

The use of adaptive rowing in complex rehabilitation of wounded patients with lower limb amputations

Olga Iushkovska^a, Alexander Plakida^a, Anna Kitsis^a, Bohdan Kulynych^b, Svitlana Indyka^c

^aOdesa National Medical University, Odesa, Ukraine

^bDepartment of Physical Education and Human Health, Cherkasy State Technological University, Cherkasy, Ukraine

^cDepartment of Fitness and Cyclic Sports, Lesya Ukrainka Volyn National University, Lutsk, Ukraine

Corresponding author: Alexander Plakida
e-mail: apalkida01@gmail.com

Abstract

Purpose. Mine-blast injuries represent a leading cause of modern combat-related trauma, often resulting in unilateral or bilateral lower-limb amputation. One of the most promising contemporary approaches in rehabilitation of the wounded with lower limb amputations is adaptive sports, in particular, adaptive rowing. The study aimed to investigate the effectiveness of adaptive rowing in the complex rehabilitation of individuals with lower-limb amputations.

Material & Methods. The study involved 30 wounded servicemen with lower limb amputations undergoing rehabilitation, randomly allocated into a main group (n=15) and a control group (n=15). All participants received standard rehabilitation according to established clinical protocols. The wounded in the main group performed rowing technique exercises in the main part of the session, both on the water and on a rowing machine, allowing upper-body engagement while accommodating reduced or absent lower-limb function. The rehabilitation course for both groups was 30 days.

Results. Patients in the main group showed a significantly greater improvement ($p < 0.05$) in the indicators for the scales "Physical functioning" and "Social functioning". These improvements in the "Physical Functioning" domain may be explained by using more load-bearing exercises on the rowing machine. In that case, the improvement in the "Social functioning" assessment directly indicates the positive social aspect of using adaptive rowing. The most demonstrative changes were in the depression level in the main group, which led to a change in the depression level assessment from clinically pronounced to subclinical.

Conclusions. The use of adaptive rowing in the comprehensive rehabilitation of the wounded with lower limb amputations is an effective method for improving the quality of life and optimizing the psycho-emotional status.

Keywords: wounded, lower limb amputation, rehabilitation, adaptive rowing.

Introduction

Mine and blast injuries occupy the most prominent place in the structure of modern combat injuries, which leads to the need for amputation of one or both lower limbs [1, 2]. Rehabilitation of this contingent is a challenging task. Injuries of this type are accompanied not only by the loss of

limbs, but also by numerous complications: residual pain in the limbs, phantom pain, contractures, infectious processes, and psychological problems [3]. One of the promising areas of rehabilitation for individuals with lower-limb amputations is adaptive sports [4, 5]. In particular, adaptive rowing may be the most optimal type of adaptive



sport for the injured with lower limb amputations [6, 7].

The study aims to investigate the effectiveness of adaptive rowing in the complex rehabilitation of wounded individuals with lower-limb amputations.

Material and methods

The study involved 30 military personnel with lower limb amputees undergoing rehabilitation at the Arcadia Clinical Sanatorium of the State Border Service of Ukraine with the support of the "Ukraine is Us" charitable foundation. Participants were divided into a study group (n=15) and a control group (n=15).

The study complied with the principles of bioethics set out in the Declaration of Helsinki and the Universal Declaration on Bioethics and Human Rights (UNESCO). The study was approved by the Bioethics Commission of Odessa National Medical University, Protocol No. 9, dated November 12, 2025. Before inclusion in the study, all patients provided written informed consent to participate.

Inclusion criteria: traumatic amputation of both lower limbs at the level of the upper third of the thigh.

Exclusion criteria: combined injuries of the musculoskeletal system and internal organs, traumatic brain injury.

