THE IMPACT OF PHYSICAL ACTIVITY ON QUALITY-OF-LIFE INDICATORS IN PATIENTS WITH CHRONIC HEART FAILURE

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ABSTRACT

Background. Heart failure is one of the most common complications of cardiovascular diseases. In this regard, physical rehabilitation programs aimed at improving the psychophysical state of patients are becoming increasingly relevant.

Aim. To assess the impact of systematic physical exercise within a multidisciplinary outpatient cardiac rehabilitation program on the quality-of-life and psychological adaptation of patients with heart failure.

Materials and Methods. The study involved 100 patients (50 men and 50 women) with diagnosed heart failure. To assess the effectiveness of rehabilitation, the Quality-of-Life scale (QoL) and the Acceptance of Illness Scale (AIS) were used. Statistical analysis was performed using Excel 365 (Microsoft, USA) and Statistica 10 (StatSoft, USA), with the Mann–Whitney U test for pairwise comparisons and the Kruskal–Wallis test with post hoc analysis for multiple group comparisons. The study was carried out as a private initiative of the authors, without additional funding and state registration of the scientific topic.

Research Ethics. The study was conducted in compliance with the basic principles of bioethics, respect for the person, confidentiality, voluntary participation, and patient safety. The participants in the experiment were informed about the details of participation in the rehabilitation program and provided written consent to participate. The results were used only for scientific purposes, with participants' anonymity ensured.

Results. This study presents the dynamics of the quality-of-life of patients with heart failure under the influence of physical rehabilitation. A comparison of the physical (FIZ) and psycho-emotional (MENT) aspects of quality-of-life, the general quality-of-life index (QoL) and the acceptance of illness scale (AIS) between men and women was conducted. The results showed that patients who participated in the physical rehabilitation program demonstrated a significant improvement in physical performance, tolerance to stress and emotional state. According to the AIS scale, statistically significant gender differences were found ($p=0.002$): women reported higher rates of disease acceptance ($M=[25.8\pm5.3]$) than men ($M=[22.7\pm6.1]$), indicating better psychological adaptation of women to a chronic disease.

Conclusions. The results confirmed that it has a significant positive impact on the general condition of patients. In the control group, a less pronounced improvement in the studied indicators was observed. The study findings emphasize the importance of systematic physical activity as an integral element of heart failure treatment and is the key to successful long-term rehabilitation.

Keywords: *physical therapy and rehabilitation, sports medicine, organization of health care, psychological adaptation, multidisciplinary approach, cardiac rehabilitation.*

Introduction

Chronic Heart Failure (CHF) is one of the most common causes of hospitalization. The disease most often affects patients in developing countries and encompasses more than 23 million individuals worldwide [1]. In the United States, CHF has been diagnosed in approximately 5.7 million adults over 65 years of age [2]. Improving the quality-of-life is one of the main goals of physical cardiac rehabilitation. Rehabilitation contributes to the alleviation of symptoms of the primary and concomitant diseases, reduces the number of repeated hospitalizations and mortality rates [1]. Symptoms such as shortness of breath, fatigue, weakness, poor exercise tolerance, peripheral edema, loss of appetite, and drowsiness affect the patient's quality-of-life [3]. Acceptance of the disease is consi-

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dered a necessary condition for patient adaptation. The course of the disease, conditions and treatment options, prognosis, as well as individual predisposition – emotions, stress management, and other factors – directly influence the patient's attitude towards the disease [4]. According to Vitomskyi V.V. et al. (2025), physical activity suppresses negative feelings associated with the disease and its treatment and reduces psychological stress [5]. A high level of acceptance reflects the willingness of patients to actively participate in cardiac rehabilitation. The literature describes the acceptance of the disease in various chronic conditions. However, there are no reports on the degree of acceptance of the disease by patients with heart failure, as well as its impact on the quality-of-life.

Regular physical activity helps patients prevent the development of skeletal myopathy, improves the quality-of-life by increasing the body's endurance, prevents the loss of muscle mass and has a positive effect on the recovery process [1]. The rationale for therapeutic exercises in cardiac rehabilitation lies in activating extracardiac mechanisms that regulate blood circulation. Regular physical exercise improves the function of the respiratory system, increases the reserve capabilities of the cardiovascular and respiratory systems, enhances the body's adaptive capacity to physical exertion. In the myocardium, metabolism is optimized, and the efficiency of coronary blood flow increases, tissue oxygenation improves. Therapeutic exercise enchance respiratory recovery and restore lung ventilation. Therapeutic exercise is one of the means of maintaining a long phase of relative compensation in the conservative treatment of patients with cardiovascular diseases. It becomes functional through the combination of three main mechanisms of action, namely: compensatory, in which extracardiac factors are activated; trophic, which increases metabolism in the myocardium and improves the efficiency of coronary blood supply; stimulating, which increases the body's adaptive ability to exercise.

