THE CONTRIBUTION OF HYDROTHERAPY AND SWIMMING TO POST-MASTECTOMY FUNCTIONAL REHABILITATION

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Abstract. *Breast neoplasm represents an abnormal multiplication of epithelial cells in the breast ducts and mammary lobules; it manifests itself clinically by the appearance of a tumour which, if not treated in time, develops both locally and at tissue distance. Following treatment, patients with breast neoplasm complain of symptoms also present in other conditions such as rheumatoid arthritis and fibromyalgia, which can be treated with hydrotherapy. Exercises performed in water have a varied spectrum of applicability, for example, improving joint mobility, increasing muscle strength and reducing chronic pain. The exercises used have the role to improve muscle strength of the whole body, joint mobility and muscle elasticity, but also to facilitate muscle contraction. In this therapy concept, hydrostatic water pressure and buoyancy help apply exercises to a wide range of conditions such as orthopaedic, oncological, neurological and rheumatologic. The aim of this study is to verify the effectiveness of an aquatic exercise programme for improving upper limb function on the side of the surgery. The research included 5 participants aged between 33 and 39 years, with radical right mastectomy. The functional assessment consisted of three tests. After the final evaluation, the average value of each test decreased, which highlighted an improvement in the functional level of the upper limb. Hydrotherapy has a positive physiological and psychosocial effect because it stimulates socialisation and, in particular, the acceptance of the condition that these people face.*

Keywords: *hydrotherapy, swimming, functional rehabilitation, breast cancer, side effects.*

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Introduction

Breast neoplasm represents an abnormal multiplication of epithelial cells in the breast ducts and mammary lobules and is clinically manifested by the appearance of a tumour. The factors that lead to the appearance and development of neoplastic cells are: external, endocrine and genetic. According to the most recent reports of the World Health Organization (2022), breast neoplasm is the most common type of cancer that manifests itself among the female population and affects about 2.09 million people worldwide.

The major risk factors that contribute to the development of breast neoplasm are: smoking, a sedentary lifestyle, a diet lacking vitamins, minerals and essential macronutrients, and

chronic infections with viruses such as: helicobacter virus, human papillomavirus, hepatitis B virus, hepatitis C virus and Epstein-Barr virus (US National Cancer Institute, n.d.).

Hydrotherapy has existed since ancient times, when the Greeks believed that water had healing powers, and the Romans built public baths that had a dual purpose, both recreational and therapeutic, being the forerunners of today's spa resorts. In the 19th century, Vincenz Priebnitz believed that the use of cold water as a method of shock improved the function of the immune system. On the other hand, Sebastian Kneipp used hot baths and sauna for relaxation. Since the 20th century, water exercises, as well as the alternation of hot and cold baths, have been increasingly used to reduce joint pain and swelling (Chowdhury et al., 2021).

Aquatic therapy uses water exercises mostly performed in groups under the guidance of a therapist, in a therapeutic pool. The exercises used have the role to improve muscle strength of the whole body, joint mobility and muscle elasticity, but also to facilitate muscle contraction. In this therapy concept, hydrostatic water pressure and buoyancy help apply exercises to a wide range of conditions: orthopaedic, oncological, neurological and rheumatologic (Becker, 2009).

Ever since ancient times, swimming has represented a need for mankind. In order to take refuge from fires, avoid enemies, in search of food or simply protect themselves from the burning sun, people have always called on the boundless potential of water to respond to individual and collective needs. People have always shown an interest in water, many of them considering it an unknown force. The different available texts changed from a gymnastic, military and utilitarian form of swimming, up until the First World War, to a more swimming sport form thereafter (Pelayo & Alberty, 2011).

Swimming tones the muscles and improves the functions of the nervous system, decreases the feeling of heaviness of the body, regulates breathing movements and heartbeats, relaxes and combats muscle contractions (Tanaka, 2009), which means no pain and easiness in the execution of movements, accelerates energy metabolism and activates venous circulation in the limbs. Thus, Barbagelata et al. (2021) noted a decrease in shoulder pain after performing an aquatic exercise programme.

Any swimming activity becomes a recreational factor when it is carried out in water that does not exceed chest level. Above this level, water can become a stressor, firstly through the loss of solid support and secondly through the maladaptation of breathing.