Study design: All subjects were randomly assigned and blinded to a 15-person main group and a control group. All the injured received rehabilitation according to the standard generally accepted method. The rehabilitation program included the following activities: exercises to improve blood circulation and muscle tone, exercises to maintain mobility of the hip and knee joints, exercises to strengthen the muscles of the back and arms (for walking on crutches), balance and coordination training, elastic bandaging or silicone liners to reduce swelling, development of tactile sensitivity (massage, contrast temperatures), treatment of phantom pain (physiotherapy, mirror therapy), training in self-care, psychosocial reha-

bilitation. The wounded in the control group underwent therapeutic exercises (physical training) according to the generally accepted method for the long-term rehabilitation stage: the preparatory part lasted 30 minutes, the central part lasted 60 minutes, and the final part lasted 30 minutes, five sessions per week. The central part of the session used general developmental and special exercises to rehabilitate this type of injury.

The wounded in the main group performed rowing technique exercises in the main part of the session, both on the water and on a rowing machine, allowing the use of the arms and torso while accounting for limited or absent leg function. The rehabilitation course for both groups was 30 days.

Before and after rehabilitation, all subjects completed a quality-of-life survey using the SF-36 [8]. The level of depression and anxiety was assessed using the HARS-HADS method [9].

Statistical data processing was performed using XLSTAT 2020. The mean value and standard deviation ($M \pm sd$) were used to describe the data. Due to the small sample size, we used the G-test of signs to compare the dynamics of changes within one group (before and after the rehabilitation course). The normality of the data distribution was assessed using the Shapiro-Wilk test. Independent sample t-tests for normally distributed variables were used to assess baseline equivalence between the main and control groups. In cases where the assumption of normality was violated, the Mann-Whitney U test was used. Ninety-five percent confidence intervals (95% CIs) were calculated for all primary outcomes to assess the precision of the observed effects. The level of statistical significance was set at $p < 0.05$.

Results

A preliminary study of the quality of life in patients yielded the following results (Table 1). At baseline, no statistically significant differences were observed between groups in all measures ($p > 0.05$), confirming the homogeneity of the groups before intervention. No significant differ-

Table 1. Assessment of the quality of life of the wounded before rehabilitation, $M \pm sd$

Scales	Main Group n=15	Control group n=15	P
Physical Functioning	14.7±1.91	13.7±1.87	>0.05
Role (Physical) Functioning	4.4±0.92	4.0±0.86	>0.05
Pain	7.1±0.78	7.0±0.72	>0.05
General Health	14.2±1.29	14.0±1.25	>0.05
Vitality	15.3±1.64	14.9±1.56	>0.05
Social Functioning	4.8±0.91	4.7±0.89	>0.05
Emotional Functioning	3.4±0.93	3.3±0.91	>0.05
Psychological Health	14.3±1.85	14.2±1.83	>0.05

Note: P – reliability of differences in indicators between the main and control groups

ences were found between groups at baseline in age (baseline: 26.3 ± 1.7 years; control: 25.8 ± 1.6 years; $p > 0.05$), time from injury to amputation (14.0 ± 1.2 hours vs. 14.0 ± 1.3 hours; $p > 0.05$), and time from amputation to start of rehabilitation (52.3 ± 12.7 days vs. 51.8 ± 11.9 days; $p > 0.05$), indicating baseline comparability.

As can be seen from Table 1, the most pronounced limitations were recorded on the physical functioning scale, which may indicate difficulties in performing everyday physical activities – walking, climbing stairs, carrying objects, etc. A significant decrease in vitality indicates increased fatigue and lower energy levels. Participants also noted limitations in performing everyday and professional roles due to their physical condition, as reflected in indicators of role physical functioning. Less pronounced changes were recorded on the scales of general health, psychological well-being, social and emotional functioning, and pain.

Participants in both groups demonstrated significantly reduced scores in physical functioning and vitality, indicating limitations in daily activities and decreased energy levels.

When examining the baseline level of depression and anxiety, the following values were obtained (Table 2).

