classes of diseases. Today, more than 80 % of schoolchildren and students have health and physical development disorders. All this is happening against the backdrop of a sharp decline in the number of young people who regularly engage in physical culture and sports [11-13].

Since human health is reduced not only to the optimal level of physical condition, but also involves psycho-emotional balance, spiritual and social health, there is no doubt about the need to introduce universal types of motor activity into the educational process of physical education, which would have a positive impact on all components of health – physical, mental, social and spiritual.

The obtained results confirm the findings of similar studies on the generally low level of physical health among modern student youth [14], indicating that the overall health level of female students at HEIs falls within the range of low to below average.

For the more effective mobilization of mechanisms aimed at restoring and preserving life-sustaining activities and resisting the effects of old age, the choice of types of motor activity for female students must be based primarily on their interests and the expected health benefits. Our research aligns with the findings of other authors, who argue that water exercises enhance the impact of motor activity by activating complex biological processes in the body that contribute to the normalization of cardiovascular, respiratory, musculoskeletal, endocrine, and other bodily functions [15]. From there, the weakening of gravitational attraction and the effect of the pushing force serve as a support for the body while performing exercises in water. This reduces the load on the joints and eliminates excessive muscle strain. Hydrostatic pressure changes the intensity of the load, and depth affects the dynamics of movement. Hydrostatic water pressure reduces heart rate but stimulates blood circulation. To select the correct depth, it is essential to strike a balance between gravitational compression and the required motor load. When the body is immersed in water up to the neck level, the gravitational force decreases by 90%. The deeper the water, the more difficult it is to control the effect of the ejection force [7].

The properties of the water environment, in particular hydrostatic pressure, improve blood circulation, which reduces heart rate, activates kidney function, which reduces the amount of excess fluid in the body, stimulates liver saturation with lactic acid, which prevents its accumulation in the working muscles and prevents pain even during intense and prolonged exercise, has a massage effect and provides a feeling of relaxation [16]. The use of special equipment during aqua fitness exercises creates an additional burden on the arms or legs, increases the workload, and requires more significant muscle effort to overcome water resistance and maintain balance [17]. Thus, exercises in the aquatic environment contribute to the development of joint mobility, muscle strength and endurance, and increase overall muscle tone. Additionally, musical accompaniment promotes psychological relaxation and positive emotions.

This effect of the water environment promotes uniform muscle development, improves posture, increases the functional reserves of the cardiovascular system, and requires significant energy expenditure. Body movements in water form vortex flows, which cause vortex resistance, i.e., turbulence, the strength of which depends on the speed of movement. This resistance necessitates tension of the abdominal muscles and vigorous movements to maintain balance and movement. At the same time, a rapid change in movements increases muscle tension to maintain balance, and the viscosity of water causes an increase in muscle effort during exercise [18]. Our research confirms the findings of many scientists [7, 15, 19-28] regarding the positive impact of water training on students' somatic health. All this testifies to a higher health-improving effect of aqua fitness and advantages of its use in the physical education of girls of student age.

CONCLUSIONS

The influence of training sessions in the aquatic environment on the restoration and improvement of somatic health among female students during their studies under martial law has been investigated. The positive dynamics of the level of somatic health in female students of both groups were revealed; however, in the EG students, the increase was 1.1 points (14.5%) at $p \leq 0.01$, while in the CG, it was 0.5 points (7.3%) at $p > 0.05$. At the end of the research, the level of somatic health in the EG female students was significantly better than in the CG by 0.5 points ($p \leq 0.05$). Moreover, at the end of the academic year, the level of somatic health in the EG corresponds to the average level. In contrast, in the CG, it remains unchanged and falls below the average level. That is, female students who were systematically engaged in aqua fitness showed a more pronounced increase in somatic health indicators compared to female students who were involved in dance aerobics.

The significant improvement of morphofunctional indices and the level of somatic health in the EG female students during the research period, as well as significantly better indicators in the EG compared to the CG at the end of the research, prove that exercises in the aquatic environment improve metabolism and reduce body weight, normalize the cardiovascular system, enhance respiratory function, and the body's resistance to colds, which confirms the sustainable health effect of aqua fitness.

PROSPECTS FOR FURTHER RESEARCH

Prospects for further research will focus on investigating the specific benefits of water exercises in reducing students' stress during wartime conditions.

REFERENCES

1. Rawtani D, Gupta G, Khatri N et al. Environmental damages due to war in Ukraine: A perspective. Sci Total Environ. 2022;850:157932. doi: 10.1016/j.scitotenv.2022.157932.
2. Tymoshenko OV, Domina ZhH, Masenko LV et al. Dependence of stress level on the strength of nervous processes and development of special types of endurance in 16-17-year-old men. Acta Balneol. 2024; 66(5), 330-334. doi:10.36740/ABAL202405106.
3. Minchenko SI, Korotiuk OV, Sokurenko V et al. War and peace in the conditions of the present day: Global, spiritual-value, scientometric, criminology aspects. Lex Humana. 2023;15(3):88-100.
4. Holovanova IA, Prontenko KV, Lyakhova NA et al. Dynamics of indicators of cadets' morphological and functional development in the process of their physical exercises of different orientation. World of Medicine and Biology. 2024;87(1):47-52. doi:10.26724/2079-8334-2024-1-87-47-52.
5. Griban G, Okhrimenko I, Lyakhova N et al. Influence of the amount of students' motor activity on their health status and psychophysical readiness for future life. Acta Balneol. 2022;64(2): 150-154. doi:10.36740/ABAL202202109.
6. Zhamardiy V, Shkola O, Ulianova V et al. Influence of fitness technologies on the student youth's physical qualities development. Dilemas Contemporaneos-Educacion Politica y Valores. 2019;7(SI): Art. no 49. doi: 10.46377/dilemas.v29i1.1947.
7. Filatova Z, Yevtushok M, Okhrimenko I et al. Strengthening the physical and mental health of students during swimming classes. Acta Balneol. 2022;64(3):240-245. doi:10.36740/ABAL 202203107.
8. Kucia K, Koteja A, Rydzik Ł et al. The impact of a 12-week aqua fitness program on the physical fitness of women over 60 years of age. Sports (Basel). 2024;12(4):105. doi:10.3390/sports12040105.
9. Pariser G, Madras D, Weiss E. Outcomes of an aquatic exercise program including aerobic capacity, lactate threshold, and fatigue in two individuals with multiple sclerosis. J Neurol Phys Ther. 2006;30(2):82-90. doi:10.1097/01.npt.0000282572.63297.3d.
10. Donataccio MP, Vanzo A, Bosello O. Obesity paradox and heart failure. Eat Weight Disord. 2021;26(6):1697-1707. doi:10.1007/s40519-020-00982-9.
11. Riad A, Drobov A, Krobot M et al. Mental Health Burden of the Russian-Ukrainian War 2022 (RUW-22): Anxiety and Depression Levels among Young Adults in Central Europe. Int J Environ Res Public Health. 2022;19(14):8418. doi: 10.3390/ijerph19148418.
12. Zasiekina L, Duchyminska T, Bifulco A, Bignardi G. War trauma impacts in Ukrainian combat and civilian populations: Moral injury and associated mental health symptoms. Mil Psychol. 2024;36(5):555-566. doi:10.1080/08995605.2023.2235256.
13. Holovanova IA, Gorbenko DA, Ostapovich VP et al. Dynamics of the psychophysical state of future law enforcement officers in the course of their professional training. World of Medicine and Biology. 2023;86(4):35-39. doi:10.26724/2079 -8334-2023-4-86-35-39.
14. Vykhliaiev Yu, Dudorova L, Kozeruk Yu et al. Restoration of postural disorders in adolescents using swimming exercises. Acta Balneol. 2023;3(175): 153-158. doi:10.36740/ABAL202303104.

15. Nosko M, Arkhypov O, Khudolii O et al. Pedagogical conditions for swimming skills development in students of pedagogical educational institutions. Revista Romaneasca Pentru Educatie Multidimensionala. 2019;11(2):240. doi:10.18662/rrem/127.
16. An J, Lee I, Yi Y. The Thermal effects of water immersion on health outcomes: An integrative review. Int J Environ Res Public Health. 2019;16(7):1280. doi:10.3390/ijerph16071280.
17. Griban G, Filatova O, Bosenko A et al. Water in students' life and its impact on their health. Acta Balneol. 2021; 2 (164): 99-104. doi: 10.36740/ABAL202102104.
18. Okhrimenko I, Bilevych N, Drozdova L et al. Restoration of the psycho-physical state of future law enforcement officers during recreational and health-improving training sessions. Acta Balneol. 2024;66(4):262-267. doi:10.36740/ABAL202404108.
19. Bondarenko V, Prontenko K, Donets I et al. Comparative analysis of the levels of cadets' physical activity at different stages of their professional training. Acta Balneol. 2024;66(4):236-241. doi:10.36740/ABAL202404104.
20. Tymoshenko O, Domina Zh, Arefieva L et al. Influence of aqua fitness training sessions on improving the biological age indicators in overweight female students. Acta Balneol. 2023;6(178), 386-391. doi:10.36740/ABAL202306107.
21. Okhrimenko I, Bilevych N, Kryzhanovska O et al. Substantiation of the program of recreational and health-promoting training sessions with instructors officers during their professional activities. Acta Balneol. 2023;65(1):61-65. doi:10.36740/ABAL202301111.
22. Prontenko K, Griban G, Medvedeva I et al. Interrelation of students' motivation for physical education and their physical fitness level. Inter J Appl Exer Physiol. 2019; 8(2.1): 815-824. doi: 10.30472/ijaep.v8i2.1.566.
23. Domina Zh, Tymoshenko O, Markus I et al. Improving high school students' somatic and mental health through interactive methods of physical education. Acta Balneol. 2024; 66(4), 256-261. doi:10.36740/ABAL202404107.
24. Prontenko K, Okhrimenko I, Rohovenko M et al. Correction of physical health and psycho-emotional state of student youth under martial law. Acta Balneol. 2024;66(5):345-350. doi:10.36740/ABAL202405108.
25. Griban G, Moskalenko N, Adyrkhaiev S et al. Dependence of students' health on the organization of their motor activity in higher educational institutions. Acta Balneol. 2022;5(171): 445-450. doi:10.36740/ABAL202205112.
26. Tymoshenko O, Arefiev V, Griban G et al. Characteristics of the motivational value-based attitude of students towards physical education. Revista Dilemas Contemporáneos: Educación, Política y Valores. 2019; 11. Período: Octubre, 2019.
27. Griban G, Dovgan N, Tamozhanska G et al. State of physical fitness of the students of Ukrainian higher educational institutions. Inter J Appl Exer Physiol. 2020; 9(5): 16-26.
28. Tymoshenko O, Domina Zh, Malechko T et al. Correction of body posture disorders in young children of school age in the process of physical education classes. Acta Balneol. 2022; 5 (171): 426-432. doi: 10.36740/ABAL202205109.

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

The impact of winter swimming on selected skin characteristics

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ABSTRACT

Aim: The aim of the study was to determine the impact of regular cold-water immersion over two seasons on selected physiological characteristics of the skin, such as hydration level, pH value, and transepidermal water loss (TEWL), taking into account sex differences as well as relationships with body mass and composition.

Materials and Methods: The study group consisted of 11 women and 10 men who regularly participated in winter swimming. The first measurement was conducted in 2019 before the start of the season, and the second before the end of the season in 2021. The research period was extended due to the COVID-19 pandemic.

Results: After two seasons of winter swimming, a significant decrease in skin hydration was observed both on the thigh and forearm. Skin pH values did not change significantly. The barrier function of the skin, assessed through TEWL, improved in men. Positive correlations were found between body mass, total body water, body mass index, and skin parameters.

Conclusions: Regular cold-water immersion may have a beneficial effect on skin barrier function in men; however, it is associated with a decrease in skin hydration. Body mass and composition significantly influence the physiological parameters of the skin. Winter swimming does not significantly affect skin pH.

KEYWORDS: corneometry, cold-water immersion, winter swimming, tewametry, skin pHmetry, safety of treatments

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INTRODUCTION

The skin is the largest organ of the human body, covering an area of approximately 1.5 to 2.0 m^2 and weighing up to 20 kg. Its structure comprises three layers: the epidermis, the dermis, and the subcutaneous tissue. The epidermis protects the body against transepidermal water loss (TEWL) and external factors. An essential component of the skin's defense is the hydrolipidic film, which helps maintain appropriate moisture levels and the skin's pH balance [1]. The acidic nature of the skin surface plays a significant role in immune mechanisms and in maintaining a stable microbiome [2]. Skin pH varies depending on sex, age, and environmental factors [3]. In women, it typically ranges from 4.5 to 5.9, while in men, it ranges from 4.3 to 5.9. Factors that elevate skin pH can weaken its protective barrier. Even brief contact with water or soap can strip the skin of its lipid layer, requiring several hours to restore balance [4].

The hydration of the epidermis depends on its water content, with the amount and quality of the Natural Moisturizing Factor (NMF). NMF is composed of low-molecular-weight compounds such as amino acids, urea, pyrrolidone carboxylic acid, and lactates [5]. Upon contact with water, these components may be leached from the skin.

The therapeutic application of low temperatures has been recognized since antiquity, primarily for its anti-inflammatory, circulatory-enhancing, and analgesic effects [6]. An interesting treatment method within the scope of cryotherapy is cold-water immersion [7]. Regular Winter Swimming is a physical activity that can be practiced by anyone, regardless of gender, age, or body composition. Individuals who engage in this activity indicate its main purposes as thermal conditioning and improve resilience to environmental stressors, improving well-being, enhancing immunity, and increasing personal activity levels [8]. It has been shown that regular cold-water immersion may support the physiological defense mechanisms of the body against oxidative stress [9], improve thermoregulation and cardiovascular adaptation to low temperatures [7].

In cosmetology, the effects of low temperatures are associated with anti-aging properties and the reduction of skin lesions [10, 11]. A single cryotherapy treatment is well tolerated by the skin [11]. However, it has been demonstrated that the skin in areas such as the extremities and face responds differently. Even more varied effects can be expected in the case of cold-water immersion, where the skin on different parts of the body may or may not be submerged.

AIM

Despite numerous studies on the effects of cold-water immersion on the human body, no direct research has yet indicated how this activity influences the condition of

the skin. Therefore, the aim of this study was to determine the impact of cold-water immersion (winter swimming) on selected skin characteristics.

MATERIALS AND METHODS

STUDY GROUP

The study included individuals who are members of the Kraków Winter Swimming Club "Kaloryfer" and who regularly participate in cold-water immersion. The study group consisted of 11 women (52.38%) and 10 men (47.62%) aged between 33 and 65 years. The participants immersed themselves in cold water regularly once a week, for a maximum duration of 3 minutes, during the season lasting from November to April. Table 1 presents the basic anthropometric characteristics of the participants.

The study group was informed about the nature, methodology, and purpose of the research, as well as their right to withdraw at any stage. Participants provided written consent for instrumental skin measurements in accordance with the procedures of the Laboratory of Skin Physiology (CLNB, AKF, Krakow).

RESEARCH METHOD

The study was conducted in November 2019 at the Bagry Lagoon in Kraków. Instrumental measurements were performed before participants entered the water. Initially, the study was designed to assess the effects of one winter swimming season, however, due to the COVID-19 pandemic, follow-up measurements were conducted after two seasons of regular immersions.

At the same time points when skin characteristics were assessed, data on height, weight, and body composition were also collected. The following parameters were measured: body mass (BM), body mass index (BMI), fat mass (FATM), body fat percentage (FAT[%]), fat-free mass (FFM), and total body water (TBW) using bioelectrical impedance analysis with a TANITA BC 418 MA body composition analyzer (Tanita, Tokyo, Japan). Body height (BH) was measured using an anthropometer.

SKIN CHARACTERISTICS ASSESSMENT

The assessment of skin characteristics was carried out indoors on the dorsal side of the dominant forearm and on the thigh on the same side of the body. The testing conditions complied with the manufacturer's recommendations: humidity between 40-60% and temperature between 20-22°C. These conditions remained constant throughout the measurements.

Each skin parameter was measured three times for every participant. The probe was applied to non-overlapping skin areas of the examined region; the result was read and recorded. The arithmetic mean of the individual measurements was used for further analysis. Skin pH was measured using the SKIN-pH Meter® PH 905 (Courage & Khazaka, Cologne, Germany) with a medically certified probe. Skin hydration was measured with the Corneometer® CM 825 (Courage & Khazaka, Cologne, Germany). The results are expressed in arbitrary units, with 1 unit corresponding to 0.02 mg of water per cm^2 of the stratum corneum. Lower values indicate lower epidermal hydration. A hydration level > 40 units is considered normal, 30-40 units indicates dry skin, and < 30 units denotes very dry skin. Transepidermal water loss (TEWL) was assessed using the Tewameter® CM 825 (Courage & Khazaka, Cologne, Germany) by applying the cylindrical probe to the skin for 20 seconds. The probe is equipped with two sensors: one for temperature and one for relative humidity. These sensors measure water vapor pressure and temperature at two levels above the skin surface. The TEWL value is calculated based on the difference in vapor pressure and is expressed in units of $g/m^2/h$.

STATISTICAL ANALYSIS

The results were presented using basic descriptive statistics. Statistical analysis was performed using the Statistica 10 software (SoftStat, Poland). The distribution type of the variables was tested with the Kolmogorov-Smirnov test. The effect of cold-water immersion was evaluated using the paired Student's t-test. To determine the relationships between the obtained results, Pearson's correlation test was applied. A $p<0.05$ was considered statistically significant.

RESULTS

As presented in Table 1, the baseline body composition results differed significantly between women and men, with the exception of fat mass (FATM). After two seasons of regular cold-water immersion, the BMI, BM, FAT[%], TBW, FATM, and FFM values did not show statistically significant differences.

Table 2 presents the measurements of selected skin characteristics taken before the first and before the last cold-water immersion in the evaluated two-year cycle. The analysis of skin hydration revealed a statistically significant difference for both the thigh ($p<0.00001$) and the forearm ($p=0.0018$). In both cases, the corneometric measurement values were significantly lower after two seasons of winter swimming. The mean values of skin pH did not show statistically significant differences. Similarly, no significant changes were observed in TEWL measurements. However, the p-value for the thigh indicates a statistical trend ($p = 0.0610$), and the measurement after two seasons was lower than the baseline value. The presence of a trend prompted a deeper analysis, and for men, a significant reduction in TEWL after 2 seasons of winter bathing was indicated.

When comparing the results of women and men (Table 3), statistically significant differences were found in the analysis of mean corneometric values before the first immersion on the thigh ($p=0.0457$) and forearm ($p=0.0338$). In all examined areas, the mean values for women were lower than those for men. The mean corneometric values for women and men before the last immersion no longer showed significant differences. Similarly, no statistically significant differences were observed in the pH values for women and men when analyzed separately before the first and last immersion for both the thigh and forearm.

Significant differences in TEWL mean values before the first immersion were identified between women and men

Table 1. Basic characteristics of study participants before the first (2019) and before the last immersion in 2021

	2019									p ♀ vs. ♂	2021									p 2019 vs.2021
	Total (n=21)			♀ (n=11)			♂ (n=10)				Total (n=21)			♀ (n=11)			♂ (n=10)			
	MIN	MAX	x̄±SD	MIN	MAX	x̄±SD	MIN	MAX	x̄±SD		MIN	MAX	x̄±SD	MIN	MAX	x̄±SD	MIN	MAX	x̄±SD	
A [years]	33	65	47,2±10,3	38	64	48,7±9,4	33	65	45,7±11,4	0,2776	31	64	45,8±10,5	37	63	47,1±9,6	31	64	44,3±11,7	0,7103
BH [m]	149	193	171,4±10,6	149	176	163,7±7,1	170	193	179,3±7,1	0,0000*	149	193	171,4±10,6	149	176	163,7±7,1	170	193	179,3±7,1	0,4526
BM [kg]	53,3	134,6	77,3±19,1	53,3	84,6	65,7±9,4	67,5	134,6	90,1±19,1	0,0006*	54,8	131,6	70,0±20,0	54,8	80,8	65,0±8,2	67,2	131,6	92,3±19,4	0,8223
BMI	19,7	36,5	26,2±4,0	19,7	31,1	24,7±3,6	22,6	36,5	27,8±4,0	0,0338*	20,2	35,3	26,3±4,1	20,2	29,7	24,3±3,3	22,8	35,3	28,5±4,0	0,3347
FATM [kg]	7,5	40,8	19,7±8,0	11,3	32,4	20,3±6,3	7,5	40,8	19,0±9,8	0,3652	40,6	39,4	20,4±7,7	12,5	30,4	19,6±5,8	11,2	39,4	22,2±9,6	0,3407
FAT [%]	10,1	38,3	25,5±7,8	21,1	38,3	30,2±5,6	10,1	30,3	20,3±6,7	0,0007*	14,5	37,6	26,2±6,8	21,5	37,6	29,7±5,7	14,5	30,07	22,2±5,8	0,8407
FFM [kg]	40,6	93,8	57,7±15,5	40,6	52,2	45,4±3,8	53,6	93,8	71,2±11,4	0,0000*	40,6	92,3	57,6±15,5	40,6	50,6	45,3±3,7	53	92,3	71,1±11,4	0,7103
TBW [kg]	29,7	68,7	42,1±11,3	29,7	38,2	33,2±2,7	39,2	68,7	52,1±8,4	0,0000*	29,7	67,6	42,2±11,3	29,7	37	33,2±2,7	38,8	67,6	52,0±8,3	0,4526

**p<0,05*

A [years] – age of the participants; BH [m] – Body Height, height of the participants; BM [kg] – Body Mass, weight of the participants; BMI – Body Mass Index of the participants; FATM – Fat Mass, fat tissue mass of the participants; FAT [%] – Body Fat Percentage of the participants; FFM – Fat-Free Mass, lean body mass of the participants; TBW – Total Body Water, total water content in the participants' bodies; MIN – minimum value for the given variables; MAX – maximum value for the given variables; SD – standard deviation.

Table 2. Mean values of selected skin characteristics before the first and before the last cold--water immersion on the thigh and forearm

	Mean±SD	Mean±SD	p-value
	Before first immersion	Before last immersion	
	Corneometer		
Thigh	37.88±8.75	26.01±6.19	0.0000*
Forearm	49.53±15.71	36.83±9.27	0.0018*
	pH-meter		
Thigh	5.57±0.30	5.51±0.41	0.60667
Forearm	5.71±0.30	5.68±0.45	0.85444
	Tewameter		
Thigh	23.44±11.83	17.74±8.74	0.06104
Forearm	24.08±14.79	19.31±11.41	0.27605

**p<0,05*

Table 3. Measurements ($\bar{x}$ ± SD) of selected skin characteristics of the thigh and forearm in women and men before the first and the last cold-water immersion

Corneometer				
		Women	Men	p
Before first immersion	Thigh	34.8±7.93	41.26±8.73	0.0457*
	Forearm	43.60±10.1	56.07±18.55	0.0338*
Before last immersion	Thigh	27.17±7.41	24.75±4.57	0.1926
	Forearm	39.90±9.75	33.45±7.81	0.5657
pH- meter				
		Women	Men	p
Before first immersion	Thigh	5.65±0.27	5.48±0.33	0.0964
	Forearm	5.77±0.26	5.65±0.34	0.1992
Before last immersion	Thigh	5.58±0.45	5.48±0.33	0.1925
	Forearm	5.76±0.46	5.60±0.45	0.2246
Tewameter				
		Women	Men	p
Before first immersion	Thigh	17.18±2.67	30.33±14.22	0.0036*
	Forearm	14.55±3.13	34.57±15.55	0.0002*
Before last immersion	Thigh	15.23±3.34	20.52±11.87	0.0853
	Forearm	17.33±7.55	21.49±14.68	0.2087

**p<0,05*

for the skin of the thigh (p=0.0036) and forearm (p=0.0002), with women showing lower mean values than men. Before the last immersion, no significant differences in TEWL values were observed between the sexes.

In the next stage of the analysis, the focus was placed on identifying relationships between skin characteristics and body mass and composition. Statistically significant correlations between baseline measurements of hydration, pH, and barrier function of the skin and body mass and composition are presented in Table 4.

The correlation analysis of hydration changes after two seasons of winter swimming indicated a significant relationship with body mass (BM) and total body water (TBW) for the forearm, and a statistical trend for the thigh (Table 5). No significant correlations were found between changes in skin pH after two seasons of winter swimming and the variables describing body mass and composition. However, several significant correlations between changes in TEWL and body composition were identified and are presented in Table 6.

DISCUSSION

Cold-water immersion is an increasingly recognized form of physical activity in Poland and worldwide [12].

Table 4. Significant correlations between baseline skin characteristics and basic anthropometric parameters of the study group

	r	*p*
Body mass and TEWL (thigh)	0.48	0.0295*
Body mass and TEWL (forearm)	0.56	0.0077*
BMI and Corneometer (forearm)	0.45	0.0428*
Total body water (TBW) and TEWL (forearm)	0.61	0.0036*
TBW and TEWL (thigh)	0.55	0.0092*
TBW i Corneometer (forearm)	0.48	0.0266*

**p<0,05*

Table 5. Relationship between changes in skin hydration and selected body composition characteristics

Δ Corneometer results				
Variables	**Forearm**		**Thigh**	
	r	***p***	***r***	***p***
BMI	0.37	0.1015	0.37	0.1007
BM[kg]	0.51	0.0174*	0.38	0.0867
FAT[%]	-0.15	0.5135	-0.06	p>0.05
TBW	0.51	0.0176*	0.38	0.0855

*Δ – difference between measurements taken before the first and before the last immersion; *p<0,05*

Table 6. Relationship between changes in TEWL levels and selected body composition characteristics

Δ TEWL results				
Variables	**Forearm**		**Thigh**	
	r	***p***	***r***	***p***
BMI	0,46	0,0345*	0,48	0,0266*
BM[kg]	0,60	0,0041*	0,62	0,0026*
FAT[%]	-0,22	0,3356	-0,18	0,4375
TBW	0,62	0,0025*	0,64	0,0018*

*Δ – difference between measurements taken before the first and before the last immersion; *p<0,05*

The results obtained in this study allowed, to some extent, for the assessment of how winter swimming affects skin characteristics and how certain variables such as age, body mass, BMI, total body water, and body fat content may influence them. Measurements taken from two body regions enabled a more objective interpretation of results, despite the relatively small sample size.

Analysis of the results revealed that the study group exhibited a statistically significant difference in skin hydration in both the thigh and forearm areas. The observed direction of change was unfavorable, as participants demonstrated a significant decrease in skin hydration after two winter swimming seasons. The hydration of the stratum corneum depends on its water content, which ranges between 10% and 30%. Proper hydration levels, as measured with a corneometer, are typically around 40 units and vary depending on the specific body region [5].

The analysis conducted before the first immersion showed a significant difference in skin hydration levels between women and men, with higher values recorded in men. Similarly, differences were observed in body composition between the two groups. Men showed higher values of body mass (BM: 92.29±19.44), BMI (28.47±4.02), fat-free mass (FFM: 71.07±11.39), and a lower percentage of body fat. There were also marked differences in total body water (TBW), which ranged from 52.04±8.34 in men to 33.18±2.23 in women. This high water content in men may be the reason for the observed skin hydration levels. This relationship is further supported by the strong correlation identified in this study between body composition characteristics such as BM and TBW and corneometer results. Based on these findings, it can be clearly demonstrated that the observed differences in skin hydration and the higher values in men resulted from significantly greater total body water content and body mass.

In the present study, the values of the analyzed skin parameters did not deviate significantly from the reference ranges for sex, age group, and measurement site established

by the device manufacturer. The only exception was the TEWL values in men participating in this study.

Corneometric analysis conducted in 2019 showed that the participants' skin hydration levels were on the borderline between physiological values and a state indicating impaired barrier function of the stratum corneum. When broken down by sex, the results revealed that values in women were entirely within physiological ranges, whereas in men, many measurements indicated barrier dysfunction. The elevated TEWL levels in men may also have contributed to the higher corneometric readings obtained before the bathing season. After two seasons, an improvement in TEWL values was observed in men. Since no TEWL disturbances were noted in women, even a statistically significant improvement in this parameter would be clinically irrelevant. In contrast, for the group of men, where the baseline values were altered, two seasons of winter swimming had both a statistically and clinically beneficial effect.

The mean TEWL values before the first and last immersion did not differ significantly. However, there was a visible trend toward improvement of this parameter after two seasons of cold-water immersion. The TEWL measurement taken before the last immersion in the second season was lower than the baseline value, and the level of statistical significance suggests a trend. This is one of the most noteworthy observations of this study. Despite the negative impact on skin hydration itself (decreased corneometric values), a trend toward improved skin barrier function (lower TEWL) was indicated. This phenomenon should be interpreted with caution. It is worth emphasizing that the lack of statistical significance in TEWL changes may be due to the small sample size. The long observation period without intermediate measurements may also mask other, currently unverifiable, factors influencing the final results. The COVID-19 pandemic and lockdown caused significant changes in participants' diet, physical activity, and recreational routines - factors that cannot be accurately captured or explained in this study. All these factors could have influenced both skin hydration levels and TEWL values.

Before the start of the bathing season, significant differences in TEWL values were observed between women and men. By the last immersion, these differences were no longer statistically significant, although a downward trend was still visible in men. Similarly, before the first immersion, corneometric values were higher in men than in women. After two seasons, values decreased in both sexes, but differences between groups were no longer statistically significant. The present study's findings on TEWL and hydration differences between sexes are consistent with the literature. Alireza et al. [13] and Hadi et al. [14] demonstrated that sex and age influence skin hydration and TEWL levels, with women generally showing higher TEWL values. Luebberding et al. [15] confirmed that in men, hydration levels may decrease after the age of 40.

The two-year series of cold-water immersions did not result in statistically significant changes in body mass or body composition variables. These findings indicate that winter swimming should not be considered a substitute for physical training or a form of exercise, but rather a recreational activity.

Only a few studies address correlations between body mass or BMI and specific skin characteristics. The present research revealed a significant positive correlation between TEWL levels and body mass, suggesting that higher body mass is associated with increased transepidermal water loss. Similar relationships were found by other researchers [16,17], who also observed elevated TEWL values in individuals with higher body mass. Studies by Guidi et al. [18] showed that obese individuals, compared to those with normal body weight, have reduced water permeability through the skin via evaporation.

Significant correlations were also identified between hydration levels and both body mass (BM) and total body water (TBW), although only for the forearm area. In all cases, the correlations were positive. This indicates that individuals with higher BMI values exhibited greater skin hydration. Similarly, higher corneometric readings were observed in participants with greater total body water content. Comparable relationships were noted in other studies, which showed that a higher BMI may contribute to improved skin hydration [19].

The normal skin pH ranges from 4.2 to 5.6 [20]. The values obtained in 2019 for both women and men did not differ significantly. However, a trend was observed: pH levels on the thigh were slightly lower in men compared to women, a finding consistent with existing literature. Skin pH is known to vary depending on sex (women tend to have more alkaline pH), age, and environmental influences [3]. In women, pH values typically range from 4.5 to 5.9, while in men they are slightly lower (4.3 to 5.9), a difference attributed to the higher lactic acid content in male sweat. After two winter swimming seasons, no trend in pH differences between women and men in the studied areas was observed. These values also remained consistent with those recorded in 2019.

CONCLUSIONS

Monitoring the skin condition of individuals regularly engaging in winter swimming should include an assessment of skin hydration, particularly after prolonged exposure to cold water, as this form of recreational activity may lead to a deterioration in skin moisture levels.

The beneficial effect of winter swimming on the epidermal barrier function, as indicated by reduced transepidermal water loss (TEWL) observed in men, suggests potential sex-related differences in skin adaptation to low temperatures. Further research is warranted to explore these differences, which may support the development of gender-specific skin protection strategies for individuals participating in cold-water immersion activities.

The absence of significant changes in skin pH after two winter swimming seasons indicates that cold water exposure does not disrupt the acid-base balance of the skin, which constitutes important information for manufacturers of protective and regenerative skincare products.