Lymphoedema is one of the most common side effects of the treatment applied to the breast neoplasm, on which we can act through hydrotherapy and swimming. But despite its high prevalence, recent research has questioned the effectiveness of aquatic therapy in clinical practice, and there is a recommendation for the inclusion of aquatic therapy in complete decongestive therapy (Yeung & Semciw, 2018). After the application of surgical, oncological and hormonal treatment, dysfunctions appear that affect the quality of everyday life and contribute to the onset of anxiety, depression and insomnia.

Reger et al. (2022) claim that, following treatment, patients with breast neoplasm complain of symptoms also present in other conditions such as rheumatoid arthritis and fibromyalgia, which can be treated with hydrotherapy. Exercises performed in water have a varied spectrum of applicability, for example, improving joint mobility, increasing muscle strength and reducing chronic pain.

Lymphoedema is characterised by an accumulation of protein-rich liquid in the interstitial space resulting from the removal of axillary lymph nodes, which leads to the creation of a breach in the lymphatic circulation (Letellier et al., 2014). We can act on lymphoedema through all specific and non-specific physical therapy means, including hydrotherapy. Thus, based on the international literature, we carried out a thorough documentation to highlight the effects of hydrotherapy on post-mastectomy sequelae and different body systems. Using water in different forms and at different temperatures can produce various effects on different body systems. Many studies (Pinto et al., 2019) have reported that the effects of hydrotherapy target very few systems, and there are a limited number of studies in the literature reporting evidence-based effects of hydrotherapy on the human body.

Breast cancer treatment is surgical and consists of mastectomy or sectorectomy combined with chemotherapy and radiotherapy. Post-operatively, the treatment is developed by a multidisciplinary team consisting of: oncologist, physiotherapist, psychologist, nutritionist, radiotherapist, immunologist, infectious disease specialist, cosmetic surgeon, radiologist and pathologist.

After surgery, the administration of chemotherapy and local radiotherapy is intended to minimise the risk of cancer recurrence. Although adjuvant treatment reduces mortality, these therapies cause side effects that are systematised by Shapiro and Recht (2001) as follows:

- conditions secondary to the application of local radiotherapy: cardiotoxicity, pneumonia, rib fractures, pain, lymphoedema, decreased mobility of the shoulder joint;
- systemic conditions resulting from the administration of chemotherapy: myelosuppression, peripheral neuropathy, premature menopause, infertility, weight gain, cardiovascular disease, nausea and vomiting, anxiety, depression, insomnia, fatigue, fear of relapse.

During the administration of adjuvant treatment, the side effects that occur negatively affect quality of life, which is an important factor in the prognosis of breast cancer patients (Browall et al., 2018). It is well known that physical activity has a positive impact on both the physique and the body's response to treatment. Irwin et al. (2011) have pointed out that the performance of physical activities (such as Nordic walking or swimming) contributes to a decrease in post-treatment mortality.

Mastectomy surgery and axillary lymph node dissection generate pain and keloid scars that lead to decreased range of motion in the upper limb joints. Post-surgical pain is transient and appears as a consequence of muscle and ligament injuries produced during surgery (Jung et al., 2003), and the administration of chemotherapy and radiotherapy can amplify its intensity.

Decreased mobility and therefore functionality of the upper limb joints is the most troublesome complication of breast cancer treatment, affecting patients' quality of life (Kaya et al., 2010). One of the most frequent sequelae of breast cancer treatment is lymphoedema, on which we can act by kinetic means. According to the US National Cancer Institute (n.d.), there is no criterion for diagnosing lymphoedema, but a difference of 2 cm from previous measurements or compared to the contralateral limb suggests oedema.

A study by Hayes et al. (2008) analyses the incidence of lymphoedema secondary to mastectomy. A total of 287 patients diagnosed with invasive breast neoplasm were evaluated

for 18 months using bioelectrical body impedance associated with a questionnaire on how lymphoedema influenced their quality of life. According to this study, 33% of patients developed lymphoedema 6 months post-operatively. Also, the authors consider that lymphoedema is a public health problem that needs special attention and systematic surveillance for early diagnosis.

Functional recovery in operated breast neoplasm requires different specific and non-specific kinetic means used partially or fully, depending on the somatic and functional characteristics of each patient and the time when they are applied.

Cordun (1999) classifies these means into:

- specific kinetic means: exercise; hydrotherapy; massage; posture;
- non-specific kinetic means: multilayer compression bandaging; compression sleeve.