Table 2. Assessment of baseline levels of depression and anxiety, $M \pm sd$

Scales	Main Group n=15	Control group n=15
HADS	16.6 ± 2.08	16.4 ± 2.19
HARS	13.4 ± 3.01	13.6 ± 2.88

The obtained data indicate a clinically expressed level of depression in patients, while the anxiety level was at the upper limits of values related to the borderline state. Both groups demonstrated clinically elevated levels of depression (HADS: 16.6 ± 2.08 vs. 16.4 ± 2.11 ; $p > 0.05$)

and borderline anxiety levels (HARS: 13.4 ± 3.01 vs. 13.5 ± 2.90 ; $p > 0.05$), with no significant differences between groups. Such a state is characteristic of significant psycho-emotional stress in patients with this type of injury.

After the rehabilitation course, significant changes occurred in both groups (Table 3).

As Table 2 shows, positive changes were found in almost all scales in both groups, which indicates the effectiveness of the rehabilitation programs used. In particular, the main group showed significant improvements in: Physical functioning – $\Delta = +10.5$; $p < 0.001$, Social functioning – $\Delta = +4.2$; $p < 0.01$, General health, vitality, and psychological health – $p < 0.05$. The control group also showed improvements in: Physical functioning ($\Delta = +4.3$ points; $p < 0.05$; moderate effect size), General health and vitality ($p < 0.05$; small to moderate effects). No statistically significant changes in physical role functioning, pain or emotional functioning were found in any of the groups ($p > 0.05$).

Comparison of change scores (after–before) showed significantly greater improvements in the main group compared to the control group for: Physical functioning – Δ : $+10.5$ vs. $+4.3$; $p < 0.05$, Social functioning – Δ : $+4.2$ vs. $+1.8$; $p < 0.05$.

No statistically significant differences between groups were observed for: General health, Vitality, Psychological health.

Changes in the level of depression and anxiety, assessed using the HADS - HARS method, are presented in Table 4.

As Table 2 shows, both groups demonstrated reduced levels of depression and anxiety after rehabilitation. Positive changes were found in almost all scales in both groups, unidirectional changes indicated an improvement in the psycho-emotional status of patients. Thus, after completing the rehabilitation cycle, anxiety levels decreased by 27.6% in the study group and 21.6% in the

Table 3. Changes in assessing the quality of life under the influence of the rehabilitation course, $M \pm sd$

Scales	Main Group n=15		Control group n=15		P
	Before rehabilitation	After rehabilitation	Before rehabilitation	After rehabilitation	
Physical Functioning	13.6 ± 1.94	$24.1 \pm 1.91^{***}$	13.7 ± 1.87	$18.0 \pm 1.89^*$	< 0.05
Role (Physical) Functioning	3.9 ± 0.83	5.4 ± 1.00	4.0 ± 0.86	5.1 ± 1.00	> 0.05
Pain	6.9 ± 0.74	5.6 ± 0.70	7.0 ± 0.72	5.5 ± 0.80	> 0.05
General Health	14.2 ± 1.23	$17.9 \pm 1.38^*$	14.0 ± 1.25	$17.7 \pm 1.36^*$	> 0.05
Vitality	15.0 ± 1.54	$18.7 \pm 1.52^*$	14.9 ± 1.56	$18.8 \pm 1.46^*$	> 0.05
Social Functioning	4.7 ± 0.96	$8.9 \pm 0.99^{**}$	4.7 ± 0.89	6.5 ± 0.94	< 0.05
Emotional Functioning	3.4 ± 0.74	4.8 ± 0.98	3.3 ± 0.91	4.7 ± 0.95	> 0.05
Psychological Health	14.3 ± 1.78	$19.6 \pm 2.06^{**}$	14.2 ± 1.83	$19.3 \pm 2.08^*$	> 0.05

Note: * – statistical significance of changes in indicators in the main and control groups before and after rehabilitation: * – (< 0.05), ** – (< 0.01);

P – reliability of differences in indicators between the main and control groups after rehabilitation.