Regular monitoring is essential to ensure that patients have experienced no exacerbations of the disease for at least four weeks. Many authors recommend including various types of physical training in the cardiac rehabilitation program, particularly, aerobic exercises. In their study, Yushkovska et al. O. (2023) [1] demonstrate that Nordic walking is an effective method for the organization of health care in patients with heart disease because such training provides aerobic load at a moderate level, increases overall physical endurance, and improves quality-of-life. Nesterak R.V. & Vakaliuk I.R. (2021) [2] emphasize the importance of a comprehensive recovery protocol after acute coronary syndrome. They argue that the combination of medication and physical training supports the phase of mild compensation, reduces the risk of recurrent cardiovascular events, and improves psycho-emotional well-being.

M. Balazh & V. Kostenko (2021) [3] demonstrate how cardio rehabilitation using telemedicine technology significantly makes physical training more accessible and allows patients with cardiovascular diseases to self-monitor their health status at a distance. According to the authors, this has a positive effect on physical activity and overall quality-of-life. Rogalya Y.L. & Kurtyak I.B. (2023) [4] draw attention to the aspect of rehabilitation of patients with heart failure against the background of metabolic syndrome. They state that regular physical activity not only improves physical condition but also reduces cardiometabolic risk. Similarly, the results of Vitomskyi V. et al. (2025) [5] demonstrated the effectiveness of inspiratory muscle training to improve respiratory function and overall endurance in patients with heart failure.

International studies confirm the global trend towards using physical activity as the primary method for preventing cardiovascular disease. Ciumărnean L. et al. (2021) [6] and Ahmadi M. et al. (2023) [7] argue that regular physical exercise among the elderly leads to a decrease in risk factors for cardiovascular diseases and an improvement in quality-of-life. Fallon N. et al. (2021) [8] state that specialised cardiac rehabilitation programmes of the 3rd phase reduce cardiovascular risks and improve physical performance of patients. Meta-analytic reviews by Dibben G.O. et al. (2023) [9]; (2021) [10]; and research of Malachias M.V.B. et al. (2020) [11] indicate that physical exercise within the framework of cardiac rehabilitation contributes to the improvement of physical endurance, the reduction of symptoms of heart failure, and the increase in the quality-of-life of patients with coronary heart disease. The most positive changes in the mental health of patients under the influence of physical exercise were observed in traditional face-to-face programs and at the same time in remote and virtual models, as confirmed by the findings of Siegmund L.A. et al. (2023) [13]. Research by Shi W. et al. (2021) [14] indicates that physical activity is a key component of cardiac rehabilitation and secondary prevention

programmes; however, implementation of these programs and patient engagement in rehabilitation activities remain insufficient. A synthesis of current scientific data confirms the advisability of further developing community-based physical rehabilitation programs to improve the functional status and quality-of-life of patients with ischaemic heart disease.

It is also crucial to remember the role of biomarkers in predicting the effectiveness of rehabilitation programs. Malachias M.V.B. et al. (2020) [11] have proven that the level of the natriuretic hormone NT-proBNP (N-terminal pro-Brain Natriuretic Peptide) correlates with mortality and events in the cardiovascular system and therefore is an excellent marker for assessing the effectiveness of physical exercises in patients with a high-risk group. All modern scientific publications unanimously confirm that physical exercise systems have an undeniable positive effect on physical condition, the psycho-emotional sphere, and the standard of living in heart failure. According to Shi W. et al. (2021) [14], the most effective exercises include training on a cycle ergometer or treadmill. Good results are achieved with moderate-intensity strength exercises, breathing exercises, and therapeutic exercises. For patients with a stable course of the disease, swimming, Nordic walking, and recreational sports are recommended.

Aim & Objectives

The ***aim*** of this study was to assess the impact of physical activity on the quality-of-life of patients with heart failure.

Research ***objectives*** include:

1) to establish the effectiveness of physical rehabilitation in improving the quality-of-life of patients with cardiovascular diseases;

2) to assess the degree of disease acceptance using the AIS scale;

3) to establish the correlation of the effectiveness of cardiac rehabilitation considering gender differences.

