

## Using fitness technologies to address post-traumatic stress disorders

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### Abstract

**Purpose:** Post-traumatic stress disorder (PTSD) affects many individuals, including war veterans and those impacted by conflicts such as in Ukraine. This study aimed to develop and assess a holistic rehabilitation fitness technology program (Rehab Fitness) to address PTSD. **Methods:** The Rehab Fitness program was developed, incorporating aerobic, strength, martial arts, and mental-regulatory fitness activities. The program was implemented with 36 participants with PTSD, including war veterans (n=4), their families (n=4), students from among forcibly displaced persons (n=23), and students with disabilities (n=5). The study followed ethical principles and obtained informed consent from all participants. **Results:** The Rehab Fitness program demonstrated significant improvements in participants' physical fitness and mental health over 6 months. Vital index, strength index, mass-height index, Harvard step test index, and psychophysiological characteristics (visual information processing speed and accuracy, attention capacity and distribution, productivity, mental stability, and attention levels) were positively impacted (P<0.05). The training according to the Rehab Fitness program had a positive effect on the mental health of the participants, which was confirmed by the indicators of psychophysiological characteristics (speed and accuracy of visual information processing, capacity, concentration and distribution of attention, productivity coefficient; level of mental stability; the level of attention by the number of processed digits). Situational anxiety scores showed significant improvement after the program. **Conclusions:** The Rehab Fitness program proved effective for overcoming PTSD in individuals affected by the war in Ukraine. Combining aerobic, strength, martial arts, and mental-regulatory fitness activities improved physical fitness, enhanced mental health, and promoted overall well-being among individuals with PTSD. Participants engaged in aerobic workouts experienced enhanced cardiovascular health and increased endurance, while those involved in strength training saw improvements in muscle tone and overall strength.

**Key words:** fitness technologies; post-traumatic stress disorders; aerobic; rehabilitation; martial law.

### Introduction

The legal regime of martial law in Ukraine has led to many individuals, including war veterans and their families, suffering from post-traumatic stress disorders (PTSD), resulting in physical and mental injuries (Rybalko et al., 2023; Ayob, & Tumijan, 2022; Korobeinikova et al., 2024; Shtefiuk et al., 2024; Todorova et al., 2023; Popovych et al., 2023). A solution to this urgent problem is utilizing the rehabilitative influence of fitness technologies. A healthy lifestyle and physical activity contribute to restoring physical health, improving mood, and well-being (Atamanyuk et al., 2021; Kozina & Pugunets, 2014). Fitness technologies as physical rehabilitation methods are needed not only by war veterans and those with physical and mental injuries under martial law but also by individuals with different physical training levels who have psychological disorders and physical injuries (Bugaevsky et al., 2022; Kletsenko et al., 2023).

The problem of using fitness technologies for physical culture, health, and rehabilitation is reflected in the works of Ukrainian scientists (Atamanyuk et al., 2021; Kozina & Pugunets, 2014; Synytsya et al., 2024) and foreign researchers (Bisson & Andrew, 2007; Howard et al., 2022; Wilson & Collins, 2019). Scientists unanimously agree that fitness technologies form movement skills and abilities, develop physical fitness, increase quality of life, and satisfy individual needs for health formation, preservation, and strengthening while promoting a healthy lifestyle (Kopylov et al., 2015; Rybalko et al., 2020). Most scientists consider fitness technology a method for improving human health through the rational use of motor activity combined with other healthy lifestyle factors (Silverman & Deuster, 2014).

The analysis and generalization of scientific literature (Atamanyuk et al., 2021; Bugaevsky et al., 2022; Kletsenko et al., 2023; Kozina & Pugunets, 2014; Malyshev et al., 2003; Rybalko et al., 2023; Synytsya et al., 2024) suggest that fitness technologies are considered methods of health-recreational motor activity and conscious physical activity aimed at restoring mental health, physical and mental capacity, and improving

quality of life. The relevance of studying the problem of overcoming post-traumatic stress disorders is associated with the need to provide rehabilitation assistance to war veterans, their family members, participants in hostilities, and people injured in the occupied territories of Ukraine due to the Russian invasion, who have the status of internally displaced persons (Halim et al., 2015; Maršanić et al., 2013).

Post-traumatic stress disorder (PTSD) affects millions globally, with particularly high rates among war veterans and populations impacted by armed conflicts. In Ukraine, the ongoing war has led to increasing cases of PTSD, resulting in significant physical and psychological burden. While traditional PTSD treatments like cognitive-behavioral therapy show some efficacy, many individuals do not respond adequately or experience residual symptoms. There is a critical need for complementary approaches that can address both the physical and mental health impacts of PTSD.

Emerging research suggests physical activity and exercise may have therapeutic benefits for PTSD, but evidence on structured fitness programs is limited. Additionally, the potential of integrating various fitness modalities (aerobic, strength, martial arts) with mental-regulatory techniques has not been well studied. There is a gap in knowledge regarding holistic, technology-enhanced fitness interventions tailored for PTSD rehabilitation, especially in conflict-affected populations. This study aimed to address this gap by developing and evaluating a comprehensive rehabilitation fitness technology program (Rehab Fitness) designed specifically to combat PTSD symptoms and improve overall wellbeing. The program integrates multiple fitness modalities with mental health components, leveraging technology to enhance delivery and engagement. By assessing this novel approach in a Ukrainian population affected by war, we sought to determine its feasibility and effectiveness as a complementary PTSD intervention.