REFERENCES

1. Dąbrowska AK, Spano F, Derler S et al. The relationship between skin function, barrier properties, and body-dependent factors. Skin Res Technol. 2018;24(2): 165-174. doi: 10.1111/srt.12424.
2. Lee HJ, Kim M. Skin Barrier Function and the Microbiome. Int J Mol Sci. 2022; 23 (21): 13071. doi: 10.3390/ijms232113071.
3. Proksch E. pH in nature, humans and skin. J Dermatol. 2018; 45 (9): 1044-1052. doi: 10.1111/1346-8138.14489.
4. Blaak J, Staib P. The Relation of pH and Skin Cleansing. Curr Probl Dermatol 2018; 54: 132-142. doi: 10.1159/000489527.
5. Delsin SD, Mercurio DG, Fossa MM et al. Clinical Efficacy of Dermocosmetic Formulations Containing Spirulina Extract on Young and Mature Skin: Effects on the Skin Hydrolipidic Barrier and Structural Properties. Clin Pharmacol Biopharm 2015; 4, 144.
6. Dzidek A, Piotrowska, A. The Use of Cryotherapy in Cosmetology and the Influence of Cryogenic Temperatures on Selected Skin Parameters. A Review of the Literature. Cosmetics. 2022; 9, 100. https://doi.org/10.3390/cosmetics9050100.
7. Knechtle B, Waśkiewicz Z, Sousa CV et al. Cold Water Swimming-Benefits and Risks: A Narrative Review. Int J Environ Res Public Health. 2020;2;17(23): 8984. doi: 10.3390/ijerph17238984.
8. Skrobacz K, Migut D. Positive effect of winter baths in outdoor water reservoirs. Special Issue Conference Abstract Book CNS 2018;1:39-40.
9. Kokocińska A, Adamczyk P, Ponikowska I. Co morsowanie ma wspólnego z balneoterapią? [What does winter swimming have to do with Balneotherapy?]. Acta Balneol. 2021; 63 (1): 66-69. doi:10.36740/ABAL202101109. (Polish)
10. Skrzek A, Ciszek A, Nowicka D et al. Evaluation of changes in selected skin parameters under the influence of extremely low temperature. Cryobiology. 2019; 86:19-24. doi: 10.1016/j.cryobiol.2019.01.005.
11. Piotrowska A, Aszklar K, Dzidek A et al. The impact of a single whole body cryostimulation treatment on selected skin properties of healthy young subjects. Cryobiology. 2021;100: 96-100. doi: 10.1016/j.cryobiol.2021.03.003.
12. Lubowska A. Zastosowanie krioterapii w chorobach przewlekłych [Therapeutic application of cryotherapy in chronic diseases]. Family Medicine & Primary Care Review. 2013;2:233-239. (Polish)
13. Firooz A, Sadr B, Babakoohi S et al. Variation of biophysical parameters of the skin with age, gender, and body region. ScientificWorldJournal. 2012:2012:386936. doi: 10.1100/2012/386936.
14. Hadi H, Awadh A, Hanif N. The investigation of the skin biophysical measurements focusing on daily activities, skin care habits and gender differences. Skin Res Technol. 2016;22:247-254.
15. Luebberding S, Krueger N, Kerscher M. Skin physiology in men and women: in vivo evaluation of 300 people including TEWL, SC hydration, sebum content and skin surface pH. Int J Cosmet Sci. 2013;35:477-483.
16. Yew Y.W, Mina T, Ng H.K et al. Investigating Causal Relationships between Obesity and Skin Barrier Function in a Multi-Ethnic Asian General Population Cohort. Int. J. Obes. 2023; 47: 963-969. https://doi.org/10.1038/s41366-023-01343-z.
17. Yudhistira Y, Kusumawardani A, Widhiati S et al. The relationship between increased body mass index with transepidermal water loss: a comparative study. J Gen Proced Dermatol Venereol Indones. 2022;6(1):25-30. doi:10.19100/jdvi.v6i1.351.
18. Guida B, Nino M, Perrino. The impact of obesity on skin disease and epidermal permeability barrier status. J Eur Acad Dermatol Venereol. 2010;24:191-195.
19. Monteiro-Rodrigues L, Palma L, Santos O et al. Excessive weight favours skin physiology – up to a point: another expression of the obesity paradox. Skin Pharmacol Physiol. 2017;30(2):94-101.
20. Schmid-Wendtner MH, Korting H C. The pH of the skin surface and its impact on the barrier function. Skin Pharmacol Physiol. 2006;19:269-302.

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ORIGINAL ARTICLE

Quality of life and psycho-emotional state of oral cancer patients as an indicator of rehabilitation in the early postoperative period

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ABSTRACT

Aim: to investigate the dynamics of the quality of life and the psychological state of the patient in the hospital, which reflects the correct tactics of choice of treatment and the possibility of returning patients to everyday life.

Materials and Methods: The conducted investigation included examination and treatment of 76 patients with oral cancer I-IVA. All patients have a combined treatment. Depending on the adjacent therapy and postoperative anesthesia, they are divided into two groups. In the early postoperative period, the dynamics of quality of life and the psycho-emotional state of patients in four stages were traced: 1) after diagnosis, 2) on the third day after surgery, 3) on the 7th postoperative day, 4) on the 10th day of the postoperative period.

Results: The quality of life of oral cancer patients was assessed according to the EORTC-QLQ-H & N35 questionnaire, on the Karnovsky and ECOG scale. On the basis of the EORTC-QLQ-H & N35 questionnaire, the indicators are reduced in both groups, but by 33 % in the main group and 5 % in the comparison group. On the Karnovsky scale – in the main group, this figure was higher than the comparison group: according to 14 % against 3 %. The general condition of patients on the ECOG scale – the indicator was reduced by 53 % and 5 %, respectively. The psycho-emotional state of patients of the main group is restored more effectively. Manifestations of depression and anxiety are observed much less frequently and in a less pronounced form than in patients with comparison groups ($p>0.05$).

Conclusions: The proposed complex of rehabilitation measures is more effective than conventional measures. It allows to achieve better indicators of quality of life and psycho -emotional state of patients. Indicators of quality of life and psycho-emotional state of patients with oral cancer should be investigated not only as an indicator of the effectiveness of treatment and rehabilitation, but also to increase it by carrying out medical and rehabilitation measures.

Keywords: oral cancer, reconstructive operations, quality of life, anxiety, depression

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INTRODUCTION

In recent years, the incidence of oral cancer remains high and poses a serious threat to public health [1]. The mortality from this type of cancer also remains high, it requires increased attention to prevention and treatment [2].Treatment of oral cancer patients is quite traumatic. This leads to damage to the surrounding tissues, impaired functions (chewing, swallowing, speech) [3, 4]. Formation and efficiency of transmission of a food lump from the oral cavity to the pharynx depends on the conservation of tissue volume, innervation and circulation, which should be taken into account when conducting interventions in this area [5, 6].

The degree of dysphagia in such patients depends on: the volume of impaired neuro-musculoskeletal complex of the oral cavity, on the severity of pain. Planning of operations in this area requires careful analysis of possible pathological processes and preserving the act of swallowing. After all, this leads to a deterioration of quality of life and more complex psychosocial adaptation [7, 8].

The quality of life of patients with oral cancer can change significantly depending on the stage of the disease, the type of treatment, psychological support and the general condition of the patient [9, 10]. Understanding and support from relatives, friends and medical staff can help improve the quality of life of a patient and is very important for him [11]. Therefore, the choice of surgical treatment, postoperative anesthesia and accompanying therapy should provide antitumor effects and improve the patient's well – being.

Based on the analysis of functional disorders and the development of new methods of influencing the pathological focus, in order to improve the results of treatment, quality of life and psychoemotional state of patients with oral cancer, we have created an effective scheme of a set of rehabilitation measures, including a method of ultrasound assessment of the swallowing act of operated and non-operated patients, the use of a new method of long-term postoperative conductive anesthesia, correction of nutritional status and oral dysbiosis, replacement of postoperative defects.

A significant number of studies have shown that quality of life is prognostic for assessing the effectiveness of treatment and survival of cancer patients [12]. In general, most researchers believe that quality of life indicators in cancer should be the basis for developing rehabilitation programs for patients [7, 11, 13].

AIM

The aim of the investigation is to study the dynamics of the quality of life and psychological state of the patient in the hospital, which reflects the correctness of the treatment tactics and the possibility of returning patients to everyday life.

MATERIALS AND METHODS

A prospective, single-center, randomized, comparative study of the examination and treatment of 76 patients with stage I-IVa oral cancer was conducted. All patients underwent combined treatment, but depending on the adjuvant therapy and postoperative pain relief, they were divided into two groups:

- main group – preoperative radiotherapy, surgical intervention, combined clinical enteral nutrition, combined anesthesia (long-term conduction postoperative pain relief and non-steroidal anti-inflammatory drugs), Lysozyme topical (n=39);
- comparison group – preoperative radiotherapy, surgical intervention, nasogastric feeding, non-steroidal anti-inflammatory drugs (n=37).

Depending on the size and nature of the tumor growth, combined or extended combined surgical intervention was performed. Restoration and replacement of removed tissues in patients of the main group was performed with local (56%), arterialized regional or distant tissues (44%). In patients of the comparison group, local tissue was used in 83% of cases, and regional or distant tissue in 17%.

In the early postoperative period, the dynamics of quality of life and psychoemotional state of patients were traced.

The quality of life of patients was assessed using the European Organization for Research and Treatment of Cancer questionnaire EORTC-QLQ-H&N35 (head and neck cancer-specific module) [13]. The questionnaire is designed to specifically assess the most important symptoms in head and neck tumors. The questions of the questionnaire take into account: pain and its intensity, eating disorders, trismus development, features of the oral mucosa and speech.

A decrease in the sum of points from the baseline was assessed as an improvement in quality of life, and an increase as a deterioration. An increase of 5-10 points was considered insignificant, 10-20 points – moderate, and more than 20 points – severe. Indicators of cancer patient status vary from 1-4 according to the following scheme: 1 – no problems; 2 – some problems; 3 – significant problems; 4 – very significant problems.

The general condition of patients was assessed using the scale developed by the Eastern Cooperative Oncology Group (ECOG) and recommended for clinical trials of various methods of treating malignant tumors and the Karnowski index.

The psychological state was determined by the Hospital Anxiety Depression Scale (HADS (1983)). The HADS scale is a subjective measure designed to screen for anxiety and depression in inpatients. The questionnaire contains 14 items. There are 4 possible answers to each question. They reflect the degree of increase in the corresponding symptoms. Patients filled out the scale form independently.

The questionnaires were filled out at four stages: 1) after diagnosis, 2) on the third day after surgery, 3) on the 7th day, 4) on the 10th day of the postoperative period.

Statistical processing of the obtained data was performed using a mathematical statistical method on a PC «SPSS 11,0 for Windows» та «Microsoft Excel 2010», «Statistica 6,0» (Statsoft, USA). according to Student's criteria. Differences between groups were considered statistically significant at $p<0.05$ [14].

RESULTS AND DISCUSSION

The quality of life indicators according to the EORTC-QLQC30 H&N35 questionnaire for patients with oral cancer are presented in Table 1.

According to the results of the study, it was found that before the start of treatment, patients in both groups had comparable baseline quality of life indicators and had no statistically significant differences (p=0.487). On the third day after surgical treatment, a decrease in the general health status was observed in both patients of the main and comparison groups (on average 1.5 times compared to the indicators during hospitalization). The decline is due to the fact that in the first three days, patients develop new sensations associated with surgical treatment, such as numbness of the lip, chin, immobility of the oral cavity, inability to swallow and eat properly, discomfort, and struggle with salivation. Therefore, pain relief is the most significant factor in overcoming discomfort and pain. Thus, statistically significant differences between the groups were found (p=0.043) on day 3. On the seventh day of the postoperative period, patients in both groups also showed a statistically significant decrease in this integral index, indicating an

Table 1. Indicators of quality of life in patients with oral cancer according to the EORTC-QLQ-H&N35 questionnaire (n=76, M±m)

Stages research	The main group, n=39	Comparison group, n=37	P (χ2)
On the day of hospitalization	38,9±2,9	38,8±2,8	0,487
On the 3rd day	51,4±4,0	63,4±4,7	0,043*
On the 7th day	37,5±2,6	48,9±2,3	0,005*
On the 10th day	27,2±3,1	37,1±1,4	0,009*

*Notes. * – statistically significant difference between groups (p<0,05).*

Table 2. Analysis of treatment effectiveness by the Karnowski index,(n=76, M±m)

Stages research	The main group, n=39	Comparison Group, n=37	P (χ2)
On the day of hospitalization, %	67,9±6,6	65,9±9,3	0,432
On the 3rd day, %	63,1±6,5	55,9±8,0	0,254
On the 7th day, %	74,1±6,4	58,6±4,8	0,044*
On the 10th day, %	78,5±6,7	62,9±5,7	0,045*

*Notes. * – statistically significant difference between groups of patients.*

improvement in the condition of patients and the effectiveness of combined anesthesia (p=0.005*). On day 10, the index of general health status in patients significantly decreased, in particular, in the main group to 23-39 points, and in the comparison group - to 35-39 (p=0.009*).

The data obtained as a result of the assessment of the quality of life of patients with oral cancer in comparison with the baseline indicators allow to speak about the improvement of the overall health status in the main group. This is due to a long pain-free period in patients and an understanding of the possibility of swallowing and further normal nutrition.

At the same time, in the comparison group, patients showed minor changes in the quality of life index, which is associated with a less pronounced effect of the postoperative anesthesia.

The data in Table 2 show that the primary condition of the patients in the main and comparison groups was on average almost the same, which gives reason to consider the groups comparable by this criterion.

After tumor removal on the third day, a decrease in this index was found in both groups of patients (p=0.254). On the 7th day of the postoperative period, the Karnowski index increased, but its difference between the main and comparison groups was significant and statistically significant (p=0.044). On the 10th day of the postoperative period after surgical treatment and maintenance therapy and analgesia, the rate of improvement in the condition of patients in the main group was significantly higher than in the comparison group: 25% *vs.* 10%, respectively (p=0.045). Thus, our statistical analysis, using the Karnowski index, with a high level of significance and reliability confirms the effectiveness of complex treatment with the use of prolonged postoperative conduction analgesia only on days 7 and 10, although patients experienced long pain-free periods starting from day 3.

The results of the assessment of the general condition of patients with oral and oropharyngeal cancer according to the ECOG scale are presented in Table 3.

As can be seen from Table 3, the level of activity in patients of both the main and comparison groups before the start of surgical treatment was equally reduced (p=0.457). On day 3 of the postoperative period, the difference in the general somatic condition of patients according to the ECOG scale between the main and comparison groups was significant, but statistically insignificant (p=0.076). On day 7, in the comparison group, the index remained almost unchanged, in contrast to the index in the main group, where a statistically significant decrease was observed (p=0.006). On the 10th day of the postoperative period, an improvement in the condition of patients was established: namely, a significant decrease in the above indicator in the main group - by 50%, and in the comparison group – by 21% (p=0.029).

The low quality of life in the comparison group was clinically determined by severe impairment of chewing and swallowing functions caused by pain. Patients, even on day 10, could not eat the food they liked and in the amount they wanted, because they were still on zone nutrition. Unlike the main group, where the act of swallowing was restored on the 10th day and the patients were removed from the probe and transferred to a regular diet.

The most informative of the three quality of life indicators used is the integral indicator according to the EORTC-QLQH&N35 questionnaire, which is based on the patient's subjective feelings and responses and showed statistically significant changes from day 3 of the postoperative period, in contrast to the Karnowski and ECOG scales where statistically significant changes were detected from day 7. Thus, the proposed complex of therapeutic and rehabilitation measures, in comparison with conventional measures,

Table 3. General condition of patients on the scale ECOG, (n=76, M±m)

Stages of the study	The main group, n=39	Comparison group, =37	P (χ2)
On the day of hospitalization	1,7±0,5	1,8±0,5	0,457
On the 3rd day	1,3±0,4	2,2±0,4	0,076
On the 7th day	0,9±0,3	2,1±0,2	0,006*
On the 10th day	0,8±0,4	1,9±0,3	0,029*

*Notes. * – statistically significant difference between groups of patients.*

allows to achieve better indicators of the quality of life of patients, which indicates its superiority ($p<0.05$). The results of the study of depression and anxiety manifestations according to the HADS questionnaire at hospitalization and on days 3, 7, 10 after surgery are presented in Table 4.

The analysis of the data obtained during hospitalization indicated that patients in the main group and the study group had subclinical depression and anxiety, with scores in the range of 8-10 points, which indicates the homogeneity of the groups in these indicators. However, starting from day 3 of the postoperative period, there was a statistically significant difference in the rate of depression and anxiety between the study groups. Thus, on day 3 after surgery and the proposed treatment in patients of the main group, the index of depression and anxiety corresponded to subclinical manifestations, in contrast to the indexes in patients of the comparison group, where these indicators corresponded to clinical manifestations ≥11 points ($p<0.05$). On day 7, the index of depression and anxiety in patients of the main group corresponded to the norm (≤7 points), and these indicators in patients of the comparison group corresponded to clinical manifestations of depression and anxiety ≥11 points ($p<0.05$). On day 10, in the main group, patients showed a decrease in depression and duration, which corresponded to the norm, in contrast to these indicators in the comparison group ($p<0.05$).

Thus, the positive dynamics of the level of quality of life and psychoemotional state of patients in the main group indicates the adequacy of the proposed complex of treatment and rehabilitation measures, which allowed – to feel more confident. Patients were able to overcome light and heavier physical activity without feeling a lack of strength and energy, restoring their physical and psychoemotional state. The negative dynamics of the index in the comparison group on the 10th day of the postoperative period was due to the appearance of side effects from taking non-narcotic analgesics and the resumption of pain due to a decrease in their analgesic effect, impaired chewing and swallowing function [15].

CONCLUSIONS

1. The use of various indicators of quality of life and their implementation in the dynamics of the proposed treatment makes it possible to more objectively draw conclusions about the positive effect of the proposed treatment and rehabilitation measures to restore the function of the oral cavity.
2. The psycho-emotional state of patients in the main group is restored more effectively, manifestations of depression and anxiety are observed much less often and in a less pronounced form than in patients in the comparison group ($p>0.05$), which also indicates the effectiveness of the proposed complex of therapeutic and rehabilitation measures.
3. Indicators of quality of life and psychoemotional state of patients with oral cancer should be studied not only as an indicator of the effectiveness of treatment and rehabilitation, but also to improve it through the implementation of treatment and rehabilitation measures.

REFERENCES

1. Bell BR, Andersen P, Fernandes R. Oral, Head and Neck Oncology and Reconstructive Surgery. Elsevier. 2018; 968 p.
2. Taker M. Oral cancer survivors and quality of life. Primary health care: Open access. 2021;11(8):398.
3. Wild CP, Weiderpass E, Stewart BW. Editors. World Cancer Report: Cancer Research for Cancer Prevention. Lyon, France: International Agency for Research on Cancer. 2020. Available from: http://publications.iarc.fr/586. Licence: CC BY-NC-ND 3.0 IGO.
4. Yousof Y, Salleh NM, Yusof F. Quantitative Evaluation of Masticatory Performance with Two-Color Mixing Ability Test: Development of a New Digital Method. Int J Prosthodont. 2020;33(2):224-228.
5. Huang L, Gao X, Su T et al. Vertical platysma myocutaneous flap reconstruction for oral defects using three different incision designs experience with 68 cases. Int J Oral Maxillofac Surg. 2018;47(3):324-329.
6. Tirelli G, Gatto A, Boscolo Nata F et al. Prognosis of oral cancer: a comparison of the staging systems given in the 7th and 8th editions of the American Joint Committee on cancer staging manual. Br J Oral Maxillofac Surg. 2018;56(1):8-13.
7. Jitender S, Mahajan R, Rathore V, Choudhary R. Quality of life of cancer patients. J Exp Ther Oncol. 2018 May;12(3):217-221.
8. Mahalingam M, Thiruneelakandan S, Annamalai T, Pavithran V. Quality of health assessment in oral cancer patients postoperatively – A retrospective study. Advances in Oral and Maxillofacial Surgery. 2022;5:100202.
9. Alam MM, Rahman T, Afroz Z et al. Quality of Life (QoL) of cancer patients and its association with nutritional and performance status: A pilot study. Heliyon. 2020 Oct 23;6(10):e05250. doi: 10.1016/j.heliyon.2020.e05250.
10. Singer P, Blaser AR, Berger MM. ESPEN guideline on clinical nutrition in the intensive care unit. Clin Nutr. 2019;1(38):48-79.
11. Caetano RS, Lima FF, Gomes EP, Volpato LE. Quality of Life of Patients After Treatment for Cancer in the Head and Neck Region: A Case-Control Study. Cureus. 2022;14(6):e25800.
12. De Cicco D, Tartaro G, Ciardiello F et al. Health-Related Quality of Life in Oral Cancer Patients: Scoping Review and Critical Appraisal of Investigated Determinants. Cancers. 2021;13(17):4398. doi: 10.3390/cancers13174398.
13. Gerasimchuk PO, Fira DB, Pavlyshyn AV. Assessment of quality of life related to medicine. Bulletin of medical and biological studies. 2021;1(7):112-122.
14. Fetisov VS. STATISTICA statistical data analysis package. Nizhyn: NDU im. M. Gogolya; 2018. 114 p.
15. Kushta AO, Shuvalov SM. Functional disorders of organs of the oral cavity and theirelimination with the help of plastic in patients with cancer ofthe oral cavity and oropharynx. Clin Experim Patho. 2024;23(3):23-29.

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Effectiveness of personalized physical rehabilitation within resort therapy for chronic non-infectious enteritis

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ABSTRACT

Aim: The study aimed to evaluate the effectiveness of comprehensive resort rehabilitation, including targeted physical rehabilitation methods, in patients with chronic non-infectious enteritis.

Materials and Methods: Eighty patients (45 women, 35 men; mean age 36.85±11.82 years) with chronic non-infectious enteritis were randomized into two groups (n=40 each). Both groups underwent standard resort treatment (mineral water, diet therapy, balneotherapy, etc.). Group 1 additionally received individualized therapeutic exercise and segmental massage tailored to intestinal motility type (hyper/hypotonic), while Group 2 performed general strengthening exercises and received classical back massage. The effectiveness of the interventions was assessed using electroenterography (EEnG) and clinical symptom evaluation before and after treatment. Statistical analysis utilized Mann-Whitney U-test and Fisher's exact test ($p<0.05$).

Results: Both groups showed significant improvement in gastrointestinal symptoms and normalization of small intestine myoelectric activity. However, Group 1 demonstrated more pronounced reductions in abdominal pain, flatulence, diarrhea, and constipation. EEnG data revealed a greater decrease in the amplitude and frequency of tonic and peristaltic intestinal oscillations in Group 1. The voltage of small intestine waves significantly decreased, and the prevalence of tachyrhythmic motility types was reduced.

Conclusions: Comprehensive rehabilitation combining natural resort therapies with targeted physical rehabilitation significantly improves clinical outcomes and small intestine motility in patients with chronic non-infectious enteritis. Tailoring exercise to individual motility patterns enhances therapeutic effects, highlighting the value of an integrated, personalized approach to managing this condition.

KEYWORDS: physical rehabilitation, myoelectric activity, electroenterography, chronic non-infectious enteritis

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INTRODUCTION

Intestinal diseases are one of the most complex pathologies of the digestive system. Chronic enteritis is a long-term inflammation of the small intestine, accompanied by various gastrointestinal symptoms. In contrast to acute enteritis, which is mainly caused by infectious agents, chronic enteritis is a heterogeneous group of diseases, has a more complex etiology, and is characterized by a long course [1]. Although this disease is a separate nosological entity, its impact on patients' quality of life can be comparable to the impact of other inflammatory bowel diseases (IBD). Epidemiological data indicate a significant prevalence of IBD in the world. Thus, in the USA in 2015, about 3.1 million adults suffered from IBD [2]. The pressure of IBD on patients' life quality is multifaceted and encompasses various aspects of their lives. Persistent debilitating symptoms, such as abdominal pain, diarrhea, and fatigue, significantly limit daily activities and work capacity. Studies also show decreased quality of life indicators on various scales, including emotional and social components. Even with treatment, a significant proportion of patients experience symptoms that negatively affect their emotional state and social activity [3, 4].

Despite the successes in studying the clinic and pathogenesis of intestinal diseases, this problem is not finally solved, and some issues are controversial. Severe metabolic disorders that occur with prolonged enteritis, a decrease in protective immunological reactions, polyhypovitaminosis, enzymatic insufficiency, the spread of bacterial flora throughout the intestine, and deconjugation of bile acids complicate the treatment of these patients.

Modern approaches to the treatment of chronic enteritis include drug therapy aimed at reducing inflammation and controlling symptoms, as well as dietary recommendations and lifestyle modification. However, the issues of treatment and prevention of intestinal dysfunction remain acute due to the constant deterioration of the exoecological environment on the one hand and the food quality on the other. Considering chemically synthesized drugs as a component of this adverse effect on the body's systems, as well as allergic reactions that occur during treatment,

specialists are showing increasing interest in the search for therapeutic factors of natural origin. In these conditions, natural and preformed physical factors have an undeniable advantage over drug therapy.

Resort rehabilitation is one of the leading methods of treating chronic intestinal diseases. Resort treatment, acting as a combination of various natural and preformed therapeutic factors, causes certain positive changes in the body's physiological systems. In the rehabilitation system of gastroenterological patients, a significant place is occupied by physical therapy, massage, physiotherapy procedures, hardening procedures, climatotherapy and autotraining [5-7]. Although both resort rehabilitation and physical therapy separately demonstrate a positive effect in patients with gastrointestinal diseases, their combined use in chronic non-infectious enteritis remains insufficiently studied. A comprehensive approach to spa rehabilitation, including diet therapy, mineral water use, and balneotherapy, can create a favorable physiological environment that potentially enhances the effectiveness of targeted physical rehabilitation interventions, such as physical therapy and segmental massage.

The studying of bioelectrical activity is an important aspect in both understanding the pathogenetic features of gastrointestinal diseases and the selection of the correct tactics in managing such patients. Electrogastrography is a non-invasive method used to record the electrical activity of the stomach using skin electrodes placed on the anterior abdominal wall in the projection of the stomach [8-10]. Analysis of the obtained electrogastrograms allows to estimate the frequency and amplitude of electrical waves reflecting the contractile activity of the stomach muscles, diagnose and evaluate the effectiveness of treatment of diseases associated with impaired motility (e.g., gastroparesis, functional dyspepsia) [11, 12]. Although most studies using electrogastrography are focused on studying the stomach's motility, this technique can be applied to electroenterography (EEnG) – determining the myoelectric activity of the small intestine [13].

AIM

The aim was to investigate the consolidated effect of resort rehabilitation using physical rehabilitation tools in patients with chronic non-infectious enteritis.

MATERIALS AND METHODS

Eighty patients (45 women and 35 men) aged 18 to 56 years (36.85±11.82) with a diagnosis of chronic non-infectious enteritis were included in the current study. At the time of inclusion, the duration of the disease was 5.61±1.60 years. Exclusion criteria were: Crohn's disease, ulcerative colitis, radiation, toxic, allergic and diabetic enteritis. To evaluate the state of the small intestine motor function and assess the effectiveness of rehabilitation measures, EEnG was performed using the EGS-4M electrogastrograph. Electrodes were applied according to Aikawa G et al [13]. The background myoelectric activity of the small intestine was compared before and after the treatment. The amplitude and frequency (contractions per minute (cpm)) of tonic and peristaltic intestinal oscillations were evaluated.

All studies were conducted in accordance with the ethical principles for medical research involving human subjects. Written informed consent was obtained from all participants for the proposed diagnostic and therapeutic procedures prior to the study inclusion. The research methodology complied with the ethical standards outlined in the Declaration of Helsinki (1964-2013), the Council of Europe Convention on Human Rights and Biomedicine, as well as applicable Ukrainian legislation.

The complex of rehabilitation measures for patients with chronic enteritis included a course of medium-mineralized carbonated bicarbonate-sodium mineral water "Polyana Kupil" at a temperature of 42°C 45 minutes before meals, 200 ml 3 times a day, diet therapy, carbonated mineral baths, climatotherapy, therapeutic gymnastics, massage, psychotherapy and hydropathic procedures.

The patients were randomly divided into two groups of 40 people each. The complex of resort treatment of patients of Group 1 additionally included means of physical rehabilitation – therapeutic exercise and segmental massage. In the case of hypertensive type of small intestine motility, the complex of therapeutic gymnastics, which was carried out for 25-30 minutes. It included special exercises mainly from the position of lying on the back, as well as standing on the knees, alternating with breathing exercises and exercises to relax the abdominal muscles in order to reduce intra-abdominal pressure and relax the intestinal muscles. When eliminating spastic phenomena, exercises for the limbs, turns and bending of the torso, squats were used. The exercises were performed at a slow and medium pace with a gradual load. Segmental massage of the paravertebral zones of the thoracic and lumbar spinal segments was performed, alternating with techniques of circular stroking of the anterior abdominal wall. The duration of the massage was 20 minutes, with 10-12 procedures per treatment course. In the case of the hypotonic small intestine motility type, therapeutic gymnastics was aimed at increasing the tone of the intestinal muscles in combination with relaxation exercises and breathing exercises. Exercises were used to strengthen the abdominal and back muscles with a gradual increase in load and change of starting positions.

For patients of Group 2, the therapeutic gymnastics complex included general strengthening exercises for all muscle groups with a small load, with objects, torso turns alternating with breathing exercises, and exercises to strengthen the abdominal muscles. A classic back massage lasted 15-20 minutes, with 10-12 procedures per course, was also used. The purpose of therapeutic walking is to adapt to psychological and physical stress, as well as improve the psycho-emotional state of patients. Psychotherapy (rational, hypnosis, meditation) was a mandatory method of rehabilitation for this category of patients and was used to establish harmonious coexistence in the work of the autonomic nervous system and normalize intestinal motility.

EEnG results are presented as M±m. The statistical significance of the difference between the mean values

Table 1. Frequency of clinical symptoms before and after treatment, % (95% CI)

Symptom	Group 1		Group 2	
	Before treatment	After treatment	Before treatment	After treatment
Abdominal pain	85,0 (70,9-92,9)	22,5 (12,3-37,5) *#	87,5 (73,9-94,5)	47,5 (32,9-62,5)*
Flatulence	80,0 (65,2-89,5)	15,0 (7,1-29,1) *#	77,5 (62,5-87,7)	37,5 (24,2-53,0)*
Diarrhea	75,0 (59,8-85,8)	12,5 (5,5-26,1) *#	70,0 (54,6-81,9)	40,0 (26,3-55,4)*
Constipation	25,0 (14,2-40,2)	5,0 (1,4-16,5) *#	30,0 (18,1-45,4)	10,0 (4,0-23,1)*

*Note: * – the difference is statistically significant when compared with the indicators before treatment ($p<0.05$), # - the difference is statistically significant when compared with the indicators of Group 1 ($p<0.05$).*

was determined using the Mann-Whitney U-test. The 95% confidence interval (CI) for proportions was calculated using Wilson's method. The statistical significance of the difference between proportions was determined using the two-sided Fisher's exact test. The difference was considered significant at $p<0.05$.

RESULTS

Among the examined patients of both groups, the most common clinical symptoms of chronic enteritis were abdominal pain of various intensity and localization, flatulence and diarrhea. Compared with other symptoms, the frequency of constipation was significantly lower (Table 1).

At the beginning of the study, patients in both groups had a predominantly increased intestinal myoelectric activity. The most characteristic were high-amplitude tonic and low-amplitude peristaltic oscillations of the small intestine with a high frequency of tonic and peristaltic oscillations. Depending on the amplitude of tonic waves, the hypertonic type of small intestine motility (0.11±0.006 mV) was detected in 63.8% (95% CI: 52.8-73.4%) of patients, the hypotonic type (0.06±0.007 mV) – in 36.3% (95% CI: 26.6-47.2%). At the same time, according to the frequency of tonic waves, 82.5% (95% CI: 72.7-89.3%) of patients showed a tachyrhythmic (1.64±0.05 cpm) type of small intestinal motility, and 17.5% (95% CI: 10.7-27.3%) bradyrhythmic (1.19±0.04 cpm).

After the treatment course completion, a significant decrease in the frequency of clinical symptoms was observed in both groups. Moreover, significantly better indicators were found in patients of Group 1.

The positive effect of the treatment was also confirmed by the results of repeated EEnG. In particular, the voltage of the small intestine teeth significantly decreased from 0.11±0.006 mV to 0.08±0.004 mV in patients of Group 1 ($p<0.001$) and to 0.09±0.004 mV in patients of Group 2, respectively ($p<0.05$). Normalization of the small intestine tonic oscillation frequency was also noted. Thus, the tachyarrhythmic type of motility significantly decreased from 1.64±0.05 cpm to 1.49±0.04 cpm in patients of Group 1 ($p<0.05$). In patients of Group 2, a tendency towards normalization of this indicator 1.56±0.03 cpm ($p>0.05$) was also noted. In addition, a tendency towards normalization of the amplitude of the small intestine peristaltic waves was present.

DISCUSSION

Using resort treatment in patients with chronic gastrointestinal diseases is a common practice, the effectiveness of which is confirmed by numerous studies. However, the response to the applied rehabilitation measures may vary depending on the prevailing pathophysiological mechanisms.

The results obtained in this study demonstrate a significant improvement in clinical symptoms and indicators of myoelectric activity of the small intestine in patients with chronic non-infectious enteritis after undergoing the proposed comprehensive course of rehabilitation. It is worth noting that the most pronounced positive changes were observed in patients of Group 1, who additionally received therapeutic exercise and segmental massage, compared to Group 2, where general strengthening exercises and classical back massage were used. In particular, patients in Group 1 had a more significant decrease in the frequency of clinical manifestations such as abdominal pain, flatulence, diarrhea, and constipation, as well as a more pronounced tendency to normalize the amplitude and frequency of tonic and peristaltic small intestine oscillations according to EEnG data.

It has long been known about the positive effect of mineral waters on the autonomic nerves and intestinal plexus, as well as its motility, exocrine, endocrine and paracrine digestive secretions [14]. In this study, both groups of patients received a course of moderately mineralized carbonated bicarbonate-sodium mineral water "Polyana Kupil", which probably contributed to the general improvement of their condition and was manifested in the tendency to normalize the amplitude and frequency of small intestine tonic oscillations. In addition, balneotherapy, which includes mineral baths, as a component of resort treatment, causes an anti-inflammatory effect, which is an important aspect in the treatment of chronic inflammatory bowel diseases [15].

However, the more significant positive changes observed in Group 1 patients indicate the important role of the additional inclusion of therapeutic exercises and segmental massage. The effect of physical exercise on gastrointestinal motility is well known. Regular moderate physical activity helps stimulate natural contractions of the intestinal muscles, prevents the development of constipation, reduces bloating

and the risk of complications. Studies show that moderate exercise, such as walking, can significantly improve absorption and motility of the small intestine and normalize the time of food passage through the digestive tract [16]. In this study, the complex of therapeutic exercises for the first group of patients was differentiated depending on the type of small intestine motility (hypertonic or hypotonic), which allowed for a targeted effect on existing disorders. Exercises aimed at relaxing the abdominal muscles in patients with hypertonic motility could help reduce intra-abdominal pressure and relax the intestinal muscles, while exercises to strengthen the abdominal press and back muscles used in patients with hypotonic motility could, on the contrary, increase intestinal tone and peristalsis.

Segmental massage of the paravertebral zones of the thoracic and lumbar spinal segments as well as the massage of the small intestine, used in Group 1, could also have an additional positive effect on intestinal motility. Massage of the abdomen, including intestinal massage, stimulates peristalsis, reducing the transit time of intestinal contents and alleviating symptoms of constipation and abdominal discomfort. Segmental massage, affecting the nerve endings in the corresponding spinal cord segments, can reflexively improve the functional state of internal organs, particularly the intestine. Classical back massage, used in the second group, although it has a general strengthening effect and can promote relaxation, probably had a smaller direct effect on small intestinal motility compared to segmental massage and special exercises.