Materials and Methods

The study was a prospective interventional trial designed to assess the effectiveness of cardiac rehabilitation. A personalized approach was applied to study the impact of physical exercise on the quality-of-life of patients with heart failure. Physical exercises were performed considering the clinical condition, functional index, and level of physical fitness of the patient. During the rehabilitation process, the load was gradually increased in accordance with the principle of adequacy to ensure safe and effective recovery of cardiorespiratory function.

A comparative analysis of quality-of-life indicators among patients with cardiovascular diseases was conducted. This comparative study included 100 patients aged [18–70] years with a confirmed diagnosis of chronic heart failure. The study population comprised 50 men and 50 women. The patients were randomly allocated into three groups using a computer-generated random number sequence: intervention group (n=33), comparison group (n=33), and control group (n=34).

The diagnosis of chronic heart failure was established by a cardiologist according to current clinical recommendations.

Inclusion criteria were: age [18–70] years; confirmed diagnosis of chronic heart failure; clinically stable condition; ability to complete the questionnaires independently; and written informed consent.

Exclusion criteria included: acute cardiovascular events during the study period; severe cognitive impairment that prevented questionnaire completion; severe concomitant diseases significantly affecting physical functioning; refusal to participate.

Health-related quality-of-life was assessed using the Medical Outcomes Study Short Form-36 Health Survey (SF-36), a validated generic questionnaire consisting of 36 items grouped into eight domains: Physical Functioning; Role Physical; Bodily Pain; General Health; Vitality; Social Functioning; Role Emotional; Mental Health. Each domain was scored according to the standard SF-36 scoring procedure and transformed into a scale ranging from 0 to 100, where higher scores indicate better health status and quality-of-life.

The physical composite index (FIZ) was derived from the Physical Functioning, Role Physical, Bodily Pain, and General Health domains, whereas the mental composite index (MENT) was derived from the Vitality, Social Functioning, Role Emotional, and Mental Health domains.

For comparative analyses, the SF-36 domains were additionally summarized into two composite indices: the physical composite index (FIZ) and the mental composite index (MENT). The overall quality-of-life index (QoL) was calculated for each participant as the sum of the FIZ and MENT scores (QoL = FIZ + MENT). This composite index was used exclusively for statistical analyses and, as a derived composite measure, does not in itself represent a standard SF-36 summary score.

Acceptance of illness was evaluated using the Acceptance of Illness Scale (AIS) described by Juczyński Z. (2009) [10]. Responses are rated on a five-point Likert scale, resulting in a total score ranging [8–40] where higher scores indicate greater acceptance of illness.

Rehabilitation sessions were performed three times per week, with each session lasting approximately [45–60] minutes. The rehabilitation programme included: a [5–10]-minute warm-up consisting of low-intensity mobility and stretching exercises; [20–30] minutes of aerobic exercise, including treadmill walking or corridor walking and cycle ergometer training, depending on the patient's functional capacity; [10–15] minutes of therapeutic exercises aimed at improving muscular endurance, coordination and functional mobility using low-intensity dynamic exercises for the major muscle groups; [5–10] minutes of breathing exercises and relaxation techniques, followed by a cool-down period.

Exercise intensity was individualized according to each patient's clinical condition, exercise tolerance, and functional capacity. The workload was increased gradually throughout the rehabilitation program in accordance with the patient's adaptation and absence of adverse symptoms.

Patients were monitored before, during, and after each rehabilitation session. Heart rate, blood pressure, and subjective symptoms (fatigue, dyspnoea, chest discomfort, and dizziness) were assessed to ensure exercise safety. Rehabilitation sessions were postponed or modified if clinically significant symptoms occurred.

The comparison group received the standard rehabilitation program routinely implemented in the clinic, consisting of general therapeutic exercises, breathing exercises, and educational counseling without individualized progression of exercise intensity. Patients in the control group received standard pharmacological treatment and recommendations regarding physical activity and lifestyle, but did not participate in supervised rehabilitation sessions.