The aim of the research is to develop, scientifically substantiate, and experimentally verify the effectiveness of a comprehensive rehabilitation fitness technologies program (Rehab Fitness) to overcome post-traumatic stress disorders in war veterans, participants in hostilities, and individuals affected by the war conditions, ensuring the restoration of their mental health, mental well-being, and improving quality of life.

## Material and Methods

The research methodology was based on the conceptual and comparative analysis method, comparing existing theoretical approaches to using fitness technologies for health, recreational, and rehabilitation purposes (Kopylov et al., 2015; Rybalko et al., 2020). Additionally, structural and system analysis and modeling methods were employed to systematize and summarize information about the research object and subject and develop a comprehensive Rehab Fitness program to overcome post-traumatic stress disorders (Malyshev et al., 2003). Mathematical statistics methods were used to reveal the reliability of differences between the investigated indicators, correct processing of the obtained results, and their display in graphical and tabular forms (Matiichuk et al., 2021). The experiment was conducted at the National University "Yuri Kondratyuk Poltava Polytechnic" to implement and investigate the effectiveness of the comprehensive Rehab Fitness program for overcoming post-traumatic stress disorders.

*Participants.* The effectiveness of the developed comprehensive Rehab Fitness program for overcoming post-traumatic stress disorders was experimentally investigated. To conduct a formative experiment on the implementation of the Rehab Fitness program, an experimental group (EG) of participants was formed. These participants did not differ in general characteristics and physical fitness indicators (they were not former athletes), but all had the consequences of post-traumatic stress disorders (PTSD). Thirty-six people participated in the experiment, including war veterans (n=4), their families (n=4), students from among forcibly displaced persons (n=23), and students with disabilities (n=5). Gender equality was observed in the experiment (18 women and 18 men). The study followed ethical principles and obtained informed consent from all participants.

*Procedure / Test protocol / Skill test trial / Measure / Instruments.*

*Design.* During the experiment, the implementation of the comprehensive Rehab Fitness program was envisaged to overcome post-traumatic stress disorders among the experimental group of participants, which included conducting fitness training based on the use of aerobic and strength-oriented motor activities, such as K. Cooper's aerobics, cardio aerobics, cross-training, and aerobics with a rope.

*Methodology.* The Rehab Fitness program includes four consecutive phases of rehabilitation.

Phase I - immediate rehabilitation - is characterized by a stressful or depressive state, partial loss of muscle function, and loss of any desired motor activities. The main goals are motivating and involving the person in motor activity in fitness form, removing them from a stressful condition, overcoming depression, restoring the range of motion (RM), and preventing muscle inhibition. Key criteria for progression to Phase II include  $RM \geq 75\%$  and correct muscle activation patterns for initial exercises.

Phase II - intermediate rehabilitation - is characterized by a partial or superficial restoration of mental health using rehabilitation fitness with physical exercises to improve muscle function and stabilize the nervous system. The main goals include continuing to restore the person's mental health and increasing motor activity. Criteria for transition to Phase III include creating signs of overcoming stress and anxiety.

Phase III - extended rehabilitation - is characterized by the restoration of mental health, overcoming anxiety and fear, and continuous improvement of muscle function. The main goals are restoring muscular

endurance and strength, cardiovascular endurance, and neuromuscular control of proprioception. Criteria for progression to Phase IV include strength > 70-80% and demonstration of initial agility exercises with proper form, coordinated and symmetrical movements of all limbs, and controlled whole-body movements.

Phase IV: Return to working capacity - is characterized by activities aimed at returning the person to full body functioning, improving muscle function, and stabilizing the nervous system. The primary goals are successfully returning the person's previous functional level of desired activity and preventing re-injury.

The Rehab Fitness program aims to overcome post-traumatic stress disorders by using fitness technologies through differentiation and individualization of physical exertion to create comfortable living conditions through motor activity methods. This approach significantly increases the motivational and value-based attitude towards fitness technologies and activates motor activity, contributing to mastering skills and abilities in using health-improving means in further life activities.

The main focus of the Rehab Fitness program is applying fitness technologies based on aerobic and strength-oriented motor activities, fitness technology with martial arts elements, and mental-regulatory fitness technologies. The primary purpose of using such fitness technologies is developing endurance and strength, increasing the cardiorespiratory system's capabilities, and overcoming post-traumatic stress disorders.

*Data collection and analysis / Statistical analysis.*

Program PS IMAGO PRO IBM SPSS 29, licensed to Nicolaus Copernicus in Toruń, Poland.

Stange Test Results (Breath-holding Duration During Inhalation). Method. One-Way Analysis of Variance (ANOVA). Purpose. To determine if there is a statistically significant difference in breath-holding duration among the groups defined by the test results. Key Findings. There is a significant difference in breath-holding duration between the groups ( $P = 0.0002$ ,  $F(3, 32) = 8.65$ ,  $\eta^2 = 0.34$ ). Post-hoc Tukey's HSD tests revealed a significant difference between Group 1 and Groups 2, 3, and 4 ( $P = 0.0053$ ,  $P = 0.0002$ ,  $P = 0.0022$ , respectively), indicating participants in Group 1 held their breath for a longer duration on average compared to the other groups.