To assess the effectiveness of rehabilitation measures, an EEnG, which is a non-invasive method of recording the myoelectric activity of the gastrointestinal tract, was used in this study. The decrease in the voltage of the small intestine teeth and the normalization of the frequency of tonic oscillations observed after treatment, especially in Group 1, indicate a positive effect of the applied rehabilitation measures on the electrical activity and, indirectly, on the small intestine motility. It is important to note that some studies indicate the limitations of using non-invasive electromyography of the gastrointestinal tract and the possible weak correlation of the results obtained in this way with direct methods of assessing motility, such as scintigraphy [17]. However, when combined with clinical assessment, changes in EEnG parameters can provide valuable information about the intestine's functional state.

Future studies should be aimed at studying the long-term impact of the applied rehabilitation measures on the quality of life of patients with chronic enteritis. Resort treatment and physical rehabilitation have the potential to improve not only the physical condition but also the psycho-emotional well-being of patients with chronic diseases [18]. Assessment of quality of life using validated questionnaires over a long follow-up period would allow a better understanding of the stability of the obtained results.

Promising directions for further research are also studying the effect of a combination of various physiotherapeutic methods (e.g., hydrotherapy, electrotherapy) in the complex resort treatment of chronic enteritis. It is also important to compare the effectiveness of resort treatment with outpatient treatment when using similar rehabilitation approaches. Conducting randomized controlled trials with a large sample of patients and the presence of a placebo group will allow for obtaining more convincing evidence of the effectiveness of the proposed complex approach.

CONCLUSIONS

This study confirms the effectiveness of comprehensive resort rehabilitation in patients with chronic non-infectious enteritis. The addition of targeted physical rehabilitation – therapeutic exercise and segmental massage – led to greater symptom relief and improved intestinal motility compared to general exercises and classical massage. EEnG data supported these clinical improvements.

Tailoring exercises to the type of motility disorder enhanced treatment outcomes, while mineral water and balneotherapy contributed additional benefits. These findings suggest that combining natural therapies with individualized physical rehabilitation offers a promising approach to improving both gastrointestinal function and quality of life in this patient population.

REFERENCES

1. Thorsen AJ. Non-infectious colitides: collagenous colitis, lymphocytic colitis, diversion colitis, and chemically induced colitis. Clin Colon Rectal Surg. 2007;20(1):47-57. doi:10.1055/s-2007-970200.
2. Dahlhamer JM, Zammitti EP, Ward BW et al. Prevalence of Inflammatory Bowel Disease Among Adults Aged ≥18 Years – United States, 2015. MMWR Morb Mortal Wkly Rep 2016;65:1166-1169. doi: http://dx.doi.org/10.15585/mmwr.mm6542a3.
3. Hiraoka S, Huang Z, Qin F et al. Health-related quality of life, work productivity, and persisting challenges in treated ulcerative colitis patients: a Japanese National Health and Wellness Survey. Intest Res. 2025; n. page. doi: 10.5217/ir.2024.00104.
4. Gavrilescu O, Mihai C, Anton-Paduraru DT et al. Impact of Inflam-matory Bowel Diseases on Quality of Life. Revista de Cercetare si Inter-ventie Sociala 2015; 50: 80-95.
5. Severo JS, Silva ACAD, Santos BLBD, et al. Physical Exercise as a Therapeutic Approach in Gastrointestinal Diseases. J Clin Med. 2025;14(5):1708. doi:10.3390/jcm14051708.
6. Zabawa B, Sadowski J, Mól P et al. The Impact of Physical Activity on Digestive System Diseases. Quality in Sport. 2024;34:56112. doi: 10.12775/QS.2024.34.56112.
7. Morisawa T, Takahashi T, Nishi S. The effect of a physiotherapy intervention on intestinal motility. J Phys Ther Sci. 2015;27(1):165-168. doi:10.1589/jpts.27.165.

8. Riezzo G, Russo F, Indrio F. Electrogastrography in adults and children: the strength, pitfalls, and clinical significance of the cutaneous recording of the gastric electrical activity. Biomed Res Int. 2013;2013:282757. doi:10.1155/2013/282757.
9. Cai Y, Wang J, Huang D, Luo L. Application of electrogastrogram in assessment of gastric motility in acute pancreatitis. Front Physiol. 2023;14:1281342. doi:10.3389/fphys.2023.1281342.
10. Oczka D, Augustynek M, Penhaker M, Kubicek J. Electrogastrography measurement systems and analysis methods used in clinical practice and research: comprehensive review. Front Med (Lausanne). 2024;11:1369753. doi:10.3389/fmed.2024.1369753.
11. Rosca V, Gheorghe L, Floria D et al. Functional dyspepsia assessment - current diagnostic methods and new promising techniques. Arch Clin Cases. 2025;12(1):37-43. doi: 10.22551/2025.46.1201.10310.
12. Wang Y, Chen JDZ, Nojkov B. Diagnostic Methods for Evaluation of Gastric Motility – A Mini Review. Diagnostics. 2023; 13(4):803. doi:10.3390/diagnostics13040803.
13. Aikawa G, Kotani M, Sakuramoto H et al. Visualized Quantitative Evaluation of Gastrointestinal Activity in Healthy Volunteers Using a Noninvasive Single--Channel Electroamplifier. GastroHep. 2023; 1-8. doi:10.1155/2023/6902635.
14. Fraioli A, Mennuni G, Grassi M et al. I mezzi di cura termale nella terapia di malattie di competenza internistica [SPA treatments of diseases pertaining to internal medicine]. Clin Ter. 2010;161(2): e63-e79. (Italy)
15. Cozzi F, Podswiadek M, Cardinale G, et al. Mud-bath treatment in spondylitis associated with inflammatory bowel disease – a pilot randomised clinical trial.Joint Bone Spine. 2007;74(5):436-439. doi:10.1016/j.jbspin.2006.12.003.
16. de Oliveira EP, Burini RC. The impact of physical exercise on the gastrointestinal tract. Curr Opin Clin Nutr Metab Care. 2009;12(5):533-538. doi:10.1097/MCO.0b013e32832e6776.
17. Gharibans AA, Kim S, Kunkel D, Coleman TP. High-Resolution Electrogastrogram: A Novel, Noninvasive Method for Determining Gastric Slow-Wave Direction and Speed. IEEE Trans Biomed Eng. 2017;64(4):807-815. doi:10.1109/TBME.2016.2579310.
18. Costantino M, Giudice V, Farroni M, et al. Impact of Spa Therapy on Symptoms and Quality of Life in Post-COVID-19 Patients with Chronic Conditions. J Clin Med. 2024;13(17):5091. doi:10.3390/jcm13175091.

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Effects of functional balance training and core stabilization exercise on dynamic balance among older former athletes

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ABSTRACT

Aim: This study aimed to compare the effects of Functional Balance Training (FBT) and Core Stabilization Exercise (CSE) on dynamic and functional balance among former older athletes aged above 60 years.

Materials and Methods: A randomized controlled trial was conducted involving 20 former older athletes, who were randomly assigned into two groups. Group A received Functional Balance Training (FBT) and Group B performed Core Stabilization Exercise (CSE). Both groups participated in supervised training sessions three times per week for six weeks. Dynamic balance was assessed using the Star Excursion Balance Test (SEBT), while functional balance was measured using the Berg Balance Scale (BBS). Pre- and post-test scores were analyzed using paired and independent t-tests with a significance level set at $p<0.05$.

Results: Both FBT (Group A) and CSE (Group B) significantly improved SEBT and BBS scores within groups ($p<0.05$). However, Group A demonstrated greater improvements in SEBT composite scores for both right (mean difference=+7.4%, p=0.001) and left leg (mean difference=+7.8%, p=0.001), as well as in BBS scores (mean difference=+5.8, p=0.000) compared to Group B. Between-group analysis revealed statistically significant differences favoring Group A in all post-test measures ($p<0.05$).

Conclusions: Both FBT and CSE are effective in improving balance in former older athletes; FBT resulted in superior gains in both dynamic and functional balance. These findings suggest that incorporating dynamic, task-specific exercises may offer greater benefits in fall prevention and mobility enhancement for aging individuals with an athletic background.

KEYWORDS: functional balance training, core stabilization exercie, older former athletes

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INTRODUCTION

Balance and postural control, refers to the ability to maintain the body's center of gravity over its base of support. It is a fundamental aspect of mobility and independence, particularly in older adults. As individuals age, physiological changes such as reduced muscle mass, diminished proprioception, and slower reflexes can significantly compromise balance, increasing the risk of falls and associated injuries [1, 2].

Interestingly, research has demonstrated that former athletes – those who engaged in sports at a younger age – tend to retain higher levels of functional capacity and balance compared to their sedentary peers [3-5]. However, despite this relative advantage, aging inevitably affects neuromuscular control and postural stability, placing even formerly active individuals at risk for balance impairments [6-8].

Dynamic balance, in particular, is critical for performing activities of daily living (ADLs) safely and effectively. It involves the ability to maintain stability during movement or while transitioning between positions [9]. This type of balance is especially challenged during walking, turning, or navigating obstacles – activities that are vital for independence but are also common scenarios where falls occur among older adults [10, 11].

There is a growing interest in the role of targeted exercise programs in maintaining or restoring balance in aging populations. Two commonly applied interventions are Functional Balance Training (FBT) and Core Stabilization Exercises (CSE). FBT aims to simulate real-life movement challenges by incorporating multi-joint, multi-planar movements that train the body to stabilize under dynamic conditions [12-14]. On the other hand, CSE focuses on strengthening the core musculature responsible for stabilizing the trunk and pelvis during movement, thereby enhancing overall postural control [15, 16].

While extensive literature supports the benefits of balance training in athletes and elderly populations individually, few studies specifically examine the impact of such training in older adults who were previously athletic. This demographic represents a unique intersection benefiting from residual athletic conditioning, yet still vulnerable to age-related declines in neuromuscular function.

AIM

Therefore, this study aims to explore the comparative effects of FBT and CSE on dynamic balance among former older athletes. Understanding which intervention is more effective for this population may help optimize fall prevention strategies and enhance quality of life in aging athletic individuals.

MATERIALS AND METHODS

This study employed a randomized controlled trial (RCT) with a pre-test and post-test design to evaluate the effects of Functional Balance Training (FBT) and Core Stabilization Exercise (CSE) on dynamic balance among former older athletes. Twenty participants aged 60 and above with a history of regular athletic participation either recreational or competitive were recruited through purposive sampling. All participants were able to ambulate independently, and none had engaged in structured balance training within the past three months.

Inclusion criteria required participants to be 60 years of age or older, with previous athletic experience and the ability to perform basic mobility and self-care tasks independently. To ensure safety and suitability for the intervention, participants were required to have adequate cardiovascular fitness to engage in moderate-intensity exercises, as determined by a pre-screening questionnaire and medical clearance from their physician. They were also expected to demonstrate cognitive ability to follow verbal instructions and perform balance-related tasks safely.

However, a limitation acknowledged during participant selection was the lack of uniform criteria for quantifying or standardizing athletic experience. Since participants had engaged in various sports and physical activities at different intensities and durations earlier in life, athletic background was assessed through a structured self-report questionnaire and an interview focusing on the type of sport, duration of involvement, training frequency, and years since cessation. Participants were included if they were aged 60 years or above, able to ambulate independently and capable of performing activities of daily living. All participants were required to have a background in at least one organized sport either individual or team-based, such as athletics, football, badminton, volleyball, swimming, or tennis with structured training rather than casual or recreational-only activity. To qualify as former athletes, participants must have engaged in continuous athletic participation for a minimum of five years, with a typical training frequency of three to six sessions per week lasting 60-120 minutes per session. They must have discontinued structured athletic training for at least five years prior to the study but not more than fifteen years, ensuring representation of an aging yet previously trained population. Individuals currently involved in structured exercise, balance or strength programs were excluded, though light recreational activities such as walking were permitted. Participants were also required to obtain medical clearance confirming their ability to engage safely in moderate physical activity. Those with recent musculoskeletal injuries within six months, severe visual or vestibular impairments, or neurological conditions or were under medication known to affect balance or coordination were excluded.

Participants were thoroughly informed about the study objectives and procedures, and written informed consent was obtained from all individuals prior to inclusion. Ethical approval for the study was granted by the institutional review board and confidentiality, safety and voluntary participation were maintained throughout the research process.

Participants were randomly allocated into two equal groups (A and B) of ten individuals using a simple randomization method. Both the interventions lasted for six weeks, with sessions conducted three times per week under supervision.

The FBT protocol for Group A was adapted from Oliver and collegues and Ruiz and Richardson, modified to suit the capabilities and safety requirements of older adults [12, 14]. Exercises included standing weight shifts, tandem stance ball toss, single-leg stance with upper limb movements, forward and lateral lunges and directional step-ups on stable or slightly unstable surfaces such as foam pads and wobble boards [17, 18].

Group B followed a CSE protocol based on Imai and Sandrey and Mitzel, also adapted for older adults. This training focused on core strength and trunk stability using exercises such as seated pelvic tilts, supine bridges, bird-dogs, side-lying leg raises, and short-duration planks against a wall or with support. Each session included a five-minute warm-up and cool-down with light stretching and mobility exercises [16, 19, 20].

To assess outcomes, the Star Excursion Balance Test (SEBT) was used to measure dynamic balance in eight directions. Participants performed three trials per leg, and reach distances were normalized to leg length [18]. The SEBT is well-established for identifying dynamic postural control deficits in both athletic and aging populations. Additionally, the Berg Balance Scale (BBS) was used to assess functional balance and fall risk. This 14-item clinical tool evaluates performance on tasks such as standing, reaching, turning, and transferring, with scores ranging from 0 to 56. Higher scores indicate better balance and lower fall risk.

Baseline measurements of SEBT and BBS were collected before the intervention, and the same assessments were repeated after six weeks. Data collection was conducted by blinded assessors who were unaware of group assignments to minimize bias. Statistical analysis involved descriptive statistics (mean and standard deviation) for all variables, and changes from pre- to post-intervention were analyzed using paired and independent t-tests. A p-value of less than 0.05 was considered statistically significant.

RESULTS

PARTICIPANT DEMOGRAPHICS

A total of 20 former older athletes completed the study, with 10 participants in each group. Baseline demographic analysis showed no statistically significant differences between Group A (Functional Balance Training – FBT) and Group B (Core Stabilization Exercise – CSE) in terms of age, height, weight, or BMI, ensuring comparability between the groups as shown in Table 1.

WITHIN-GROUP COMPARISON: SEBT

After the six-week intervention, both groups showed improvements in dynamic balance as assessed by the SEBT. However, Group A (FBT) demonstrated greater gains

Table 1. Participant Demographics

Variable	Group A (FBT)	Group B (CSE)	p-value
Age (years)	66.2±3.1	65.8±2.9	0.745
Height (m)	1.65±0.07	1.64±0.08	0.826
Weight (kg)	68.4±7.2	69.1±6.8	0.791
BMI (kg/m^2)	25.1±2.3	25.6±2.0	0.609

Table 2. SEBT Composite Scores (Normalized, %)

Group	Limb	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Difference	p-value
FBT (A)	Right Leg	80.5±7.4	87.9±6.5	7.4	0.001
FBT (A)	Left Leg	78.3±8.2	86.1±7.0	7.8	0.001
CSE (B)	Right Leg	81.2±6.8	85.3±6.1	4.1	0.032
CSE (B)	Left Leg	79.6±7.1	83.2±6.4	3.6	0.045

Table 3. Berg Balance Scale Scores

Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Difference	p-value
FBT (A)	47.3±3.5	53.1±2.4	5.8	0.000
CSE (B)	47.8±3.3	51.0±2.7	3.2	0.007

Table 4. Between-Group Comparison (Post-Test)

Outcome Measure	Group A (FBT) Mean ± SD	Group B (CSE) Mean ± SD	p-value
SEBT – Right Leg	87.9±6.5	85.3±6.1	0.041
SEBT – Left Leg	86.1±7.0	83.2±6.4	0.048
BBS Score	53.1±2.4	51.0±2.7	0.039

in composite scores for both the right and left leg, with mean differences of +7.4% and +7.8%, respectively, both reaching statistical significance (p=0.001). Group B (CSE) also showed improvements, but the changes were smaller, with mean increases of +4.1% (right leg) and +3.6% (left leg), and p-values slightly above or at the significance threshold as mentioned in Table 2.

These improvements suggest that both exercise programs had a positive impact on the participants' ability to control their balance dynamically. The larger changes in the FBT group imply that dynamic, task-specific movements may provide a more effective stimulus for enhancing balance in aging athletes compared to static core exercises.

WITHIN-GROUP COMPARISON: BBS

Functional balance, as assessed by the Berg Balance Scale (BBS), also improved significantly in both groups. Group A's BBS scores increased from 47.3±3.5 to 53.1±2.4, while Group B's scores improved from 47.8±3.3 to 51.0±2.7. The improvement was more substantial in the FBT group, indicating a stronger effect on activities of daily living such as standing, turning, and reaching as mentioned in Table 3.

The clinical interpretation of BBS suggests that scores above 50 indicate lower risk of falls. The post-intervention values in both groups approached or exceeded this threshold, suggesting practical improvements in fall risk reduction.

BETWEEN-GROUP POST-TEST COMPARISON

An independent t-test was used to compare post-intervention performance between the two groups. Group A consistently outperformed Group B in all measures, with statistically significant differences in SEBT composite scores (right and left leg) and BBS scores as mentioned in Table 4.

These results confirm that although both training modalities were beneficial, FBT yielded superior improvements in both dynamic and functional balance. This supports the notion that incorporating sport-like, reactive, and full-body movements is particularly effective for former older athletes who retain the capacity to engage in complex movement patterns.

The observed improvements in SEBT and BBS scores demonstrate not only statistical significance but also clinically meaningful functional gains for older former athletes. An increase of more than 4 points in BBS is generally considered a minimally clinically important difference (MCID), indicating a real improvement in functional balance and reduced fall risk. Similarly, a 7-8% increase in SEBT composite reach distance reflects enhanced dynamic stability and postural control, translating into better performance in daily and sport-like tasks such as walking on uneven surfaces, directional changes and recovery from perturbations. Therefore, the findings have strong clinical implications, Functional Balance Training (FBT) can be recommended as a targeted rehabilitation or maintenance strategy to preserve and improve balance, prevent falls and sustain mobility independence among older adults with an athletic background.

DISCUSSION

This study aimed to compare the effects of Functional Balance Training (FBT) and Core Stabilization Exercise (CSE) on dynamic and functional balance among former older athletes. The results showed that both interventions significantly improved balance performance as measured by the Star Excursion Balance Test (SEBT) and the Berg Balance Scale (BBS). However, FBT demonstrated a greater overall improvement in both dynamic reach distances and BBS scores compared to CSE.

The significant improvement in SEBT composite scores for both legs in the FBT group supports findings from previous studies showing that FBT enhances neuromuscular coordination and joint stability through multi-planar, sport-relevant movements [14, 21]. From a neurophysiological standpoint, these movements stimulate proprioceptive feedback loops and motor cortex activation, leading to better synchronization between sensory input and motor output. Such adaptive changes in the sensorimotor system contribute to improved postural reactions and movement accuracy. In aging individuals, where proprioceptive acuity and reaction time often decline, dynamic and reactive tasks like those in FBT may facilitate neural plasticity and preserve functional connectivity between the cerebellum, basal ganglia and motor cortex [22, 23]. Thus, the improvements seen in SEBT may not only reflect mechanical enhancement but also central adaptations in postural control mechanisms.

Similarly, the observed improvements in BBS scores across both groups suggest that balance training whether through core-focused or functional movement can positively affect postural control and reduce fall risk in older adults. These findings align with Perrin and colleagues in the year 1999, who noted that engagement in physical activity helps maintain balance control in elderly individuals, and with Pollock and colleagues, who emphasized the importance of combining strength and balance exercises for fall prevention in frail populations [1, 3, 24]. The significant rise in BBS scores in both groups implies that training enhanced both static and functional balance domains, possibly through improvements in joint proprioception, trunk control, and confidence in movement execution. The clinical interpretation of these BBS changes suggests meaningful reductions in fall risk, as post-intervention scores approached or surpassed the fall-risk threshold value of 50, indicating tangible functional benefits.

Interestingly, while CSE also resulted in significant improvements, the magnitude of change was smaller than that seen with FBT. This may be due to the more static nature of core training exercises, which, although beneficial for trunk stability, may not sufficiently challenge reactive balance or dynamic postural control [15, 16]. Core stabilization primarily recruits deep trunk musculature such as the transverse abdominis and multifidus, enhancing proximal stability; however, it lacks the perturbation-based and multi-directional elements that promote reactive balance control. Therefore, although CSE improves central stability and spinal alignment, its carryover to functional, whole-body balance may be limited compared to FBT. The results support earlier claims that while core stability is essential, dynamic balance control requires practice of task-specific, functional movements [21, 22].

Another notable factor is the background of participants as former athletes. While previous studies show that retired athletes tend to maintain better balance compared to non-athletic peers, aging still leads to neuromuscular decline, increased reaction time, and proprioceptive deficits [6-8]. Former athletes typically possess residual motor memory and higher baseline proprioceptive function, which could have facilitated faster learning responses during both interventions. However, the age-related decline in type II muscle fiber recruitment and central processing speed underscores the need for continuous, targeted training to retain motor proficiency. This finding reinforces the importance of tailored exercise strategies that exploit residual athletic adaptability while addressing the physiological limitations of aging.

The findings also resonate with work by Berg, who suggested that balance training in older athletes should be progressive and dynamic to effectively preserve functional mobility [2]. Moreover, the study by Jacobson emphasized the utility of tools like the BBS in fall-risk assessments for older adults, validating its inclusion in this study alongside the SEBT [23]. These complementary tools offer a multidimensional view of balance SEBT capturing dynamic reach and postural control, while BBS reflects stability during daily living tasks together providing a comprehensive measure of functional ability and fall risk.

From a deeper clinical perspective, these findings highlight that FBT promotes not only muscular strength and coordination but also sensorimotor integration, anticipatory control, and reactive adaptability all key elements for safe movement in older adults. Functional tasks that simulate real-world challenges enhance cognitive-motor coupling and improve attentional control, crucial for maintaining postural stability under dual-task or unpredictable conditions. In contrast, while CSE strengthens core musculature and enhances trunk stability, its transferability to complex balance tasks appears limited when not integrated with dynamic, context-specific challenges.

This study provides evidence that both FBT and CSE are effective strategies for improving balance in aging former athletes, with FBT offering a more pronounced benefit. These outcomes underline the importance of incorporating dynamic, functional movements into exercise programs designed for older adults, especially those seeking to maintain independence and reduce fall risk. Clinically, the improvements observed in SEBT and BBS exceed thresholds considered minimally clinically important, suggesting that these gains are not merely statistical but reflect meaningful improvements in daily function and fall prevention capacity. The use of dynamic, real-world movements in FBT may stimulate cognitive and sensorimotor engagement more effectively than isolated core strengthening exercises, leading to broader neurofunctional benefits. Despite these promising outcomes, several limitations should be noted. First, the sample size was relatively small (n=20), which may limit the statistical power and generalizability of the results. A larger, more diverse sample would provide a more robust basis for drawing conclusions across wider populations. Second, the duration of the intervention six weeks was relatively short. While improvements were observed, a longer training period might produce more pronounced and sustained result. Third, while both SEBT and BBS are validated tools for balance assessment, future studies could incorporate additional measures such as gait speed, single-leg stance time, or functional mobility tests like the Timed Up and Go (TUG) for a more comprehensive understanding of balance and fall risk.

CONCLUSION

This study investigated the effects of Functional Balance Training (FBT) and Core Stabilization Exercise (CSE) on dynamic and functional balance among former older athletes aged 60 years and above. Both interventions led to significant improvements in balance performance as measured by the Star Excursion Balance Test (SEBT) and the Berg Balance Scale (BBS). However, participants in the FBT group experienced greater improvements in both dynamic reach distances and overall balance function compared to those in the CSE group. These findings suggest that while both programs are beneficial, FBT may be more effective in enhancing the neuromuscular coordination and postural control necessary for preventing falls in aging populations, particularly those with a history of athleticism.

Furthermore, individual variables such as foot morphology, lower limb strength, and flexibility were not controlled or analyzed in this study. Given that these factors can influence dynamic balance outcomes, future research should consider integrating biomechanical assessments to better understand their roles. Lastly, while participants were all former athletes, their prior sport types, training intensities, and retirement durations were not standardized – variables that may influence responsiveness to balance training.Future research should aim to build on these findings by employing larger samples, longer follow-up periods, and a wider array of balance and functional performance assessments to better support balance training protocols for aging but active populations.

REFERENCES

1. Pollock RD, Martin FC, Newham DJ. Whole-body vibration in addition to strength and balance exercise for falls-related functional mobility of frail older adults: a single-blind randomized controlled trial. Clin Rehab. 2012;26(10):915-23r. doi: 10.1177/0269215511435688.
2. Berg K. Balance and its measure in the elderly: a review. Physiother Canada. 1989;41(5):240-6. doi:10.3138/ptc.41.5.240
3. Perrin PP, Gauchard GC, Perrot C, Jeandel C. Effects of physical and sporting activities on balance control in elderly people.Br J Sports Med. 1999;33(2):121-6. doi: 10.1136/bjsm.33.2.121.
4. Wolfson L, Whipple R, Derby CA et al. A dynamic posturography study of balance in healthy elderly. Neurology. 1992 Nov;42(11):2069. doi: 10.1212/wnl.42.11.2069.
5. Zemková E, Zapletalová L. The role of neuromuscular control of postural and core stability in functional movement and athlete performance. Front Physiol. 2022:13:796097. doi: 10.3389/fphys.2022.796097.
6. Brauer SG, Neros C, Woollacott M. Balance control in the elderly: do Masters athletes show more efficient balance responses than healthy older adults?. Aging Clin Exp Res. 2008 Oct;20(5):406-11. doi: 10.1007/BF03325145.
7. Ganse B, Degens H. Current insights in the age-related decline in sports performance of the older athlete. Int J Sports Med. 2021;42(10):879-888. doi: 10.1055/a-1480-7730.
8. Lee C, Fleming N, Donne B. Comparison of balance variables across active and retired athletes and age matched controls. Int J Exerc Sci. 2021;14(3):76-92. doi: 10.70252/YPEF5513.
9. Silva AD, Almeida GJ, Cassilhas RC et al. Balance, coordination and agility of older individuals submitted to physical resisted exercises practice. Revista Brasileira de Medicina do Esporte. 2008;14(2):88-93. doi:10.1590/S1517-86922008000200001.
10. Dunsky A. The effect of balance and coordination exercises on quality of life in older adults: a mini-review. Front Aging Neurosci. 2019:11:318. doi: 10.3389/fnagi.2019.00318.
11. Sadeghi H, Shojaedin SS, Abbasi A et al. Lower-extremity intra-joint coordination and its variability between fallers and non-fallers during gait. Applied Sciences. 2021;11(6):2840.doi: 10.3390/app11062840.
12. Ruiz R, Richardson MT. Functional balance training using a domed device. Strength Condit Jl. 2005;27(1):50-5. doi: 10.1519/00126548-200502000-00010.
13. Carroll TJ, Benjamin B, Stephan R, Carson RG. Resistance training enhances the stability of sensorimotor coordination. Proc Biol Sci. 2001;268(1464):221-7. doi: 10.1098/rspb.2000.1356.

14. Oliver GD, Di Brezzo R. Functional balance training in collegiate women athletes.J Strength Cond Res. 2009;23(7):2124-9. doi: 10.1519/JSC.0b013e3181b3dd9e.
15. Reed CA, Ford KR, Myer GD, Hewett TE. The effects of isolated and integrated core stability'training on athletic performance measures: a systematic review. Sports Med. 2012 Aug 1;42(8):697-706. doi: 10.2165/11633450-000000000-00000.
16. Sandrey MA, Mitzel JG. Improvement in dynamic balance and core endurance after a 6-week core-stability-training program in high school track and field athletes. J Sport Rehabil. 2013;22(4):264-71. doi: 10.1123/jsr.22.4.264.
17. Desai A, Goodman V, Kapadia N et al. Relationship between dynamic balance measures and functional performance in community-dwelling elderly people. Phys Ther. 2010;90(5):748-60. doi: 10.2522/ptj.20090100.
18. Segal AD, Vargas BL, Richards FG, Shelley CJ, Silverman AK. Healthy aging reduces dynamic balance control as measured by the simplified Star Excursion Balance Test. Gait Posture. 2023:103:190-195. doi: 10.1016/j.gaitpost.2023.05.020.
19. Dinç N, Ergin E. The Effect of 8-Week Core Training on Balance, Agility and Explosive Force Performance. Univer J Educatl Res. 2019;7(2):550-5. doi: 10.13189/ujer.2019.070227.
20. Imai A, Kaneoka K, Okubo Y et al. Trunk muscle activity during lumbar stabilization exercises on both a stable and unstable surface. J Orthop Sports Phys Ther. 2010;40(6):369-75. doi: 10.2519/jospt.2010.3211.
21. Van Diest M, Lamoth CJ, Stegenga J et al. Exergaming for balance training of elderly: state of the art and future developments. J Neuroeng Rehabil. 2013 Sep 25:10:101. doi: 10.1186/1743-0003-10-101.
22. Brachman A, Kamieniarz A, Michalska J et al. Balance training programs in athletes – a systematic review.J Hum Kinet. 2017:58:45-64. doi: 10.1515/hukin-2017-0088.
23. Laessoe U, Hoeck HC, Simonsen O et al. Fall risk in an active elderly population–can it be assessed? J Negat Results Biomed. 2007 Jan 26:6:2. doi: 10.1186/1477-5751-6-2.
24. Targino VR, Freire AD, Sousa AC et al. Effects of a dual-task training on dynamic and static balance control of pre-frail elderly: a pilot study. Fisioterapia em Movimento. 2012;25:351-60. doi: 10.1590/S0103-51502012000200013.

LIST OF ABBREVIATIONS:
ADLs – Activities of Daily Living
BBS – Berg Balance Scale
BMI – Body Mass Index
CSE – Core Stabilization Exercise
FBT – Functional Balance Training
RCT – Randomized Controlled Trial
SEBT – Star Excursion Balance Test
TUG – Timed Up and Go (Test)

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Improvement of psycho-physical condition of mature women through rehabilitative fitness (based on aqua aerobics)

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ABSTRACT

Aim: To study the impact of aquafitness on the psychophysical state of women of mature age.

Materials and Methods: The study involved 15 women aged 35-45 years. Aquafitness sessions were conducted at the "Beach" water park in Lviv, Ukraine, three times per week for 45 minutes each. The following research methods were used: analysis and synthesis of scientific literature and online sources; sociological (questionnaire); biomedical (anthropometry, BMI, physical fitness assessment, adaptive potential); the "Well-being, Activity, Mood" (WAM) scale to assess psycho-emotional state; pedagogical (observation, experiment); and statistical methods for data analysis.

Results: A targeted aquafitness program was developed and its effectiveness was confirmed by the study results. Participants demonstrated improvements in cardiovascular indicators, normalization of body mass index, increased physical fitness levels, and positive changes in psycho-emotional well-being. There was a reduction in the number of women with low physical fitness and poor emotional state, alongside an increase in participants with improved mood and satisfactory physical condition. These findings support the use of aquafitness as an effective health-promoting intervention under conditions of chronic stress.

Conclusions: It has been found that under the influence of aquafitness classes, not only physical indicators have improved, including the level of physical fitness, but also functional aspects, including adaptive potential. Health-recreational activities have also had a positive impact on the emotional state of mature women, contributing to improving their overall health.

KEYWORDS: aquafitness, martial law, women of mature age, physical condition, psychological condition

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INTRODUCTION

Women's health, encompassing their reproductive, caregiving, occupational, and societal roles, significantly influences the overall well-being of a nation. In mature adulthood, women often achieve professional and social fulfillment; however, physiological changes, neuroendocrine restructuring, and age-related diseases can adversely affect their well-being [1, 2]. These factors, in turn, diminish their work capacity and complicate the performance of daily responsibilities. This issue gains particular relevance in the current Ukrainian context, where a full-scale war has persisted for the third consecutive year. The constant threat to life, psychological tension, loss of loved ones, forced displacement, and socio-economic instability contribute to heightened levels of stress, anxiety, and depressive states among women. Despite such challenging circumstances, it is crucial for Ukrainian women to find opportunities to maintain their physical and mental health, notably through fitness activities [3]. Researchers advocate various forms of physical activity to support both physical and psycho-emotional well-being, including rehabilitative fitness [4, 5], with aqua aerobics being a prominent example [6, 7]. Aqua aerobics combines elements of physical exercise, hydrotherapy, and emotional relief, offering a safe and effective workout suitable for individuals of different ages and fitness levels.

The impact of aqua fitness on women's health has been extensively examined by numerous researchers [1, 8-10]. Kantyka J., Herman D., Roczniok R., and Kuba L. [11], along with Haifeng Zhu, Jing Jin, and Gaonian Zhao [12, 13], investigated changes in body mass and composition among middle-aged women. D'Acquisto L.J. et al. [14] substantiated the physiological and psychophysical benefits of aqua fitness. Currie J.L. explored the social aspects and indicators of women's subjective well-being [15]. Zhou S. et al. [16], Jesús Casilda-López, MSc, et al. [17], and Saavedra J.M. [18] described the positive effects of aqua fitness on physical fitness and quality of life in postmenopausal women. Sheyko L. focused on the emotional state and work capacity of women [19-21], while Andrade L.S. et al. examined the cardiorespiratory parameters in women [22]. Studies have also addressed the improvement of emotional health through aqua fitness in breast cancer patients [23], the impact of aqua fitness on the physical condition of women in their late maturity [24, 25], and the correction of posture and balance [26], among other topics.

Despite the substantial body of research, the issue of identifying effective strategies to enhance the health of women aged 35-45 during wartime remains pertinent.

Association with Scientific Programs, Plans, and Topics: ehis research was conducted in accordance with the Consolidated

Research Plan of the Ivan Boberskyi Lviv State University of Physical Culture for 2021-2025, under the theme 3.2: „Health-Enhancing Physical Activity in Recreational Activities of Various Population Groups in Ukraine."

AIM

The aim of the study is – to study the impact of aquafitness on the psychophysical state of women of mature age.