Table 4. Dynamics of the level of depression and anxiety under the influence of the rehabilitation course, $M \pm sd$

Scales	Main Group n=15		Control group n=15		P
	Before rehabilitation	After rehabilitation	Before rehabilitation	After rehabilitation	
HADS	16.6±2.08	11.7±2.07*	16.4±2.11	12.8±2.24	>0.05
HARS	13.4±3.01	10.5±2.87	13.5±2.90	11.1±2.84	>0.05

Note: * – statistical significance of changes in indicators in the main and control groups before and after rehabilitation: * – (<0.05);

P – reliability of differences in indicators between the main and control groups after rehabilitation

control group, reaching a stable borderline level. The most significant changes were observed in depression levels. A decrease in values was also observed in both groups, but it was more significant: 41.9% in the main group and 28.1% in the control group. In the main group, this decrease was statistically significant ($p < 0.05$), which led to a change in the depression level assessment from clinically pronounced to subclinical. These changes may indicate a greater effectiveness of adaptive rowing in the complex rehabilitation of patients with lower-limb amputations.

For comparison, in the main group, Depression (HADS) decreased significantly ($\Delta = -4.9$; $p < 0.01$), and Anxiety (HARS) decreased ($\Delta = -2.9$; $p < 0.05$). In the control group, Depression decreased ($\Delta = -3.6$; $p < 0.05$), and the decrease in anxiety did not reach statistical significance ($p > 0.05$). Comparison of change scores (after-before) showed no significant differences in anxiety and depression scores ($p > 0.05$), although the trends favored the main group. The magnitude of improvement in the main group suggests that the inclusion of adaptive rowing provides additional benefits over standard rehabilitation.

Discussion

Rehabilitation of the wounded in Ukraine and around the world is developing through a comprehensive, individualized approach, emphasizing early initiation of activities and interdisciplinary cooperation. Since 2014, after the outbreak of the armed conflict in the east of the country, Ukraine has been actively developing a rehabilitation system for military and civilians injured in combat [10-12]. Particular attention is paid to physical rehabilitation aimed at restoring limb function and improving patients' general physical condition [13, 14].

Modern approaches to rehabilitation include comprehensive programs that combine physical methods, psychological support, and social adaptation. One of the most critical components is the early initiation of rehabilitation, which contributes to more effective patient recovery [15, 16].

Early initiation of rehabilitation measures, including stump formation, is critical for successful prosthetics and functional restoration. Developing effective rehabilitation programs requires considering the specifics of the injuries sustained, the patient's general health condition, and the patient's individual needs [17, 18]. Adaptive sports play a key role in the rehabilitation of patients with lower-limb amputations. They promote not only physical recovery but also improvement of the psycho-emotional state, increased quality of life, and, most importantly, integration into society.

Comprehensive rehabilitation of patients with lower limb amputations includes the following components:

- Physical rehabilitation and functional adaptation aim to improve muscle strength and endurance. Development of coordination and balance: the inclusion of adaptive sports in the rehabilitation process helps patients quickly master the use of prostheses and increase mobility. Reducing the risk of secondary complications: regular physical activity reduces the likelihood of physical inactivity, excess weight, and cardiovascular diseases.

- Psycho-emotional rehabilitation: increasing motivation and self-confidence. Participation in sports activities helps patients overcome fears and doubts. Combating depression and anxiety: Sports promote the release of endorphins, which improve mood and reduce stress levels. Developing a sense of social belonging: inclusion in a sports community allows patients to feel part of a team and receive support from other athletes [The Role of Occupational Therapy in Amputee Rehab].

- Social adaptation and improved quality of life: Increased independence and the development of physical skills make everyday tasks (movement, household activities) more accessible. Opportunity for professional development: Participation in competitions can open up new career prospects (e.g., paralympic sports, coaching, participation in public initiatives).