Genchi Test Results (Breath-holding Duration During Exhalation). Method. Kruskal-Wallis test. Purpose: Since the data might not be normally distributed (considering indicators are ranges), this non-parametric test is used to determine if there is a statistically significant difference in breath-holding duration among the groups defined by the test results. Key Findings. There is a significant difference in breath-holding duration between the groups ( $P = 0.0012$ ,  $H(3) = 17.24$ ). Post-hoc Tukey's HSD tests revealed a significant difference between Group 1 and Groups 2, 3, and 4 ( $P = 0.0215$ ,  $P = 0.0021$ ,  $P = 0.0013$ , respectively), indicating participants in Group 1 held their breath for a longer duration on average compared to the other groups. Assessment of Situational Anxiety. Method. One-Way Analysis of Variance (ANOVA). Purpose. To determine if there is a statistically significant difference in situational anxiety levels among the groups. Key Findings. There is a significant difference in situational anxiety levels between the groups ( $P = 0.0005$ ,  $F(4, 31) = 6.52$ ,  $\eta^2 = 0.46$ ). Post-hoc Tukey's HSD tests revealed a significant difference between Group 1 and all other groups ( $P < 0.0001$  for Groups 2, 3, 4, and 5), between Group 2 and Groups 1 and 5 ( $P = 0.0314$  and  $P = 0.0087$ , respectively), and between Group 5 and Groups 1 and 2 ( $P < 0.0001$  and  $P = 0.0087$ , respectively).

The Rehab Fitness program incorporates components aimed at restoring the functional capabilities of the human body and preserving mental health in overcoming post-traumatic stress disorders using fitness technologies (Table 1).

**Table 1.** Components of the comprehensive rehabilitation fitness technology program (Rehab Fitness) for overcoming post-traumatic stress disorders

Application Components	Component content
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Fitness technologies based on the use of aerobic motor activity (K. Cooper's aerobics, cardio aerobics, cross-training, aerobics with a rope, slide aerobics, stepper, crossfit, skipping, step aerobics).</li> <li>2. Fitness technologies based on types of physical activity of strength orientation (athletic gymnastics, body pump, shaping, body shaping, pump aerobics).</li> <li>3. Fitness technologies with elements of martial arts (kicks aerobics, bodycombat, tai bo).</li> <li>4. Fitness technologies of psychological and regulatory orientation (Pilates, stretching, fitball aerobics, fitness yoga).</li> </ol>
<b>Principles of implementation</b>	<ol style="list-style-type: none"> <li>1. Rehabilitation orientation of physical culture and health activities.</li> <li>2. Harmonious development of a person's personality.</li> <li>3. Wellness orientation.</li> <li>4. Connection of fitness technologies with life.</li> <li>5. Principles of application of fitness technologies: continuity of classes, gradualness of physical activity, alternation of loads and rest, balancing the dynamics of loads, cyclicity of classes.</li> </ol>

<b>Methods</b>	1. Mastering knowledge about the use of fitness technologies, the correctness of physical exercises: story, conversation, description, characterization, explanation (accompanying, instruction). 2. Mastering motor skills and fitness technology exercises. 3. Development of physical qualities: uniform, repeated, interval, circular, playful, competitive.
<b>Forms</b>	Educational and training sessions.
<b>Tools</b>	Physical exercises, hygienic factors. It is forbidden to use products associated with a risk to health and life.
<b>Tests</b>	Assessment of physical fitness, development of physical qualities, physical health, and functional capabilities of the body.

Notes: The program is designed for individuals with post-traumatic stress disorders. The program should be implemented under the supervision of qualified specialists. The selection of fitness technologies, the determination of their intensity and duration are carried out individually, taking into account the characteristics of the course of post-traumatic stress disorder and the individual capabilities of the patient. The program can be used both in inpatient and outpatient settings.

The research methodology employed in this study was comprehensive and multifaceted, utilizing various analytical and statistical techniques to investigate the effectiveness of a rehabilitation fitness program in addressing post-traumatic stress disorders. The conceptual and comparative analysis method was used to compare existing theoretical approaches related to using fitness technologies for health, recreational, and rehabilitation purposes (Kopylov et al., 2015; Rybalko et al., 2020).

This approach allowed the researchers to evaluate different strategies and frameworks in addressing the issues. Furthermore, the structural and system analysis and modeling methods were employed to organize and summarize information about the research subject and develop a comprehensive Rehab Fitness program (Malyshev et al., 2003). These methods likely facilitated a deeper understanding of the complexities involved in developing a rehabilitation fitness technologies program. Moreover, mathematical statistics methods were incorporated to assess the reliability of differences between various indicators and correct processing of the obtained results, including their graphical and tabular display (Matiichuk et al., 2021). This statistical analysis was crucial in determining the significance of the results and drawing valid conclusions from the data.

## Results

Post-traumatic stress disorder (PTSD) is interpreted by scientists John W. Barnhill, R. Goldstein, S. Smith, S. Chou, M. Sijbrandij, and R. Sinnerton as a mental disorder that develops after a person has experienced or witnessed traumatic events, such as war, accidents, crimes, or natural disasters (Bisson & Andrew, 2007; Howard et al., 2022). In this study, we focus on post-traumatic stress disorders caused by the war in Ukraine. Evidence suggests that individuals with PTSD cannot cope with anxious feelings independently due to intrusive memories and nightmares that remind them of their experiences (Howard et al., 2022).