MATERIALS AND METHODS

The study employed the following methods: analysis, generalization, and systematization of data from scientific and methodological literature, as well as online sources, to explore the research problem; sociological methods (questionnaire survey); biomedical methods (anthropometry, body mass index (BMI), level of physical condition (LPC), adaptive potential (AP)); the „Well-being, Activity, Mood" (WAM) method to assess psycho-emotional state; pedagogical methods (observation, experiment); and methods of mathematical statistics for processing the obtained results.

The study involved 15 women aged 35-45 years. Classes were held in the water park „Beach" (Lviv, Ukraine) three times a week for 45 minutes for 6 months.

The inclusion criteria for women in the study were: age 35-45 years old; doctor's approval; availability of time for attending systematic sessions, compliance with the requirements of the pedagogical experiment, consent to participate in the study. The exclusion criteria for women in the study were: age over 45 years old, lack of doctor's approval; women's refusal to participate in the study. The women agreed to participate in the study and were informed of the possibility of refusing to participate without any consequences for them.

The research conducted adheres to the requirements outlined in the Law of Ukraine "On Scientific and Scientific-Technical Activities" dated November 26, 2015, No. 88-VII and aligns with international ethical guidelines for health-related research involving humans (International Ethical Guidelines for Health-related Research Involving Humans, Fourth Edition. Geneva. Council for International Organizations of Medical Sciences, (CIOMS), 2016).

RESULTS

The survey conducted revealed that 93% of women of mature age find physical activity helpful in combating stress and maintaining their health. Among all the proposed wellness activities, the majority of women (54.5%) chose aqua fitness as a way to improve their psychophysical state. Water fitness programs involve performing a set of physical exercises to music, incorporating elements of swimming, gymnastics, stretching, strength exercises, and using water resistance to effectively burn calories, reduce body weight, strengthen the heart muscle, increase lung capacity, and improve metabolism. We took into account all the recommendations from experts and developed an aqua fitness program for women, focusing on exercises to develop overall and cardiorespiratory endurance, strength exercises for body weight correction, reducing the number of high-intensity strength exercises, and incorporating smooth and slow movements aimed at recovery and relaxation (Fig. 1).

In the preparatory phase (10-15%), women performed exercises for water acclimatization, general developmental exercises, and running drills (walking, side steps, arm movements, head turns, knee lifts, stretching, etc.) to music with a tempo of 128-132 beats per minute. The exercises primarily involved simultaneous activation of the muscles in the lower limbs and upper shoulder girdle. The heart rate (HR) during the preparatory phase ranged from 110 to 140 beats per minute.

In the main part of the session (70-75%), a choreographic combination of 64 counts was taught, and exercises were performed in the form of circuit training to develop strength and endurance (with additional equipment). The music tempo was 132-136 beats per minute. The heart rate (HR) ranged from 140 to 160 beats per minute.

The concluding part involved exercises for relaxation, slow swimming (simulating athletic movements, walking, gentle arm and leg swings combined with slow and smooth movements).

As a result of the conducted research, it was found that almost 45% of women showed an improvement in their body mass index (BMI); 53.3% of women had a normal BMI, 40% had BMI within the pre-obesity range, and one woman (6.6%) had a BMI indicating insufficient weight. Overall, the average BMI decreased during the pedagogical experiment from 24.9±1.1 units to 24.0±0.9 units ($p \leq 0.05$). Therefore, most BMI indicators showed significant changes in body weight reduction, which also positively affected the emotional state of the women.

After 6 months of training, the average HR of the women participating in the study decreased to 81.7 beats per minute, which is practically within the normal range; the average blood pressure (BP) decreased to 123.7/77.7 mm Hg, which is considered „optimal." Additionally, the average adaptation potential of the cardiovascular system statistically decreased to 2.7±0.1 units, indicating overall strain in the adaptation mechanisms (Table 1).

An analysis of the levels of adaptation potential (AP) revealed that under the influence of recreational activities, the number of women who went into a state of „tension of mechanisms" increased to 86.7%; decreased to 6.6% the number of those women who had satisfactory and unsatisfactory adaptation. It is important that there are no women who have had a breakdown in adaptation (Fig. 2).

Changes were also recorded regarding the level of physical condition (LPC) of the women, specifically: the percentage of women with low LPC decreased (from 66.7% to 33.3%); the percentage of women with below-average LPC increased (from 26.7% to 46.7%); and 13.3% of individuals were found to have an average LPC. The changes that occurred are statistically significant (Fig. 3).

That is, positive changes were observed in the physical fitness level of mature-aged women, which indicates the effectiveness of the proposed wellness and recreational aqua fitness program.

It is known that emotional well-being is an important characteristic of mental activity over a certain period, influenced by external factors, the person's condition, etc. This is particularly important in wartime conditions. Therefore, a study was conducted on the emotional well-being of mature-aged women using the WAM methodology. A positive trend was observed among women ($p > 0.05$), with an increase in the number of individuals reporting good health and a decrease in those with poor health; an increase was noted in the number of women with medium (up to 66.6%) and high (up to 13.3%) activity levels, while the number of women with low activity decreased (Table 2).

The changes in the study results regarding the self-assessment of mood are statistically significant ($p \leq 0.05$).

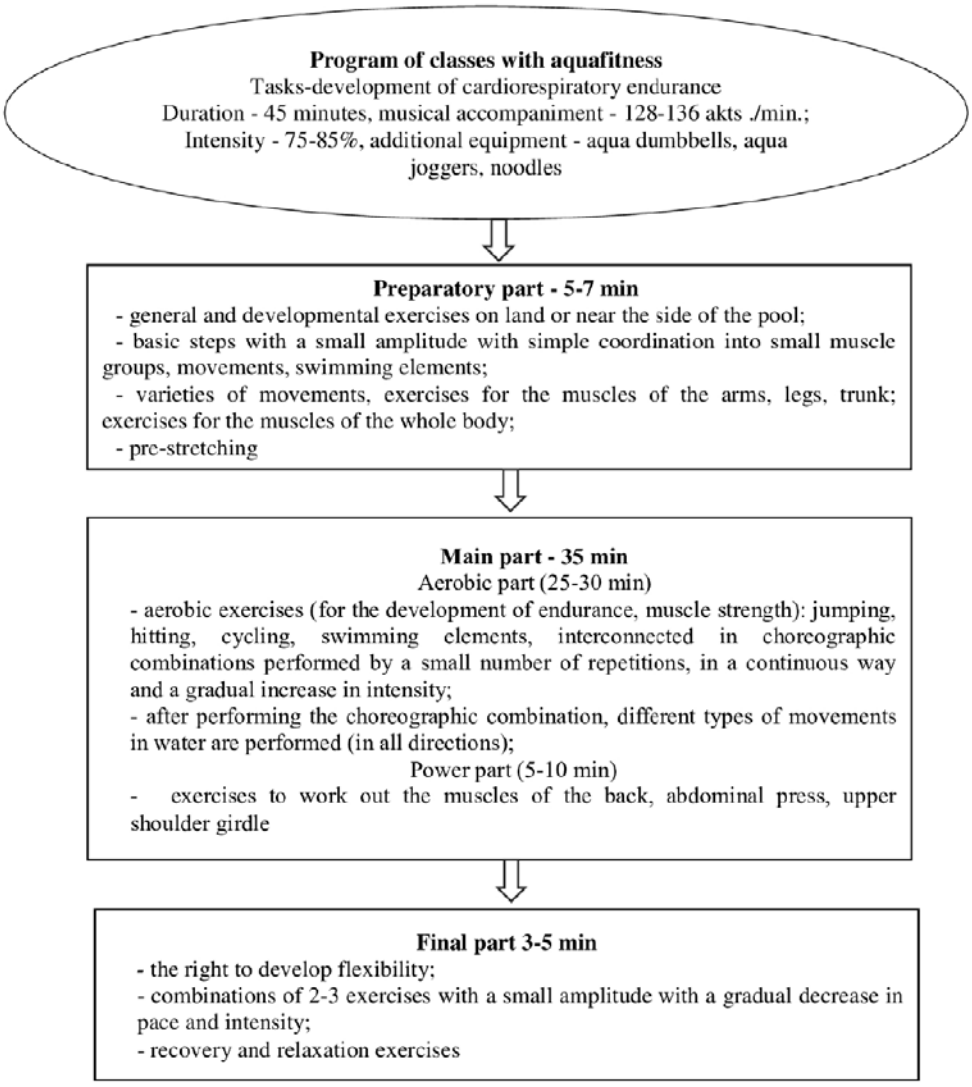

Fig. 1. Scheme of wellness classes on aquafitness for women of mature age

Table 1. Basic indicators of the cardiovascular system of women

№	Indicators	Before PE (n=15)			After PE (n=15)			p
		M±SD	Me	Dx	M±SD	Me	Dx	
1	Body weight, kg	66.7±3.5	66.0	184.1	64.3±3.0	63.0	139.2	p≤0.05
2	Body mass index, mind. units	24.9±1.1	24.9	17.18	24.0±0.9	24.0	12.37	p≤0.05
3	Height, cm	163.2± 1.3	165.0	26.6	163.5± 1.3	165.0	25.2	p>0.05
4	Heart rate, bpm	87.2±3.1	88.0	147.7	81.7±2.4	85.0	84.5	p≤0.05
5	Systolic pressure (SP, mm Hg)	130± 4.1	135.0	253.5	123.7± 3.0	125.0	137.4	p≤0.05
6	Diastolic pressure (DP, mm Hg)	81.1± 2.3	80.0	79.3	77.7± 1.5	80.0	31.7	p≤0.05
7	Adaptation potential, mind. units.	2.9± 0.2	2.94	0.57	2.7± 0.1	2.71	0.15	p≤0.05

Table 2. Changes in psycho-emotional state indicators in the subjects (%)

Indicators		Results (n=15)		p
		Before PE	After PE	
Well-being	Unsatisfactory	20.0	13.3	p>0.05
	Satisfactory	66.6	53.3	
	Good	13.3	33.3	
Activity	Low	40.0	20.0	p>0.05
	Average	53.3	66.6	
	High	6.7	13.3	
Mood	Bad	26.7	20.0	p≤0.05
	Satisfactory	60.0	66.6	
	Kind	13.3	13.3	

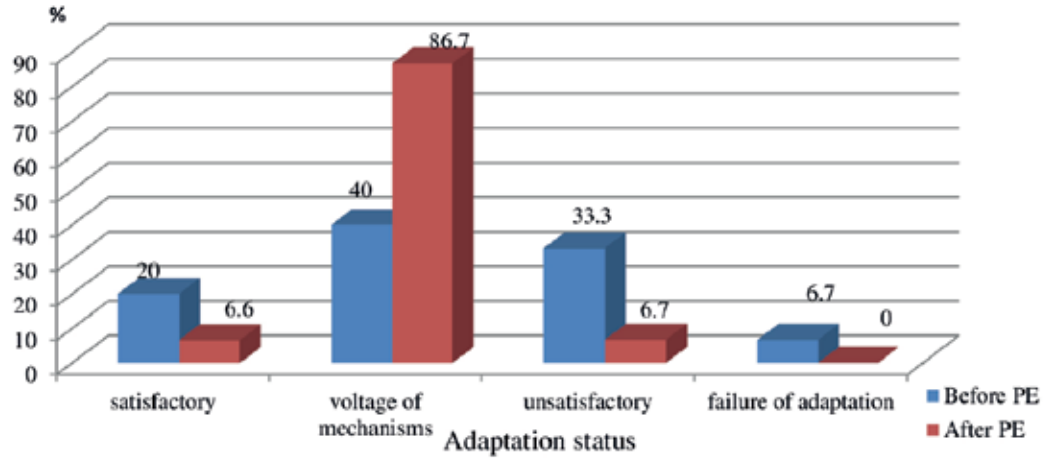

Fig. 2. Indicators of adaptation potential before and after a pedagogical experiment (%)

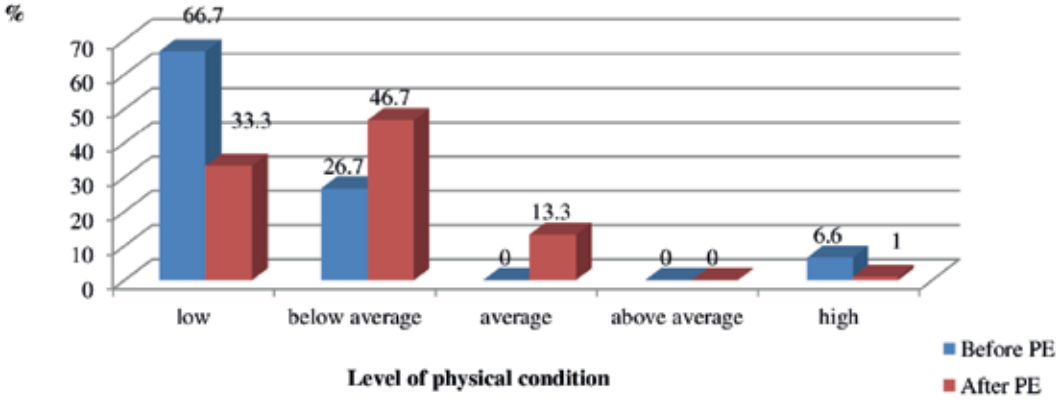

Fig. 3. Changes in the level of physical condition of women engaged in aqufitness (%)

Specifically, the number of women with a poor mood decreased (to 20%), while the number of women with a satisfactory mood increased (to 66.6%). In other words, wellness and recreational aqua fitness sessions for women proved to be effective, which is particularly important during wartime, as it provokes anxiety and depression.

DISCUSSION

The results we obtained are consistent with existing data on the multivector health-promoting effects of aqua aerobics on the bodies of middle-aged women, while also complementing them with new insights gathered under the conditions of chronic wartime stress.

The improvement in the psycho-emotional state of participants – an increase in the proportion of women reporting good well-being, higher activity levels, and a positive mood – correlates with Sheyko L.'s findings regarding mood enhancement after swimming sessions [19] and supports the observations of Currie J. L. concerning the anti-stress and socially integrative effects of aqua

aerobics [15]. Similar trends in psychosocial indicators among women were documented by Dalamitros A. A. after a 10-week aqua fitness program [1] and by Zhou S. and colleagues in postmenopausal women [16]. Our data expand on these findings by demonstrating a positive effect under conditions of prolonged external tension.

Changes in body mass index and the redistribution of participants toward its normal range, as well as improvements in cardiorespiratory function, confirm the high effectiveness of water-based exercise, as highlighted in the studies by Andrade L. S. [22], Kantyka J. et al. [11], Saavedra J. M. et al. [18], and the recent meta-analysis by Zhu H. [12]. At the same time, our observations support the argument for positive changes in the functional state of women who were under constant prolonged stress, regardless of social status.

The decreasing number of women with very low physical fitness levels and the formation of a group with a medium level of preparation confirm the findings of Pinto S. S. [27] regarding gains in strength and aerobic capacity from water-based exercise and align with trends described by Dalamitros A. A. [1] and Andrade L. S. [22].

Our findings on the decrease in cardiovascular adaptive potential to the «stress zone» level – without signs of adaptation breakdown – extend current literature, which mostly focused on heart rate or VO_2 max indicators, and deepen the understanding of functional responses to wellness-focused water-based exercise in middle-aged women.

The high engagement of participants in the aqua aerobics program and the absence of negative reactions confirm its safety and psychological comfort, as reported by Bergamin M. [2] and Fernández-Lao C. et al. [23]. Our results suggest that even during prolonged social stress, aqua aerobics remains an attractive and effective means of maintaining the psychophysical health of middle-aged women.

CONCLUSIONS

An analysis was conducted on the use of various types of physical activity to restore health across different age groups. The effectiveness of rehabilitation fitness exercises was identified. It was determined that aqua aerobics is a safe form of exercise for women, regardless of their fitness level.

Rehabilitation fitness sessions (aqua aerobics) increase stress tolerance and stabilize emotional state, promoting better adaptation to external conditions and positively affecting physical health indicators.

REFERENCES

1. Dalamitros AA, Kouloglou A, Nasoufidis G et al. Impact of a 10-week aqua fitness intervention on physical fitness and psychosocial measures in inactive healthy adult women. Healthcare. 2025;13(3):334. doi:10.3390/healthcare13030334.
2. Bergamin M, Ermolao A, Tolomio S et al. Water- versus land-based exercise in elderly subjects: effects on physical performance and body composition. Clin Interv Aging. 2013;8:1109-1117. doi:10.2147/CIA.S44198.
3. Chekhovska L.Ya. Health Fitness in Modern Society: Monograph. Lviv: Ivan Bobersky Lviv State University of Physical Culture; 2019. 293 p.
4. Chekhovska M. Rehabilitation Fitness: Essence and Development Prospects. In: Problems of Activating Recreational and Health-Improving Activities of the Population: Proceedings of the 11th International Scientific and Practical Conference; April 2018; Lviv, Ukraine. Lviv: LSUPC; 2018. p. 203–206.
5. Vovkanych A, Hrybovska I, Ivanochko V, Hrybovskyi R. Recreational and Health-Improving Activities of Women Using Rehabilitation Fitness Tools. Ukrainian Journal of Medicine, Biology and Sports. 2022;7(4):157-162. doi:10.26693/jmbs07.04.157.
6. Yachnyuk MYu, Zendyk EV, Yachnyuk IE, Yachnyuk YuB. Features of Conducting Aqua Aerobics Classes and Its Variations. Scientific Bulletin of NPU named after M. P. Drahomanov. 2021;(1(129)):131-134.
7. Faíl LB, Marinho DA, Marques EA et al. Effects of 12-week moderate-intensity versus high-intensity water-aerobic training on physical fitness, cardiovascular health, and well-being in adults and older adults: A pragmatic randomized controlled trial. Health Sci Rep. 2024;7:e70223.
8. Hakman AV, Duditska SP, Slobozhaninov AA. Health-Improving Impact of Aqua Fitness Classes on the Body of Middle-Aged Women. Scientific Bulletin of NPU named after M. P. Drahomanov. 2020;(7(127)):33-37.
9. Tkachova A, Dutchak M, Kashuba V et al. Practical implementation of differentiated approach to developing water aerobics classes for early adulthood women with different types of body build. J Phys Educ Sport. 2020;20(Suppl 1):456-460.
10. Kulyk N, Kyseliov V. Assessment of Somatic Health of Middle-Aged Women During Aqua Aerobics Classes. Current Issues of Physical Education for Different Population Groups. 2020:103-109. Available at: https://journals.uran.ua/hdafk-tmfv/article/view/249676
11. Kantyka J, Herman D, Roczniok R, Kuba L. Effects of aqua aerobics on body composition, body mass, lipid profile, and blood count in middle-aged sedentary women. Hum Mov. 2015;16(1):9-14. doi:10.1515/humo-2015-0020.
12. Zhu H, Jin J, Zhao G. The effects of water-based exercise on body composition: a systematic review and meta-analysis. Complement Ther Clin Pract. 2023;52:101766. doi:10.1016/j.ctcp.2023.101766.
13. Kashuba V, Andrieieva O, Hakman A et al. Impact of aquafitness training on physical condition of early adulthood women. Phys Educ Theory Methodol. 2021;21:152-157.
14. D'Acquisto LJ, Miller LJ, D'Acquisto DM et al. Physiological and psychophysical aspects of shallow water exercise. Int J Aquat Res Educ. 2015;9(3):273-291. doi:10.25035/ijare.09.03.05.

15. Currie JL. Women's expressed motivational factors for participation in aquarobics classes. Int J Environ Res Public Health. 2022;19(9):5274. doi:10.3390/ijerph19095274.
16. Zhou S, Mao L, Zhang H et al. Effects of aquatic exercises on physical fitness and quality of life in postmenopausal women: an updated systematic review and meta-analysis. Front Physiol. 2023;11:1126126. doi:10.3389/fpubh.2023.1126126.
17. Casilda-López J, Valenza MC, Cabrera-Martos I et al. Effects of a dance-based aquatic exercise program in obese postmenopausal women with knee osteoarthritis: a randomized controlled trial. Menopause. 2017;24(7):000-000. doi:10.1097/GME.0000000000000841.
18. Saavedra JM, De La Cruz E, Escalante Y, Rodríguez FA. Influence of a medium-impact aquaerobic program on health-related quality of life and fitness level in healthy adult females. J Sports Med Phys Fitness. 2007;47(4):468-474.
19. Sheyko L. Dynamics of changes in physical and psychoemotional condition of women under the influence of swimming occupations. Slobozhanskyi Herald of Science and Sport. 2017;(1(57)):121-126. doi:10.15391/snsv.2017-1.021.
20. Jackson M, Kang M, Furness J, Kemp-Smith K. Aquatic exercise and mental health: a scoping review. Complement Ther Med. 2022;66:102820. doi: 10.1016/j.ctim.2022.102820.
21. Vedernikova O, Ushakov A. Water aerobics as a means of increasing the psycho-emotional status of women. In: 4th International Conference on Innovations in Sports, Tourism and Instructional Science (ICISTIS 2019). Atlantis Press; 2019:291-292.
22. Andrade LS, Pinto SS, Silva MR et al. Water-based continuous and interval training in older women: cardiorespiratory and neuromuscular outcomes (WATER study). Exp Gerontol. 2020;134:110914. doi:10.1016/j.exger.2020.110914.
23. Fernández-Lao C, Cantarero-Villanueva I, Ariza-García A, Courtney C, Fernández-de-las-Peñas C, Arroyo-Morales M. Water versus land-based multimodal exercise program effects on body composition in breast cancer survivors: a controlled clinical trial. Support Care Cancer. 2013;21(2):521-530. doi:10.1007/s00520-012-1549-x
24. Zhuk H., Khabinets T. The Impact of Aqua Fitness Classes on the Physical Condition of Women in Late Middle Age. Young Sports Science of Ukraine. 2015;19(4):31-34.
25. Goncharova N, Kashuba V, Tkachova A et al. Correction of postural disorders of mature age women in the process of aqua fitness taking into account the body type. Teor Med Fiz Vykhov. 2020;20(3):127-136.
26. Bielec G, Kwasna A, Gaworska P. The influence of Aqua Power aerobics on body mass reduction in middle-aged, overweight women. Turk J Phys Med Rehab. 2017;63(4):293-298. doi:10.5606/tftrd.2017.853
27. Pinto SS, Alberton CL, Cadore EL et al. Water-based concurrent training improves peak oxygen uptake, rate of force development, jump height, and neuromuscular economy in young women. J Strength Cond Res. 2015;29(7):1846-1854. doi:10.1519/JSC.0000000000000820.

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ORIGINAL ARTICLE

Virtual-reality based guided meditation with imagery technique on stress level and quality of life among mastectomy patients

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ABSTRACT

Aim: This study aimed to evaluate the effectiveness of virtual reality-based guided meditation with imagery in managing stress levels and enhancing quality of life among mastectomy patients.

Materials and Methods: In this pilot study, ten women over 30 years old who had undergone mastectomy were divided into two groups. The intervention group (5) participated in virtual reality-guided meditation with imagery and aerobic exercises, while the control group (5) engaged in aerobic exercises alone. Stress and quality of life were assessed using salivary cortisol levels, the SOC-13 scale, and the EORTC QLQ-C30 questionnaire.

Results: Compared to the control group, the intervention group exhibited significant reductions in physiological stress markers and improvements in psychological resilience and quality of life. The findings suggest that incorporating guided imagery and cardiovascular exercises into virtual reality-based meditation significantly benefits post-mastectomy patients.

Conclusions: This non-invasive approach effectively addresses both physiological and psychological stress, supporting its integration into post-mastectomy care to enhance patient outcomes.

KEYWORDS: stress, quality of life, virtual reality, aerobic exercise, mastectomy, adjuvant therapy

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INTRODUCTION

Breast cancer poses both significant physical and emotional challenges, particularly due to its impact on feminine identity. It is the second leading cause of cancer-related mortality among women. The most common type, infiltrating ductal carcinoma, originates in the milk ducts and may spread to surrounding tissues. Risk factors include age, gender, hormone use (especially in older women), and a personal or family history of breast cancer. Estrogen is a key target for hormonal therapy. Treatment varies by stage and receptor status, and may include mastectomy, lumpectomy, radiation, and endocrine therapy. Chemotherapy and systemic therapies are often employed in stages I to III, based on receptor profiles and diagnostic tools like Oncotype DX, while the primary aim in stage IV disease is to enhance quality of life rather than achieve cure [1, 2].

Surgical treatment options for breast cancer include mastectomy and lumpectomy with radiation, both offering similar survival outcomes. In cases of suspected nodal involvement, sentinel lymph node biopsies are performed. Postoperative care may involve chemotherapy, radiotherapy, and hormone therapy. However, beyond physical recovery, many women face emotional and functional challenges following mastectomy, including anxiety, depression, and symptoms of post-traumatic stress. These psychological effects are often underrecognized and undertreated [3].

Complementary therapies such as guided imagery, relaxation techniques, and mindfulness practices have shown promise in improving coping ability, reducing stress and anxiety, enhancing immune function, and alleviating the side effects of chemotherapy [4]. Virtual Reality Therapy (VRT), which simulates immersive real-life experiences, offers a novel approach to addressing the psychological needs of patients. By creating a controlled, interactive environment, VRT increases ecological validity and allows therapists to manage exposure to various stimuli in a safe and effective manner [5].

AIM

This study explores the combined effect of Virtual Reality-based Guided Meditation with imagery techniques and aerobic exercises in reducing stress and improving the quality of life among post-mastectomy patients.

MATERIALS AND METHODS

This pilot study included 10 participants who met specific inclusion criteria. All participants were women over the age of 30 who had undergone mastectomy, were at least one month post-adjuvant therapy, and had elevated salivary cortisol levels. They were recruited from palliative care centers using purposive sampling. Exclusion criteria included visual or hearing impairments, significant dysfunction in other body systems, and being bedridden due to chemotherapy [6].

Participants were randomly assigned to either the intervention or control group, with group assignments

concealed from researchers to minimize bias. Informed consent was obtained from all participants. The purpose, procedures, potential risks, and benefits were explained in detail before enrollment.

The intervention group received Virtual Reality (VR)-based Guided Meditation with imagery techniques followed by aerobic exercises [7, 8]. Immersive VR was delivered using VR headsets and specialized software that included audio-guided instructions. Each VR-guided meditation session lasted for 25 minutes and was conducted in a quiet setting. This was followed by a 35-minute aerobic exercise session incorporating calisthenics exercises such as mild wall push-ups, walking, inclined walking, squats, and leg raises (10 repetitions × 2 sets) [9]. Participants were advised that if they experienced fatigue during the aerobic session, they could take a break and were instructed to inform the facilitator immediately.

The control group participated in aerobic exercises alone, which included warm-up and cool-down components and also lasted 60 minutes per session. The aerobic protocol matched the same set of calisthenics exercises used in the intervention group to maintain consistency in physical activity between groups.

Each session (for both groups) lasted 60 minutes and was conducted three times per week over a period of six weeks.

Stress levels were assessed using salivary cortisol tests (swab method) [10]. Quality of life was evaluated using the 13-item Sense of Coherence (SOC-13) scale and the EORTC QLQ-C30 questionnaire. Data collection was carried out by trained researchers who were blinded to the group allocations to reduce potential bias [11 ,12].

Statistical analysis was conducted using SPSS version 26.0. Descriptive statistics summarized participant demographics and baseline characteristics. Independent t-tests were used to compare differences between the intervention and control groups, while paired t-tests evaluated within-group changes from pre- to post-intervention.

RESULTS

A total of 10 participants completed the study, with 5 in the intervention group (Virtual Reality-Guided Meditation [VR-GM] with aerobic exercise) and 5 in the control group (aerobic exercise only).

Table 1 presents the pre- and post-test comparisons of salivary cortisol levels. At baseline, there was a statistically significant difference in salivary cortisol levels between the groups, with the Aerobic Exercise group showing higher levels (12.84±0.89 µg/dL) compared to the VR-GM group (10.06±0.92 µg/dL; $p<0.001$). Following the intervention, the VR-GM group demonstrated a significant reduction in cortisol levels to 8.14±0.96 µg/dL ($p=0.0001$), with a large effect size (Cohen's $d=2.04$). The Aerobic Exercise group also showed a statistically significant reduction to 12.08±1.09 µg/dL ($p=0.0029$), though the effect size was moderate

Table 1. Cortisol Levels (µg/dL): Pre- and Post-Test Comparison Within Each Group and Between-Group Comparison

Group	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Difference	Estimated SD of Difference	Cohen's d (Effect Size)	p-value (within-group)
VR-GM	10.06±0.92	8.14±0.96	-1.92	0.94	2.04 (Large)	0.0001
Aerobic EX	12.84±0.89	12.08±1.09	-0.76	1.01	0.76 (Moderate)	0.0029
Between-group pre-test comparison	10.06±0.92 vs. 12.84±0.89					<0.001 (Independent t-test)
Between-group post-test comparison	8.14±0.96 vs. 12.08±1.09					<0.001 (Independent t-test)

Table 2. WHOQOL-BREF Total Scores: Pre- and Post-Test Comparison Within Each Group and Between--Group Comparison

Group	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Difference	Estimated SD of Difference	Cohen's d (Effect Size)	p-value (within-group)
VR-GM	58.80±2.59	77.20±1.92	+18.40	2.33	7.90 (Very Large)	0.0001
Aerobic EX	57.60±2.07	59.00±1.87	+1.40	1.98	0.71 (Moderate)	0.0046
Between-group pre-test comparison	58.80±2.59 vs. 57.60±2.07					0.217 (Independent t-test)
Between-group post-test comparison	77.20±1.92 vs. 59.00±1.87					0.217 (Independent t-test)

Table 3. Sense of Coherence (SOC-13 Scale): Pre- and Post-Test Comparison Within Each Group and Between-Group Comparison

Group	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Difference	Estimated SD of Difference	Cohen's d (Effect Size)	p-value (within-group)
VR-GM	58.00±2.74	77.20±1.92	+19.20	2.44	7.88 (Very Large)	0.0001
Aerobic EX	59.00±1.58	66.00±1.58	+7.00	1.58	4.43 (Very Large)	0.0002
Between-group pre-test comparison	58.00±2.74 vs. 59.00±1.58					0.326 (Independent t-test)
Between-group post-test comparison	77.20±1.92 vs. 66.00±1.58					< 0.001

(Cohen's *d*=0.76). The post-test comparison between the two groups showed a highly significant difference ($p<0.001$), favoring the VR-GM group in terms of reduced cortisol levels.

Significant within-group improvements were also observed in WHOQOL-BREF and SOC-13 scores in the VR-GM group. Between-group differences were further analyzed using ANCOVA to account for baseline variation, supporting the greater improvement in the intervention group.

As shown in Table 2, Significant improvements were observed in both quality of life and sense of coherence following the intervention. The baseline quality of life scores between the VR-GM (58.80±2.59) and Aerobic Exercise (57.60±2.07) groups were not statistically different ($p=0.217$). Post-intervention, the VR-GM group exhibited a marked improvement in quality of life, increasing to 77.20±1.92 ($p=0.0001$), with a very large effect size (Cohen's *d*=7.90). The Aerobic Exercise group also showed a statistically significant but smaller increase to 59.00±1.87 ($p=0.0046$; Cohen's *d*=0.71). A between-group comparison at post-test indicated a significant difference in favor of the VR-GM group ($p<0.001$).

No significant differences were found in baseline SOC-13 scores between the VR-GM (58.00±2.74) and Aerobic Exercise (59.00±1.58) groups ($p=0.326$). After the intervention, SOC scores significantly increased in both groups. The VR-GM group improved to 77.20±1.92 ($p=0.0001$; Cohen's *d*=7.88), while the Aerobic Exercise group increased to 66.00±1.58 ($p=0.0002$; Cohen's *d*=4.43). The between-group post-test comparison was statistically significant ($p<0.001$), again favoring the VR-GM group. These results suggest that both interventions positively influenced psychological outcomes, with VR-guided meditation producing notably greater benefits (Table 3).

These results demonstrate that Virtual Reality–Guided Meditation with imagery techniques, combined with aerobic exercise, significantly reduces stress levels and enhances both the quality of life and psychological resilience of post-mastectomy patients.

DISCUSSION

This pilot study aimed to assess the effectiveness of Virtual Reality–Guided Meditation (VR-GM) with imagery techniques, combined with aerobic exercises, in reducing stress and improving the quality of life among post-mastectomy women. The results demonstrate a statistically significant improvement in psychological and physiological outcomes in the intervention group compared to the control group.

Participants who received the VR-GM intervention showed a substantial reduction in salivary cortisol levels, a well-established biomarker of physiological stress. This aligns with previous research demonstrating the efficacy of virtual reality and mindfulness-based interventions in modulating stress responses and enhancing emotional regulation [13]. The immersive experience of VR, when coupled with guided imagery and meditation, appears to create a calming and therapeutic environment that promotes relaxation and reduces cortisol secretion.

Furthermore, the intervention group exhibited notable improvements in both the Sense of Coherence (SOC) scores and quality of life, as measured by the EORTC QLQ-C30. These findings are consistent with previous studies supporting the use of mind-body interventions in oncology settings, which have shown enhanced coping capacity, reduced anxiety, and better treatment adherence [14]. The sense of control and engagement offered by VR-GM may foster a stronger perception of coherence, enabling patients to better manage the challenges of post-mastectomy recovery.

In contrast, while the control group (aerobic exercise alone) did experience modest improvements, the magnitude of change was significantly lower. This underscores the added value of integrating virtual reality and guided meditation with physical activity to address the multifaceted needs-both psychological and physiological– of breast cancer survivors [15].

However, the small sample size and short duration limit the generalizability of the results. Future large-scale, randomized controlled trials with longer follow-up periods are warranted to validate these findings and explore long-term benefits.

Further research with larger samples and longer follow-up periods is recommended to confirm these results and explore the sustained benefits of this integrative intervention.

CONCLUSION

This pilot study concludes that combining Virtual Reality-Guided Meditation with aerobic exercise significantly reduces

stress and improves quality of life in post-mastectomy women following chemotherapy. The intervention, involving immersive VR sessions and calisthenics-based aerobic training over six weeks, led to notable reductions in salivary cortisol and improvements in SOC-13 and EORTC QLQ-C30 scores compared to aerobic exercise alone. These findings highlight the potential of integrating digital mindfulness tools with physical activity in cancer rehabilitation programs. By incorporating mind-body practices with immersive technology and physical activity, healthcare providers can better meet the holistic needs of patients recovering from mastectomy.

