

The effectiveness of two individualized physical interventions on the upper limb condition after radical mastectomy

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Abstract

Introduction. The aim of the study was to compare the effectiveness of two individualized physical interventions on the upper limb condition after radical mastectomy.

Methods. Overall, 68 patients after breast cancer surgery participated in 12-week outpatient rehabilitation. They were randomly enrolled for water individualized physical intervention (water exercise group, $n = 34$) and Pilates physical intervention (Pilates group, $n = 34$). Upper limb force (dynamometry), size of upper limb lymphedema (circumference), and active range of motion (goniometry) on the affected side were determined before and after 36 individualized physical rehabilitation sessions.

Results. After 12-week physical rehabilitation, the average values of active range of flexion and abduction were statistically significantly higher in the water exercise group compared with the Pilates group by 8.73 degrees ($p < 0.01$) and 6.87 degrees ($p < 0.01$), respectively. The size of lymphedema in the area of forearm and hand was significantly lower in the water exercise group compared with the Pilates group by 0.46 cm ($p < 0.05$) and 0.44 cm ($p < 0.05$), respectively. There were no statistically significant differences in upper limb force between the studied groups at the end of the 12-week intervention.

Conclusions. The results have confirmed that elaborated individualized physical interventions might be considered as effective methods for range of motion improvement and decrease in breast cancer-related lymphedema in patients with post-mastectomy syndrome. The 3-month water exercises were more effective in improving mobility and muscle force of the upper limb and decreasing lymphedema than Pilates exercises.

Key words: lymphedema, physical exercises, range of motion, breast cancer

Introduction

Breast cancer is a common pathology, primarily affecting women throughout the world [1, 2]. Breast cancer-related lymphedema, decrease in upper limb strength, and impairment in the range of motion in the shoulder joint are still the major long-term complications of surgical treatment and radiotherapy [3, 4]. Numerous studies of patients with breast cancer indicate that intensity of lymphedema, impairment of the shoulder range of motion, and severity of clinical damage of the cervico-brachial plexus increase over time after surgery [5, 6].

Rehabilitation measures are considered as the basis for the treatment of lymphedema, and physical exercises are an integral part of such rehabilitation [7–9]. In the absence of proper treatment, lymphedema provokes the emergence of secondary complications, such as adipositis, lymphangitis, axillary vein thrombosis, and even lymphosarcoma [5–7].

Recent studies have shown the acute necessity to create and implement specialized measures to improve the function of the upper extremity because limitation of shoulder joint mobility and lymphedema significantly affect the patients' quality of life and create barriers to returning to active labour [10, 11].

The majority of women are treated with complex physiotherapy methods that prove effective. Many reports showed

the effectiveness of acupuncture [12], lymphatic drainage [13], Pilates-based exercises [14–16], yoga exercises [17, 18], Nordic walking [19], aquatic exercises [20–23], and pneumatic compression therapy [24–26] for the treatment and prevention of postoperative breast cancer-related lymphedema, and quality of life improvement in women.

Considering the high frequency of lymphedema and contracture after breast cancer treatment, it is necessary to provide management for women with post-mastectomy syndrome when implementing a rehabilitation program.

The presence of breast cancer surgery complications demonstrates the need of elaboration and implementation of individualized physical interventions alongside with the necessity to determine their impact on the improvement of upper extremity disorders in breast cancer survivors.

The aim of this study was to compare the effectiveness of two individualized physical interventions for the upper limb condition after radical mastectomy.