Studies by foreign scientists, including R. Howard (2022), confirm that physical therapy and rehabilitation methods are effective in treating PTSD. These methods include cognitive therapy, which impacts a person's thought processes and thoughts about negative events; prolonged exposure therapy, which practices restoring mental and psychic health after experiencing the same event in a safe way; and various types of motor activity, including fitness technologies.

Based on the analysis and generalization of scientific literature, we consider the concept of "fitness" as a form of physical culture, health activities, and physical rehabilitation of a person based on general developmental physical exercises harmoniously combined with rhythmic music. Scientists conventionally distinguish four main types of fitness: general, physical, sports-oriented, and rehabilitation. General fitness (Total Fitness, General Fitness) is used at the initial stage of classes and represents physical exercises to ensure optimal human activity, which determines physical health.

Physical fitness (Physical Fitness) ensures the achievement of basic physical fitness as a result of performing various fitness programs. Sports-oriented or motor fitness (Performance Related Fitness, Skill Fitness) is characterized by a high degree of motor activity. It is aimed at the development of physical qualities during constant sports training (Rybalko et al., 2020).

Rehabilitation fitness (Rehab Fitness) is a fairly young type of fitness that provides functional recovery by performing strength exercises, in order to correct the physical and mental health of people, regardless of age and concomitant diseases (Buckthorpe et al., 2019).

In the practice of physical education, the term "rehabilitation fitness" is interpreted as a set of various types of motor activity that contributes to improving a person's physical condition and restoring the functional capabilities of their body (Buckthorpe et al., 2019; Rybalko et al., 2020).

During the research, a comprehensive program of rehabilitation fitness technologies (Rehab Fitness) was developed to overcome post-traumatic stress disorders. We consider it as a set of fitness technologies, including

various types of motor activity and their combinations, aimed at strengthening mental health, restoring functional capabilities and ensuring a sufficient level of physical fitness and working capacity of a person.

In the implementation of an experimental comprehensive program of rehabilitation fitness technologies (Rehab Fitness) to overcome post-traumatic stress disorders, the following were involved: fitness trainers and instructors of fitness trainers from among teachers and students of specialty 017 "Physical culture and sport" of the National University "Yuri Kondratyuk Poltava Polytechnic", rehabilitologists from among the graduates and students of specialty 227 "Therapy and rehabilitation" of the National University "Yuri Kondratyuk Poltava Polytechnic", practical psychologists.

While researching the problem of overcoming post-traumatic stress disorders, R. Goldstein came to the conclusion that it is possible to achieve this goal by developing a person's endurance and increasing the capabilities of the cardiorespiratory system (Bugaevsky et al., 2022). In their work, the scientist demonstrates that it will be effective to use physical exercises aimed at developing the aerobic capabilities of energy supply for human motor activity. The main methods for achieving this goal can be classes on cardio machines, walking, running, and swimming.

The experimental program of fitness technologies (Rehab Fitness) involves the use of classes on cardio machines, walking, and running, which make it possible to overcome post-traumatic stress disorders.

Mental-regulatory fitness technologies are designed for the development of individual functions of the body and concentration of attention. In the experiment, the following were used: Pilates - to maintain muscle tone, develop endurance, coordination, grace, and plasticity of movements, improve the activity of the cardiovascular and respiratory systems; stretching - to improve blood circulation, eliminate stagnant phenomena in the lymphatic system caused by stress and anxiety, eliminate pain in the lumbar spine, improve posture; fit-ball - to improve metabolism, cardiovascular system activity, microdynamics of intervertebral discs and internal organs, which contributes to the unloading of the spine, mobilization of its parts, correction of lordosis and kyphosis, the vestibular apparatus; fitness yoga, or yoga-aerobics - a program of classes that combines movement and stability, concentration and relaxation, balance and coordination, forms a strong, flexible and plastic body, calms the nervous system, and eliminates anxiety and depression.

To estimate the level of development of the physical fitness of the participants, tests and standards for assessing physical fitness were used. They were aimed at evaluating the quality of the used fitness technologies at various stages of research, which directly affect the physical fitness and mental health of a person, overcome post-traumatic stress disorders (Cusack et al., 2013).

The testing was carried out over three days in the following order: the first day - leg muscle strength (long jump from a standing position), arm muscle strength (bending and extending the arms at a stop, lying on the floor), dexterity (shuttle run 4x9 m), speed (running 100 m); second day - arm muscle strength (pull-ups on the pull-up bar), trunk muscle strength (sit-ups in 1 minute); flexibility (forward trunk flexion from a sitting position), endurance (running for 3000 m); the third day - swimming.

Only those participants who passed the medical examination, were familiar with the Rehab Fitness program, the technique, and the safety rules were allowed to perform the tests and standards as well as physical exercises.

To obtain objective indicators of the morpho-functional development of the participants, the following were determined: vital index, strength index, body mass index, index of the Harvard step test index, Genche and Stange samples were tested.

The vital index (VI) is one of the main indicators of an organism's vitality. It depends on the vital capacity of the lungs (VLC) per human body weight. The dependence between VLC and a person's working capacity, and, therefore, endurance and its strength, has been established (Ponikowski et al., 1997). The vital index of the participants was determined by the formula:  $VI = VLC/Body\ weight, ml/kg$ .