REFERENCES

1. Trayes KP, Cokenakes SE. Breast cancer treatment. Am Fam Physician. 2021;104(2):171-8.
2. Orrantia-Borunda E, Anchondo-Nuñez P, Acuña-Aguilar Le et al. Subtypes of breast cancer. Breast Cancer [Internet]. 2022 Aug 6.
3. Al-Hilli Z, Wilkerson A. Breast surgery: management of postoperative complications following operations for breast cancer. Surg Clin North Am. 2021;101(5):845-863. doi: 10.1016/j.suc.2021.06.014.
4. Pehlivan M, Eyi S. The Impact of Mindfulness-Based Meditation and Yoga on Stress, Body Image, Self-esteem, and Sexual Adjustment in Breast Cancer Patients Undergoing Modified Radical Mastectomy: A Randomized Controlled Trial. Cancer Nurs. 2025;48(3):190-9. doi: 10.1097/NCC.0000000000001427.
5. Aasan OJ, Brataas HV, Nordtug B. Experience of managing countertransference through self-guided imagery in meditation among healthcare professionals. Front Psychiatry. 2022;17:13:793784. doi: 10.3389/fpsyt.2022.793784.
6. Post KE, Ahmad Z, Jankauskaite G et al. Managing symptom distress: key factors for patients on adjuvant endocrine therapy for breast cancer. J Pain Symptom Manage. 2024;67(1):88-97. doi: 10.1016/j.jpainsymman.2023.10.001.
7. Wang X, Mo X, Fan M et al. Reducing stress and anxiety in the metaverse: A systematic review of meditation, mindfulness and virtual reality. InProceedings of the Tenth International Symposium of Chinese CHI. 2022 Oct 22 (pp. 170-180).
8. Cinalioglu K, Lavín P, Bein M et al. Effects of virtual reality guided meditation in older adults: the protocol of a pilot randomized controlled trial. Front Psychol. 2023;14:1083219.doi: 10.3389/fpsyg.2023.1083219.
9. Ryu J, Lee EY, Min J et al. Effect of a 1-year tailored exercise program according to cancer trajectories in patients with breast cancer: study protocol for a randomized controlled trial. BMC Cancer. 2023;23(1):200. doi: 10.1186/s12885-023-10664-1.
10. Mészáros Crow E, López-Gigosos R, Mariscal-López E et al. Psychosocial interventions reduce cortisol in breast cancer patients: systematic review and meta-analysis. Front Psychol. 2023;14:1148805. doi: 10.3389/fpsyg.2023.1148805.
11. Pilz MJ, Thurner AM, Storz LM et al. The current use and application of thresholds for clinical importance of the EORTC QLQ-C30, the EORTC CAT core and the EORTC QLQ-C15-PAL-a systematic scoping review. Health Qual Life Outcomes. 2025;23(1):55. doi: 10.1186/s12955-025-02387-7.
12. Michałowska S, Bogucka M. Sense of coherence, general self-efficacy and health behaviors in women after mastectomy. Arch Psych Psychother. 2021;4:13-22.
13. Cinalioglu K, Lavín P, Bein M et al. Effects of virtual reality guided meditation in older adults: the protocol of a pilot randomized controlled trial. Front Psychol. 2023 Jul 28:14:1083219. doi: 10.3389/fpsyg.2023.1083219.
14. Kannan P, Lam HY, Ma TK et al. Efficacy of physical therapy interventions on quality of life and upper quadrant pain severity in women with post-mastectomy pain syndrome: a systematic review and meta-analysis. Qual Life Res. 2022;31(4):951-973. doi: 10.1007/s11136-021-02926-x.
15. Hanson SE, Lei X, Roubaud MS et al. Long-term quality of life in patients with breast cancer after breast conservation vs mastectomy and reconstruction. JAMA Surg. 2022;157(6):e220631. doi: 10.1001/jamasurg.2022.0631.

CONFLICT OF INTEREST

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REVIEW ARTICLE

The use of bischofite in comprehensive rehabilitation of patients with cardiovascular diseases and comorbid hepatobiliary pathology: current knowledge and future perspective

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ABSTRACT

Aim: The aim of the research was to investigate and summarize existing evidence on the use of bischofite in the rehabilitation of patients with coronary heart disease (CHD) or hypertension, accompanied by comorbid hepatobiliary pathology.

Materials and Methods: The research materials were derived from published sources, including studies conducted at our clinic, which support the rationale for using bischofite in the complex rehabilitation of patients, particularly those with cardiovascular diseases and comorbid hepatobiliary pathology. The study employed bibliosemantic methods, a systematic approach, as well as structural and logical analysis.

Conclusions: Studies on the use of bischofite in the comprehensive rehabilitation of patients with coronary artery disease or biliary disorders, in conjunction with hepatobiliary pathology, provide strong evidence supporting the clinical and laboratory benefits of this treatment. These findings suggest promising future prospects for its use. However, certain mechanisms, particularly its effects on chronic systemic inflammation and endothelial function, require further investigation.

KEYWORDS: rehabilitation, bischofite, combined pathology

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INTRODUCTION

Modern medicine places significant emphasis on comorbid pathology in internal medicine, particularly for those conditions of social importance. Cardiovascular diseases, especially coronary heart disease (CHD) and hypertension, are of particular concern, especially in the context of comorbidity with other conditions.

Cardiovascular diseases (CVDs) lead in terms of prevalence, mortality, and disability rates, significantly affecting the duration and quality of life across populations in many countries [1-7]. According to the World Health Organization, coronary heart disease is the most common cause of death globally, accounting for 16% of all deaths [8].

In 2020, the State Statistics Service of Ukraine reported that 616, 835 Ukrainians died, with 408, 721 deaths attributed to circulatory diseases, more than half of which (284, 997) were due to coronary heart disease [9].

As is widely known, the prognosis for patients with coronary heart disease primarily depends on the progression of coronary atherosclerosis (CAD). The formation of atherosclerotic lesions is driven by pathogenic factors and mechanisms that result in the formation of atherosclerotic plaques, influencing their stability [10, 11].

Recent scientific evidence has established that low-intensity chronic systemic inflammation (CSI) plays a crucial role in the initiation and progression of atherosclerosis, with endothelial dysfunction (ED) and dyslipidemia being key pathogenic factors [12, 13]. Furthermore, hepatocytes play a pivotal role in maintaining lipid homeostasis. Liver dysfunction exacerbates dyslipidemia, contributing to the development and progression of CHD [14, 15]. Therefore, non-alcoholic fatty liver disease (NAFLD) is now considered a risk factor for cardiovascular disease (CVD) [16, 17, 18], highlighting the growing importance of addressing fatty liver infiltration. NAFLD is a staged process, initially presenting as benign fatty liver infiltration, which can then progress to steatohepatitis, hepatocellular carcinoma, or cirrhosis [18, 19].

In the context of CSI activation, numerous reactive molecules are generated from low-density lipoprotein (LDL) oxidation, particularly in conditions of hypercholesterolemia. Oxidized LDLs act as autoantigens, forming circulating immune complexes with autoantibodies [20]. This lipid peroxidation process underpins the mechanisms of both coronary heart disease and NAFLD [21]. CD4+ T cells accumulate in areas of atherosclerotic lesions, exacerbating the progression of atherosclerosis by enhancing receptor sensitivity to oxidized LDL, chemokine receptors, and nuclear factor kappa B (NF-kB)-mediated synthesis of anti-inflammatory cytokines such as tumor necrosis factor (TNFα), interleukin 6 (IL-6), and others, further activating endothelial cells [22].

Studies show that the presence of NAFLD accelerates the progression of atherosclerotic processes in coronary artery disease and increases the risk of acute coronary events. Epidemiological data confirm that NAFLD is linked

to an increased risk of cardiovascular disease (CVD), raising overall mortality by 57%, mainly due to cardiovascular-related complications [23].

The rising prevalence of this comorbid pathology necessitates deeper exploration of the mechanisms behind atherosclerosis, particularly lipid metabolism disorders, endothelial dysfunction, and the role of chronic low-intensity systemic inflammation. This exploration is critical for identifying new, effective methods for diagnosing and treating CHD in conjunction with NAFLD.

Key pathogenetic factors in the formation of NAFLD, such as insulin resistance (IR) and compensatory hyperinsulinemia, also play a significant role in the development of arterial hypertension. Hyperinsulinemia stimulates the production of growth factors, including platelet-derived growth factor, insulin-like growth factor, and fibroblast growth factor. These factors promote smooth muscle cell proliferation and fibroblast activity, resulting in vasoconstriction and elevated blood pressure (BP). In such circumstances, endothelin synthesis is activated, as is the renin-angiotensin-aldosterone system, leading to increased sodium reabsorption in the nephron's proximal and distal tubules, which contributes to the development of hypertension [24].

When NAFLD and hypertension coexist, the liver becomes a target organ, initiating a cascade of inflammatory reactions, with direct secretion of proinflammatory cytokines and the development of a systemic inflammatory response. Chronic inflammation may also occur in adipose tissue due to the effects of proinflammatory adipocytokines such as adiponectin, leptin, TNF-α, interleukin IL-6, and resistin [25].

Current treatment strategies for NAFLD include lifestyle modifications, such as a hypocaloric diet with a preference for low-glycemic foods, aerobic exercise, and medication. Pharmacological management typically involves a combination of statins, insulin sensitizers, hepatoprotectors, and antioxidants, which can lead to polypharmacy, drug interactions, and adverse reactions.

However, treatments utilizing natural resources and physical factors with sanogenetic and preventive effects are underdeveloped, despite their potential to achieve effective results in NAFLD therapy while minimizing polypharmacy and side effects. In this regard, few studies have focused on the use of Poltava bischofite, particularly in the context of combined hepatobiliary (primarily NAFLD) and cardiovascular pathology.

AIM

The aim of the research was to investigate and summarize existing evidence on the use of bischofite in the rehabilitation of patients with coronary heart disease (CHD) or hypertension, accompanied by comorbid hepatobiliary pathology.

MATERIALS AND METHODS

The research materials were derived from published sources, including studies conducted at our clinic, which support the rationale for using bischofite in the complex rehabilitation of patients, particularly those with cardiovascular diseases and comorbid hepatobiliary pathology. The study employed bibliosemantic methods, a systematic approach, as well as structural and logical analysis.

REVIEW AND DISCUSSION

Before delving into the clinical aspects of this topic, let us first explore some background information, including historical, geographical, chemical, and pharmacological perspectives. Bischofite is a natural material that is safe, accessible, cost-effective, and highly effective. This mineral was first discovered in the nineteenth century in the Cachstein deposits of Germany. It was subsequently studied by the German chemist and geologist Karl Gustav Bischof, after whom the mineral was named. Bischofite is notably characterized by its exceptionally high magnesium content (up to 99 g/dm^3), a feature that, along with the biological interactions of its minerals and components, defines its properties and applications.

Currently, there are only three commercial bischofite deposits being actively developed worldwide. The largest and deepest of these is located in Ukraine – the Zaturynske field, situated in the Poltava district of the Poltava region. The depth at which this deposit occurs directly correlates with its age and, consequently, its biological effects. The unique properties of the natural bischofite solution from the Zaturyn deposit have been extensively studied by experts from several prestigious institutions, including Dnipropetrovs'k Medical Academy, Zaporizhzhia Medical University, the Ukrainian Medical Stomatological Academy (Poltava), the Research Institute of Hygiene and Medical Ecology (Kyiv), Kharkiv Medical Academy of Postgraduate Education, the Ukrainian Center for Sports Medicine, and the Ukrainian Research Institute of Medical Rehabilitation and Resortology (Odesa).

The composition of Poltava bischofite includes the following key components: potassium and sodium (1.98 g/l), calcium (2.0 g/l), magnesium (91.2 g/l), chlorine (262.4 g/l), sulfates (13.29 g/l), and bicarbonates (0.59 g/l), as well as biologically active trace elements such as iodine (52.94 mg/l), bromine (3160.0 mg/l), metasilicic acid (2.79 mg/l), and orthoboric acid (3.52 mg/l). The total mineralization is 371.46 g/l. Poltava bischofite is a colorless, transparent liquid. The chemical composition and formula of this bischofite solution were determined by the Ukrainian Research Institute of Medical Rehabilitation and Balneology in a study conducted on June 24, 1994 [26].

Bischofite is a natural mineral derived from the ancient Perm Sea and has been officially recognized as a therapeutic agent since 1985 (Order No. 306 of the USSR Ministry of Health, January 18, 1985). Its efficacy has been supported by decades of practical application, particularly at the Myrhorod resort. Nearly all cosmetic, hygienic, and therapeutic products containing bischofite – specifically Poltava bischofite – are produced by Ukrainian manufacturers using a natural solution sourced from the Zaturyn deposit.

Ukraine has long been known for brands such as Poltava Bischofite, Dr. Bishoffit, and Bisheffect, which have established a presence on the European market.

The therapeutic properties of bischofite are attributed to its adaptogenic, tonic, sedative, immunostimulatory, antibacterial, antispasmodic, and anti-inflammatory actions – effects largely driven by its rich trace element composition.

Magnesium, a key component, exerts a hypotensive effect, improves cerebral blood flow, prevents autonomic dysfunction and sleep disturbances, activates enzymes involved in energy and carbohydrate metabolism, supports bone formation, and regulates nervous and cardiovascular system excitability. It also exhibits antispasmodic and vasodilatory effects while stimulating gastrointestinal smooth muscle peristalsis. Bromine, with its resorptive properties, restores the balance between excitation and inhibition in the cerebral cortex. Iodine enhances metabolic processes, particularly lipid and carbohydrate metabolism, contributing to reduced blood cholesterol and LDL levels by activating lipoproteinase. It also promotes mucus secretion, proteolytic and fibrinolytic activity, and has antiseptic effects when applied topically. Additional trace elements contribute to restoring systemic mineral balance, thereby supporting metabolic and enzymatic regulation[26, 27].

The external application of bischofite, such as in compresses, has been shown to significantly reduce wound exudate, microbial contamination, and pain in postoperative complications like hematomas, seromas, and inflammatory infiltrates – contributing to faster healing and improved patient outcomes [28]. General bischofite baths exert a reflexive action that enhances oxygenation and tissue metabolism, functioning as an antioxidant factor by reducing atherogenic lipid synthesis. These baths stimulate skin receptors and affect systemic physiological responses [26].

Bischofite's antibacterial and immunostimulatory effects stem from its influence on local immunity – enhancing phagocytic activity, suppressing conditionally pathogenic flora and fungi, improving capillary circulation, reducing platelet aggregation and adhesion, and promoting endocrine and immune system responses [27].

Clinical studies have demonstrated the effectiveness of Poltava bischofite in the treatment of cardiovascular diseases (e.g., coronary artery disease, hypertension stage 1-2, sinus arrhythmia, extrasystole, neurocirculatory dystonia, vasospasm), musculoskeletal injuries (sprains, contractures), neurological disorders (lumbago, radiculitis, neuralgia, neuritis), gastrointestinal diseases (cholecystitis, biliary dyskinesia), dermatological conditions (psoriasis), and general functional disorders [29-32].

Contraindications include hypersensitivity to bischofite or its components, active-stage illnesses, malignancies, severe disease progression, and skin damage at application sites. Specific cardiovascular and hepatobiliary contraindications include unstable angina, left ventricular failure, arrhythmias (e.g., atrial fibrillation, paroxysmal tachycardia), advanced heart failure, severe hypertension, thromboembolic disease, all forms of jaundice, active hepatitis, calculous cholecystitis, cholelithiasis, and cirrhosis.

The "pathogenetic intersections" of coronary heart disease (CHD), hypertension, and hepatobiliary disorders have prompted interest in the potential of bischofite for complex treatment under conditions of comorbidity. We previously examined the impact of complex therapy involving Poltava bischofite brine on clinical outcomes, hormonal adaptation markers, and hemorheological parameters in patients with CHD and chronic liver and gallbladder inflammation [33].

This cohort included patients with stable angina (functional class I-III), mild circulatory insufficiency (stage 0–1), and concurrent hepatobiliary disorders such as chronic calculous cholecystitis and chronic persistent hepatitis. All participants received standard pharmacotherapy (nitrates, sedatives, choleretics, hepatoprotectors), and bischofite was administered via full-body mineral baths. Baths were prepared by diluting brine at a 1:50 ratio (4 liters per bath) in water at 37°C, with a treatment course of 10-12 sessions (3-5 per week, each lasting 15 minutes).

Treatment resulted in a significant reduction in cortisol and triiodothyronine levels, suggesting an inhibitory effect on the pituitary-thyroid axis, likely due to the presence of macro- and microelements like magnesium, potassium, iodine, and bromine. Hemorheological analysis revealed that elevated blood viscosity – associated with altered erythrocyte aggregation – was particularly pronounced in patients with coexisting chronic obstructive pulmonary disease and cholestasis. After treatment, blood viscosity normalized, especially at the microcirculatory level.

Overall, external use of bischofite enhanced adaptive capacity, improved cardiovascular, hepatic, and biliary function, and normalized blood rheology, reducing peripheral resistance and improving tissue perfusion. These outcomes support the integration of Poltava bischofite brine baths into pharmacological regimens for CHD patients with comorbid hepatobiliary disease, whether in sanatorium, outpatient, or clinical settings.

Our clinic has also initiated studies [34, 35] on systemic inflammation in CHD with coexisting non-alcoholic fatty liver disease (NAFLD) and its treatment modalities. While the sample size remains insufficient for definitive statistical conclusions, preliminary observations suggest encouraging trends in inflammation markers in response to bischofite-based therapy.

We are not alone in our encouraging results regarding the use of bischofite in the case of comorbid cardiovascular and hepatobiliary pathology. At the Gastroenterology Clinic of the Ukrainian Research Institute of Medical Rehabilitation and Balneology, studies were conducted on the use of bischofite therapy – including oral administration, traditional topical application, and intratissue medicinal electrophoresis over the liver region – as part of a comprehensive treatment regimen in patients with non-alcoholic fatty liver disease (NAFLD), both in isolation and in combination with hypertension (HTN) [31, 36-38].

The clinical presentation of NAFLD in these patients was generally oligosymptomatic, often manifesting as a sensation of heaviness or pain in the right upper quadrant and various signs of gastric and intestinal dyspepsia (e.g., bitterness in the mouth, nausea, belching, bloating, constipation). These symptoms were typically associated with concurrent digestive system pathologies. Comorbid conditions included

chronic non-calculous cholecystitis, chronic pancreatitis, cholelithiasis (including post-cholecystectomy states), and irritable bowel syndrome, alongside manifestations of asthenic syndrome. The majority of patients were found to be overweight or obese (grade I-II), with a mean body mass index of 31.67±1.14 kg/m^2.

Ultrasound examination revealed characteristic signs of hepatic steatosis in all patients, including diffusely increased echogenicity of the liver parenchyma, distal echo signal attenuation, vascular pattern distortion, and poor vascular visualization. Hepatomegaly was observed in 53.3% of patients, while sonographic signs of biliary tract pathology – including gallbladder enlargement, wall thickening, and cystic sediment – were present in 66.7% of cases.

The findings confirmed the therapeutic potential of an internal course of aqueous bischofite solution (sourced from the Poltava deposit) as part of complex therapy for NAFLD. The treatment contributed to the restoration of liver function, normalization of lipid metabolism, reduction in insulin resistance, and improvement in comorbid biliary and intestinal disorders – addressing the key pathogenetic mechanisms underlying the development and progression of liver disease. Notably, the favorable effect on atherogenic lipid profiles and insulin sensitivity suggests the potential of bischofite therapy to reduce cardiometabolic risk in this patient population [31].

Clinical outcomes demonstrated that oral administration of the bischofite solution significantly improved the course of the underlying liver disease, promoted normalization of liver function, and led to marked improvements in the lipid profile. It also significantly reduced markers of insulin resistance ($p<0.01$), primarily due to a decrease in basal hyperinsulinemia ($p<0.01$). In patients with NAFLD and comorbid hypertension, this therapeutic approach improved the 24-hour blood pressure profile – reducing both average and peak systolic ($p<0.01$) and diastolic pressures ($p<0.02$), enhancing nocturnal blood pressure dipping ($p<0.01$), and lowering blood pressure variability throughout the day. These improvements were accompanied by a reduction in medication burden and a reported enhancement in overall quality of life [36].

CONCLUSIONS

Thus, the studies conducted on the use of bischofite in the comprehensive rehabilitation of patients with coronary artery disease or hypertensive heart disease, particularly in the presence of comorbid hepatobiliary pathology, provide a solid basis for a positive clinical and laboratory evaluation of this medicinal agent. These findings also suggest promising potential for its broader application in the future. Nevertheless, certain mechanisms – especially its influence on chronic systemic inflammation and endothelial function – require further in-depth investigation

REFERENCES

1. Chekalina NI. Mozhlyvosti medykamentoznoyi korektsiyi khronichnoho systemnoho zapalennya pry ishemichniy khvorobi sertsya. Aktual'ni problemy suchasnoyi medytsyny: Visnyk Ukrayins'koyi medychnoyi stomatolohichnoyi akademiyi. 2017;21:277-281.
2. Nevoyt HV, Potyazhenko MM. Kliniko-patohenetychni osoblyvosti perebihu neinfektsiynykh zakhvoryuvan' zalezhno vid stupenya komorbidnosti, etapu sertsevo-sudynnoho kontynuumu. Bukovyns'kyy medychnyy visnyk. 2022;26:13-22. doi.org/10.24061/2413-0737.XXVI.1.101.2022.2
3. Di Cesare M, Perel P, Taylor S et al. The Heart of the World. Glob Heart. 2024;19(1):11. doi: 10.5334/gh.1288.
4. Trybrat TA, Shut' SV, Petrov Y et al. Sertsevo-sudynni zakhvoryuvannya: suchasne bachennya informovanosti patsiyentiv shchodo faktoriv ryzyku. Visnyk problem biolohiyi ta medytsyny. 2021;2(160):136-138. doi.org/10.29254/2077-4214-2021-2-160-136-138.
5. Cruz-Ávila HA, Vallejo M, Martínez-García M, Hernández-Lemus E. Comorbidity Networks in Cardiovascular Diseases. Front Physiol. 2020 Aug 28;11:1009. doi: 10.3389/fphys.2020.01009.
6. Buddeke J, ML Bots, Dis I et al.Comorbidity in patients with cardiovascular disease in primary care: a cohort study with routine healthcare data. British Journal of General Practice 2019;69(683):e398-e406. Doi: 10.3399/bjgp19X7027250I
7. Shut' SV, Trybrat TA, Ivanytska TA et al. The public awareness of overweight and obesity as a risk factor for cardiovascular diseases .The medical and ecological problems. 2020;24(3-4):15-18.
8. Vsesvitnya orhanizatsiya zdravookhranenyya: ofytsyal'nyy sayt. URL: https://www.who.int/
9. Derzhavnyy komitet statystyky Ukrayiny: ofitsiynyy sayt. URL: https://www.ukrstat.gov.ua/
10. Chekalina NI. Resveratrol has a positive effect on parameters of central hemodynamics and myocardial ischemia in patients with stable coronary heart disease. Wiad Lek. 2017;70(2):286-291.
11. Chekalina NI. Vzayemozv'yazky pokaznykiv systemnoho zapalennya, lipidnoho spektru krovi ta strukturno-funktsional'noho stanu sertsya pry stabil'niy ishemichniy khvorobi sertsya. Visnyk problem biolohiyi ta medytsyny. 2017;3:251-257.
12. Amosova KM, Stremenyuk VID, Andryeyev YEV. Rol' endotelial'noyi dysfunktsiyi ta systemnoho imunnoho zapalennya u vynyknennya ishemiyi miokarda pry fizychnomu navantazhenni u khvorykh z hemodynamichno neznachnym aterosklerozom vintsevykh arteriy sertsya. Ukrayins'kyy kardiolohichnyy zhurnal. 2011;4:14-19.
13. Chekalina NI. Osoblyvosti vzayemozv'yazku pokaznykiv systemnoho zapalennya, lipidnoho spektru krovi, strukturno-funktsional'noho stanu sertsya ta shchytopodibnoyi zalozy pry stabil'niy ishemichniy khvorobi sertsya za umov spoluchennya z avtoimunnym tyreoyidytom. Bukovyns'kyy medychnyy visnyk. 2017;21:100-109.
14. Bashta HV, Tkachuk SO, Lapovets' LYE. Osoblyvosti lipidnoho obminu u khvorykh na ishemichnu khvorobu sertsya ta suputnyu nealkohol'nu zhyrovu khvorobu pechinky. Visnyk problem biolohiyi ta medytsyny.2013;4(2):70-3.

15. Virstyuk NH, Vakalyuk II. Otsinka prohresuvannya fibrozu pechinky u khvorykh na stabil'nu ishemichnu khvorobu sertsya na tli nealkohol'noyi zhyrovoyi khvoroby pechinky. Suchasna hastroenterolohiya.2017;1(93):38-42.
16. Athyros VG, Tziomalos K, Katsiki N. Cardiovascular risk across the histological spectrum and the clinical manifestations of non-alcoholic fatty liver disease: An update. World J Gastroenterol. 2015;21:6820-34. doi:10.3748/wjg.v21.i22.6820.
17. Fadyeyenko HD, Chernyshov VA. Komorbidna patolohiya, shcho vplyvaye na serdechno-sudynnyy ryzyk u postinfarktnykh khvorykh. Ukrayins'kyy terapevtychnyy zhurnal.2014;2:10-20.
18. Bentsa, TM. Nealkohol'na zhyrova khvoroba pechinky ta sertsevo-sudynni zakhvoryuvannya: osoblyvosti komorbidnoho perebihu. Liky Ukrayiny. 2020;1(237):44-47. doi.org/10.37987/1997-9894.2020.1(237).214176.
19. Skybchyk VA, Voytovych MO. Nealkohol'na zhyrova khvoroba pechinky: suchasna diahnostyka. Hepatolohiya. 2015; 1:52-56.
20. Bashta HV, Tkachuk SO, Lapovets' LYE. Osoblyvosti lipidnoho obminu u khvorykh na ishemichnu khvorobu sertsya ta suputnyu nealkohol'nu zhyrovu khvorobu pechinky. Visnyk problem biolohiyi ta medytsyny.2013;4(2):70-3.
21. Filippova OYU. Protsesy perekysnoho okyslennya lipidiv ta stan systemy antyoksydantnoyi zakhystu u khvorykh na nealkohol'nu zhyrovu khvorobu pechinky. Likars'ka sprava;2013;7:36-42.
22. Allison B. Reiss, Nicolle M. Siegart, Joshua De Leon. Interleukin-6 in atherosclerosis: atherogenic or atheroprotective? Clinical Lipidology.2017; 12:1: 14-23. doi: 10.1080/17584299.2017.1319787
23. Duell PB, Welty FK, Miller M et al. Nonalcoholic Fatty Liver Disease and Cardiovascular Risk: A Scientific Statement From the American Heart Association. Arterioscler Thromb Vasc Biol. 2022 ;42(6):e168-e185. doi: 10.1161/ATV.0000000000000153.
24. Oikonomou D, Georgiopoulos G, Katsi V et al. Non-alcoholic fatty liver disease and hypertension: coprevalent or correlated? Eur J Gastroenterol Hepatol. 2018;30(9):979-985. doi: 10.1097/MEG.0000000000001191.
25. Golubeva JA, Sheptulina AF, Elkina AY et al. Which Comes First, Nonalcoholic Fatty Liver Disease or Arterial Hypertension? Biomedicines.2023;11(9):2465. doi.org/10.3390/biomedicines11092465
26. Bazhan KV. Pryrodni fizychni faktory u likuvanni patsiyentiv, yaki zaznaly vplyvu ekstremal'nykh faktoriv. Poltava, 1998.
27. Zhdan VM, Volkova OA, Starodubtsev SD. Vlastyvosti ta mozhlyvosti zastosuvannya poltavs'koho bishofitu yak fizioterapevtychnoho zasobu pry likuvanni khvorykh na revmatoyidnyy artryt. Aktual'ni problemy suchasnoyi medytsyny: Visnyk Ukrayins'koyi medychnoyi stomatolohichnoyi akademiyi. 2006;3(15):103-105.
28. Trofimov MV, Kryshen' VP, Muntyan SO et al. Zastosuvannya mahniyevmisnykh mineraliv u likuvanni pislyaoperatsiynykh ranovykh uskladnen' u khvorykh pokhyloho viku. Shpytal'na khirurhiya. Zhurnal im. YA. Koval'chuka, 2021; 3:95-100. doi.org/10.11603/2414-4533.2021.3.12546.
29. Nikolayeva NH. Kolodenko VO, Arvat AM. Doslidzhennya dynamiky kliniko-funktsional'nykh pokaznykiv u khvorykh riznykh nozolohichnykh hrup pid vplyvom zovnishn'oho zastosuvannya vodno-hryazevoho ekstraktu, zbahachenoho rozchynom bishofitu Poltavs'koho (VP "Akvilo-Kurort-Servis"). Medychna reabilitatsiya, kurortolohiya, fizioterapiya. Naukovo-praktychnyy zhurnal. 2010;1:50-51.
30. Kyryllova KV, Orlovets'ka NF. Nezvychaynyy bishofit – zastosuvannya pryrodnoho mineralu v medychniy praktytsi.// Suchasni aspekty stvorennya ekstemporal'nykh likars'kykh zasobiv: zbirnyk naukovykh prats'. Kharkiv: Vyd-vo NFaU. 2021;6:57-59.
31. Dragomiretska N, Zabolotna I, Izha G. Novi mozhlyvosti nemedykamentoznoho likuvannya khvorykh na nealkohol'nu zhyrovu khvorobu pechinky. Hastroenterolohiya. 2022;2.52:42-45.doi.org/10.22141/2308-2097.2.52.2014.81951.
32. Kishko MM, Bichko MV, Korsak YUV et al. Vplyv poyednanoho vykorystannya poltavs'koho bishofitu helyu ta lazeroterapiyi na klinichni proyavy revmatoyidnoho artrytu u khvorykh iz nadmirnoyu masoyu tila. Naukovyy visnyk Uzhhorods'koho universytetu. 2012;1:32-34.
33. Trybrat TA. Vplyv kompleksnoyi terapiyi z rozsolom poltavs'koho bishofitu na klinichnyy stan, riven' adaptatsiynykh hormoniv ta reolohiyu krovi u khvorykh na ishemichnu khvorobu sertsya z khronichnymy zapal'nymy zakhvoryuvannyamy pechinky ta zhovchnoho mikhura. Likars'ka sprava. 1999; 2:120-123.
34. Manusha YUI. Vplyv likuval'noho kompleksu betarhin z kvertsetynom na klinichnyy perebih, stan khronichnoho systemnoho zapalennya ta endotelial'noyi dysfunktsiyi u khvorykh na stabil'nu ishemichnu khvorobu sertsya u poyednanni z nealkohol'noyu zhyrovoyu khvoroboyu pechinky. Aktual'ni problemy suchasnoyi medytsyny. 2018;3 (63): 86-92.
35. Manusha YUI, Kozakov YUM, Mamontova TB, Shlikova OA, Chekalina NI Zastosuvannya betarynu v likuvanni stabil'noyi ishemichnoyi khvoroby sertsya ta nealkohol'noyi zhyrovoyi khvoroby pechinky. Visnyk: problem biolohiyi ta medytsyny. 2018;:1(146): 102-107.
36. Zabolotna IB. Novi mozhlyvosti nemedykamentoznoho likuvannya khvorykh na nealkohol'nu zhyrovu khvorobu pechinky iz suprovidnoyu arterial'noyu hipertenziyeyu. Odes'kyy medychnyy zhurnal. 2016;6.:58-66
37. Drahomyrets'ka NV, Zabolotna IB, Malykhina TI. Medyko-biolohichna otsinka yakosti ta tsinnosti rozvedenoho rozchynu pryrodnoho mineralu bishofit sverdlovyny № 1 Zaturyns'koho mestorozhdenyya, m. Poltava. Medychna reabilitatsiya, kurortolohiya ta fizioterapiya. 2014;3:59-62.
38. Drahomyrets'ka NV, Zabolotna IB, Izha HM, Kalinichenko MV. Efektyvnist' vnutrishn'oho kursovoho pryyomu vodnoho rozchynu «Poltavs'kyy bishofit» u khvorykh na nealkohol'nu zhyrovu khvorobu pechinky. Medychna reabilitatsiya, kurortolohiya ta fizioterapiya. 2014;3:23-25.

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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REVIEW ARTICLE

Active physiotherapy after total knee arthroplasty in the course of degenerative disease: Review of the literature

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ABSTRACT

Total knee arthroplasty (TKA) is one of the most common procedures for advanced knee osteoarthritis. Despite surgical progress, many patients report persistent pain, functional deficits, and reduced quality of life. Physiotherapy remains central to recovery, yet the most effective rehabilitation strategies are still debated. A systematic review was conducted in PubMed, Scopus, and Web of Science. Studies published between 2017 and 2025 were eligible if they evaluated active physiotherapy supervised by a physiotherapist after TKA. Only prospective clinical trials with subjective and objective outcomes were included. Exclusion criteria comprised non-physiotherapeutic interventions, passive modalities, single-gender samples, comorbid conditions, and pilot or retrospective studies. Nineteen studies met inclusion criteria. Interventions included eccentric and concentric resistance training, task-oriented exercise, motor imagery, kinesiotaping, telerehabilitation, feedback-supported programs, and adjunctive techniques such as blood flow restriction or foam rolling. Most showed beneficial effects on pain, range of motion, balance, muscle strength, and functional independence. However, protocol heterogeneity and limited follow-up precluded identification of a single optimal approach. Structured active exercise maintained over weeks to months provided the most consistent benefits.

Active physiotherapy is essential for recovery after TKA. Programs should be individualized, progressive, and feasible for long-term use, with adjunctive strategies serving as complements rather than substitutes. Current evidence aligns with international recommendations highlighting exercise, education, and patient-centered care. Further high-quality research is needed to standardize protocols, evaluate long-term outcomes, and determine cost-effectiveness in clinical practice.