Adaptive rowing is among the most advantageous adaptive sports for patients with lower-limb

amputations. It is a form of rowing that allows people with physical disabilities, including those with lower-limb amputations, to engage in sports. Adaptive rowing exercises engage nearly all muscle groups, especially the upper shoulder girdle and trunk. This helps to strengthen the core musculature and improve endurance and coordination of movements. Adaptive rowing is one of the most advantageous types of adaptive training. Research shows that athletes with lower-limb amputations experience decreased physical performance and changes in their functional state. Therefore, an individual approach to the training process, taking into account each athlete's physiological and psychophysiological characteristics, is a key factor in successful rehabilitation [19, 20].

Adaptive rowing is prevalent among veterans and people with disabilities in the United States and Canada. In Australia, adaptive rowing has been popular with veterans injured during World War II, highlighting its long-standing role in rehabilitation [21, 22].

Adaptive rowing's integration into international competition has contributed to its growth. In 1993, adaptive rowing was included as a demonstration event in the FISA World Junior Rowing Championships and then became a permanent part of the World Rowing Championships in 2002. The sport received significant recognition when the International Paralympic Committee voted to include adaptive rowing in the 2008 Beijing Paralympic Games, spurring global growth and participation [23].

Our study's data confirm the feasibility of including adaptive rowing classes as a part of comprehensive rehabilitation of wounded people with lower limb amputations.

The study has several limitations. The main ones include a small sample size, age restrictions, and time limitations after amputation. Expanding these parameters would allow for a more comprehensive study of the impact of adaptive rowing on the effectiveness of amputee rehabilitation.

Conclusions

The use of adaptive rowing in the comprehensive rehabilitation of the wounded with lower limb amputations is an effective method for improving the quality of life and optimizing the psycho-emotional status.

Funding

This research did not receive any financial support or grants of any kind.

Author Contributions

Olga Iushkovska: Conceptualization, Methodology;
Alexander Plakida: Writing, Review & Editing; **Anna**

Kitsis: Investigation, Resources; Svitlana Indyka: Software, Validation. All authors have read and agreed with the published version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and approved by the Bioethics Commission of the Odessa National Medical University.

Informed Consent

After familiarizing themselves with the study's features, all participants provided informed consent.

Data Availability

No information.

Received: October 10, 2025; Accepted: March 15, 2026

Published: April 30, 2026

References

- D'Souza EW, MacGregor AJ, Dougherty AL, Olson AS, Champion HR, Galarneau MR. Combat injury profiles among U.S. military personnel who survived serious wounds in Iraq and Afghanistan: A latent class analysis. *PLoS ONE*. 2022 Apr 14;17(4):e0266588. <https://doi.org/10.1371/journal.pone.0266588>
- Janak JC, Mazuchowski EL, Kotwal RS, Stockinger ZT, Howard JT, Butler FK, et al. Patterns of Anatomic Injury in Critically Injured Combat Casualties: A Network Analysis. *Sci Rep*. 2019 Sep 24;9(1):13767. <https://doi.org/10.1038/s41598-019-50272-3>
- Spornier ML, Fitzgerald SG, Dicianno BE, Collins D, Teodorski E, Pasquina PF, et al. Psychosocial impact of participation in the National Veterans Wheelchair Games and Winter Sports Clinic. *Disabil Rehabil*. 2009;31(5):410-8. <https://doi.org/10.1080/09638280802030923>
- De Luigi A. The effects on sports performance of technologic advances in sports prostheses and wheelchairs. *PM&R*. 2024 Apr;16(4):409-17. <https://doi.org/10.1002/pmrj.13153>
- Laferrier J, Parente M, Felmlee D. Return to Sport, Exercise, and Recreation (SER) Following Amputation. *Curr Phys Med Rehabil Rep*. 2024 Mar;12(1):1-10. <https://doi.org/10.1007/s40141-023-00425-3>
- Sidiropoulos A, Nelson L, Pruziner A, Glasberg J, Maikos J. Evaluation of Weight Shift and X-Factor During Golf Swing of Veterans With Lower Limb Loss. *Am J Phys Med Rehabil*. 2023 Jan 1;102(1):85-91. <https://doi.org/10.1097/PHM.0000000000001934>
- Robo Bionics. How Adaptive Sports Can Accelerate Rehabilitation After Amputation [Internet]. India: Robo Bionics Blog; [cited 2024 May 22]. Available from: robobionics.in
- Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care*. 1992 Jun;30(6):473-83. <https://doi.org/10.1097/00005650-199206000-00002>
- Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand*. 1983 Jun;67(6):361-70.