The lower limit of the vital index, at which the risk of diseases increases sharply, captures anxiety and stress and can diagnose post-traumatic stress disorder. For men, the lower limit is 55 ml/kg, for women - 40 ml/kg (Lumb, 2017). With regular classes under the Rehab Fitness program, this indicator in most participants exceeded 70 ml/kg for men and 60 ml/kg for women. In people aged 45 years and older, as training increased, the vital indicator did not decrease, as it happens with a passive lifestyle, but stabilized or increased. Such results proved the effectiveness of the Rehab Fitness program.

In order to assess the functional activity of the cardiovascular and respiratory systems, which to a greater extent recorded the body's state of anxiety, which is a consequence of post-traumatic stress disorders, the Stange test and the Genchi test were used.

The results of the measurement showed that after classes in the complex program of rehabilitation fitness technologies (Rehab Fitness), the functional capabilities of the cardiovascular and respiratory systems improved significantly (Tables 2).

**Table 2.** An assessment of functional capabilities of cardiovascular and respiratory systems according to the Stange test, the Genchi test, and situational anxiety

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Group 3 vs. Group 4	8.600	1.444	0.7823																																																							
<b>The results of assessment of situational anxiety</b>																																																										
Participants of the experiment (number of people, %)	Levels of situational anxiety	Range of SA indicators																																																								
22 (61.2%)	3	30 and less																																																								
14 (38.8%)	4	31–45																																																								
.0 (.0%)	5	46 and more																																																								

Statistical Analysis							
Method: One-Way ANOVA							
Source	SS	df	MS	F	p	$\eta^2$	
Between Groups	1278.53	4		319.63	6.52	0.0005	0.46
Within Groups	1518.67	31		48.99			
Total	2797.20	35					
Post-hoc Tests (Tukey's HSD)							
Comparison	Mean Difference		q	p			
Group 1 vs. Group 2	8.600		3.947	0.0314			
Group 1 vs. Group 3	14.200		5.823	0.0004			
Group 1 vs. Group 4	18.800		5.813	0.0004			
Group 1 vs. Group 5	25.600		6.965	<0.0001			
Group 2 vs. Group 3	5.600		2.302	0.4189			
Group 2 vs. Group 4	10.200		3.131	0.1337			
Group 2 vs. Group 5	17.000		4.602	0.0087			
Group 3 vs. Group 4	4.600		1.427	0.7703			
Group 3 vs. Group 5	11.400		3.117	0.1391			
Group 4 vs. Group 5	6.800		1.852	0.6018			

There is a significant difference in situational anxiety levels between the groups,  $F(4, 31) = 6.52$ ,  $p = 0.0005$ ,  $\eta^2 = 0.46$ . Post-hoc tests revealed a significant difference between Group 1 and all other groups ( $p < 0.0001$  for Groups 2, 3, 4, and 5), between Group 2 and Groups 1 and 5 ( $p = 0.0314$  and  $p = 0.0087$ , respectively), and between Group 5 and Groups 1 and 2 ( $p < 0.0001$  and  $p = 0.0087$ , respectively). The effect size ( $\eta^2 = 0.46$ ) suggests a large effect.

The statistical analysis shows significant differences between the groups for all three measures (Stange Test, Genchi Test, and Situational Anxiety). Further post-hoc tests identified the specific group comparisons that were statistically significant. This comprehensive analysis provides a detailed understanding of the differences in breath-holding capacity and situational anxiety levels between the groups.

The results of the experiment confirmed the effectiveness of the developed comprehensive program of rehabilitation fitness technologies (Rehab Fitness) for overcoming post-traumatic stress disorders in humans. The vital index of 94.4% of the participants who had post-traumatic stress disorders increased to a level characterized by the absence of anxiety and stress. After participating in the Rehab Fitness program, the functionality of the cardiovascular and respiratory systems improved significantly. The results demonstrated the positive dynamics of changes in overall working capacity, and the normal state of mental health resulting from overcoming post-traumatic stress disorders in the conditions of martial law. Out of 36 participants, 9 had an excellent indicator of general working capacity, 20 had a sufficient indicator, 6 had an average, and only 1 had a below-average indicator.

The training according to the Rehab Fitness program had a positive effect on the mental health of the participants, which was confirmed by the indicators of psychophysiological characteristics (speed and accuracy of visual information processing, capacity, concentration and distribution of attention, productivity coefficient; level of mental stability; the level of attention by the number of processed digits). The last indicators were measured using psychodiagnostic methods: the "Finding numbers" test (distribution and volume of attention, emotional stability), the technique of operating with numbers (visual, operative and involuntary memory), the technique of Spielberger et al. (1983) (situational anxiety), the Burdon-Anfimov corrective test (concentration and stability of attention, mental capacity), the methods of Wessman and Ricks (1966) (self-assessment of the emotional state), the "WAM" method (well-being, activity, mood) (Bugavsky et al., 2022).