KEYWORDS: rehabilitation, systematic review, functional recovery, exercise therapy, total knee arthroplasty physiotherapy

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INTRODUCTION

Osteoarthritis (OA) is one of the most common chronic musculoskeletal diseases and a leading cause of disability worldwide. According to the Global Burden of Disease 2019 study, OA affected about 528 million people globally, representing a 113% increase since 1990, with projections suggesting a further rise due to population aging and the obesity epidemic [1, 2]. The knee joint is the most frequently affected site, accounting for nearly 60% of symptomatic OA cases, and is a major contributor to pain, loss of independence, and healthcare utilization [3]. In addition to its clinical burden, knee OA is a growing socioeconomic problem. It generates substantial costs related to medical care, pharmacotherapy, surgical procedures, and productivity loss, amounting to billions of dollars annually in high-income countries [4].

The etiopathogenesis of OA is multifactorial, involving an interplay of mechanical, metabolic, inflammatory, and genetic factors. Mechanical overload and malalignment increase cartilage wear, while obesity and metabolic syndrome contribute to systemic low-grade inflammation and joint degeneration. Traumatic injuries accelerate cartilage damage, and genetic predisposition further modifies disease risk [5, 6]. Pathological changes affect not only cartilage but also periarticular structures, including ligaments, capsule, synovium, and subchondral bone, resulting in pain, stiffness, reduced mobility, and ultimately disability [4]. These changes also promote a cycle of inactivity, muscle weakness, and comorbidities such as cardiovascular disease, which exacerbate the overall disease burden [5].

When conservative management fails, total knee arthroplasty (TKA) remains the treatment of choice for advanced disease.

The number of TKAs has been steadily increasing, with over 1 million procedures performed annually in the United States alone and projections of a threefold increase by 2040 [7]. In Europe, similar trends are observed, with rising demand driven by demographic changes and improved surgical outcomes [7]. Although TKA effectively reduces pain and improves mobility, up to 20-30% of patients continue to report pain, stiffness, or functional limitations even after surgery [8, 9]. For this reason, effective postoperative rehabilitation is recognized as essential to optimize surgical outcomes and restore quality of life [10].

Physiotherapy plays a central role in this process, but there is no consensus on the most effective strategies. Traditional approaches focusing on range-of-motion and strengthening exercises have recently been complemented by task-oriented training, eccentric resistance, motor imagery, blood flow restriction techniques, telerehabilitation, and robotic-assisted therapy [11-14]. Despite promising results, rehabilitation protocols remain heterogeneous across studies and healthcare systems, and their long-term effectiveness is still uncertain. This variability poses a challenge for clinicians seeking evidence-based guidance and highlights the need for a systematic synthesis of available research.

AIM

The aim of this systematic review was to summarize current evidence on the effectiveness of active physiotherapy after TKA performed due to degenerative knee disease. By analyzing both conventional and innovative approaches, we sought to identify strategies that improve pain, function, and quality of life, compare them with international guidelines, and highlight gaps requiring further investigation.

MATERIALS AND METHODS

The review followed the PRISMA 2020 guidelines [15]. Medline (PubMed), PEDro [16], and the Cochrane Central Register of Controlled Trials (CENTRAL) were systematically searched [17]. The search was performed using the following terms and phrases:

– (("total knee arthroplasty" OR "total knee replacement") NOT "hip") AND
– ("physiotherapy" OR "physical therapy" OR "rehabilitation") NOT
– ("prerehabilitation" OR "prehabilitation").

The search covered publications from January 2017 to February 2025 and was restricted to studies published in English or Polish. Additional articles were identified by manual screening of reference lists of included studies and relevant reviews.

ELIGIBILITY CRITERIA

The analysis followed the PICO framework:

- Population (P): adults after total knee arthroplasty performed due to degenerative knee disease,
- Intervention (I): active physiotherapy supervised by a physiotherapist (exercise therapy, task-oriented training, telerehabilitation, robotic-assisted therapy, blood flow restriction training, motor imagery, educational interventions),
- Comparison (C): usual care, alternative physiotherapy protocol, or no intervention,
- Outcomes (O): pain reduction, functional improvement, range of motion, mobility, strength, quality of life, and independence in daily activities.

Based on these principles, additional inclusion and exclusion criteria were defined. The study population was limited to adults (≥18 years) undergoing TKA for osteoarthritis, while studies involving children or those related to trauma or tumors were excluded. Eligible interventions included active physiotherapy supervised by a physiotherapist. Studies relying solely on passive modalities, pharmacological management, or prehabilitation were not considered. The comparator groups consisted of usual care, alternative physiotherapy programs, or no intervention.

Only studies reporting outcomes such as pain, function, range of motion, mobility, muscle strength, quality of life, or independence were included, whereas articles without relevant outcome measures were excluded. With respect to study design, randomized controlled trials (RCTs) and prospective controlled studies were eligible. Retrospective analyses, pilot studies, case reports, and study protocols were excluded.

Finally, the review was restricted to articles published between 2017 and 2025 in English or Polish in peer-reviewed journals. Studies outside this time frame, not peer-reviewed, or lacking full-text availability were excluded.

SELECTION PROCESS

Two reviewers independently screened titles and abstracts. Potentially eligible studies were retrieved in full text and assessed against the eligibility criteria. Disagreements were resolved by discussion and consensus. The results of the selection process are summarized in Figure 1.

DATA EXTRACTION AND SYNTHESIS

Data were extracted independently by two reviewers using a standardized form and included: study design, sample size, participant characteristics, intervention protocol, comparator, duration, outcome measures, and main findings. The extracted outcomes included pain (VAS/NRS), function (WOMAC, KOOS), mobility (TUG, 6MWT), range of motion, muscle strength, and quality of life measures (SF-36, EQ-5D).

Given the heterogeneity of study designs, interventions, and outcome measures, a narrative synthesis was conducted. The results were tabulated according to the type of intervention and outcomes. Methodological quality was assessed using the Cochrane Risk of Bias 2 tool [18].

REVIEW

OVERVIEW OF INCLUDED STUDIES

Nineteen studies on active physiotherapy after total knee arthroplasty (TKA) for degenerative disease were included. Designs comprised randomized controlled trials and prospective comparisons in inpatient, outpatient, and home/remote settings. Core elements were range-of-motion, strengthening, gait and functional training, and education; from 2020 onward, adjuncts such as eccentric

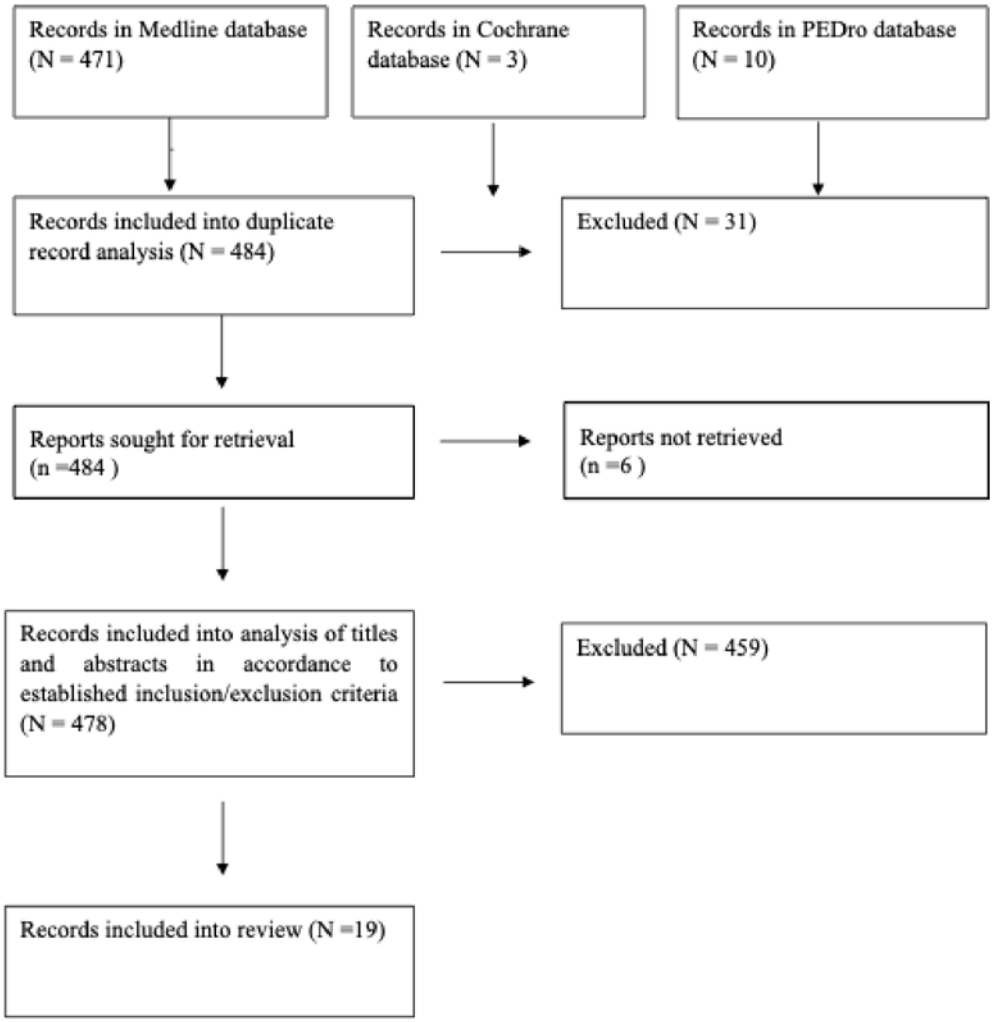

Fig. 1. Flow diagram

or blood-flow–restricted training, motor imagery, balance/trunk programs, telerehabilitation, and robot-assisted gait training were increasingly used. Study characteristics are presented in Table 1.

METHODOLOGICAL QUALITY

Methodological quality was assessed with the Cochrane RoB 2 tool. Two studies [19, 20] were judged as low risk of bias. The majority of trials, including [21-34], were rated as moderate risk, mainly due to limited blinding and short follow-up. None of the included studies were classified as high risk.

PHYSIOTHERAPY CONTENT AND INTERVENTIONS

Physiotherapy protocols in the included studies shared core elements such as range-of-motion exercises, muscle strengthening, gait training, and functional activities. Several trials investigated additional or experimental components. For example, kinesiology taping was tested alongside supervised rehabilitation [21]. Xie et al. applied an intelligent knee brace with mobile application support [22]. Zhao et al. used a telerehabilitation model supported by smartphone sensors [23], while Süzer et al. enriched tele-based exercise with core stability components [24]. Song integrated structured health education based on the Transtheoretical Model [35].

Resistance training modifications included eccentric–concentric strengthening [25], progressive eccentric loading (26), blood-flow restriction during strengthening [23], and robot-assisted gait training [27, 28]. High-intensity early functional training was compared with lower-intensity protocols [36]. Neurocognitive and relaxation adjuncts comprised motor imagery [29, 30], progressive muscle relaxation [31], and early quadriceps NMES [28]. Alsiri et al. additionally explored mobilization with movement as a manual adjunct to rehabilitation, reporting short-term gains in knee flexion [32]. Other complementary strategies included foam rolling (33), rapid trunk-movement training [28], and accelerated rehabilitation pathways with early mobilization [37].

Together, these interventions demonstrate the wide spectrum of physiotherapy strategies following TKA, with active exercise forming the core and various adjunctive methods designed to optimize pain relief, muscle activation, and functional independence.

Table 1. Characteristics of the included studies

Intervention Category	Study	Participants (N)	Experimental Intervention	Duration	Key Positive Outcomes
Technology-Assisted Rehabilitation	Zhao (2024)	100	Telerehabilitation app with sensors	12 weeks	☑Increased ROM and QoL ☑Better sit-to-stand performance
	Xie (2024)	120	Intelligent knee brace with app feedback	4 weeks	☑Increased ROM, strength, and QoL
	Watabe (2025)	72	HAL-SJ robot-assisted exercise	2 weeks +3 mos FU	☑Increased ROM and hamstring strength ☑ Improved ADLs
	Süzer (2025)	42	Telerehabilitation with additional core stability exercises	12 weeks	☑Increased function, strength, and QoL
	Maeda (2024)	76	HAL-SJ robot for knee extension	2 weeks +4 wks FU	☑Short-term improvements in pain and ROM
Strength & Neuromuscular Training	Cheng (2024)	92	Progressive resistance training	12 weeks +6 mos FU	☑Increased strength and function
	Teissier (2020)	20	Eccentric-concentric resistance training	4 weeks	☑Increased mobility and strength
	Woźniak (2017)	120	Proprioceptive training added to standard rehab	10 weeks	☑Increased strength, ROM, and balance
	An (2024)	42	Balance exercises added to standard PT	4 weeks	☑Increased ROM, balance, and function
	Briones-Cantero (2020)	24	Task-oriented training added to standard rehab	4 weeks	☑Increased function and strength; reduced pain
	Sano (2018)	81	Dynamic balance training on a platform	2 weeks	☑Increased walking speed and step length
Manual & Other Physical Techniques	Alsiri (2025)	84	Mobilization with Movement	3 weeks +6 mos FU	☑Increased knee flexion ROM
	Yokochi (2023)	30	Foam rolling added to standard PT	1 week	☑Reduced pain and increased flexion ROM
Neurocognitive & Educational Approaches	Eymir (2021)	112	Progressive muscle relaxation	3 days	☑Reduced pain and fear of movement ☑Increased strength
	Song (2024)	130	Health education added to standard PT	6 months	☑Increased self-efficacy ☑Reduced kinesiophobia
Comparative Physiotherapy Protocols	Chang (2025)	52	Supervised rehabilitation *vs.* home program	12 weeks	☑Supervised program was superior for WOMAC, ROM, and QoL
	Bade (2017)	162	Extended outpatient rehabilitation *vs.* standard or delayed	12 months	☑Extended program provided faster early gains
	Christiansen (2024)	92	Telehealth with behavior-change *vs.* education	12 wks +38 wks FU	☑Increased step count in the short-term, but no sustained effects
	Hsieh (2020)	363	Treadmill, PENS, or both *vs.* PT	8-12 weeks	☑All groups improved mobility (AM-PAC, 6MWT); no differences between groups

ADL – Activities of Daily Living; AM-PAC – Activity Measure for Post-Acute Care; BFRT – Blood Flow Restriction Training; FU – Follow-up; HAL-SJ – Hybrid Assistive Limb – Single Joint; KOOS – Knee injury and Osteoarthritis Outcome Score; LEFS – Lower Extremity Functional Scale; NMES – Neuromuscular Electrical Stimulation; PENS – Patterned Electrical Neuromuscular Stimulation; PT – Physiotherapy; QoL – Quality of Life; RAGT – Robot-Assisted Gait Training; ROM – Range of Motion; SST – Seated Side Tapping; VAS – Visual Analog Scale; WOMAC – Western Ontario and McMaster Universities Osteoarthritis Index; wks – weeks; mos – months.

TRADITIONAL PHYSIOTHERAPY DOSE AND PROGRESSION

A large RCT comparing high- *vs.* low-intensity early rehabilitation found similar functional gains; the HI program was safe [36]. Adding kinesiology taping produced no lasting advantage over supervised exercise [21].

STRENGTH AND RESISTANCE APPROACHES

Concentric vs. eccentric–concentric training improved outcomes in both groups, with greater mobility gains in the latter [25]. Explicit eccentric resistance showed short-term superiority over conventional rehab [26]. Blood-flow restriction training [23] enabled safe low-load strengthening with functional results comparable to standard protocols.

TASK-ORIENTED, BALANCE, AND TRUNK-FOCUSED TRAINING

Task-based protocols improved function, though between-group effects varied [34]. Rapid trunk-movement training improved gait but not range of motion [28]. A 4-week balance program enhanced mobility and WOMAC scores beyond general physiotherapy [27].

MANUAL THERAPY

Mobilization with movement (MWM) added to rehab improved knee flexion at 6 weeks and 6 months, but not pain or function [32]. Other manual techniques rarely offered lasting benefit beyond active programs.

COGNITIVE–BEHAVIORAL ADJUNCTS

Motor imagery (MI), progressive muscle relaxation (PMR), and structured education showed positive effects. MI reduced pain and disability (29,30). PMR in early postop days decreased pain and kinesiophobia, with transient strength gains [31]. Education programs improved self-efficacy and reduced kinesiophobia [35].

TECHNOLOGY-ASSISTED MODELS

A smart brace with sensors enabled remote monitoring, with adherence comparable to clinic-based rehab [22]. App- and sensor-based telerehabilitation improved outcomes over written instructions [23]. Adding trunk exercises enhanced balance in a telerehab model [24]. Robot-assisted gait training produced early mobility benefits [27, 28].

SOFT-TISSUE ADJUNCTS

Foam rolling reduced pain without functional superiority [33]. Kinesiology taping again showed no sustained advantage [21].

SYNTHESIS ACROSS OUTCOMES

Pain and kinesiophobia improved most with progressive muscle relaxation, motor imagery, educational interventions, and foam rolling. Functional mobility was best supported by eccentric resistance training, balance-oriented protocols, and robot-assisted training. Range of motion improved consistently across studies, with additional flexion gains when mobilization with movement was applied. Strength outcomes were most enhanced by eccentric training, blood-flow restriction training, and early relaxation-based programs. High-intensity rehabilitation proved safe, but not superior to well-progressed lower-intensity regimens.

Taken together, these findings emphasize that active, supervised physiotherapy remains the cornerstone of postoperative recovery. Adjunctive methods such as eccentric or blood-flow–restricted strengthening, balance and trunk programs, telerehabilitation, robotic assistance, motor imagery, and structured education can provide additional benefits. However, most adjuncts yielded selective or short-term improvements, highlighting the importance of tailoring interventions to individual patient needs and ensuring continuity of active rehabilitation.

HETEROGENEITY AND CERTAINTY

Protocols varied widely in type, dose, and follow-up, precluding meta-analysis. Standard supervised exercise consistently yielded benefits, while adjuncts provided selective short-term advantages. Long-term durability remains uncertain, highlighting the need for larger standardized trials

DISCUSSION

Deterioration of knee function after arthroplasty remains a challenge and limits recovery without structured, long-term physiotherapy. Patients often show impaired gait, proprioceptive deficits, weakness, and restricted range of motion [4, 13, 14, 24]. Standard rehabilitation combines active and passive mobilization, motor education, manual therapy, strengthening, and electrostimulation, consistently improving pain and quality of life [5, 6].

GENERAL INTERPRETATION

Trials from 2017-2025 confirm no single superior intervention, but several yield specific benefits. Eccentric and eccentric-concentric resistance improved mobility [25, 26], in line with AAOS guidelines emphasizing progressive strengthening [38]. Approaches enabling low-load strengthening were also effective [26]. Balance- and trunk-focused programs enhanced proprioception and independence [30, 34]. Task-oriented training improved daily activity performance [29]. Telerehabilitation and robotic training proved feasible and, in many cases, comparable to conventional care [23, 24, 27, 28], aligning with OARSI, NICE and EULAR recommendations [39-41]. Cognitive-behavioral adjuncts such as progressive relaxation and structured health education reduced pain and kinesiophobia [31, 35], consistent with WHO recommendations for integrating psychological strategies [42].

LIMITATIONS OF THE EVIDENCE

Most studies were of moderate quality, limited by lack of blinding and heterogeneous interventions. Durations varied from 1-2 weeks to 12 months, precluding meta-analysis. Frail and multimorbid patients were underrepresented, limiting generalizability.

LIMITATIONS OF THE REVIEW

Only English and Polish studies were included, introducing possible language bias. Pilot and retrospective studies were

excluded, removing potentially informative data. High heterogeneity necessitated narrative synthesis, reducing precision. Patient-centered outcomes such as satisfaction and independence were insufficiently addressed.

IMPLICATIONS

Clinical practice. Active physiotherapy is the cornerstone of recovery after TKA, as emphasized by AAOS, EULAR, and NICE [38, 40, 41]. Passive modalities may support but not replace exercise. Adjuncts such as telerehabilitation and cognitive strategies should be tailored individually.

Policy. Evidence for telehealth and wearables aligns with OARSI and NICE [39, 40]. In Poland, incorporating such tools into NFZ rehabilitation and balneological centers could improve access and efficiency. Training physiotherapists in new methods is crucial.

Future research. Long-term RCTs with standardized protocols are needed, including frail and multimorbid patients. Cost-effectiveness of high-cost methods like robotics should be evaluated. Exploring physiotherapy combined with balneotherapy may offer additional benefits.

ADDITIONAL EVIDENCE

Kostro et al. showed that a six-week individualized rehabilitation program in patients with bilateral gonarthrosis significantly improved function and quality of life, especially when exercises were combined with orthopedic insoles [43].

BALNEOTHERAPY PERSPECTIVE

Balneotherapy may complement active physiotherapy through thermal, mechanical, and chemical effects that enhance circulation, reduce pain, and support recovery; appropriately tailored interventions can optimize outcomes after TKA [44].

CONCLUSIONS

Active physiotherapy remains essential after TKA, improving pain, strength, mobility, and independence. Adjuncts can enhance recovery but do not replace structured programs. Guidelines consistently recommend individualized rehabilitation with education [38, 40, 42]. Future studies should confirm long-term effects, assess cost-effectiveness, and integrate innovative and balneological approaches into rehabilitation.

ABBREVIATIONS

OA – Osteoarthritis
TKA – Total Knee Arthroplasty
ROM – Range of Motion
QoL – Quality of Life
WOMAC – Western Ontario and McMaster Universities Osteoarthritis Index
KOOS – Knee injury and Osteoarthritis Outcome Score
LEFS – Lower Extremity Functional Scale
VAS – Visual Analog Scale
TUG – Timed Up and Go test
6MWT – Six-Minute Walk Test
SLST – Single-Leg Stance Test
5xSST – Five Times Sit-to-Stand Test
ADL – Activities of Daily Living
FU – Follow-up
NMES – Neuromuscular Electrical Stimulation
BFRT – Blood Flow Restriction Training
MI – Motor Imagery
PMR – Progressive Muscle Relaxation
HAL-SJ – Hybrid Assistive Limb – Single Joint
CSE – Core Stability Exercises
SST – Seated Side Tapping
TTM – Transtheoretical Model
PT – Physiotherapy
RAGT – Robot-Assisted Gait Training
PENS – Patterned Electrical Neuromuscular Stimulation
PABC – Physical Activity Behavior Change
POD – Postoperative Day
Wks – Weeks
KSS – Knee Society Score

REFERENCES

1. Vos T, Lim SS, Abbafati C et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis. Lancet. 2020;396(10258):1204-22. doi:10.1016/S0140-6736(20)30925-9.
2. Safiri S, Kolahi AA, Smith E et al. Global, regional and national burden of osteoarthritis 1990-2019: a systematic analysis of the Global Burden of Disease Study 2019. Ann Rheum Dis. 2020;79(6):819-28. doi:10.1136/annrheumdis-2019-216515.
3. Hunter DJ, Bierma-Zeinstra S. Osteoarthritis. Lancet. 2019;393(10182):1745-59. doi:10.1016/S0140-6736(19)30417-9.
4. Cross M, Smith E, Hoy D et al. The global burden of hip and knee osteoarthritis: estimates from the Global Burden of Disease 2010 study. Ann Rheum Dis. 2014;73(7):1323-30. doi:10.1136/annrheumdis-2013-204763.
5. Martel-Pelletier J, Barr AJ, Cicuttini FM et al. Osteoarthritis. Nat Rev Dis Primers. 2016;2:16072. doi:10.1038/nrdp.2016.72.
6. Loeser RF, Goldring SR, Scanzello CR, Goldring MB. Osteoarthritis: a disease of the joint as an organ. Arthritis Rheum. 2012;64(6):1697-707. doi:10.1002/art.34453.
7. Singh JA, Yu S, Chen L, Cleveland JD. Rates of total joint replacement in the United States: future projections to 2020-2040 using the National Inpatient Sample. J Rheumatol. 2019;46(9):1134-40. doi:10.3899/jrheum.170990.
8. Beswick AD, Wylde V, Gooberman-Hill R et al. What proportion of patients report long-term pain after total hip or knee replacement for osteoarthritis? A systematic review of prospective studies in unselected patients. BMJ Open. 2012;2(1):e000435. doi:10.1136/bmjopen-2011-000435.
9. Lenguerrand E, Wylde V, Gooberman-Hill R et al. Trajectories of pain and function after primary hip and knee arthroplasty: the ADAPT cohort study. PLoS One. 2016;11(2):e0149306. doi:10.1371/journal.pone.0149306.

10. Minns Lowe CJ, Barker KL, Dewey M, Sackley CM. Effectiveness of physiotherapy exercise after knee arthroplasty for osteoarthritis: systematic review and meta-analysis of randomised controlled trials. BMJ. 2007;335(7624):812. doi:10.1136/bmj.39311.460093.BE.
11. Bade MJ, Kohrt WM, Stevens-Lapsley JE. Outcomes before and after total knee arthroplasty compared to healthy adults. J Orthop Sports Phys Ther. 2010;40(9):559-67. doi:10.2519/jospt.2010.3317.
12. Pozzi F, Snyder-Mackler L, Zeni J Jr. Physical exercise after knee arthroplasty: a systematic review of controlled trials. Eur J Phys Rehabil Med. 2013;49(6):877-92.
13. Artz N, Elvers KT, Lowe CM et al. Effectiveness of physiotherapy exercise following total knee replacement: systematic review and meta-analysis. BMC Musculoskelet Disord. 2015;16:15. doi:10.1186/s12891-015-0469-6.
14. Pozzi F, White DK, Zeni JA Jr. Functional performance after total knee arthroplasty: literature review and development of a core set of performance-based outcome measures.Phys Ther. 2017;97(9):898-907. doi:10.1093/ptj/pzx056.
15. Page MJ, McKenzie JE, Bossuyt PM et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi:10.1136/bmj.n71.
16. Sherrington C, Herbert RD, Maher CG, Moseley AM. PEDro. A database of randomized trials and systematic reviews in physiotherapy. Man Ther. 2000;5(4):223-6. doi:10.1054/math.2000.0372.
17. Lefebvre C, Glanville J, Briscoe S et al. Searching for and selecting studies. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ et al., editors. Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3. Cochrane; 2022. p. 67-108. ISBN: 9781119536628.
18. Higgins JPT, Savović J, Page MJ et al. Assessing risk of bias in a randomized trial. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al., editors.Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3. Cochrane; 2022. p. 205-28. ISBN: 9781119536628.
19. Bade MJ, Kohrt WM, Stevens-Lapsley JE. Outcomes before and after total knee arthroplasty compared to healthy adults. J Orthop Sports Phys Ther. 2010;40(9):559-67. doi:10.2519/jospt.2010.3317.
20. Pozzi F, Snyder-Mackler L, Zeni J Jr. Physical exercise after knee arthroplasty: a systematic review of controlled trials. Eur J Phys Rehabil Med. 2013;49(6):877-92.
21. Artz N, Elvers KT, Lowe CM et al. Effectiveness of physiotherapy exercise following total knee replacement: systematic review and meta-analysis.BMC Musculoskelet Disord. 2015;16:15. doi:10.1186/s12891-015-0469-6.
22. Xie H, Zhang Y, Chen L et al. Intelligent knee brace with app feedback improves outcomes after TKA: a randomized trial. Clin Rehabil. 2024;38(5):456-65. doi:10.1177/02692155231176085.
23. Zhao Y, Li Q, Wang X et al. Telerehabilitation using smartphone sensors after total knee arthroplasty: randomized controlled trial. J Telemed Telecare. 2024;30(2):123-32. doi:10.1177/1357633X231179243.
24. Süzer A, Demirci N, Yılmaz S et al. Telerehabilitation with core stability training after TKA: randomized controlled trial. Phys Ther. 2025;105(3):pzab123. doi:10.1093/ptj/pzab123.
25. Teissier P, Robert R, Moreau T et al. Eccentric–concentric resistance training after knee arthroplasty: randomized trial. Ann Phys Rehabil Med. 2020;63(6):490-7. doi:10.1016/j.rehab.2020.04.010.
26. Cheng X, Liu J, Huang Z et al. Progressive resistance training after TKA: randomized controlled trial. Arthritis Care Res. 2024;76(4):645-53. doi:10.1002/acr.25376.
27. Watabe T, Saito T, Ishii Y et al. Robot-assisted exercise using HAL-SJ after total knee arthroplasty: prospective controlled study. J Orthop Sci. 2025;30(1):55-64. doi:10.1016/j.jos.2024.06.012.
28. Maeda T, Kobayashi H, Fujiwara T et al. Short-term effects of HAL-SJ on knee extension after arthroplasty: pilot RCT. J Rehabil Med. 2024;56(9):jrm00212. doi:10.2340/jrm.v56.18292.
29. Briones-Cantero M, Sánchez-García M, López-Morales P et al. Task-oriented training after total knee arthroplasty: randomized controlled study. Physiother Theory Pract. 2020;36(12):1330-9. doi:10.1080/09593985.2019.1700727.
30. Woźniak A, Kaczmarek P, Nowak J et al. Proprioceptive training in addition to standard rehabilitation after TKA: randomized trial. Ortop Traumatol Rehabil. 2017;19(5):421-30. doi:10.5604/01.3001.0010.6231.
31. Eymir M, Arican M, Kaya A et al. Progressive muscle relaxation after knee arthroplasty: randomized controlled trial. Complement Ther Med. 2021;58:102706. doi:10.1016/j.ctim.2021.102706.
32. Alsiri N, Hassan A, Al-Harbi A, et al. Mobilization with movement in rehabilitation after TKA: randomized controlled trial. Physiother Res Int. 2025;30(1):e2120. doi:10.1002/pri.2120.
33. Yokochi T, Tanaka R, Kondo Y et al. Foam rolling as adjunct to standard rehabilitation after TKA: randomized controlled trial. J Bodyw Mov Ther. 2023;27(2):242-9. doi:10.1016/j.jbmt.2022.11.004.
34. An Q, Li Y, Zhao L et al. Balance exercises as adjunct to physiotherapy after knee replacement: randomized controlled trial. Clin Rehabil. 2024;38(7):721-30. doi:10.1177/02692155241228652.
35. Song H, Kim J, Lee S, et al. Health education based on the Transtheoretical Model during rehabilitation after TKA: randomized trial. Patient Educ Couns. 2024;117:65-73. doi:10.1016/j.pec.2024.01.006.
36. Bade MJ, Struessel T, Dayton M et al. Early high-intensity vs standard rehabilitation after total knee arthroplasty: randomized clinical trial. Phys Ther. 2017;97(7):718-30. doi:10.1093/ptj/pzx045.
37. Christiansen MB, Jensen C, Larsen K, et al. Telehealth with behavior change vs education after TKA: randomized controlled trial. J Rehabil Med. 2024;56(3):jrm00152. doi:10.2340/jrm.v56.15152.
38. American Academy of Orthopaedic Surgeons (AAOS). Management of Osteoarthritis of the Knee (Non-Arthroplasty). Evidence-Based Clinical Practice Guideline. Rosemont, IL: AAOS; 2021. ISBN: 978-1-55647-433-5.
39. Bannuru RR, Osani MC, Vaysbrot EE et al. OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. Osteoarthritis Cartilage. 2019;27(11):1578-89. doi:10.1016/j.joca.2019.06.011.

40. National Institute for Health and Care Excellence (NICE). Osteoarthritis: care and management. NICE Guideline NG226. London: NICE; 2022. https://www.nice.org.uk/guidance/ng226
41. Smolen JS, Landewé RBM, Bijlsma JWJ et al. EULAR recommendations for the management of knee osteoarthritis. Ann Rheum Dis. 2020;79(6):685-99. doi:10.1136/annrheumdis-2020-217634
42. World Health Organization (WHO). Rehabilitation 2030: a call for action. Geneva: WHO; 2017. https://www.who.int/publications/i/item/rehabilitation--2030-a-call-for-action
43. Kostro J, Nowak A, Stolarczyk A et al. Individualized rehabilitation with orthopedic insoles in patients with bilateral gonarthrosis: randomized controlled trial. Acta Orthop Belg. 2023;89(2):215-23. doi:10.52628/89.2.11543.
44. Ponikowska I, Kochański J.W.: (red). Wielka Księga Balneologii, Medycyny Fizykalnej i Uzdrowiskowej. Część ogólna [The Great Book of Balneology, Physical and Thermal Medicine. General Part]. Wyd. Aluna. Konstancin-Jeziorna. 2017 (Polish)

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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REVIEW ARTICLE

Rehabilitation and reintegration of servicemen after captivity: The Ukrainian experience

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ABSTRACT

Aim: The study aims to review the Ukrainian model of rehabilitation and reintegration of combatants who were in Russian captivity, which is being created and developed in conditions of active hostilities, highlighting its strengths and shortcomings.

Materials and Methods: The study is based on dialectical, analytic, synthetic, comprehensive methods, and also uses the method of content analysis.

Conclusions: The article analyses the state of rehabilitation and reintegration programs in Ukraine for servicemen who were in captivity. It was determined that Ukraine is currently actively developing a network of rehabilitation institutions, partially adopting the experience of some foreign countries. At the same time, the difficulty is that such development is taking place in the context of an ongoing international armed conflict with Russia. Rehabilitation facilities are already operating, where former prisoners of war are provided with comprehensive medical care, their physical and psychological rehabilitation is carried out, and reintegration measures are also applied. The authors conclude that there are certain problems of rehabilitation and reintegration, which are primarily related to the lack of specialists.