Subjects and methods

Patients

The total of 68 patients after breast cancer surgery took part in and completed a 12-week outpatient individualized exercise program. They were randomized into the water

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Table 1. Baseline demographic and treatment-related characteristics of the study 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 ² (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
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

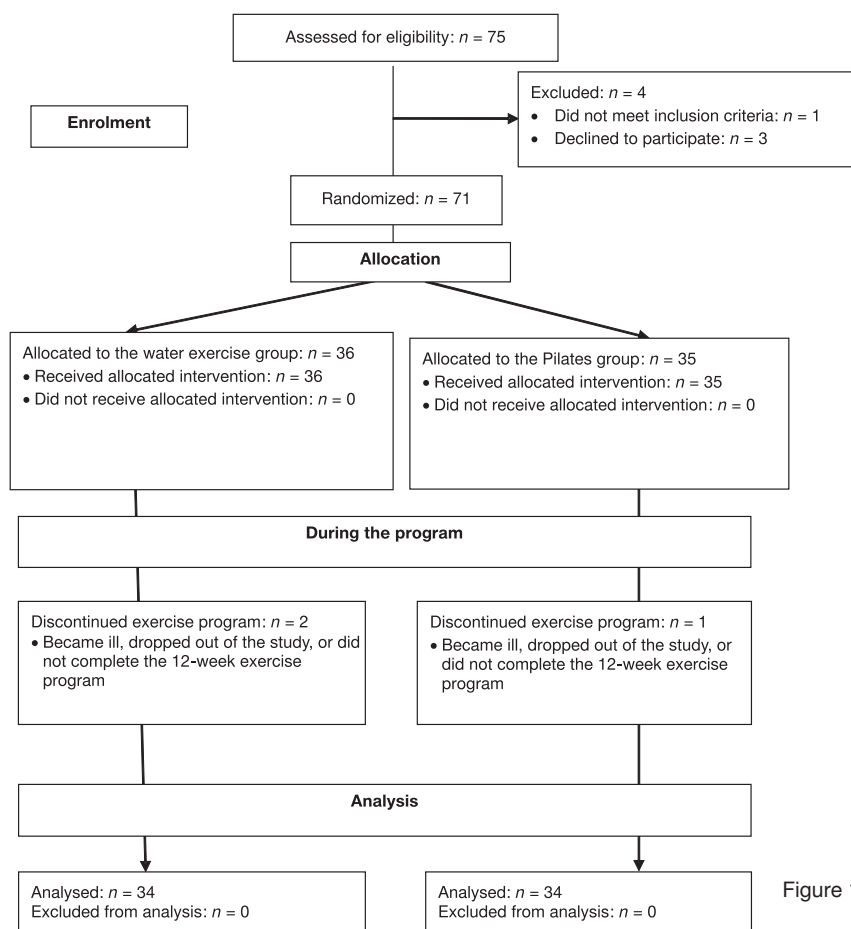


Figure 1. Detailed process of patient recruitment (CONSORT flow diagram)

exercise group (n = 34) and the Pilates group (n = 34). Both groups received 36 individualized rehabilitation sessions 3 times a week for 1 hour during 3 months.

The inclusion criteria were the following: age between 50 and 60 years, I–II cancer stage, radical mastectomy by Madden, presence of lymphedema, impairment of the active range of motion in the joints of the shoulder complex, decrease in the upper limb strength, time after surgery not more than 6 months. Excluded were patients with III cancer stage, metastatic breast cancer, bilateral lymphedema, primary lymphedema, infection of the affected limb, congestive heart failure.

We screened 75 potential women for eligibility (the CONSORT flow chart is presented in Figure 1); 4 participants (5%) were excluded (1 did not meet the inclusion criteria and 3 declined to participate). The program was eventually completed by 34 patients in the water exercise group and 34 in the Pilates group. There were no statistically significant differences between the patients' pre-intervention treatment-related or demographic characteristics (Table 1). Overall, 28 women (82%) in the water exercise group and 27 (79%) in the Pilates group were married; 38% and 35%, respectively, were high school graduates. The average value of body mass index was $25.92 \pm 0.42 \text{ kg/m}^2$ in the water exercise group and $26.01 \pm 0.81 \text{ kg/m}^2$ in the Pilates group.

Training methods

Physical training in the water exercise group and the Pilates group was conducted during 12 weeks, 3 times a week.