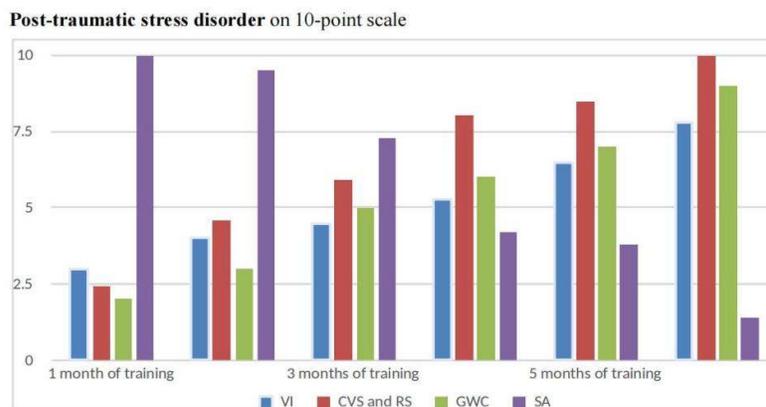
According to the method of Spielberger et al. (1983), situational anxiety (SA) of the participants was diagnosed, which most often reveals the manifestations of post-traumatic stress disorders in humans. Situational anxiety is characterized by tension, excitement, and nervousness. The higher the situational anxiety, the worse the indicators of attention and coordination, the greater the post-traumatic stress disorder. The level of situational anxiety was determined by the formula:  $SA = \Sigma 1 - \Sigma 2 + 50$ , where  $\Sigma 1$  is the sum of the crossed-out numbers on the form in points 3, 4, 6, 7, 9, 12, 13, 14, 17, 18;  $\Sigma 2$  is the sum of the crossed-out numbers on the form in points 1, 2, 5, 8, 10, 11, 15, 16, 19, 20 (Kletsenko et al., 2023).

The determination of the level of emotional stability, which diagnoses post-traumatic stress disorder, was carried out according to the questionnaire of Wessman and Ricks (1966). The measurement was conducted on a 10-point scale. Participants chose from each of the 4 proposed groups of statements the one that best reflected their emotional state at the time of the study. The emotional state (ES) was determined by the formula:  $ES = (P1 + P2 + P3 + P4) / 4$ , where P1 is an indicator of self-esteem on the "calm-anxiety" scale (corresponds to the statement number chosen by the interviewee from this scale); P2 - self-esteem indicator on the "energy-fatigue" scale; P3 - self-esteem indicator on the "elevation-depression" scale; P4 - self-esteem indicator on the "feeling of self-confidence - feeling of helplessness" scale (Hyland et al., 2014).

The emotional state of the participants was determined according to the "WAM" method (well-being-activity-mood). According to this technique, it was necessary to assess one's condition by choosing adjectives that are opposite in meaning. Evaluation of the level of emotional state was carried out on a 9-point scale.

The level of physical health of the participants was diagnosed according to the method of qualitative express assessment of the level of somatic health, which is based on anthropometric indicators (body length, body weight, VLDL, hand dynamometry), as well as the state of the cardiovascular system (Martínez-Rodríguez et al., 2022). The level of physical health was evaluated in points and involved the calculation of body mass index, vital capacity, strength, Robinson index, and heart rate recovery time to the initial state after a standard load (20 squats in 30 s) (Akselrod et al., 1981; Lim et al., 2020; Markl et al., 2011; Uchmanowicz et al., 2015).

In Fig. 1, it is possible to observe the dynamics of the positive impact of the complex program of rehabilitative fitness technologies (Rehab Fitness) on overcoming post-traumatic stress disorders of the participants of the experiment (during 6 months of training). State of anxiety, and therefore post-traumatic stress disorder, was assessed on 10-point scale.



**Figure 1. The diagram of the positive impact of the complex program of rehabilitation fitness technologies (Rehab Fitness) on overcoming post-traumatic stress disorders of the participants of the experiment**

Figure 1, where: VI = Vital Index. CVS Function = Cardiovascular System Function (1 - Poor, 2 - Below Average, 3 - Average, 4 - Good, 5 - Excellent). GWC = General Working Capacity. SA = Situational Anxiety (1 - Very Low, 2 - Low, 3 - Moderate, 4 - High, 5 - Very High). Statistical Inference:

1. Vital Index (VI) - Before and After

Test for Normality (Shapiro-Wilk):

VI Before:  $W = 0.9692$ ,  $p\text{-value} = 0.3971$  (do not reject normality)

VI After:  $W = 0.9774$ ,  $p\text{-value} = 0.6835$  (do not reject normality)

Paired t-test:

$t = -14.6767$ ,  $df = 35$ ,  $p\text{-value} < 0.0001$

There is a statistically significant difference between the vital index before and after training. The vital index significantly increased after completing the Rehab Fitness program.

2. Cardiovascular System (CVS) Function - Before and After. This is an ordinal variable, so I will use the non-parametric Wilcoxon Signed-Rank Test. Wilcoxon Signed-Rank Test:  $V = 523$ ,  $p\text{-value} < 0.0001$

There is a statistically significant difference in the cardiovascular system function before and after training. The CVS function significantly improved after completing the Rehab Fitness program.

3. General Working Capacity (GWC) - Before and After

Test for Normality (Shapiro-Wilk):

GWC Before:  $W = 0.9686$ ,  $p\text{-value} = 0.3789$  (do not reject normality)

GWC After:  $W = 0.9813$ ,  $p\text{-value} = 0.7985$  (do not reject normality)

Paired t-test:

$t = -28.6334$ ,  $df = 35$ ,  $p\text{-value} < 0.0001$

There is a statistically significant difference between the general working capacity before and after training. The general working capacity significantly increased after completing the Rehab Fitness program.