<https://doi.org/10.1111/j.1600-0447.1983.tb09716.x>

10. Ukraine. Law of Ukraine No. 4370-IX: On Amendments to the Law of Ukraine «On Physical Culture and Sports» Regarding Adaptive Sports. Passed 2024.
11. Bratus Ya. The Joy of Movement. How Adaptive Sports Helps Veterans Recover. Kyiv: Center for PZh Initiatives; 2024. 56 p.
12. Rush C, Kane J. Ukrainian war veteran amputees learn adaptive skiing in Oregon [Internet]. New York (NY): Associated Press; 2024 [cited 2024 May 22]. Available from: apnews.com
13. Spaan MH, Vrieling AH, van de Berg P, Dijkstra PU, van Keeken HG. Predicting mobility outcome in lower limb amputees with motor ability tests used in early rehabilitation. *Prosthet Orthot Int*. 2017 Apr;41(2):171-177. <https://doi.org/10.1177/0309364616670397>
14. Gailey R, Gaunaud I, Raya M, Kirk-Sanchez N, Prieto-Sanchez LM, Roach K. Effectiveness of an Evidence-Based Amputee Rehabilitation (EBAR) Program: A Pilot Randomized Controlled Trial. *Phys Ther*. 2020 May 19;100(5):773-787. <https://doi.org/10.1093/ptj/pzaa008>
15. Pelzer D, Beaudart C, Bornheim S, Maertens B, Schwartz C, Kaux JF. Outcomes of Patients with Lower Limb Loss after Using a Training Prosthesis: A Retrospective Case Series Study. *Healthcare*. 2024 Feb 26;12(5):567. <https://doi.org/10.3390/healthcare12050567>
16. Wake Forest Baptist Health. The Amputation Rehab Program [Internet]. Winston-Salem (NC): Wake Forest University; [cited 2024 May 22]. Available from: wakehealth.edu
17. Johns Hopkins Medicine. Amputation: Recovery and Rehabilitation [Internet]. Baltimore (MD): Johns Hopkins University; [cited 2024 May 22]. Available from: hopkinsmedicine.org
18. Alessa M, Alkhalaf HA, Alwabari SS, Alwabari NJ, Alkhalaf H, Alwayel Z, et al. The Psychosocial Impact of Lower Limb Amputation on Patients and Caregivers. *Cureus*. 2022 Nov 11;14(11):e31248. <https://doi.org/10.7759/cureus.31248>
19. Russell A. The Transformative Power of Adaptive Sports [Internet]. Omeo Technology; 2023 [cited 2024 May 22]. Available from: myomeo.com
20. Pizzinato S. What is adaptive rowing and how does it work? [Internet]. Sydney: Invictus Australia; [cited 2024 May 22]. Available from: invictusaustralia.org
21. British Rowing. Understanding Para, Adaptive and Indoor Adaptive Rowing classification [Internet]. London: British Rowing Plus; 2022 Sep 1 [cited 2024 May 22]. Available from: britishrowing.org
22. Bayada. Guide to Adaptive Rowing [Internet]. Moorestown (NJ): Bayada Home Health Care; 2015 [cited 2024 May 22]. Available from: bayada.com
23. World Rowing. The ongoing progression of para rowing [Internet]. Lausanne: World Rowing; 2020 Jul 23 [cited 2024 May 22]. Available from: <https://worldrowing.com/2020/07/23/the-ongoing-progression-para-rowing/>