The normality of continuous variables was assessed using the Shapiro–Wilk test. For variables with a normal distribution ($p>0.05$), data are presented as Mean ± Standard Deviation ($M \pm SD$). For variables with a non-normal distribution ($p<0.05$), data are presented as Median (Me) and interquartile range (Q_1–Q_3). Group comparisons were performed using the Mann–Whitney U test for pairwise comparisons and the Kruskal–Wallis test with post hoc Mann–Whitney U test and Bonferroni adjustment for multiple comparisons. Spearman's rank correlation coefficient (R) was applied to assess the correlation between two continuous variables. Calculations were performed using Excel 365 (Microsoft, USA) and Statistica 10 (StatSoft, USA). A two-sided p-value < 0.05 was considered statistically significant.

Research Ethics

The study was a prospective interventional trial designed to assess the effectiveness of cardiac rehabilitation.

The research was carried out in compliance with the ethical principles outlined in the World Medical Association's Declaration of Helsinki (1964–2024) and the requirements of Order No.690 of the Ministry of Health of Ukraine dated September 23, 2009. Ethical approval for the study protocol was obtained from the Bioethics Committee of the State Higher Educational Institution "Uzhhorod National University" (Protocol No.4 dated May 20, 2021). Prior to enrolment, all participants signed written informed consent confirming their voluntary participation in the study.

Results

A prerequisite for the appointment of physical cardiac rehabilitation was a good result of physical tolerance tests. *Table 1* presents the results of testing the impact of physical rehabilitation on the quality-of-life of patients with heart failure.

Table 1 compares the physical (FIZ) and psycho-emotional (MENT) components of quality-of-life, the general quality-of-life index (QoL) and the acceptance of illness scale (AIS) between men and women. The median of the physical component of quality-of-life (FIZ) in men and women is 61.0 and 69.0, respectively. The difference between the groups is statistically significant ($p=0.005$). This means that women assess their physical condition slightly higher than men. The psycho-emotional component (MENT) shows a median of 39.0 for men and 49.0 for women. The difference is also statistically significant ($p=0.004$), indicating better psycho-emotional adaptation in women. The general quality-of-life index (QoL) for men is 100.0 and for women, 118.0. This is also a significant difference ($p<0.05$), which confirms the higher overall assessment of quality-of-life in women.

The Acceptance of Illness Scale (AIS) shows the same median of 24.0 for both groups; although the interquartile range for women is wider ([15.0–35.0] versus [20.0–31.0] for men), and the difference is statistically significant ($p=0.002$). This indicates that women are psychologically better

Table 1. Comparison of physical (FIZ) and psycho-emotional (MENT) aspects of quality-of-life, general quality-of-life index (QoL) and acceptance of illness scale (AIS) between men and women

Indicator	Men (*n*=50)			Women (*n*=50)			*p*
	Median	Q_1	Q_3	Median	Q_1	Q_3	
FIZ (physical component of QoL)	61.0	41.0	86.5	69.0	41.0	86.5	0.005
MENT (psycho-emotional component of QoL)	39.0	23.0	48.0	49.0	23.2	58.0	0.004
QoL (general quality-of-life index)	100.0	61.0	129.5	118.0	71.0	139.5	0.005
AIS (acceptance of illness scale)	24.0	20.0	31.0	24.0	15.0	35.0	0.002

Notes:
FIZ – assessment of the patient's physical functioning and exercise tolerance;
MENT – assessment of the psycho-emotional state, including the level of anxiety, depression and life activity;
QoL – general quality-of-life, which integrates physical and psycho-emotional components;
AIS – acceptance of illness scale, which reflects psychological adaptation to cardiovascular disease;
p-values were obtained using the Mann–Whitney U test.

adapted to their disease. As a result, women rate their quality-of-life and psycho-emotional adaptation to the disease higher than men, and physical exercise may have a positive effect on both groups. The results in *Table 1* showed that the physical and psycho-emotional state of patients after cardiac rehabilitation with physical exercise did not differ statistically significantly between men and women. The statistical evaluation of the parameters of psychological adaptation (AIS) is presented in *Table 2*.

According to the AIS scale, the assessment of psychological adaptation to the disease revealed statistically significant differences between men and women who participated in the study (p= =0.002). The mean AIS score in women was [25.8±5.3], while in men it was [22.7±6.1], which indicates a higher level of acceptance of the disease in women. The median AIS value in women was 26.0 (Q_1–Q_3: 22–29), while in men it was 23.0 (Q_1–Q_3: 18–27). The minimum and maximum values for women ranged from 14 to 34, while for men it was from 12 to 33. Women demonstrated significantly higher AIS scores than men, indicating better illness acceptance.