Hydrotherapy consists in performing exercises or movements with the body in immersion, being "an approach which uses water and its characteristics to maintain health, prevent and cure diseases" (Almassmoum et al., 2018), which is why it plays an important role in post-mastectomy medical recovery. Hydrotherapy for patients with breast neoplasm involves the application of physiotherapy concepts using the principles of hydrostatics and hydrodynamics, thus multiplying the induced beneficial effects (Siqueira et al., 2020). Immersion can be partial or total and can be done in bathtubs, basins and swimming pools.

According to the study by Srámek et al. (2000), one hour of immersion in water at different temperatures (32°C, 20°C and 14°C) produces different effects. While the metabolic rate was unchanged by immersion at 32°C, it decreased heart rate by 15%, systolic blood pressure by 11% and diastolic blood pressure by 12% compared with controls at ambient air temperature. Along with heart rate and blood pressure, the plasma renin activity, plasma cortisol and aldosterone concentrations were also lowered by 46%, 34% and 17%, respectively, while diuresis was increased by 107%.

The effects of hydrotherapy on the body

Since the earliest recorded history, water has been thought to promote healing and be beneficial in a wide range of medical conditions. Both natural springs and therapies involving water have become the central topic of many health promotion establishments, so healers around the world have noticed over time the effects of water on various medical problems. Through observation, centuries of trial and error and constantly updated scientific methodology, healing methods based on aquatic treatments have developed due to the multiple biological effects of water. Over the last few decades, the external therapeutic application of water, usually by partial or total immersion of the body in order to obtain these biological effects, has been called medical hydrology (Antonelli et al., 2021).

Since energy must still be dissipated, the body uses another mechanism that allows energy to be lost through latent heat of sweat evaporation and respiratory failure, further cooling the skin. This mechanism is remarkably efficient because the loss through evaporation of 2.5 ml of water cools the body by 0.94°C. The second circumstance has been the recognition that water immersion is an ideal environment to imitate imponderability (Haffor et al., 1991).

Body immersion has positive biological effects, extending to all homeostatic systems. These effects are both immediate and in the long term and allow water to be used therapeutically for a wide variety of conditions, including breast cancer.

As cardiac filling and cardiac output increase with progression, the depth of immersion from the symphysis to the xiphoid usually causes the heart rate to decrease. This decrease is variable and dependent on water temperature. Typically, at average pool temperatures, the heart rate decreases by 12% to 15% (Perini & Veicsteinas, 2003). This is where a significant relationship is created between water temperature and heart rate. At 25°C, the heart rate decreases by about 12 to 15 beats per minute, at thermoneutral temperatures, the decrease is less than 15%, while at high temperatures, the rate increases significantly, generally contributing to the major increase of cardiac output (Schmid et al., 2007).

Hydrotherapy in breast cancer

In the case of patients with breast neoplasm, mechanical factors are the most important factors of water that act on the body. The buoyant force is based on Archimedes' Law and generates an apparent decrease in the weight of the body, which is directly proportional to the level at which it is submerged. Thus, the biomechanics of movement is facilitated, and exercises and mobilisations can be performed even with patients who are not able to perform them on land or have a contraindication in this regard.

Water resistance accompanies every movement and allows weight-bearing exercises to be performed in all directions. The hydrostatic pressure of water achieves a real massage of the segments, which contributes to the prevention of lymphoedema and facilitates its reduction (Cordun, 1999).

Specialists from the Földi European Lymphology Centre (Földi College, n.d.) use hydrokinetic therapy as a component of kinetic treatment and suggest that the water temperature should be between 22°C and 30°C. Freestyle swimming is recommended post-surgery because it provides gentle stretching and contributes to increasing the range of motion of the upper limb. During and after the administration of chemotherapy, swimming offers multiple benefits to the cardiovascular system, representing an important source of aerobic exercise using water resistance (Devoogdt et al., 2010). The horizontal position of the body during swimming lowers heart rate and improves cardiac output. Regarding swimming during the administration of local radiotherapy, patients need the consent of the attending physician, as they may experience skin irritations that water with high chlorine content can exacerbate (Pittinger & Graves, 2013).

Mohammed et al. (2014) have highlighted in a study conducted at the Benha Teaching Hospital that hydrotherapy has beneficial effects on the abduction movement performed at the scapulohumeral joint. A number of 30 patients benefited from a water exercise programme performed 3 times a week for 6 weeks; at the end of the treatment, the pain felt in the shoulder decreased, and the functional level improved.