The exercises were individualized depending on the degree of lymphedema and upper limb condition. The differentiation of water and land exercises for women with various degrees of lymphedema referred to the duration of exercises, choice of the most optimal starting position, and the application of special equipment (water dumbbells, noodles, fitball, bar bells, rubber tube). Patients with 1st or 2nd degree of lymphedema performed special exercises from different initial positions: standing, lying on the back, lying on a side, sitting on a fitball. Women with 3rd degree of lymphedema performed the majority of exercises from initial lying positions, without special equipment. To successfully overcome lymphedema, it is essential to perform exercises with the upper limb positioned above the level of heart to provide lymph outflow. In addition, such special exercises were performed not only as an independent part, but also after each series of strength exercises to relieve stress by lifting the upper limb as high as possible with the implementation of light shaky movements. In both exercise programs (Pilates and water), we included cardiovascular exercises to improve aerobic fitness. During the selection of appropriate means of physical rehabilitation to increase the women's body functionality, we followed the principle of physical activity adequacy in accordance with the patient's functional state. The exercise intensity was individualized depending on the cardiovascular system functional level. Women with a low functional level of the cardiovascular system performed exercises with the intensity of 45–50% of heart rate reserve; those with a moderate level involved 50–60% of heart rate reserve. In order to reduce the activity of the sympathetic division of the autonomic nervous system (for women with sympathicotonia), respiratory exercises were used to increase the duration of exhalation and exhalation delay.

The scheme of water individualized physical intervention included a variety of breathing exercises (static, diaphragmatic, dynamic) and physical exercises (active, active-pas-

sive, special, combined developing, sports-applied), which helped to solve current tasks. It was proposed to apply resistance exercises and exercises with a rubber expander to increase muscle strength. Noodles, blades, and water dumbbells were also used to increase the load.

The Pilates exercises consisted of roll-downs, hundreds, one-leg stretch, Chester stretch, dumb waiter, swan dive, resistive and stretch exercises for the upper extremity. In addition, the program included resistance exercises with an elastic band to increase upper limb strength, as well as a set of breathing exercises to activate the lymph system. We also proposed hand-arm-shoulder shaky movements between specific Pilates exercises to decrease the lymphedema volume.

Measurement methods

All measurements were performed twice: at the beginning and after the 12-week exercise programs.

Active range of motion (degrees) was determined with a goniometer. The following active movements were tested in the joints of the shoulder complex: flexion, extension, abduction, internal and external rotation.

The circumference (cm) of both upper extremities was measured symmetrically, at the same levels of the upper third of the shoulder, forearm, and under the thumb of the hand. After that, for detecting lymphedema, the difference was calculated in circumferences between the upper extremity on the side of surgery and that where the operation was not performed.

Muscle strength of the upper limb was assessed with the DRP-10 hand-held dynamometer. The strength of the flexor was measured in the standing position with straight upper limb. The power index was calculated by the formula:

$$(\text{absolute values of dynamometry [kg]} / \text{body weight [kg]}) \times 100\%$$

The dynamometry results for both the healthy and the affected upper limb were used to estimate muscle strength.

Statistical analysis

Analysis of lymphedema, muscle strength, and range of motion were performed with the use of the Statistica for Windows software (version 8.00). All variables were analysed for normality with the Shapiro-Wilk test. The average and standard error of mean were determined to describe the results. The analysis of the intra-group pre- and post-intervention results was performed with the dependent samples *t*-test. The inter-group post-intervention results were analysed with the *t*-test for independent samples.

Ethical approval

The research related to human use has been 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 (number 2017/12–11).

Informed consent

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

Results

The study demonstrated a beneficial effect of the proposed individualized physical interventions on the improvement of the functional state of upper extremity in women after breast cancer surgery. Changes of shoulder motion range in patients of both groups during the 12-week interventions are presented in Table 2.

The results obtained in the water exercise group suggest that active movements in the shoulder joint in all directions were statistically significantly improved during the 12-week intervention, particularly the range of flexion, which increased by 19.2 degrees ($p < 0.001$). Extension increased by 6.13 degrees ($p < 0.001$), abduction by 15.33 degrees ($p < 0.001$), internal rotation by 4.93 degrees ($p < 0.001$), external rotation by 3.47 degrees ($p < 0.01$).