At the same time, lower AIS scores in men may reflect a lower tendency to be aware of their own vulnerability, which is a typical gender feature in the perception of chronic diseases. The results of the study emphasize the importance of considering psychological and gender aspects in the rehabilitation process of patients with heart failure, since the level of acceptance of the disease has a direct impact on treatment adherence, motivation for physical exercise, and overall quality-of-life for these individuals.

Table 2. Table 2. Psychological adaptation to illness (AIS) in patients with heart failure

Indicator	Patient group	*n* (%)	*M*±*SD*	*Me*	Q_1–Q_3	min. – max.
AIS (Acceptance of Illness Scale)	Women	50 (50)	25.8±5.3	26.0	22–29	14–34
	Men	50 (50)	22.7±6.1	23.0	18–27	12–33
p	0.002					

Notes:
AIS – Acceptance of Illness Scale;
n (%) – number of participants and proportion of the total number in the group;
M±*SD* – mean and standard deviation;
Me – median;
Q_1–Q_3 – lower and upper quartiles;
min.–max. – minimum and maximum values;
p-values obtained using Mann–Whitney *U test*.

The results of the comparison of quality-of-life between the groups that underwent 2 months of physical rehabilitation and the control group are presented in *Table 3*.

Table 3 illustrates the dynamics of quality-of-life indicators in patients with heart failure in response to physical rehabilitation. After 2 months, the intervention group showed significant improvements in physical and emotional functioning, vitality, and general and mental health ($p<0.05$). In the intervention group, the largest improvements were observed for Emotional Functioning (42.1 to 61.4), General Health (38.7 to 51.3), and Mental Health (45.1 to 55.5). The comparison group showed less pronounced improvement, while the control group remained relatively stable. The results emphasize the effectiveness of comprehensive cardiac rehabilitation in improving the quality-of-life of patients with heart failure.

Discussion

The results confirmed the positive effect of regular physical exercise on the physical and psycho-emotional state of patients with heart failure [1; 9]. After completing the outpatient cardiac rehabilitation program, a significant improvement in physical performance, an increase in the general quality-of-life index (QoL), and the level of illness acceptance (AIS) was found. The results obtained show that women participating in the cardiac rehabilitation programme emotionally adapt to heart failure better than men. This may be related to higher levels of emotional openness, willingness to accept help, and more active participation in the treatment process. These data are consistent with the results of the study by Balazh M. and Kostenko V. (2021) [3], who reported that structured physical training reduces depression, and anxiety and increases exercise tolerance in patients after cardiac surgery.

Similar results are reported in the work of Vitomskyi V.V. et al. (2025) [5], who indicate that multicomponent cardiac rehabilitation, including physical exercise, psychological support and lifestyle modification, significantly reduces the risk of recurrent cardiovascular events and improves the quality-of-life of patients. Our study confirms these findings, demonstrating improvements in both physical and psycho-emotional indicators in a multidisciplinary group, in which patients received support from a team of specialists including a cardiologist, a physiotherapist, a dietitian and a psychologist [7; 10]. The results are also consistent with the studies of a group of researchers led by Fallon N. et al. (2021) [8]. Researchers have shown that outpatient cardiac rehabilitation programs supervised by medical professionals contribute to increased patient adherence to treatment and reduce the frequency of hospitalizations. In our study, treatment adherence was also higher among patients who participated in a multidisciplinary program than in the control group. It is

Table 3. Dynamics of life quality in patients with heart failure under the influence of physical rehabilitation (SF-36), n=100

Quality-of-life index (SF-36)	Intervention group (*n*=33)		Comparison group (*n*=33)		Control group (*n*=34)	
	At the beginning	After 2 months	At the beginning	After 2 months	At the beginning	After 2 months
Physical Functioning	43.9±7.9	50.9±7.2	42.0±8.5	49.5±5.6	45.2±8.1	44.3±7.8$^{\#\wedge}$
Role Functioning	36.8±15.3	46.6±8.3	40.0±12.6	48.8±5.6	36.9±12.8	41.7±12.1
Pain	63.9±8.9	69.6±8.1	64.9±8.5	73.6±5.9	61.7±8.7	64.7±8.6
General Health	38.7±11.0	51.3±6.8	39.5±11.6	52.3±4.7	41.7±7.9	41.4±8.9
Vitality	40.0±8.8	47.8±4.5	41.5±9.5	49.0±5.5	42.1±6.6	43.6±7.8$^{\#\wedge}$
Social Functioning	63.2±8.8	71.1±7.3	62.5±9.1	70.6±7.3	61.9±9.2	64.9±7.5
Emotional Functioning	42.1±15.1	61.4±12.5	41.7±14.8	61.7±12.2	42.9±15.4	41.8±15.1
Mental Health	45.1±8.2	55.5±5.3	47.2±6.8	54.9±3.0	44.8±8.1	46.4±6.2

