

# Influence of a water physical rehabilitation program on the hemodynamic parameters in breast cancer survivors

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Tetiana Odynets<sup>1</sup>, Yuriy Briskin<sup>1</sup>, Ievgeniia Zakharina<sup>2</sup>, Anzhelika Yefremova<sup>3</sup>

<sup>1</sup> Department of Theory of Sport and Physical Culture, Lviv State University of Physical Culture, Lviv, Ukraine

<sup>2</sup> Department of Theoretical Foundations of Physical and Adaptive Education, Classic Private University, Zaporizhzhya, Ukraine

<sup>3</sup> Department of Physical Education and Sport, Ukrainian State University of Railway Transport, Kharkiv, Ukraine

## Abstract

**Introduction.** Numerous women experience fatigue, arrhythmias, heart failure, ischemic heart disease, and pulmonary side effects induced by breast cancer treatment. The aim of the study was to analyse the changes in hemodynamic parameters in breast cancer survivors under the influence of a water physical rehabilitation program.

**Methods.** Overall, 34 women after breast cancer treatment completed a water physical rehabilitation program (group A) and 34 completed a Pilates program (group B). In both groups, the participants performed the same number of sessions 3 times a week for 3 months. The study was conducted during outpatient rehabilitation. Hemodynamic parameters were evaluated with impedance cardiography.

**Results.** Significant improvement was observed in both groups but it was more significant in group A. The actual value of cardiac output was higher in group A compared with group B by 0.64 l/min ( $p < 0.01$ ), left ventricular power by 0.49 W ( $p < 0.01$ ), and left ventricular work by 0.54 gm-m/beat ( $p < 0.01$ ).

**Conclusions.** The water program resulted in more significant improvements in cardiac output, stroke index, systemic vascular resistance, left ventricular work, and left ventricular power compared with the Pilates program during outpatient rehabilitation in women after breast cancer treatment.

**Key words:** cardiovascular system, breast cancer, physical therapy

## Introduction

Modern approaches used in breast cancer treatment have resulted in increasing survival rates. However, the incidence of significant adverse events such as cardiotoxicity or cardiovascular complications remains high [1–4]. Numerous women experience fatigue, arrhythmias, heart failure, ischemic heart disease, and pulmonary side effects induced by breast cancer treatment [5, 6].

Cardiovascular disease is the most common cause of mortality in patients who have survived a cancer [7]. Latest studies [8–11] have shown high prevalence of cardiovascular side effects, which results in a need for constant monitoring in breast cancer survivors.

Taking into consideration the high frequency of cardiovascular risk factors and deterioration of physical functioning, more specific attention is required in breast cancer survivors during the physical intervention.

An increasing number of studies [12–15] show that physical exercises have a potential beneficial impact on the modulation of cardiovascular risk factors, prevention of cardiac dysfunction, and improvement in physical condition of patients during and after breast cancer treatment. Some studies suggested that combined exercises (aerobic and resistance) led to significant increase in cardiorespiratory fitness, others showed the importance of using aerobic and stretching exercises to improve cardiopulmonary parameters. Only few studies reported the application of water exercises to eliminate or reduce the manifestations of lymphostasis [16–18],

upper extremity impairments [19], pain [20], or cancer-related fatigue [21]. However, they did not include criteria for the selection and application of adequate means, methodological recommendations for exercises that would individualize the process of physical therapy in breast cancer survivors.

Nevertheless, it is important to emphasize that the exercise modality, frequency, duration, and intensity must be specialized for women in compliance with their physical activity level.

With the consideration of these issues, the purpose of this study was to analyse the changes in hemodynamic parameters in breast cancer survivors under the influence of water physical rehabilitation program.

## Subjects and methods

Overall, 75 participants were tested for eligibility (the process of recruitment, screening eligibility, and drop-outs are shown in Figure 1), of which 4 women were excluded. A total of 68 patients who completed the study were analysed. The study groups were homogeneous by all parameters at baseline. Treatment information and demographic characteristics of the sample are presented in Table 1. The research was conducted among women aged 50–60 years with I–II cancer stage, not more than 6 months after surgery. The focus on women aged 50–60 years was used because the incidence of breast cancer is the highest in this age category. Women with III cancer stage, metastases, congestive heart failure, and

*Correspondence address:* Tetiana Odynets, Department of Theory of Sport and Physical Culture, Lviv State University of Physical Culture, 79000, 11, Kostyushko Str., Lviv, Ukraine, e-mail: [tatyana01121985@gmail.com](mailto:tatyana01121985@gmail.com)