Pilates physical intervention also had a positive influence on the range of flexion, which increased by 11.73 degrees ($p < 0.001$). The range of extension increased by 6.93 degrees ($p < 0.001$), the range of abduction by 9.93 degrees

($p < 0.001$), the range of internal rotation by 4.00 degrees ($p < 0.01$), the range of external rotation by 3.06 degrees ($p < 0.01$).

A comparison of the results for the joints of the shoulder complex between the patients of both groups after the exercise program revealed that the active range of flexion and abduction were statistically significantly higher in the water exercise group than in the Pilates group by 8.73 degrees ($p < 0.01$) and 6.87 degrees ($p < 0.01$), respectively.

It was found that implementing the individualized physical intervention in the water exercise group during the 12-week rehabilitation (Table 3) helped to reduce lymphedema by 1.03 cm ($p < 0.001$) in the area of the upper third of the shoulder, by 0.66 cm ($p < 0.001$) in the area of the forearm, and by 0.87 cm ($p < 0.001$) in the area of hand.

Among the women in the Pilates group, statistically significant changes were recorded at the end of the 12-week intervention only in reducing lymphedema in the area of the upper third of the shoulder: by 0.66 cm ($p < 0.01$).

Statistically significant differences were found between the groups at the end of the experiment. The border of sig-

Table 2. Comparison of active joints of the shoulder complex motion ($M \pm m$) on the affected side in patients of the study groups before and after the exercise program

Indicator	Water exercise group (n = 34)			Pilates group (n = 34)		
	Beginning	After 12 weeks	p	Beginning	After 12 weeks	p
Flexion	146.53 ± 2.50	165.73 ± 1.80*	< 0.001	145.27 ± 2.20	157.00 ± 1.94	< 0.001
Extension	48.87 ± 1.24	55.00 ± 0.72	< 0.001	47.40 ± 1.09	54.33 ± 0.98	< 0.001
Abduction	145.67 ± 1.67	161.00 ± 1.36*	< 0.001	144.20 ± 1.88	154.13 ± 1.77	< 0.001
Internal rotation	55.80 ± 1.38	60.73 ± 1.18	< 0.001	54.80 ± 1.47	58.80 ± 0.96	< 0.01
External rotation	72.93 ± 1.82	76.40 ± 1.38	< 0.01	72.67 ± 1.60	75.73 ± 1.38	< 0.01

* $p < 0.01$ compared with the results of the 12-week intervention between the water exercise group and the Pilates group
 M – mean, m – error of mean

Table 3. Comparison of the circumference of the upper limb ($M \pm m$) on the affected side in patients of the study groups before and after the exercise program

Indicator	Water exercise group (n = 34)			Pilates group (n = 34)		
	Beginning	After 12 weeks	p	Beginning	After 12 weeks	p
Upper third of the shoulder (cm)	2.70 ± 0.23	1.67 ± 0.22	< 0.001	2.53 ± 0.23	1.87 ± 0.19	< 0.01
Forearm (cm)	2.03 ± 0.21	1.37 ± 0.16*	< 0.001	2.03 ± 0.17	1.83 ± 0.16	> 0.05
Hand (cm)	1.70 ± 0.17	0.83 ± 0.12*	< 0.001	1.47 ± 0.14	1.27 ± 0.16	> 0.05

* $p < 0.05$ compared with the results of the 12-week intervention between the water exercise group and the Pilates group
 M – mean, m – error of mean

Table 4. Comparison of dynamometry indicators of the upper limb ($M \pm m$) in patients of the study groups before and after the exercise program

Indicator	Water exercise group (n = 34)			Pilates group (n = 34)		
	Beginning	After 12 weeks	p	Beginning	After 12 weeks	p
Strength on the affected side (kg)	19.80 ± 0.82	24.07 ± 0.73	< 0.001	19.93 ± 1.07	25.00 ± 0.96	< 0.001
Strength on the healthy side (kg)	24.07 ± 0.99	26.07 ± 0.83	< 0.001	23.53 ± 1.31	26.80 ± 1.00	< 0.001
Power index on the affected side (%)	24.31 ± 1.20	30.86 ± 1.47	< 0.001	26.47 ± 1.50	33.48 ± 1.67	< 0.001
Power index on the healthy side (%)	30.16 ± 1.59	33.33 ± 1.56	< 0.001	31.49 ± 1.95	35.91 ± 1.75	< 0.001

M – mean, m – error of mean

nificant changes between the water exercise group and the Pilates group after the program was observed for the areas of forearm and hand ($p < 0.05$).