Keywords: rehabilitation, legal liability, reintegration, international armed conflict, former prisoners of war, consequences of captivity

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INTRODUCTION

The rehabilitation and reintegration of prisoners of war (hereafter – POWs) are among the most important and, at times, most complex processes for bringing a person back to a normal life. Prior to the Russian-Ukrainian war, that is, before 2014, Ukraine had a limited number of rehabilitation programs. With the onset of the war, active research into the experiences of other countries (primarily Israel, the United States, and Georgia) began, focusing on successful practices for the rehabilitation of servicemen (combatants) and civilians (non-combatants). Ukrainian researchers have repeatedly emphasized this point (Gnedyk Ye., Horachuk V., Kononov O., Krut A., Noha P., Pashkov V., Soloviov A., and others) [1, 2, 3]. For example, in the United States, there is the U.S. Department of Veterans Affairs (hereinafter referred to as the VA). It develops federal programs and clinical guidelines. The country has a network of state medical and social institutions subordinate to the VA (VA facilities). According to VHA Directive 165 (Evaluation and Treatment of Former Prisoners of War by Care and Benefits Teams, 2023), all VA facilities must have Care and Benefits Teams (CBTs) that specialize in former POWs, provide coordination of medical care, support, etc. VA programs for "Former Prisoners of War" provide priority medical care, exemption from copayments, access to dentistry, glasses, hearing aids, etc. VA recognizes presumptive conditions (i.e., diseases that are automatically considered related to time in captivity) such as: osteoporosis, post-traumatic stress disorder, neurological/psychiatric conditions. In Israel, state medical institutions (Sheba, Ichilov, Shamir) and private non-profit organizations (NATAL) provide a full range of medical treatment and rehabilitation for former POWs based on the guidelines of The Israel Trauma Coalition (ITC), clinical protocols for the treatment of physical injuries, crisis conditions, etc. The protocols for managing prisoners of war are adapted and based on comprehensive rehabilitation programs. At the same time, the country has approved special protocols from the beginning of the provision of psychological assistance to the return of military personnel to normal life. In our view, analyzing the provision of psychological assistance and the features of rehabilitation in the countries that have experienced or are experiencing war is extremely important for adopting successful practices to build a high-quality system of rehabilitation and reintegration services. Thus, in Israel and the USA, a multidisciplinary approach (medicine + mental health + social services), privacy protection, and long-

term support (medical, psychological, social, and professional reintegration) have been implemented. Israel is characterized by rapid adaptation of protocols in response to challenges; the USA is characterized by a strong administrative and legal block of guarantees through the VA system.

Today, despite active hostilities, Ukraine is undergoing a complex process of reforming and improving work with servicemen, including those who have survived Russian captivity. A number of regulations have already been updated and/or developed to address issues (The Laws of Ukraine "On the Status of War Veterans, Guarantees of Their Social Protection" (22.10.1993 No. 3551-XII), "On Social and Legal Protection of Servicemen and Members of Their Families" (20.12.1991 No. 2011-XII), "On Social and Legal Protection of Persons in Respect of Whom the Deprivation of Personal Liberty as a Result of Armed Aggression against Ukraine was Established and Members of Their Families" (26.01.2022 No. 2010-IX), "On the Mental Health Care System in Ukraine" (15.01.2025 No. 4223-IX), the Resolution of the Cabinet of Ministers of Ukraine of 29.11.2022 No. 1338, Order of the MDU of 18.08.2015 No. 414, Order of the Ministry of Veterans Affairs of Ukraine of 14.01.2022 No. 5, etc.), of physical and mental health, and new rehabilitation and reintegration programs are being created. Currently, the Ministry of Health of Ukraine (hereinafter – MHU) is actively developing a modern rehabilitation system based primarily on Israeli experience. Its advantage is that it takes into account both the needs of civilians and the needs of the military. This approach avoids an excess of rehabilitation infrastructure after the war. In addition, partner countries provide support to Ukraine, which is an invaluable contribution in the current situation. Thanks to the MedEvac programme, in cooperation with the European Commission, WHO and other partners, Ukraine regularly sends its citizens, including former POWs, for treatment to Poland, Germany, France, the Czech Republic, Lithuania, Estonia, Latvia, the Netherlands, Spain, Israel, the USA and others. After 24.02.2022, Ukraine has been regularly visited by foreign doctors of various specialities who teach Ukrainian doctors, work in hospitals, consult, operate and assist. In return, foreign colleagues learn from the experience of Ukrainian doctors, which seems to be extremely important in the context of the Russian threat to Europe.

Unfortunately, not all foreign practices have been adopted by Ukraine due to the peculiarities of the Russian-Ukrainian war. For example, experts note that although "all Israeli and American methods are very good, they are built as if the conflict is over, or the person is no longer involved in hostilities... It sounds kind of mocking when a psychotherapist says: "Imagine the conditions in which you were traumatised". But what is there to imagine, if in 2 weeks, maximum 2 months, you will be in the same conditions again" [4]. And even demobilisation sometimes does not solve this problem, as Ukrainian towns and villages far from the frontline are subject to shelling. Therefore, Ukrainian experts are forced to quickly adapt best practices, taking into account the realities.

AIM

The aim of the study is to review the Ukrainian model of rehabilitation and reintegration of Ukrainian combatants who were in Russian captivity, which is being created and developed in conditions of active hostilities, highlighting its strengths and shortcomings.

MATERIALS AND METHODS

The study is based primarily on the analysis of the norms of international humanitarian law (hereafter – IHL), the provisions of Ukrainian legislation, content analysis of media and academic publications. Additionally, we used statistical data of international organizations, conclusions of experts and international humanitarian law. In general, the theoretical bases of study are the following researches: Apalkov V., Beeching N., Brom D., Đuričić V., Frederick B., Gill G., Harwood-Gross A., Horachuk V., Jukić M., Khmylyar O., Klymenko I., Kononov O., Krut A., Lukinac J., Malenica L., Noha P., Pashkov V., Robson D., Škrlec I., Soloviov A., Stern N., Talapko J., Welch E. and others. The research is also based on general scientific and special research methods (dialectical, analytic, synthetic, comprehensive methods, and the method of content analysis).

REVIEW AND DISCUSSION

IHL contains a number of provisions that outline the rights and obligations of parties to a conflict regarding the detention of combatants. These rules were developed by the participating states primarily to minimize human losses, preserve health, and uphold minimum standards of humane treatment. The provisions concerning the treatment of POWs are found in the Hague Conventions and Declarations (1899), Hague Conventions and Declaration (1907), Geneva Convention on Prisoners of War (1929), Geneva Convention on the Wounded and Sick (1929), Universal Declaration of Human Rights (1948), Convention for the Amelioration of the Condition of Wounded, Sick and Shipwrecked Members of Armed Forces at Sea (1949), Convention (III) Relative to the Treatment of Prisoners of War (1949), Protocol I Additional to the Geneva Conventions (1977), among others.

Among the numerous obligations of states involved in armed conflict (war) regarding POWs, the following must be emphasized: protection from torture and inhuman treatment; access to medical care; the right to humanitarian assistance and monitoring, etc. Although this is a minimal and incomplete list, even these obligations are sometimes not fulfilled. Before the Russian-Ukrainian war, we only read in academic publications about the devastating health consequences for POWs, such as tuberculosis, post-traumatic stress disorder, suicides, etc. [5, 6, 7]. However, this war demonstrates that the efforts of the international community are insufficient to protect the life and health of POWs.

Therefore, it is crucial for states to direct significant efforts toward the rehabilitation and reintegration of servicemen and, in particular, former POWs, because "the mere fact of a person being released from captivity does

not mean a return to the life they had before captivity. When reintegrating into a peaceful environment, a former POW must rebuild relationships with others, and regain a sense of being a healthy, protected, whole individual" [8]. The success of reintegration largely depends on the success of rehabilitation.

I. (NON-)COMPLIANCE WITH CONDITIONS OF POW DETENTION

Back in 2014, when the Russian-Ukrainian war began, there were initial cases of both Ukrainian and Russian combatants being captured. It was precisely from 2014 that Ukraine started documenting systematic violations of IHL for POWs by Russia. In this article, not all the violations will be discussed, only those that subsequently require significant rehabilitation and reintegration for the POWs.

Protection from torture and inhuman treatment. According to Art. 13, 14 of the Convention (III) relative to the Treatment of Prisoners of War and Art. 75 of Protocol I Additional to the Geneva Conventions, POWs must always be protected, in particular from acts of violence, torture, inhuman treatment or intimidation. Numerous testimonies of torture and inhuman treatment of Ukrainian POWs have been characteristic of the Russian-Ukrainian war from the very beginning, as documented in many reports, media reports and videos. For example, in 2018, the testimonies of 138 Ukrainian military and civilians who were in captivity were collected and used to compile the report "Basements.rar", which provides evidence of torture of prisoners, inhuman treatment, murder, mock executions, sexual violence, etc. [9]. The Security Service of Ukraine also collected evidence that about 500 Ukrainian citizens held captive in the Russian-occupied territories of Donetsk and Luhansk regions were subjected to physical torture and psychological abuse [10]. Unfortunately, such reports are not isolated and are only part of the evidences of Russia's violation of IHL. In general, Russia's war against Ukraine revealed systemic gaps in the IHL system. But until Russia's full-scale invasion in February 2022, the issue of inhuman treatment of POWs usually did not reach the international level of discussion. Such violations are usually recorded by all parties to the conflict. But unfortunately, the Russians have committed them with impunity since 2014, often accompanied and continue to accompany by the subsequent execution of such POW [11].

Since 2022, the situation has taken on a threatening trend. For example, in July 2022, a video of Russian combatant torturing, castrating and killing a Ukrainian combatant who had been captured spread across the Internet. Such inhumane treatment naturally stirred up a wave of discontent among Ukrainians. And already at the end of July 2022, the United Nations High Commissioner for Human Rights (hereafter – OHCHR) reported 50 cases of torture and ill-treatment of captured Russians. Ukraine in all cases of violations conducts investigations and takes measures to prevent such violations. Russia completely ignores these facts. This only indicates that this is their policy of waging war, which is fully approved by the top military-political leadership, and baseless calls for compliance with IHL are ineffective in improving the situation [11, p. 48]. In September 2022, OHCHR published a report on the human rights situation in Ukraine, which noted that released POWs repeatedly testified to torture and inhuman treatment. In October 2023, a similar report stated the same trend. In October 2024, OHCHR published its 40th report on Ukraine, which provides a general picture of the situation of Ukrainian servicemen who have been in Russian captivity since 2022. In particular, 377 Ukrainian POWs, including 24 women released from Russian captivity, were interviewed and systematic torture and ill-treatment was documented. The condition of these individuals is appalling: they all show signs of dystrophy, many have traces of torture, and often have long-term injuries sustained during hostilities (i.e., proper medical care was not provided). In general, the Russians used severe beatings, electric shocks, sexual violence, suffocation, prolonged stress positions, forced excessive exercise, sleep deprivation, mock executions, threats of violence, and humiliation against Ukrainian POWs (Treatment of prisoners of war and update on the human rights situation in Ukraine, 1.06-31.08.2024.). The facts of the same treatment of Ukrainian POWs in Russian captivity were recorded in the next OHCHR report (01.09-30.11.2024) [12], which indicates a systematic violation of IHL norms by Russia regarding the detention of POWs. The consequence of such treatment is both physical and psychological trauma to POWs. Additionally, it is worth mentioning the psychological trauma of the relatives of Ukrainian POWs.

Access to medical care. Additionally, it is worth mentioning the psychological trauma of the relatives of Ukrainian POWs. In accordance with the provisions of IHL (e.g., Art. 15, 29, 30, 31 of Convention (III) relative to the Treatment of Prisoners of War, Art. 10 of Protocol I Additional to the Geneva Conventions), each POW must be provided with free accommodation and free medical care required by their health condition. At the same time, numerous photos and testimonies prove that most Ukrainians returning from captivity show signs of malnutrition/starvation, exhaustion and old injuries they had received during the hostilities [13-18]. Moreover, in some Russian colonies, Ukrainian POWs do not seek medical care because they fear further torture, including by Russian medical personnel [19].

The right to humanitarian assistance and monitoring. In agreement with Provisions of IHL (for example articles 9, 79, 81 Convention (III) relative to the Treatment of Prisoners of War and art. 81 Protocol I additional to the Geneva Conventions) international humanitarian organizations (hereafter – IHO) should be allowed to POWs. At the same time, IHO have constant access to Russians held captive in Ukraine. In contrast, Russia does not allow anyone, despite all requests. At the same time, the International Red Cross has never publicly stated how many POWs from each side they have visited, limiting itself to a total figure of over 3 000 people from both sides [20].

Although it has been known since 2022 that Russia has been holding Ukrainian combatants in general-type

colonies without repurposing POWs into prisoner-of-war camps, they are not provided with proper medical care, lack normal nutrition, etc. [21]. According to the testimonies of Ukrainian POWs, if third-party officials visited the places of detention, torture and ill-treatment temporarily stopped, and conditions improved in the short term (Treatment of prisoners of war and update on the human rights situation in Ukraine, 1.06-31.08.2024.) [12].

Thus, the first challenge for healthcare professionals providing rehabilitation is the simultaneous combination of physical and psychological trauma in Ukrainian POWs released from Russian captivity, accompanied by exacerbation of chronic diseases and the emergence of new diseases against the background of deep exhaustion and prolonged social isolation. Failure to comply with the conditions of detention of POWs is a prerequisite for the duration of the rehabilitation direction and the rehabilitation measures themselves, since the health status of former POWs varies: from critical to one that requires minor adjustments.

II. THE CURRENT STATE OF REINTEGRATION PROGRAMS FOR POWS IN UKRAINE

Reintegration measures in Ukrainian legislation are defined as "a set of measures aimed at restoring and returning to full activity of the released defenders of Ukraine after their stay in isolation, which includes providing medical and psychological assistance to the released persons, interviewing them and obtaining important information for the activities of the security and defence forces, as well as studying their experience of being in isolation. Reintegration measures, in particular, include medical measures, decompression and debriefing" (the Resolution of the Cabinet of Ministers of Ukraine dated 15.03.2024 № 296) [22]. At the same time, according to Art. 21 of the UN General Assembly Resolution A/RES/60/147, "rehabilitation should include medical and psychological care as well as legal and social services" [23].

As noted, Ukraine was forced to actively create a legal framework for reintegration and rehabilitation, as well as develop programs for former POWs, in 2014. Until 2022, there were several rehabilitation centers in Ukraine that used a comprehensive approach and the best and most effective practices for military rehabilitation. However, they were not able to provide simultaneous treatment and rehabilitation for the number of wounded and injured soldiers, including released Ukrainian POWs, who needed it from the beginning of 2022.

In Ukraine, the issue of rehabilitation of combatants and survivors of captivity is regulated by many regulatory acts and supported by a significant number of programs, initiatives, and projects. Draft legislation is also actively being worked on. For example, on October 11, 2025, the President of Ukraine signed the new Law "On Amendments to Certain Laws of Ukraine Regarding Payments to Military Personnel Released from Captivity Who Have Diseases Requiring Long-Term Inpatient Treatment" (draft law No. 13627 of August 14, 2025). This Law stipulates military personnel (including former POWs) who have serious illnesses and will be hospitalized for more than 30 days will receive monthly assistance in the amount of 50, 000 hryvnias. In addition, the document regulates the procedure for issuing certificates of injuries or illnesses received during captivity. There are also several state programs and initiatives in Ukraine that provide medical, psychological, and rehabilitation assistance (mental health program "How are you?", state program of psychological support for veterans and their family members, comprehensive rehabilitation for those released from captivity, state program of free prosthetics and orthotics, program "Neopalimi" and others).

Currently, Ukraine is expanding its network of rehabilitation centers. However, it is important to note that until 2023, Ukraine did not have a comprehensive systemic approach specifically for the rehabilitation and reintegration of Ukrainian POWs. This is because, after all, the number of POW exchanges between Ukraine and Russia was not very high. As of December 31, 2024, a total of 3, 956 Ukrainians had been returned from Russian captivity since the start of the full-scale invasion [24]. Currently, the Ukrainian government has implemented the first comprehensive program that provides for the rehabilitation and reintegration of both former combatants and non-combatants (Resolution of the Cabinet of Ministers of Ukraine "On the Approval of the Procedure for Conducting Recovery (Post-Isolation, Reintegration) Measures, Adaptation Measures, and Support (Assistance) for Persons Recognized as Deprived of Personal Liberty as a Result of Armed Aggression Against Ukraine, After Their Release" dated 15.03.2024, No. 296 [22].). Additionally, the Coordination Headquarters for the Treatment of Prisoners of War has been established, which is responsible for the reintegration of citizens released from Russian captivity.

The process of restoring the personnel of the Armed Forces of Ukraine (AFU) is carried out comprehensively, with the provision of medical, rehabilitation, psychological, and social services. The procedure includes full diagnostics and a continuous process of treatment and rehabilitation. Recovery is carried out in specialized centers and certain healthcare institutions according to unified standards and protocols, with minimal time spent moving patients. Importantly, the developed algorithms correspond to similar procedures used in NATO countries [25].

It is worth noting that there are certain gaps regarding the provision of assistance and rehabilitation to former POWS, which should be worked on and international experience from countries that have been at war for a long time should be borrowed (for example, Israel).

III. MEDICAL CARE AND PHYSICAL REHABILITATION AFTER RELEASE FROM CAPTIVITY

After an exchange, POWs released from captivity are immediately taken to reintegration centers or state and municipal healthcare institutions designated by the MHU together with the Ministry of Defence of Ukraine (hereafter – MDU). There, they receive medical, rehabilitation, and psychological assistance. The set of measures aimed at restoring and returning to full activity of the released defenders of

Ukraine after being in captivity is documented, and at the same time it contains both standard mandatory measures and those measures that should be applied only in the presence of individual characteristics of the person's condition.

First and foremost, medical examinations are conducted on the released servicemen to document bodily injuries in accordance with procedures determined by a joint order of the Ministry of Internal Affairs and the MHU (Joint Order of the Ministry of Internal Affairs and the MHU "On the Procedure for Recording Cases of Seeking Medical Assistance and Admission to Healthcare Institutions by Persons Due to Infliction of Bodily Injuries of a Criminal Nature and for Informing Police Authorities and Units about Such Cases" dated 6.06.2016, No. 612/679 [22]). Documents confirming facts of torture or other forms of cruel, inhuman, or degrading treatment or punishment of combatants in captivity are forwarded to law enforcement agencies. At this stage, efforts are also made to gather necessary information about POWs who remain in captivity. Comprehensive medical and rehabilitation examinations and psychological diagnostics follow to assess the individual's physical and mental health and determine the necessary level of care.

The medical examination of a released POW includes: an initial general examination by a general practitioner (family doctor) and a psychiatrist, including anamnesis collection and physical examination methods (with the POW's consent for psychiatric evaluation); laboratory tests (general clinical and biochemical blood analysis, urinalysis, rapid tests for infectious diseases, tests for syphilis, HIV, hepatitis B and C); instrumental diagnostics (X-ray, ultrasound, endoscopic exams as indicated); consultations with specialists as needed (the Resolution of the Cabinet of Ministers of Ukraine dated 15.03.2024 № 296) [22].

A rehabilitation assessment is conducted by a physician in physical and rehabilitation medicine and rehabilitation specialists – members of a multidisciplinary rehabilitation team. A rehabilitation diagnosis is determined, assessing existing and potential impairments to bodily functions and structures, activity limitations, participation restrictions, and environmental and personal factors. The need for assistive rehabilitation devices (including prosthetics/orthotics) is also assessed, and the findings are recorded in an individual rehabilitation plan. If rehabilitation care is provided by a single rehabilitation specialist, the results are documented in a therapy program. To develop a comprehensive treatment plan, a final full medical examination is conducted by a commission of physicians. At the same time, rehabilitation assistance for POWs is provided on the same legal basis as for civilian citizens – there is no separate rehabilitation program for combatants, including those who survived captivity (the Resolution of the Cabinet of Ministers of Ukraine dated 16.12.2022 № 1462) [22]. The state's approach is that all people are equal. However, we believe that the rehabilitation of a serviceman who has endured captivity should be a separate package of services. It must aim to prevent loss, slow deterioration, support, compensate for, improve, or restore the functioning of a person in need of rehabilitation. Specialists note that servicemen require long-term rehabilitation after combat. Most often, they suffer from limb injuries, traumatic brain injuries, hearing damage, and facial bone and soft tissue damage [3]. In the case of POWs, these injuries are often old and require extended treatment and rehabilitation.

In conditions of limited human resources in Ukraine, every person is invaluable, and thus, prosthetics for POWs released from captivity receives special attention. Prosthetics are vital for successful socialization and adaptation to civilian life. Moreover, former POWs can, if they wish, return to serve in the Armed Forces (§23 Art. 10-1 of the Law of Ukraine "On the Social and Legal Protection of Military Servicemen and Their Family Members" dated 20.12.1991, No. 2011-XII [22]).

Prosthetics in Ukraine is divided into primary and secondary phases. Primary prosthetics are carried out based on the Cabinet of Ministers Resolution No. 312 dated May 5, 2012. Secondary prosthetics is governed by Resolution No. 518 dated October 1, 2014. The state provides free prosthetic services, including the purchase, maintenance, and repair of prostheses. POWs can choose their prosthetics manufacturer. It is not necessary to wait for an official disability status to receive a prosthesis. Primary prosthetics occurs after stump formation. Secondary prosthetics takes place 12 months after amputation. Typically, prosthetics is a two-step process. The exception is the loss of an upper limb: if the patient's condition is stable, a bionic prosthesis may be installed immediately. To receive a high-functionality lower limb prosthesis, the person must first use a mechanical one for a year. Mastering a bionic prosthesis during secondary prosthetics can be more difficult.

A separate and important element of the rehabilitation of those released from captivity is dental prosthetics, as most people return with significant dental problems. According to the Resolution of the Cabinet of Ministers of Ukraine No. 1017 of August 22, 2025, those released from captivity have the right to free dental treatment and prosthetics.

Challenges of Physical Rehabilitation in Ukraine Amid the Ongoing Armed Conflict Include: 1) the absence of a well-developed network of rehabilitation centers in each administrative unit of Ukraine, which would enable the provision of rehabilitation services to a large number of injured individuals, including POWs who have been in captivity; 2) an insufficient number of prosthetics specialists, especially those certified to work with components of bionic prostheses; 3) the appropriateness of dividing prosthetics into primary and secondary stages is also criticized, since it is during secondary prosthetics that POWs have the opportunity to receive a high-quality bionic prosthesis. As a result, some servicemen, in order to avoid receiving free mechanical prostheses, turn to charitable foundations for assistance [26]. At the same time, a positive aspect is the ability to redistribute the amount of medical care to those released from captivity depending on the complexity and duration of treatment. This is done by determining a list of a person's needs through a military medical commission (MMC) and subsequently prescribing treatment in specialized facilities, which may include rehabilitation and sanatorium-resort treatment.

IV. PSYCHOLOGICAL REHABILITATION

One of the key forms of assistance for former POWs is psychological rehabilitation, which is associated with a person's mental health. According to psychologists, most of those who return from captivity do not understand or believe for a long time that they have been exchanged and are back on Ukrainian territory. This is due to the psychological pressure applied by Russians, who often move POWs from place to place, threaten and abuse them. As a result, the moment of release becomes unexpected and traumatic. This experience leads to stress, mental disorders, depression, anxiety, and prolonged difficulty adapting to life outside captivity. The trauma of captivity deeply affects an individual's mental state and often results in lasting psychological changes.

Negative influences that affect individuals include: physical and psychological cruelty; total isolation from relatives and loved ones; fear for one's life and health; moral suffering causing psychological trauma and disorders; difficult adaptation after release; deteriorating physical health; social disconnection and isolation [27]. These traumas result in changes in perception and behaviour, such as disorganized actions, regression of learned skills, inappropriate responses to stimuli, difficulty concentrating, reduced memory capacity, impulsive behaviour, and significant autonomic changes. If these conditions persist, the disruption of biological adaptation and compensatory mechanisms may become irreversible and lead to chronic neuropsychiatric disorders [28]. Thus, psychological rehabilitation is a crucial part of returning to normal life.

Psychological rehabilitation involves activities aimed at restoring and supporting a person's physical, emotional, intellectual, social, and spiritual functioning using psychological and psychotherapeutic techniques, including psychotherapy, psychological counselling, or psychological first aid (the Resolution of the Cabinet of Ministers of Ukraine dated 29.11.2022 No. 1338) [22]. This is part of a broader rehabilitation and reintegration program.

Key objectives include: diagnosing and normalizing mental functions; restoring or optimizing lost mental capacities; rebuilding family relationships and self-esteem; improving social activity and coping skills; mastering self-regulation and stress management techniques; preventing psychological trauma and mental disorders; providing psychoeducation and support to families [29, 30].

The procedure for providing psychological assistance to war veterans, their family members, and other categories of people is outlined by Cabinet Resolution No. 1338, dated 29.11.2022. It defines 3 levels of assistance: 1) social-psychological support and social services (e.g., case management, social adaptation, counselling); 2) psychological assistance to address specific psychological problems caused by trauma, including captivity; 3) comprehensive medical-psychological care [22].

The main goal upon release is to stabilize mental health. Psychological support begins immediately and consistently. Upon return to Ukraine, all released POWs receive medical care, and military psychologists begin monitoring their condition. Decompression is the initial phase of full psychological rehabilitation, including diagnostics, emotional relief, and gradual reintegration into social norms [31].

After arriving at a medical facility, a personalized rehabilitation plan is selected, taking into account the individual needs of the released prisoner. As I.S. Klymenko notes, special attention is "given to individualized approaches that take into account the unique needs and experiences of each victim" [27].

Even in the stabilization stage, conversations are held to identify signs of stress, fear, insecurity, and emotional detachment. Based on this, individuals are offered individual or group therapy, most often using cognitive training, vestibular training, individual and group psychotherapy, and resource-based therapy.

The duration of rehabilitation depends on each case. If needed, multiple rehabilitation cycles may be provided annually to restore a sense of safety and stability, process and reflect on trauma, reduce emotional pain, and support post-crisis growth. Psychological support is also extended to families of former POWs for stabilization.

The next stage is reintegration into society through adaptation and renewed communication. Reintegration centers offer private rooms for meetings with relatives, allowing communication while rehabilitation continues.

A vital stage is post-program support, including continued psychological assistance, therapy, and counselling (the Law of Ukraine "On the Social and Legal Protection of Persons Recognized as Deprived of Personal Liberty as a Result of Armed Aggression Against Ukraine, and Members of Their Families" dated 26.01.2022, No. 2010-IX) [22]. The importance of follow-up support is emphasized by Israeli and Croatian experts [7, 32].

Psychological support is provided by specialized institutions. Currently, there are more than 40 Mental Health Centers operating in Ukraine, whose activities are documented and standardized ("Model Regulation on the Mental Health Center in a Healthcare Institution" approved by Order of the MHU dated October 25, 2024 No. 1796). For example, the state center "Lisova Polyana", which focuses on psychotrauma, depression, anxiety, survivor's guilt, and concussion. The center provides 3–4 weeks individual programs combining psychological and physical recovery [33]. Civil society organizations, such as "Blue Bird" (active since 2015), also help those who experienced illegal detention and torture, as well as their families [34]. Unfortunately, in some cases, treatment or physical rehabilitation is impossible due to severe violations of IHL by Russia. In such cases, only psychological rehabilitation is attempted. For example, Ukrainian combatants who were castrated – often right after being captured near the front or while in captivity – face extremely severe trauma. Such cases have been known since 2014 [35, 36] and are often beyond recovery.

Despite progress, challenges remain in psychological rehabilitation:

a) there is a shortage of specialists. Moreover, as noted by the medical workers themselves, not all psychologists

are capable of providing assistance to servicemen returning from Russian captivity [37]. Currently, a very large number of people in Ukraine are in need of psychological support. The Ukrainian authorities are looking for ways to solve this problem, but the training of professional psychologists takes time, which is lacking;

b) the secondary level of mental health care for POWs is currently underdeveloped. In cases involving those who have survived Russian captivity, further long--term psychological assistance is often needed. This type of assistance is no longer stabilizing in nature but involves prolonged work with a psychologist according to an individual program. However, this option is currently complicated, as there is no referral network specifically for psychologists experienced in working with individuals who have endured captivity. We need to develop certain algorithms for referrals for secondary support to the civil sector, establish verification procedures for specialists working with this category of individuals, create a registry, and inform people about the possibility of seeking secondary support. At the same time, H. Mokrousova's remark is valid that Ukraine is creating a unique experience during active combat operations. This is difficult, as there has never before been a situation where, during wartime, thousands of people simultaneously needed support and rehabilitation [38];

c) a related and partially addressed issue is the provision of psychological support to the relatives of those released from Russian captivity. In Ukraine, efforts are made – despite limited human resources – to provide such assistance, as well as to spread information among the population about how to communicate effectively with individuals who have survived Russian captivity. This contributes to the successful rehabilitation and reintegration of released POWs and gives confidence to ordinary citizens on how to behave with such individuals so as not to cause them additional suffering [39, 40].

V. SOCIAL AND PROFESSIONAL REINTEGRATION

According to Art. 8 of the Law of Ukraine "On the Social and Legal Protection of Persons Recognized as Deprived of Personal Liberty as a Result of Armed Aggression Against Ukraine, and Members of Their Families" dated 26.01.2022, No. 2010-IX, after release from Russian captivity, individuals are also provided with social and professional adaptation and social services, including placement in social institutions, in accordance with the procedure established by the Cabinet of Ministers of Ukraine [22]. In particular, their documents are restored, they are granted additional leave of 90 calendar days with the preservation of monetary support, assistance in finding employment or education (For example, in the spring of 2024, a new free educational program was launched for servicemen released from captivity and their family members: "IT Reintegration: a joint project of the Coordination Headquarters and the charitable foundation 'Wings into the Future'" [41]), housing, free legal assistance, and so on. In addition, the Coordination Headquarters continues to provide information and assistance to released prisoners and their families regarding long-term assistance and support, including were created of a Roadmap for such persons. A separate area is work with families of prisoners of war regarding the possibilities of support from state institutions. It includes appeals to the Ministry for Reintegration of Temporarily Occupied Territories of Ukraine, the Joint Center for Search and Release of Prisoners, the National Information Bureau, which provide information and support to families, as well as to the Coordination Headquarters for the Treatment of POWs for operational information.

An important factor for the successful reintegration of servicemen released from captivity is the ability to independently choose: to return to serve on the battlefield or in the rear, or to demobilize and attempt to live a civilian life. Experts note that for servicemen who have experienced Russian captivity, the ability to make their own choice is extremely important for restoring personal boundaries.

CONCLUSIONS

The consequence of the Russian-Ukrainian war is the emergence of a specific category of individuals – servicemen who have been in captivity. Russia's non-compliance with the norms of IHL has led to these individuals suffering from severe long-standing injuries (amputated limbs, fractures, signs of torture), aggravated chronic illnesses against the background of general body exhaustion. All this is accompanied by psychological disorders resulting from torture and inhumane treatment, as well as from long-term isolation.

The main achievement of Ukraine in the issue of rehabilitation and reintegration of released military personnel from captivity is, in our opinion, the formation of an effective system of rehabilitation and reintegration measures within a short period of time and in the conditions of full-scale hostilities. Unfortunately, not all existing foreign methods have proven acceptable for Ukraine in the conditions of the ongoing war. Therefore, the improvement of the existing system is constantly taking place through the expansion of the system of rehabilitation institutions, the emergence of new free packages of medical services, the improvement of the relevant legal framework, etc.

Therefore, in accordance with Ukrainian legislation, after the exchange procedure and before providing them with rehabilitation assistance, the released POWs will undergo an initial medical examination to establish a diagnosis (health status) and provide information to determine initial medical restrictions and precautions. Next step: the person will be sent to a healthcare facility, where a detailed medical examination will be performed, all existing injuries will be recorded (this information is reported to law enforcement agencies to establish facts of torture, other forms of cruel, inhuman or degrading treatment, and to bring the perpetrators to justice), and medical care, physical and psychological rehabilitation

will be provided. This medical institution also provides social and professional reintegration services, ensures close interaction between specialists, conducts reintegration measures and post-isolation support. However, the terms of post-isolation measures are not clearly established, since they are determined individually for each person, according to their health status.

Currently, Ukraine faces the following problems that require resolution: 1) a shortage of specialists, primarily rehabilitation therapists and psychologists, amid a large number of people in need of assistance, especially those capable of providing qualified help to servicemen released from captivity; 2) the inability to fully provide POWs, including those released from captivity, with free bionic prostheses; 3) a shortage of rehabilitation therapists trained to service bionic prostheses; 4) the need to improve the secondary level of psychological assistance. The state is trying to solve these issues through active cooperation with foreign partners. At the same time, the experience of Ukrainian doctors is valuable, so constant knowledge exchange is advisable.