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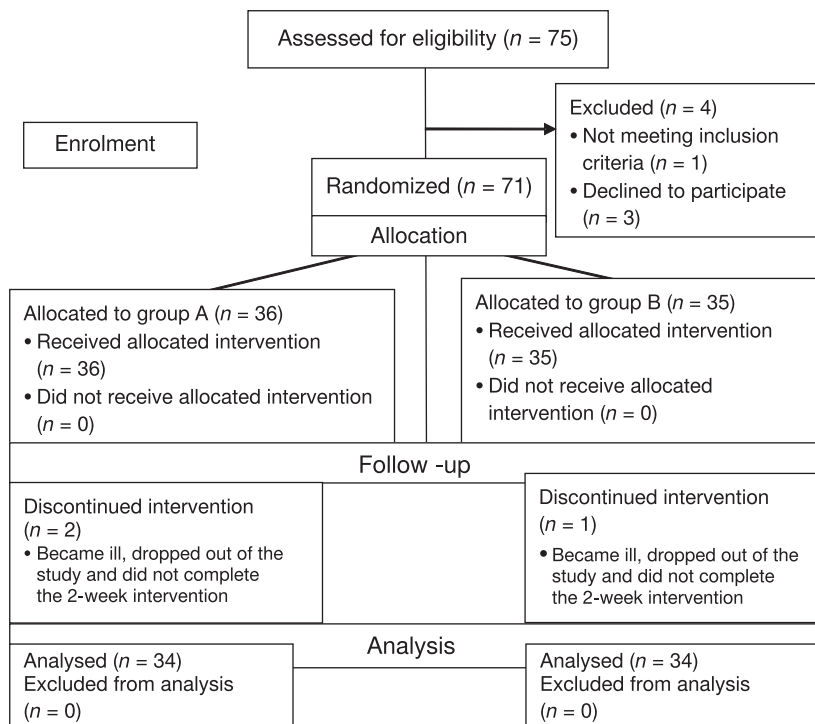


Figure 1. The CONSORT flow diagram

Table 1. Demographic and treatment-related characteristics of the participants

Characteristics	Water exercise group (n = 34)	Pilates group (n = 34)	p
Age, M ± m	57.44 ± 2.16	57.99 ± 2.24	> 0.05
Race			
White, n (%)	33 (97%)	32 (94%)	> 0.05
Black, n (%)	1 (3%)	2 (6%)	> 0.05
Married / committed relationship, n (%)	28 (82%)	27 (79%)	> 0.05
High school graduate, n (%)	13 (38%)	12 (35%)	> 0.05
College graduate, n (%)	19 (56%)	20 (59%)	> 0.05
Post-graduate, n (%)	2 (6%)	2 (6%)	> 0.05
Body mass index, kg/m <sup>2</sup> , M ± m	25.92 ± 0.42	26.01 ± 0.81	> 0.05
Treatment			
Surgery type: mastectomy by Madden, n (%)	34 (100%)	34 (100%)	> 0.05
Adjuvant therapy			
Radiotherapy, n (%)	30 (88%)	31 (91%)	> 0.05
Chemotherapy, n (%)	4 (12%)	3 (9%)	> 0.05
Time after surgery, months	5.23 ± 0.32	5.11 ± 0.42	> 0.05
Cancer stage			
I, n (%)	12 (35%)	13 (38%)	> 0.05
II, n (%)	22 (65%)	21 (62%)	> 0.05
Degree of lymphedema			
1, n (%)	5 (15%)	6 (17%)	> 0.05
2, n (%)	19 (56%)	19 (56%)	> 0.05
3, n (%)	10 (29%)	9 (27%)	> 0.05

M – mean, m – error of mean

metastatic breast cancer were excluded from the current investigation.

Women after breast cancer treatment participated in a 12-week water physical rehabilitation program (group A,  $n = 34$ ) and Pilates program (group B,  $n = 34$ ). They were randomized with the use of sequentially numbered, opaque, sealed envelopes. In both groups, the patients performed the same number of sessions 3 times a week for 3 months.

The proposed water rehabilitation program for 50–60-year-old women after breast cancer treatment included a differential selection of means for overcoming cardiovascular complications, with the consideration of the patients' motor function status. In order to regulate the motor function status of women during the implementation of the water program, 3 motion activity modes were applied – dose-sparing, training, and conditional regimens. There were defined individual tasks and means of their implementation, as well as methodological features in each regimen.