Note: *p*-values for multiple group comparisons were obtained using the Kruskal–Wallis test with post-hoc Mann–Whitney *U* test and Bonferroni correction;

$^{\#}$ – $p<0.05$ vs. intervention group after 2 months;

$^{\wedge}$ – $p<0.05$ vs. comparison group after 2 months.

worth noting that the results regarding gender differences in quality-of-life indicators coincide with the findings of Siegmund L.A. et al. (2023) [13]. Nesterak R.V. & Vakalyuk I.R. [2] found that women more often report higher levels of subjective satisfaction from participation in rehabilitation programs, whereas men show a more pronounced improvement in physical parameters. A similar trend was observed in our study, although no statistically significant difference in QoL and AIS indicators was found between men and women.

The observed improvements in quality-of-life domains are consistent with the current recommendations of the European Society of Cardiology (ESC), which emphasize that multidisciplinary cardiac rehabilitation should include not only exercise training but also patient education, psychosocial support, and promotion of self-management. According to the latest ESC Guidelines for the management of chronic heart failure, exercise-based cardiac rehabilitation is recommended to improve functional capacity, quality-of-life, and reduce heart failure-related hospitalizations [16]. The present findings support these recommendations by demonstrating favorable changes in both physical and psychological outcomes following a two-month rehabilitation program.

Thus, the findings of the study confirm the effectiveness of physical exercise as part of a comprehensive cardiac rehabilitation program in improving the physical condition, psycho-emotional well-being, and quality-of-life of patients with heart failure. The data obtained complement scientific ideas about the role of physical activity as a key component of the rehabilitation process, which contributes not only to the restoration of the body's functional reserves but also to increasing the psychological resilience of patients.

Study limitations

The present study has several limitations that should be considered when interpreting the findings. First, functional classification of chronic heart failure according to the New York Heart Association (NYHA) and quantitative assessment of left ventricular ejection fraction were not available in the study database and were therefore not included in the analyses. Consequently, the relationship between disease severity and quality-of-life outcomes could not be evaluated. Second, the study was conducted at a single centre and included a relatively small sample of participants. Finally, the follow-up period was limited to two months, which precluded assessment of the long-term effects of the rehabilitation programme. Further multicentre studies with larger patient populations and longer follow-up are required to confirm the present findings.

Conclusions

The findings of the study confirmed that the inclusion of physical exercise in a comprehensive cardiac rehabilitation program has a significant positive impact on the quality-of-life of outpatients with heart failure. Analysis of the Acceptance of Illness Scale demonstrated that women generally have a higher level of psychological adaptation to heart failure than men (p=0.002).

The results obtained indicate that gender differences affect perceptions of the disease and the effectiveness of rehabilitation measures, thereby requiring individualisation of treatment approaches. The results show that even in patients with chronic heart failure, regular moderate-intensity training leads to a significant improvement in the physical and psycho-emotional state, thereby contributing to a reduction in the risk of recurrent cardiovascular events. It has been confirmed that the inclusion of physical exercise in the outpatient cardiac rehabilitation structure not only enhances patient's functional capabilities but also improves their overall quality-of-life. Future research directions include the development of personalized rehabilitation programs considering gender and age characteristics, the degree of compensation of heart failure, and the psycho-emotional state of patients.

Authors' Contributions

Contribution / Authors	A	B	C	D	E	F
Meleha K.P.	+	+			+	+
Sierkov O.Iu.			+	+		+
Nikolenko O.I.			+			+

Notes: A – concept; B – design; C – data collection;
D – statistical processing and interpretation of data; E – writing or critical editing of the article;
F – approval of the final version for publication and agreement to be responsible for all aspects of the work.

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Declarations

Conflict of interest is absent.

The authors of the manuscript state that in the process of conducting research, preparing, and editing this manuscript, they did not use any generative AI tools or services to perform any of the tasks listed in the Generative AI Delegation Taxonomy (GAIDeT, 2025). All stages of work (from the development of the research concept to the final editing) were carried out without the involvement of generative artificial intelligence, exclusively by the authors.

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