The results for dynamometry (Table 4) showed that the muscle strength in the affected upper limb significantly improved in the water exercise group and the Pilates group during the 12-week rehabilitation: by 4.27 kg ($p < 0.001$) and 5.07 kg ($p < 0.001$), respectively.

The power index in the affected upper limb improved by 6.55% ($p < 0.001$) in the water exercise group and by 7.01% ($p < 0.001$) in the Pilates group. There were no statistically significant differences in dynamometry indicators between the studied groups at the end of the 12-week intervention.

Discussion

It was identified that the proposed individualized physical interventions contributed to a significant improvement of the functional state of the upper extremity in women after breast cancer surgery.

Abundant research [3, 5–7] indicates that women who undergo breast surgery, axillary radiotherapy, or chemotherapy are more likely to have higher risk of breast cancer-related lymphedema and impaired shoulder range of motion. The importance of the problem is underlined by the presence of numerous surgical methods [3, 4] and conservative therapies [11–14, 20–26] for overcoming upper extremity disorders in breast cancer survivors.

Despite the achieved progress in the treatment of breast cancer-related lymphedema, the problem related to physical rehabilitation of the patients remains relevant. Some studies [24–26] have shown that pneumatic compression therapy and manual lymphatic drainage significantly reduce breast cancer-related lymphedema of the affected limb. In these studies, a rational combination of two treatments (decongestive therapy with compression pumping or manual lymphatic drainage with compression bandage) proved effective in reducing lymphedema and improving the range of motion. According to Saputa et al. [11], manual lymphatic drainage was the most effective method of post-mastectomy lymphedema treatment after 2-week physiotherapy.

Other studies have confirmed the effectiveness of aqua lymphatic therapy in women who suffer from breast cancer treatment-related lymphedema [20–23]. Women participated in 10-week water training once a week for increasing aerobic capacity, strength, and mobility without exercise individualization [21]. The aqua lymphatic program proposed by Tidhar and Katz-Leurer [23] included skin care, manual element, compression, and exercise component and was implemented in a hydrotherapy pool with the temperature of 32–33°C. The clinical Pilates exercise program applied for 8 weeks had a positive impact on the lymphedema volume, grip strength, and quality of life of breast cancer patients [14]. Differences in conditions, study duration, lymphedema development time, time after surgery, and outcome variables make it difficult to directly compare the previous studies and the current one.

The obtained results confirm the researchers' opinion that applying active water exercises in outpatient rehabilitation is an effective method for decreasing breast cancer treatment-related lymphedema.

Our study applied differentiated exercises for the upper limb, with the consideration of the severity of lymphedema and the limitation of the shoulder joint mobility. The duration and intensity of the applied water and land exercises depended on the functionality of the women's upper limbs after breast cancer surgery. On the basis of the obtained results, it may

be concluded that active shoulder range of flexion, extension, abduction, internal rotation, and external rotation improved significantly in both groups. The degree of lymphedema reduction was much more significant in patients of the water exercise group compared with the Pilates group.

Limitations

Our findings have some limitations because the research was conducted on a small sample and the obtained results may not be generalizable to the whole population of women suffering from breast cancer.

Conclusions

In conclusion, we confirmed that in women after breast cancer surgery, 3-month water exercises were more effective in improving mobility and muscle force of the upper limb and decreasing lymphedema than Pilates exercises. Individualized physical interventions might be considered as effective methods for improving the range of motion and decreasing breast cancer-related lymphedema in patients with post-mastectomy syndrome.

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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