The individualization of session intensity and length depended on the participants' cardiovascular functional status. Women with a low level of cardiovascular functional status performed exercises with the intensity of 45–50% of heart rate reserve, lasting 50 min; those below the average level practised with 50–55% of heart rate reserve, for 55 min; in subjects with an average level, the intensity was 55–60% of heart rate, duration of 60 min. Exercises with low intensity and coordinating complexity were used in the dose-sparing motor activity, avoiding exercises with tension, rapid movement, or high amplitude. Special pool equipment was applied for performing strength exercises, like padded bar float, noodles, fitness bar bells. Exercises like sidestroke, deep breathing, and flotation were performed to improve water adaptation and to reduce water-repellency, as well as to ensure the participants' comfort in moving around the pool. With regard to tasks of the motor activity regimen, the program involved breathing exercises, gliding, active and passive exercises, different swimming styles, exercises for relaxation and stretching of the muscles.

The difficulty of the session content increased with the rising coordination complexity of exercises, number of means used, and the duration or intensity in the training regimen of motor activity. The content of the conditional regimen was gradually complicated with the rising coordination complexity of exercises, their intensity and duration, and additional equipment.

The Pilates program included active and passive stretching, exercises for good posture, and resistive exercises, with their intensity related to the cardiovascular functional status. Resistance and flexibility exercises targeted at all major muscle groups.

The assessments of hemodynamic parameters were undertaken twice: at baseline and after the 12-week outpatient rehabilitation. Impedance cardiography indicators were evaluated with the electrocardiographic complex KARDIOLAB (Scientific and Technological Centre of Radio-Electronic Medical Equipment and Technologies XAI-Medica of the National Aerospace University, Kharkiv, Ukraine, registration certificate number 6037/2007, conformity certificate number UA-MI/2p-2765-2009). The following indicators were assessed:

1. stroke volume (ml/beat): amount of blood pumped by the left ventricle at each heartbeat;
2. cardiac output (l/min): amount of blood pumped by the left ventricle per minute;
3. stroke index (ml/beat/m<sup>2</sup>): stroke volume normalized for body surface area;

4. systemic vascular resistance (dyne · s · cm<sup>5</sup>): the resistance to the flow of blood in the vasculature;

5. left ventricular work (gm-m/beat): the amount of work that the left ventricle must perform to pump blood each minute;

6. left ventricular power (W): left ventricular work performed per time unit [22].

All indicators of impedance cardiography were equivalent in the study groups at the beginning of the rehabilitation. Thus, the groups were homogeneous at the start of the study. The analyses of impedance cardiography indicators were performed by using the Statistica software. All variables were analysed for normality with the Shapiro-Wilk test. According to the Shapiro-Wilk test, the data tested were normally distributed. To analyse the differences between the studied groups, the independent samples *t*-test was applied. The dependent samples *t*-test served to describe intra-group pre- and post-intervention changes. Impedance cardiography parameters were presented as means and standard errors of mean.

### Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethics Committee of Khortytsia National Academy, Zaporizhzhya, Ukraine (No. 2017/12–11).

### Informed consent

Informed consent has been obtained from all individuals included in this study.

### Results

Repeated examination was conducted to assess the efficiency of the proposed rehabilitation programs for women after breast cancer surgery. The study revealed a significant impact of the applied water physical rehabilitation program and Pilates program on the patients' cardiovascular function. Statistically significant improvements were identified in both groups ( $p < 0.05$ ).

The dynamics of hemodynamic parameters in both group participants during the 12-week outpatient rehabilitation is shown in Table 2.

The results suggest that all indicators of the cardiovascular function improved significantly after the 12-week water program in group A. This particularly refers to the actual stroke volume, which improved by 7.05 ml/beat ( $p < 0.001$ ); to stroke index, which improved by 0.41 ml/beat/m<sup>2</sup> ( $p < 0.001$ ); to cardiac output, which improved by 0.69 l/min ( $p < 0.001$ ); to left ventricular work, which improved by 0.68 gm-m/beat ( $p < 0.001$ ); and to left ventricular power, which improved by 0.38 W ( $p < 0.001$ ). Also, a significant decrease in systemic vascular resistance by 343.33 dyne · s · cm<sup>5</sup> ( $p < 0.001$ ) should be noted.

Regarding the hemodynamic parameters of group B, there were no statistically significant changes during the 12-week rehabilitation period.

Comparing the results of cardiovascular function after the 12-week appropriate outpatient programs, it was found that in women of group A compared with those of group B, the actual value of cardiac output was higher by 0.64 l/min ( $p < 0.01$ ), that of left ventricular power by 0.49 W ( $p < 0.01$ ), and that of left ventricular work by 0.54 gm-m/beat ( $p < 0.01$ ). The actual value of systemic vascular resistance was statistically lower by 265.77 dyne · s · cm<sup>5</sup> ( $p < 0.05$ ) in group A than in group B.