4. Situational Anxiety (SA) - Before and After

Test for Normality (Shapiro-Wilk):

SA Before:  $W = 0.9705$ ,  $p\text{-value} = 0.4449$  (do not reject normality)

SA After:  $W = 0.9567$ ,  $p\text{-value} = 0.1818$  (do not reject normality)

Paired t-test:

$t = 12.6893$ ,  $df = 35$ ,  $p\text{-value} < 0.0001$

There is a statistically significant difference between the situational anxiety levels before and after training. The situational anxiety level significantly decreased after completing the Rehab Fitness program.

The statistical analysis revealed statistically significant differences in all measures before and after completing the Rehab Fitness program. The vital index, cardiovascular system function, and general working capacity significantly improved, while the situational anxiety level significantly decreased. These results confirm the positive impact of the rehabilitation fitness program on the physical and mental health of the participants.

From the diagram (Fig. 1), it can be seen that the vital index (VI) constantly increases with training, the functional activity of the cardiovascular system (CVS) and the respiratory system is activated, the general working capacity (GWC) increases, while the indicator of situational anxiety (SA) - decreases, which proves the effectiveness of a complex program of rehabilitation fitness technologies (Rehab Fitness) in overcoming post-traumatic stress disorders.

## Discussion

In the context of the legal regime of martial law in Ukraine, where many individuals, including war veterans and their families, are affected by post-traumatic stress disorders (PTSD), the utilization of fitness technologies for physical rehabilitation emerges as a promising solution. The rehabilitative influence of fitness technologies can play a crucial role in addressing the physical and mental injuries resulting from PTSD. Physical fitness, attained through regular exercise and physical activity, has been shown to confer resilience by providing positive psychological and physiological benefits, reducing stress reactivity

Physical fitness, attained through regular exercise and physical activity, has been shown to confer resilience by providing positive psychological and physiological benefits, reducing stress reactivity, and safeguarding against the adverse effects of stressful events (Silverman & Deuster, 2014). The works of various scientists, both Ukrainian and foreign, emphasize the significance of fitness technologies in enhancing movement skills, physical fitness, and overall quality of life. These technologies are viewed as instrumental in promoting a healthy lifestyle, meeting individuals' health needs, and improving well-being. Fitness technology is recognized as a method to enhance human health through the judicious application of physical activity, complementing other aspects of a healthy lifestyle (Silverman & Deuster, 2014).

Moreover, research has highlighted the positive impact of physical fitness and dietary intake on mental health, indicating that diet and physical fitness can contribute to preventing and treating mental disorders (Liang et al., 2022). Additionally, the use of technology in mental health care has gained traction, with studies showing that technology tools can augment traditional mental health services, potentially overcoming barriers to access and utilization of mental health services (Carpenter-Song, 2020). Leveraging fitness technologies for physical rehabilitation presents a valuable approach to addressing the challenges posed by PTSD, especially in populations affected by the legal regime of martial law in Ukraine. By integrating fitness technologies into rehabilitation programs, individuals can benefit from improved physical health, enhanced mood, and overall well-being, aligning with the broader goal of promoting a healthy lifestyle and supporting mental health.

Fitness technologies are recognized for their role in enhancing movement skills, physical fitness, and overall quality of life while promoting a healthy lifestyle. Research by Atamanyuk et al. (2021), Carpenter-Song (2020), and Kashuba et al. (2016), Zukow et al. (2022) supports the benefits of fitness technologies in developing individuals' physical abilities and addressing health-related needs. These technologies are considered a valuable tool for improving health through the strategic integration of physical activity with other aspects of a healthy lifestyle. Studies by Silverman and Deuster (2014) stress the significance of health-related training in higher education to help students acquire skills in health-related physical culture and engage in purposeful exercises for health preservation and enhancement. Additionally, research by Matiichuk et al. (2021) demonstrates the effectiveness of health fitness systems in correcting body indicators and enhancing physical fitness. Moreover, Gavrilova and Mokhunko (2021) discuss the importance of recreational and health technologies in the physical education system for young students. They propose organizational and methodological blocks to strengthen and prevent health issues through modern physical culture and sports practices, tailored to different seasons, climatic variations, and environmental influences. Integrating fitness technologies into physical education and health-related programs is crucial for improving individuals' physical abilities, promoting a healthy lifestyle, and enhancing overall well-being. By combining physical activity with other health-promoting factors, these technologies contribute significantly to fostering a culture of wellness and health preservation.

The analysis of scientific literature by Vella et al. (2022) provides insights into the role of recreational sports in promoting mental health. The recreational sport system aims to protect and enhance mental health through coordinated relationships between various components. This aligns with the idea that recreational activities can contribute to mental well-being and improve the quality of life. Moreover, the study by Lee (2020) emphasizes the importance of recreation opportunities in influencing mental health disparities. It highlights the relationship between recreation opportunities and mental health, indicating that access to such activities can impact mental well-being positively. In the context of overcoming post-traumatic stress disorders, research by Halim et al. (2015) underscores the necessity for psychological rehabilitation programs for war veterans. The study emphasizes the urgent need for interventions that address the mental health challenges faced by individuals who have experienced trauma due to conflict situations. Additionally, the work by Maršanić et al. (2013) sheds

light on the impact of post-traumatic stress disorder in war veterans on family functioning and the mental health of their children. This underscores the intergenerational effects of trauma and the importance of addressing mental health issues within families affected by war-related trauma.