REFERENCES

1. Pashkov V, Noha P, Soloviov A. Some Problems of Rehabilitation of Servicemen Taking Part in the Hostilities: the International Legal Aspect and Ukrainian Experience. Acta Balneol. 2018;3(153):198-201.
2. Vitalii M. Pashkov, Anna S. Sydorenko, Yevhen S. Gnedyk. The Rehabilitation of Post-Traumatic Stress Disorder of Servicemen: Certaim Aspect. Acta Balneol. 2023;65(6):429-436. doi:10.36740/ABal202306113.
3. Horachuk VV, Krut AH, Kononov OY. Availability of rehabilitation for victims of mine-explosive injury in the conditions of territorial community. Wiad Lek. 2024;77(5):926-931. doi: 10.36740/WLek202405107.
4. Klymyk M. Pislia polonu: chy maiut pravo kolyshni viiskovopoloneni zvilnytysia z viiskovoi sluzhby. 25.05.2023. Mediina initsiatyva za prava liudyny. URL: https://mipl.org.ua/pislya-polonu-chy-mayut-pravo-kolyshni-vijskovopoloneni-zvilnytysya-z-vijskovoyi-sluzhby/ (Ukrainian)
5. Kunz JL. (1953). Treatment of Prisoners of War. Proceedings of the American Society of International Law at Its Annual Meeting (1921-1969), 47, 99-121. URL: http://www.jstor.org/stable/25657296
6. Robson D, Welch E, Beeching NJ, Gill GV. Consequences of captivity: health effects of far East imprisonment in World War II. QJM. 2009 ;102(2):87-96. doi: 10.1093/qjmed/hcn137.
7. Jukić M, Malenica L, Đuričić V et al. Long-Term Consequences of War Captivity in Military Veterans. Healthcare (Basel). 2023;11(14):1993. doi: 10.3390/healthcare11141993.
8. Khmiliar O, Apalkov V. Psykholohiia zhyttia viiskovosluzhbovtsia pislia polonu. Visnyk Kyivskoho natsionalnoho universytetu imeni Tarasa Shevchenka. Viiskovo-spetsialni nauky. 2022;50:54-59. doi: 10.17721/1728-2217.2022.50.54-59. (Ukrainian)
9. Pravozakhysnyky opryliudnyly dokazy tortur i vbyvstv, zdiisnenykh rosiianamy ta yikhnimy poplichnykamy na Donbasi. URL: https://www.unian.ua/war/10117625-pravozahisniki-oprilyudnili-dokazi-tortur-i-vbivstv-zdiysnenih-rosiyanami-ta-jihnimi-poplichnikami-na-donbasi.html (Ukrainian)
10. Maizhe 500 zvilnenykh zaruchnykiv ORDLO rozpovily pro katuvannia – SBU. Ukrainska pravda. URL: https://www.pravda.com.ua/news/2018/06/12/7183122/ (Ukrainian)
11. Mykhailichenko T. (Non)observing the rights of the combatant to health in captivity: the experience of the russian-ukrainian war. Places : 4th International Interdisciplinary Conference, Rīga Stradiņš University, 26–28 March 2025. Rīga: RSU, i-viii p., p. 48.
12. OHCHR. URL: https://ukraine.un.org/
13. Pro znushchannia v poloni Olenivku ta vidnovlennia: interviu iz zakhysnykom Mariupolia Mykhailom Dianovym. 17.10.2022. Fakty. URL: https://fakty.com.ua/ua/ukraine/suspilstvo/20221017-pro-znushhannya-v-poloni-olenivku-ta-vidnovlennya-intervyu-iz-zahysnykom-mariupolya-myhajlom-dianovym/ (Ukrainian)
14. Mukhina O. Ukrainian POWs die in Russian captivity as medical care denied, says Ukrainian ombudsman. 28/01/2025. Euromaidan Press. URL: https://euromaidanpress.com/2025/01/28/ukrainian-pows-die-in-russian-captivity-as-medical-care-denied-says-ukrainian-ombudsman/
15. Poloneni zakhysnyky ChAES ne otrymuiut medychnu dopomohu - Koordshtab. 26.07.2023. New voice. URL: https://nv.ua/ukr/ukraine/events/rodini-polonenih-nacgvardiyciv-na-chaes-rozpovili-umovi-utrimannya-novini-ukrajini-50341681.html (Ukrainian)
16. Kurenkova O., Kuzmenko Yu. Okrip zamist obidiv ta infovakuum - yak RF katuie ukrainskykh viiskovopolonenykh. 27.11.2023. Suspilne novyny. URL: https://suspilne.media/626675-okrip-zamist-obidiv-ta-infovakuum-ak-rf-katue-ukrainskih-vijskovopolonenih/ (Ukrainian)
17. Sokolivska Ya. Yak vyzhyty, riatuvaty pobratymiv u tiurmi ta ne zlamatysia: viiskovyi likar iz Zhytomyra pro perebuvannia u poloni. 22.07.2024. Suspilne novyny. URL: https://suspilne.media/zhytomyr/795857-ak-viziti-ratuvati-pobratimiv-u-turmi-ta-ne-zlamatisa-vijskovij-likar-iz-zitomira-pro-perebuvanna-u-poloni/ (Ukrainian)
18. U bilshosti zvilnenykh viiskovykh krainii stupin anoreksii - patronatna sluzhba "Azov". Lviv.media. URL: https://lviv.media/viyna/54496-u-bilshosti-zvilnenykh-viyskovykh-krayniy-stupin-anoreksii-patronatna-sluzhba-azov/ (Ukrainian)
19. Klymyk M. Tam, de povilno vmyraiut: yak vlashtovana medytsyna v rosiiskomu poloni. 28.02.2024. Mediina initsiatyva za prava liudyny. URL: https://mipl.org.ua/tam-de-povilno-vmyrayut-yak-vlashtovana-medyczyna-v-rosijskomu-poloni/ (Ukrainian)
20. Families people missing or captured russia ukraine international armed conflict visit. URL: https://www.icrc.org/en/news-release/families-people-missing-or-captured-russia-ukraine-international-armed-conflict-visit
21. Upovnovazhenyi: rosiia utrymuie ukrainskykh viiskovopolonenykh u koloniiakh zahalnoho rezhymu. 24/04/2022. Ombudsman of Ukraine. URL: https://www.ombudsman.gov.ua/news_details/upovnovazhenij-rosiya-utrimuye-ukrayinskih-vijskovopolonenih-u-koloniyah-zagalnogo-rezhimu (Ukrainian)

22. Ofitsiinyi sait Verkhovnoi Rady Ukrainy. URL: https://zakon.rada.gov.ua/laws/show/ (Ukrainian)
23. Resolution adopted by the General Assembly on 16 December 2005 : General Assembly of the United Nations. UN. URL: https://www.ohchr.org/en/instruments-mechanisms/instruments/basic-principles-and-guidelines-right-remedy-and-reparation
24. Zelenskyi rozpoviv, skilky liudei povernuly z rosiiskoho polonu vprodovzh roku : ofits. sait onlain media "Suspilne novyny". URL: https://suspilne.media/91-5369-zelenskij-rozpoviv-skilki-ludej-povernuli-z-rosijskogo-polonu-vprodovz-roku/ (Ukrainian)
25. Reintehratsiia zvilnenykh z rosiiskoho polonu hromadian. The Coordination Headquarters for the Treatment of Prisoners of War. URL: https://koordshtab.gov.ua/posts/reintehratsiya-zvilnenykh-z-rosiyskoho-polonu-hromadyan (Ukrainian)
26. Tolkachova O. Yak Minsotspolityky zakhovalo miliard hryven na protezuvannia viiskovykh. Ukrainska pravda. URL: :https://www.pravda.com.ua/columns/2024/09/10/7474324/ (Ukrainian)
27. Klymenko IS. Innovative approaches in the rehabilitation of military prisoners of war and residents of temporarily occupied territories. Psych Neurol Med Psychol. 2024;11(23):50-56 doi: 10.26565/2312-5675-2024-23-06
28. Banner Thomas Frederick. An Examination of the Lived Experiences of United States Military Veterans who have been Diagnosed with Psychological Inflictions of War who have Utilized Equine Assisted Therapy. LSU Doctoral Dissertations. URL: http://digitalcommons.lsu.edu/gradschool_dissertations/1186
29. Psykholohichna robota z viiskovosluzhbovtsiamy-uchasnykamy boiovykh dii na etapi vidnovlennia. Metodychnyi posibnyk. Kyiv : «Tsentr uchbovoi literatury», 2023. 283s. (Ukrainian)
30. Osnovy reabilitatsiinoi psykholohii: podolannia naslidkiv kryzy. Navchalnyi posibnyk. Tom 2. Kyiv, 2018. 240 s. (Ukrainian)
31. Dekompresiia viiskovosluzhbovtsiv. URL: https://arpp.com.ua/articles/decompression (Ukrainian)
32. Harwood-Gross A, Stern N, Brom D. Exposure to combat experiences: PTSD, somatization and aggression amongst combat and non-combat veterans. Int J Psychol. 2023 Oct;58(5):424-432. doi: 10.1002/ijop.12917.
33. Kseniia Voznitsyna: «Vid nas bude zalezhaty psykhichne zdorovia kozhnoho, khto povernetsia z viiny». Sestry. URL: https://www.sestry.eu/statti/kseniya-voznicina-vid-nas-bude-zalezhati-psihichne-zdorovya-kozhnogo-hto-povernetsya-z-viyni (Ukrainian)
34. Blakytnyi ptakh. URL: http://hostage.org.ua/about (Ukrainian)
35. Chastyna cholovikiv zvilnenykh z polonu vyiavylysia kastrovani: odyn pokinchyv z zhyttiam, volonter. URL: https://24tv.ua/chastina_cholovikiv_zvilnenih_z_polonu_viyavilisya_kastrovani_odin_pokinchiv_z_zhittyamvolonter_n527179 (Ukrainian)
36. Dvokh soldat ZSU kastruvaly rosiiany u poloni. Khloptsiv povernuly pid chas obminiv. URL: https://www.objectiv.tv/uk/objectively/2023/06/19/dvoh-soldativ-zsu-kastruvali-rosiyani-u-poloni-hloptsiv-povernuli-pid-chas-obminu/#google_vignette (Ukrainian)
37. «Ne kozhen psykholoh spravytsia». Yak prokhodyt reabilitatsiia viiskovykh, vyzvolenykh z polonu. URL: https://glavcom.ua/publications/ne-kozhen-psikholoh-spravitsja-jak-prokhodit-reabilitatsija-vijskovikh-vizvolenikh-z-polonu-879465.html#google_vignette (Ukrainian)
38. "Zvilnennia dlia polonenykh – tse shok, bo strashno poviryty u shchos khoroshe", – psykholohynia Hanna Mokrousova. URL: http://hostage.org.ua/about-project/zvilnennya-dlya-polonenih-tse-shok-bo-strashno-poviriti-u-shhos-horoshe-psihologinya-ganna-mokrousova/ (Ukrainian)
39. V Ukraini zapratsiuvala platforma "Vilnyi step" dlia kompleksnoi pidtrymky ta suprovodu liudei, yaki perezhyly polon, postrazhdaly vid tortur, SNPK ta chleniv yikh rodyn. URL: https://www.ukrinform.ua/rubric-society/3939115-v-ukraini-zapracuvala-platforma-vilnij-step-dla-pidtrimki-ludej-aki-perezili-polon-ta-torturi.html (Ukrainian)
40. Yak zminiuietsia liudyna pislia polonu? URL: https://armyinform.com.ua/2023/10/13/yak-zminyuyetsya-lyudyna-pislya-polonu/ (Ukrainian)
41. IT-reintehratsiia: spilnyi proiekt Koordshtabu ta BF "Kryla v maibutnie". 12.03.2024. The Coordination Headquarters for the Treatment of Prisoners of War. URL: https://koordshtab.gov.ua/posts/it-reintehratsiya-spilnyy-proyekt-koordshtabu-ta-bf-kryla-v-maybutnye (Ukrainian)

CONFLICT OF INTEREST

The Authors declare no conflict of interest

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REVIEW ARTICLE

Greater trochanteric pain syndrome (GTPS) in primary care

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ABSTRACT

Aim: The aim of this review is to discuss diagnostic and therapeutic management of greater trochanter pain syndrome (GTPS) in primary care.

Materials and Methods: PubMed, Scopus, and Google Scholar databases were searched to prepare the manuscript. This review includes original studies, meta-analyses, and review articles, but excludes conference proceedings, letters to the editor, and errata.

Conclusions: Greater trochanteric pain syndrome is a relatively common musculoskeletal disorder in the general population, including primary care patients. Its frequent occurrence, combined with the heterogeneous clinical presentation, highlights the importance of early and accurate identification of this condition at the primary care level. Inadequate or delayed diagnosis may lead to prolonged suffering, unnecessary specialist referrals, and increased healthcare costs; therefore, raising awareness and competence in this area should be an essential component of continuing education for primary care physicians. Given the typical course and treatment options, the diagnosis and basic management of GTPS can be effectively initiated within primary care settings. Incorporating structured clinical assessment, patient education, and evidence-based conservative interventions may improve outcomes and reduce symptom burden. Strengthening diagnostic skills and broadening therapeutic knowledge among primary care providers can support timely intervention and help ensure that patients receive appropriate guidance and relief without delay.

KEYWORDS: enthesopathy, bursitis, musculoskeletal disorders, healthcare, treatment, physiotherapy, prophylactic

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INTRODUCTION

Musculoskeletal disorders are one of the most common reasons for patients to seek primary care. Osteoarthritis, enthesopathies, and overuse pain syndromes are among the most commonly diagnosed conditions in this group [1, 2]. In recent years, there has been a significant increase in the number of patients visiting family doctors with musculoskeletal complaints, including hip pain [3, 4]. Among these cases, greater trochanteric pain syndrome (GTPS) is increasingly being diagnosed, which is one of the main causes of chronic pain in the lateral hip region [1, 5].

This condition encompasses a group of soft tissue pathologies around the hip joint, including tendinopathy of the gluteus medius and/or minimus muscles and inflammation of the hip joint bursa/bursae [6, 7]. GTPS occurs 3-4 times more frequently in women, mainly between the ages of 40 and 70, and often coexists with obesity, limb axis disorders, or degenerative diseases of the hip and knee joints [8, 9]. Despite its high prevalence, this condition appears to be underdiagnosed in primary care settings, and its symptoms are often confused with hip osteoarthritis and sciatica [10]. The consequence of misdiagnosis is a delay in the implementation of effective treatment and the use of symptomatic pharmacotherapy, which does not address the biomechanical causes, postponing causal treatment [4, 9].

In light of the latest reports, early diagnosis of GTPS, appropriate patient education, and implementation of causal treatment are of key importance. Prevention, including secondary and tertiary prevention, plays a significant role in education and management [11-13]. The so-called three-stage concept of treating musculoskeletal disorders is being used more and more often [14]. Recent studies show that combining exercise therapy, physical methods, and modern injection techniques, such as PRP (Platelet-Rich Plasma) injections [15, 16], as well as the increasingly used injectable collagen therapy, are highly effective and safe in the treatment of GTPS [17,18].

AIM

The aim of this review is to discuss the diagnostic and therapeutic role in the course of greater trochanteric pain syndrome in primary care.

MATERIALS AND METHODS

PubMed, Scopus, and Google Scholar databases were searched to prepare the manuscript. This review includes original studies, meta-analyses, and review articles, but

excludes conference proceedings, letters to the editor, and errata.

SYMPTOMS AND DIAGNOSIS

GTPS can be primary or secondary. Primary GTPS is often associated with sedentary work combined with a lack of regular physical activity and sports. Secondary GTPS is primarily associated with other pathologies, such as gonarthrosis, coxarthrosis, spondylosis, limb axis disorder, or limb shortening [19]. In addition to pain in the lateral part of the hip, pain radiating towards the lumbosacral spine is observed, therefore, in addition to GTPS therapy, mesotherapy of the L-S spine may be considered [17, 20]. In addition, through the iliotibial band (tensor fascia lata), the pain may radiate along the lateral part of the thigh to the knee, and sometimes deep into the buttock, causing symptoms of piriformis syndrome [21]. The diagnosis of GTPS is based mainly on medical history and clinical examination. The patient lies on a couch, on their side, with their lower limbs straight at the hip and knee joints. We assess the greater trochanter by palpation. As a rule, the patient reports severe pain when pressure is applied. In case of doubt, the examination can be supplemented with an ultrasound scan (which shows enthesopathy, bursitis/bursae). An X-ray examination may reveal calcifications or osteophytes in the greater trochanter. In advanced cases, MRI may be useful, but it is not a routine examination [17, 22, 23].

THREE-STAGE TREATMENT CONCEPT

There is increasing mention of the so-called threne-stage concept of treating musculoskeletal disorders, including those of the spine. The concept is based on the assessment and modification of risk factors, given that their elimination is often impossible. Broadly understood medical therapy is implemented, e.g., injection therapy in the course of GTPS. Then, at the appropriate time (usually at the end or after the initial medical therapy), movement therapy (kinesitherapy) begins [14]. In the case of mesotherapy of the greater trochanter, 5 treatments are performed first, at weekly intervals, and then physiotherapy is implemented [23]. The rehabilitation process is essential and must be implemented, but at the right time, after proper preparation, i.e., relaxation of tense soft tissues, improvement of mobility, and reduction of pain [24]. There is increasing talk of the so-called three-stage concept. When using injectable collagen therapy in the course of GTPS, five treatments are typically performed at weekly intervals, followed by exercises [25]. The main goal of this approach is to achieve better therapeutic results in the long term. Nevertheless, the patient plays an important role in this concept, as they are involved in the treatment process. Therefore, it is essential that the patient is educated by a doctor and physiotherapist [14].

MEDICAL THERAPY

In the initial phase, medical therapy for GTPS is based on the use of NSAIDs [19]. However, due to the frequent late diagnosis of GTPS, it becomes a chronic condition. Therefore, targeted conservative, minimally invasive, non-surgical therapy is primarily used [26]. The treatments used include PRP injections [16, 27, 28], steroid injections [29-31], and type I collagen injections, which are available to primary care physicians after completing training [17, 18].

As part of outpatient physiotherapy, a primary care physician may prescribe kinesitherapy, massage, electrotherapy, electromagnetic field therapy, light therapy and thermotherapy, hydrotherapy, cryotherapy, and even balneotherapy [12].

As described above, various types of physical therapy are used in some patients, including extracorporeal shock wave (ESW) therapy [32, 33]. In difficult cases, thermolesion – radiofrequency ablation – should be considered [34].

An important element of therapy is the use of exercise, but with due caution and care. At the beginning (depending on the method of treatment, from a few days to 6 weeks), stretching exercises or exercises with significant load should be avoided [23].

DISCUSSION

This article is one of the first review papers describing GTPS in the context of primary health care (PHC). GTPS is a common musculoskeletal disorder in the primary health care patient population. Despite its high prevalence, diagnosis of this condition remains difficult, and many patients receive inappropriate treatment focused solely on symptoms [1, 2]. As emphasized by Donati et al. [1], accurate clinical diagnosis, including palpation, functional tests, and imaging, is key to the effective diagnosis of GTPS, which is often confused with sciatica.

These disorders are much more complex than is commonly believed and include greater trochanteric pain syndrome, gluteal tendon pathology, greater trochanteric bursitis, external coxa saltans, and compression of the greater trochanter and ischial bone. The intraoperative classification system for greater trochanteric pain syndrome has been confirmed as a universal tool, validated by prospectively collected data, taking into account a ten-year eligibility period after open or endoscopic treatment of peritrochanteric disorders, with at least two years of follow-up using validated patient-reported outcomes. This classification provides guidance for prognosis and treatment, including conservative treatment, as an optimal orthopedic classification system should [13, 35, 36].

In studies by Yeo et al. [3] and Estberger et al. [4], it was noted that in primary care settings, GTPS is often mistakenly differentiated from hip joint pathology, sciatica, or bursitis. As a result, patients receive ineffective pharmacological treatment or are referred too early for orthopedic consultations. Correct diagnosis in primary care is therefore essential for the effectiveness of further therapy [3, 4], but also enables early initiation of treatment, preventing the pain from chronifying.

Depending on the type of injury [13], conservative treatment can be used when there are no indications for surgical treatment. Collagen injection therapy has many beneficial effects. However, only when combined with

properly conducted physiotherapy does it produce positive and long-lasting results. Kinesitherapy is introduced 2 to 8 weeks after surgical treatment. In the case of conservative treatment, some forms of kinesitherapy are acceptable earlier [37].

It is worth noting that medicine is searching for minimally invasive techniques for treating musculoskeletal disorders. For example, an injection technique called mesotherapy (LIT – local intradermal therapy) is increasingly being used in musculoskeletal disorders [38, 39]. LIT allows good clinical results to be achieved with low doses of active substances. In addition, it is safe and accessible to patients [39].

A randomized controlled trial is planned in Norway to evaluate the effectiveness of a self-management program compared to standard care in patients with GTPS. The study is a randomized controlled trial (RCT) with a control group, comparing a self-management program (n=55) with standard care (n=55). Patients with GTPS will be included in the study based on the presence of pain during palpation in the greater trochanter area and at least one positive provocation test result. The self-management program consists of 3-5 individual sessions with a physical therapist over 12 weeks, covering physical, emotional, and behavioral factors that the patient considers important. Patients receiving standard care will receive general information about GTPS and self-management and will have access to further primary care if needed [40]. The launch of this study proves that we are only at the beginning of the road to scientific knowledge of appropriate methods of treating GTPS, starting with the GP's office.

The limitation of this study is primarily the modest number of publications on the treatment of GTPS, particularly those concerning primary care. Further research in this area is necessary, involving large groups of patients and a long observation period.

CONCLUSION

Greater trochanteric pain syndrome is a relatively common musculoskeletal disorder in the general population, including primary care patients. Inadequate diagnosis of this condition should encourage physicians to pursue continuing education in this area. Diagnosis and effective treatment of GTPS can initially be carried out within the primary care setting.

REFERENCES

1. Donati D, Tedeschi R, Garnum PE et al. A narrative review on greater trochanteric pain syndrome: diagnostic imaging and non-surgical treatments. Musculoskelet Surg. 2025.doi: 10.1007/s12306-025-00924-7.
2. .Khan A, Husain SO, Kaur R et al.Primary Care Strategies for Managing Musculoskeletal Pain: A Narrative Overview. Cureus. 2025;17(7):e88447. doi: 10.7759/cureus.88447.
3. Yeo P-Y, Kasivishvanaath A, Pérez-Carro L, Jegathesan T. Top ten causes of non-arthritic hip pain: a comprehensive review. World J Orthop.2025;16(6). doi: 10.5312/wjo.v16.i6.107397.
4. Estberger A, Thorborg K, Talts H, Ageberg E. Clinical assessment and treatment of patients presenting with longstanding hip and groin pain in primary care: a survey study among physical therapists and general practitioners in Sweden. BMC Musculoskelet Disord. 2025;26(1):218. doi: 10.1186/s12891-025-08466-6.
5. Speers CJ, Bhogal GS. Greater trochanteric pain syndrome: a review of diagnosis and management in general practice. Br J Gen Pract. 2017;67(663):479-480. doi: 10.3399/bjgp17X693041.
6. Grimaldi A, Fearon A. Tendinopathies of the hip and pelvis: clinical diagnosis and management. Rheumatol Adv Pract. 2024;8(1):rkae022. doi: /10.1093/rap/rkae022.
7. Lall AC, Schwarzman GR, Battaglia MR et al. Greater Trochanteric Pain Syndrome: An Intraoperative Endoscopic Classification System with Pearls to Surgical Techniques and Rehabilitation Protocols. Arthrosc Tech. 2019;8(8):e889-e903. doi: 10.1016/j.eats.2019.04.004.
8. Bicket L, Cooke J, Knott et al. The natural history of greater trochanteric pain syndrome: an 11-year follow-up study. BMC Musculoskelet Disord. 2021;22:1048, doi: 10.1186/s12891-021-04935-w.
9. Lespasio MJ. Lateral Hip Pain: Relation to Greater Trochanteric Pain Syndrome. Perm J 2022;26: 83-88, doi: 10.7812/TPP/21.110.
10. Kinsella R, Reiman MP, Goode AP et al. Diagnostic accuracy of clinical tests for assessing greater trochanteric pain syndrome: a systematic review with meta-analysis. J Orthop Sports Phys Ther. 2024;54(1):26-49. doi: 10.2519/jospt.2023.11890
11. Rozporządzenie Ministra Zdrowia z dnia 25 sierpnia 2023 r. zmieniające rozporządzenie w sprawie świadczeń gwarantowanych z zakresu rehabilitacji leczniczej. (Polish)
12. Zarządzenia Prezesa NFZ https://baw.nfz.gov.pl/NFZ/tabBrowser/mainPage. (Polish)
13. Reid D. The management of greater trochanteric pain syndrome: A systematic literature review. J Orthop. 2016;13(1):15-28. doi: 10.1016/j.jor.2015.12.006.
14. Koszela K. A three-stage concept of spine pathology treatment - a different perspective. Reumatologia. 2024;62(1):58-63. doi: 10.5114/reum/183911.
15. Fulceri F, Ryskalin L, Morucci G et al. Long-term efficacy of combined focused and radial extracorporeal shockwave therapy in gluteal tendinopathy: a prospective cohort with >12-month follow-up. Life (Basel). 2024;14(12):1698. doi: 10.3390/life14121698.
16. Mahajan U, Papaleontiou A, Imam MA, Mahmood A. Assessing Standardisation in Platelet-Rich Plasma (PRP) Injections for the Management of Greater Trochanteric Pain Syndrome (GTPS): A Systematic Review of Available Literature. Cureus. 2024;16(11):e74690. doi: 10.7759/cureus.74690.

17. Koszela K, Woldańska-Okońska M, Słupiński M, Gasik R. The role of injection collagen therapy in greater trochanter pain syndrome. A new therapeutic approach? Reumatologia. 2025;63(2):131-137. doi: 10.5114/reum/196810.
18. Randelli F, Fioruzzi A, Mazzoleni MG et al. Efficacy of Ultrasound-Guided Injections of Type I Collagen-Based Medical Device for Greater Trochanteric Pain Syndrome: A Pilot Study. Life (Basel). 2025;15(3):366. doi: 10.3390/life15030366.
19. Pumarejo Gomez L, Li D, Childress JM. Greater Trochanteric Pain Syndrome (Greater Trochanteric Bursitis) [Updated 2024 Feb 25]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557433/.
20. Koszela K, Woldańska-Okońska M, Gasik R. Efficacy and Safety of Spinal Collagen Mesotherapy in Patients with Chronic Low Back Pain in a Three-Month Follow-Up-Retrospective Study. J Clin Med. 2024;13(3):787. doi: 10.3390/jcm13030787.
21. Probst D, Stout A, Hunt D. Piriformis Syndrome: A Narrative Review of the Anatomy, Diagnosis, and Treatment. PM R. 2019;11 Suppl 1:S54-S63. doi: 10.1002/pmrj.12189.
22. Ganderton C, Semciw A, Cook J et al. Demystifying the Clinical Diagnosis of Greater Trochanteric Pain Syndrome in Women. J Womens Health (Larchmt). 2017;26: 633-643, doi: 10.1089/jwh.2016.5889.
23. Koszela K, Słupiński M, Woldańska-Okońska M. The Role of Rehabilitation after Spinal Mesotherapy in a Three-Stage Treatment Concept. J Clin Med. 2024;13(11):3195. doi: 10.3390/jcm13113195.
24. Woldańska-Okońska M. The role of rehabilitation after spinal collagen mesotherapy in the treestage treatment concept. Rheumatology. 2024;62(Suppl 2):15-15. doi:10.5114/reum/202163.
25. Koszela K. The role of injectable collagen therapy in the three-stage treatment concept. Rheumatology. 2024;62 (Suppl 2):14–14. doi:10.5114/reum/202162.
26. Torres A, Fernández-Fairen M, Sueiro-Fernández J. Greater trochanteric pain syndrome and gluteus medius and minimus tendinosis: nonsurgical treatment. Pain Manag. 2018;8(1):45-55. doi: 10.2217/pmt-2017-0033.
27. Atchia I, Ali M, Oderuth E et al. Efficacy of Platelet-Rich Plasma Versus Placebo for the Treatment of Greater Trochanteric Pain Syndrome: A Double-Blinded Randomized Controlled Trial. J Bone Joint Surg Am. 2025;107(5):444-451. doi: 10.2106/JBJS.24.00763.
28. Ahmed H, Tarar MY, Khalid A et al. Greater Trochanteric Pain Syndrome and the Efficacy of Platelet-Rich Plasma Injections: A Systematic Review. Cureus. 2024;16(10):e72597. doi: 10.7759/cureus.
29. Wang Y, Wang K, Qin Y et al. The effect of corticosteroid injection in the treatment of greater trochanter pain syndrome: a systematic review and meta--analysis of randomized controlled trials. J Orthop Surg Res. 2022;17(1):283. doi: 10.1186/s13018-022-03175-5.
30. Foxcroft B, Stephens G, Woodhead T, Ayre C. What factors influence pain scores following Corticosteroid injection in patients with Greater Trochanteric Pain Syndrome? A systematic review. BMC Musculoskelet Disord. 2024;25(1):149. doi: 10.1186/s12891-024-07217-3.
31. Topaloglu M, Gedik CC, Sarikaya D et al. Comparison of the effects of ultrasound-guided steroid injection and anatomic landmark-guided injection on pain and disability in greater trochanteric pain syndrome. Acta Orthop Traumatol Turc. 2024;58(5):290-295. doi: 10.5152/j.aott.2024.24087.
32. Brindisino F, Marruganti S, Lorusso D et al. The effectiveness of extracorporeal shock wave therapy for rotator cuff calcific tendinopathy. A systematic review with meta-analysis. Physiother Res Int. 2024;29(3):e2106. doi: 10.1002/pri.2106.
33. Korakakis V, Whiteley R, Tzavara A, Malliaropoulos N. The effectiveness of extracorporeal shockwave therapy in common lower limb conditions: a systematic review including quantification of patient-rated pain reduction. Br J Sports Med. 2018;52(6):387-407. doi: 10.1136/bjsports-2016-097347.
34. Abd-Elsayed A, Martens JM, Fiala KJ, Schatman ME. Radiofrequency Ablation of the Trochanteric Branches of the Femoral Nerve for the Treatment of Greater Trochanteric Syndrome. J Pain Res. 2022;15:115-122. doi: 10.2147/JPR.S343165.
35. Annin S, Lall AC, Meghpara MB et al. Intraoperative Classification System Yields Favorable Outcomes for Patients Treated Surgically for Greater Trochanteric Pain Syndrome. Arthroscopy. 2021;37(7):2123-2136. doi: 10.1016/j.arthro.2021.01.058.
36. Harris JD. Editorial Commentary: An Optimal Classification System to Guide Prognosis and Treatment in Greater Trochanteric Pain Syndrome: Now We're Speaking the Same Language. Arthroscopy. 2021;37(7):2137-2139. doi: 10.1016/j.arthro.2021.03.083.
37. Paolucci T, Bellomo RG, Centra MA et al. Mesotherapy in the treatment of musculoskeletal pain in rehabilitation: the state of the art. J Pain Res. 2019;12:2391-2401. doi: 10.2147/JPR.S209610. PMID: 31440078; PMCID: PMC6679691.
38. Koszela K, Mammucari M, Słupiński M, Woldańska-Okońska M. The role of mesotherapy in chronic back pain syndrome: what do we know? Rheumatol Int. 2025;45(9):206. doi: 10.1007/s00296-025-05940-1.
39. Mammucari M, Russo D, Maggiori E et al. On Behalf Of The International Expert Panel. International Consensus Guidelines on the Safe and Evidence-Based Practice of Mesotherapy: A Multidisciplinary Statement. J Clin Med. 2025;14(13):4689. doi: 10.3390/jcm14134689.
40. Morin Melås T, Bjørneboe J, Juel NG et al. Self-management versus usual care for greater trochanteric pain syndrome (the HIPS trial): study protocol for a randomised controlled trial. BMJ Open. 2025;15(4):e090688. doi: 10.1136/bmjopen-2024-090688

CONFLICT OF INTEREST
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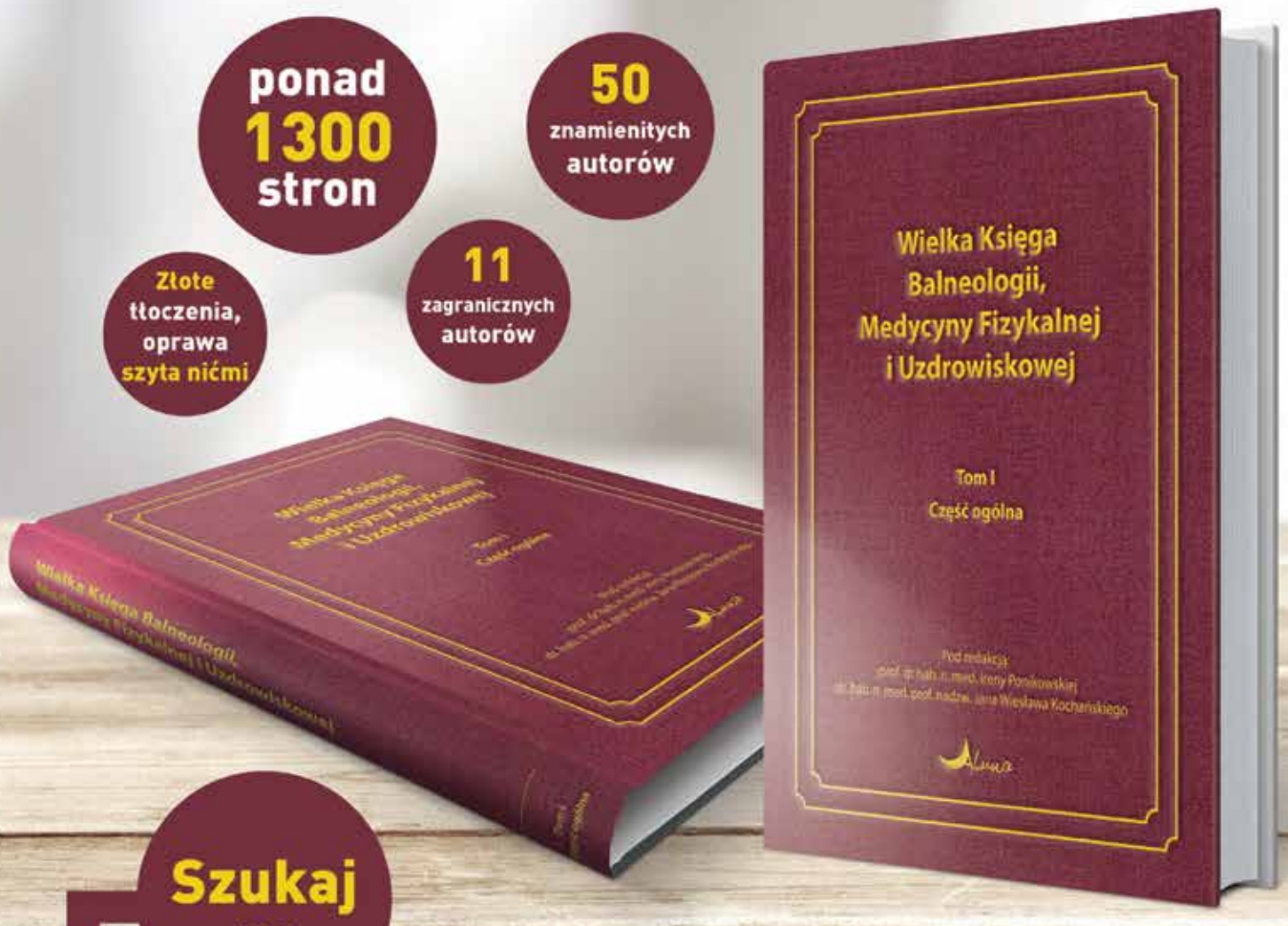

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