Table 2. Dynamics of hemodynamic parameters in groups A and B during the 12-week outpatient rehabilitation

Indicator	Group A (n = 34)		p	Group B (n = 34)		p	
	Beginning	12 weeks		Beginning	12 weeks		
Stroke volume (ml/beat)	actual	47.18 ± 2.25	54.23 ± 1.78	< 0.001	47.53 ± 2.00	50.26 ± 2.11	> 0.05
	% of predicted	75.83 ± 2.84	88.47 ± 3.03	< 0.001	76.43 ± 3.27	81.00 ± 3.73	> 0.05
Cardiac output (l/min)		3.53 ± 0.14	4.22 ± 0.17**	< 0.001	3.44 ± 0.13	3.58 ± 0.13	> 0.05
Stroke index (ml/beat/m <sup>2</sup> )		1.99 ± 0.07	2.40 ± 0.10*	< 0.001	2.03 ± 0.09	2.11 ± 0.09	> 0.05
Systemic vascular resistance (dyne · s · cm <sup>5</sup> )	actual	2080.03 ± 84.26	1736.70 ± 76.27*	< 0.001	2097.60 ± 82.36	2002.47 ± 87.98	> 0.05
	% of predicted	129.87 ± 5.08	108.23 ± 4.62*	< 0.001	128.77 ± 5.48	122.57 ± 5.39	> 0.05
Left ventricular power (W)	actual	2.27 ± 0.09	2.65 ± 0.09***	< 0.001	2.16 ± 0.08	2.16 ± 0.07	> 0.05
	% of predicted	85.60 ± 2.77	100.80 ± 3.60***	< 0.001	82.13 ± 3.12	82.67 ± 3.13	> 0.05
Left ventricular work (gm-m/beat)	actual	4.27 ± 0.13	4.95 ± 0.15**	< 0.001	4.38 ± 0.12	4.41 ± 0.12	> 0.05
	% of predicted	76.42 ± 2.11	88.73 ± 2.71**	< 0.001	77.44 ± 2.12	77.94 ± 2.12	> 0.05

\* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001 for comparison of the 12-week intervention results between groups A and B

## Discussion

The performed research has presented a significant impact of outpatient rehabilitation on improving the functional status of the cardiovascular system in breast cancer survivors. The positive results might be associated not only with the rational scheme of the rehabilitation process, but also with the physiological influence of the aquatic environment.

The hydrostatic pressure of the water medium contributes to the emergence of compensatory reactions from the cardiovascular system in the form of pulse deceleration and decreased blood circulation, which might lead to the economization of functions [17, 19]. Most studies confirm the positive influence of aerobic and water exercises on physical fitness, body composition, and blood pressure of older adults [23–25].

The water physical rehabilitation program resulted in significant improvements in the stroke volume, cardiac output, stroke index, systemic vascular resistance, left ventricular work, and left ventricular power in women during outpatient rehabilitation.

A detailed analysis of literary sources [4, 9, 10, 13, 23, 24], including randomized clinical trials, pilot-analysis, and meta-analysis, showed that women after breast cancer treatment experienced radiotherapy- and chemotherapy-induced cardiovascular system adverse events, fatigue, and cardiotoxicity. Some papers considered aerobic physical activity [26] and water physical therapy [20, 27, 28] for pain and lymphedema reduction in post-mastectomy women, but they did not examine the effect of water exercises on the improvement of hemodynamic parameters in breast cancer survivors.

The proposed water program applied load differentiation in the exercise intensity and duration depending on the patients' cardiovascular system functional status. Three motion activity modes were applied for the gradual expansion of the functional capabilities of the women's cardiovascular system. Significant improvement was observed in both groups but it was more significant in group A. The more positive effect of the water program compared with the Pilates program may be due to the properties of the aquatic environ-

ment that helped improve the parameters of central hemodynamics, in particular the hydrostatic pressure and lack of static tension, in combination with deep rhythmic breathing and dynamic muscle contraction. All of the above created favourable conditions for facilitated blood circulation and increased functionality of the cardiovascular system.

## Limitations

Despite these strengths, the current research also has some important weaknesses. Firstly, our investigation involved a limited number of patients. Secondly, the received results cannot be applied to all breast cancer survivors because of the specific experiment conditions and cultural background.

## Conclusions

Significant improvement was observed in both groups but it was more significant in group A. The water physical rehabilitation program resulted in more significant improvements in cardiac output, stroke index, systemic vascular resistance, left ventricular work, and left ventricular power compared with the Pilates program during outpatient rehabilitation in women after breast cancer therapy.

## Disclosure statement

No author has any financial interest or received any financial benefit from this research.

## Conflict of interest

The authors state no conflict of interest.

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