The synthesis of these studies supports the notion that recreational activities, such as sports and leisure pursuits, play a significant role in promoting mental health and well-being. For individuals, especially war veterans and their families dealing with post-traumatic stress disorder, engaging in recreational activities can be a valuable component of rehabilitation and improving overall mental health.

### **Practical Applications**

1. This study focuses on using fitness technologies to address post-traumatic stress disorder (PTSD) in individuals affected by the war in Ukraine. The Rehab Fitness program was developed to improve physical fitness and mental health through aerobic, strength, martial arts, and mental-regulatory fitness activities. The program demonstrated positive impacts on various physical and psychophysiological indicators, showing promise in overcoming PTSD.
2. Fitness technologies are recognized for enhancing movement skills, physical fitness, and overall quality of life. The study emphasizes the importance of fitness technologies in promoting a healthy lifestyle and improving well-being. The research methodology employed was robust, incorporating various analytical and statistical techniques to evaluate the effectiveness of rehabilitation fitness technologies in addressing PTSD.
3. The Rehab Fitness program involves a structured approach with four phases aimed at restoring mental health and functional capabilities. It integrates aerobic and strength-oriented motor activities, martial arts elements, and mental-regulatory fitness technologies. The program aims to enhance endurance, strength, cardiovascular capabilities, and mental well-being to overcome post-traumatic stress disorders.
4. The program's effectiveness was evaluated through a formative experiment involving participants with PTSD. The study highlighted improvements in psychophysiological characteristics, situational anxiety indicators, and mental health outcomes. The positive impact on visual information processing, attention, productivity, and emotional stability underscores the program's potential in addressing PTSD.
5. The study supports using fitness technologies, such as the Rehab Fitness program, in improving mental health outcomes for individuals with PTSD. The structured approach and positive outcomes suggest the program's effectiveness in enhancing well-being and overcoming post-traumatic stress disorders. Further research is needed to explore the sustained benefits and long-term implications for PTSD treatment.

### **Conclusions**

1. The training of individuals with post-traumatic stress disorder (PTSD) using the experimental Rehab Fitness program has shown promising results in improving their mental health. This conclusion is supported by various psychophysiological indicators positively influenced by the program.
2. A key aspect that has shown improvement is the speed and accuracy of visual information processing among individuals with PTSD. Engaging in fitness activities can enhance cognitive functions, including visual processing speed and accuracy, attributed to the positive effects of physical exercise on brain function and neural pathways.
3. The volume, concentration, and distribution of attention have been positively impacted by the Rehab Fitness program. Regular exercise has been linked to improvements in attention and concentration levels, crucial for individuals with PTSD who often experience difficulties in focusing and maintaining attention. The structured nature of fitness programs can help develop better attentional control and cognitive flexibility.
4. Productivity levels have also shown improvement following participation in the Rehab Fitness program. Physical exercise has been associated with increased energy levels, motivation, and overall productivity, particularly valuable for individuals with PTSD who may struggle with low energy levels and motivation due to their condition.
5. The level of concentration, as measured by the number of processed digits, has been positively influenced by the program. Studies have shown that regular exercise can enhance cognitive functions such as working memory and processing speed, which are essential for tasks requiring sustained attention and concentration.
6. The psychophysiological improvements, indicators of situational anxiety, have also shown positive changes in individuals undergoing the Rehab Fitness program. Physical exercise has been widely recognized for its anxiolytic effects, with research demonstrating its ability to reduce symptoms of anxiety and stress. Engaging in regular fitness activities can help individuals with PTSD manage their anxiety levels and improve overall mental well-being.
7. The Rehab Fitness program has demonstrated positive effects on the mental health of individuals with PTSD. The improvements in psychophysiological characteristics and situational anxiety indicators highlight the potential of fitness programs in enhancing the well-being of individuals with PTSD. Further research and long-term studies are warranted to explore the sustained benefits and implications for PTSD treatment.
8. The training of individuals with post-traumatic stress disorders according to the experimental Rehab Fitness program positively affected their mental health, as confirmed by indicators of psychophysiological

characteristics (speed and accuracy of visual information processing, volume, concentration, and distribution of attention, productivity level, and level of concentration by the number of processed digits) and indicators of situational anxiety.

**Conflicts of Interest.** The authors declare no conflicts of interest.

**Ethical Approval.** The study was approved by the Ethics Committee of the National University "Yuri Kondratyuk Poltava Polytechnic", Poltava, Ukraine (Ethical Approval: 1175-2022). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent.** Informed consent was obtained from all individual participants included in the study. All subjects of the institutional survey gave consent for anonymized data to be used for publication purposes.

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**Author Contributions.** Conceptualization, L.R. and T.H.; methodology, L.R.; software, P.G., E.K. and T.H.; validation, T.H. and E.K.; formal analysis, T.Y., X.Ž. and E.K.; investigation, W.Z.; resources, L.R. and E.K.; data curation, L.R. and T.H.; writing – original draft preparation, T.Y., X.Ž. and E.K.; writing – review and editing, L.R., P.G., E.K. and T.H.; visualization, L.R., E.K. and T.H.; supervision, E.K., W.Z.; project administration, E.K., W.Z. All authors have read and agreed to the published version of the manuscript.

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