Tofighi et al. (2020) analysed the effects of hydrotherapy on the psychological sphere in a study carried out in Iran. The authors applied an aquatic exercise programme 3 times a week for 6 weeks and noted a statistically significant improvement in quality of life and especially

cognitive flexibility. Likewise, Lin et al. (2021) observed that aquatic exercise contributed to combating the fatigue manifested following the treatment applied to patients.

Gupta (2022) emphasises in a meta-analysis the importance of the post-operative application of a complex treatment made up of melotherapy, psychotherapy, compression bandaging, yoga, hydrotherapy and physical therapy. These therapies have beneficial effects on quality of life, lymphoedema secondary to mastectomy as well as upper limb disability and pain, which is also highlighted by Hack et al. (2015).

Researchers (Bills et al., 2017) reveal a very important effect of hydrotherapy on post-mastectomy sequelae, namely the reduction of lymphoedema. According to this study, there are treatment centres in Australia that use hydrotherapy in the treatment of lymphoedema. Tidhar and Katz-Leurer (2009) state that hydrotherapy has immediate beneficial effects on lymphedema; however, in the long term, it is necessary to use all specific and non-specific kinetic means. This study involved 16 patients who benefited from an exercise programme once a week, which took place in a 1.2-meter deep pool with water temperature of 32-33°C. Patients also experienced improvement in social and emotional domains, as shown by the Quality-of-Life Assessment Questionnaire.

Aquatic exercises performed at a slow pace have much better effects on lymphoedema compared to traditional water aerobics exercises (Deacon et al., 2019). Siqueira et al. (2020) observed that, following a 12-week post-mastectomy aquatic exercise programme, the shoulder range of motion improved in the movements of abduction, flexion, extension, internal rotation and external rotation.

Cantarero-Villanueva et al. (2012) proposed, for patients with pain caused by hormone therapy, an exercise programme performed 3 times a week in a pool with a depth of 140 cm and a water temperature of 30-32°C. A session lasted 60 minutes and was systematised as follows: 5 minutes of warm-up, 15-20 minutes of aerobic exercise, 15 minutes of mobility exercise, and 20 minutes of recovery exercise. The authors observed that pain decreased after 24 sessions. It was also noticed that exercising in a 200 cm deep pool at a water temperature of 28°C reduced fatigue, anxiety and depression (Cantarero-Villanueva et al., 2013).

The *purpose* of this study is to verify the effectiveness of an aquatic exercise programme aimed at improving upper limb function on the side of the surgery.

Methodology

Participants and Procedure

The study included 5 participants aged 33-39 years, with radical right mastectomy. This research was conducted between March and July 2021. Inclusion criteria: type of surgery: radical mastectomy and axillary lymph node dissection; age: 33-39 years. Exclusion criteria: the presence of metastases; non-operated breast neoplasm; double mastectomy.

The participants performed twice a week, for 3 months, the following exercise programme (the number of repetitions was 10 per exercise):

- Flexion and extension of the upper limbs (Figure 1);
- Abduction and adduction of the upper limbs in the frontal plane (Figure 2);
- Abduction and adduction of the upper limbs in the transverse (horizontal) plane;

- Circumduction performed in an lateral/medial direction with small amplitude, with the upper limbs maintained at different degrees of flexion;
- Circumduction performed in an anterior/posterior direction with small amplitude, with the upper limbs maintained at different degrees of abduction (Figure 3);
- Shoulder circumduction in an anterior and posterior direction;
- Flexion and extension at the elbow joint (Figure 4);
- Finger flexion and extension;
- Wrist circumduction (Figure 5);
- Swimming in backstroke, freestyle and crawl.

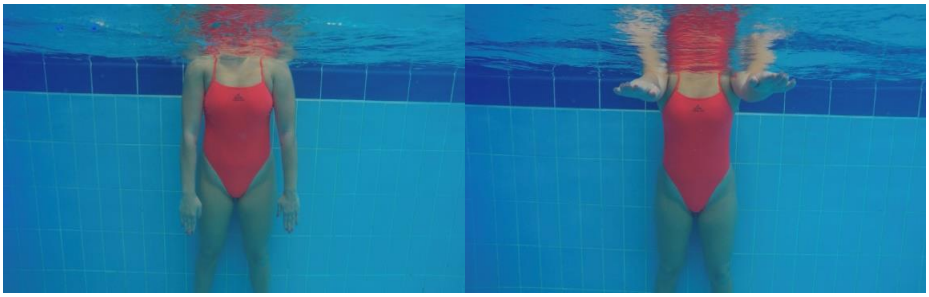

Figure 1. Flexion and extension of the upper limbs

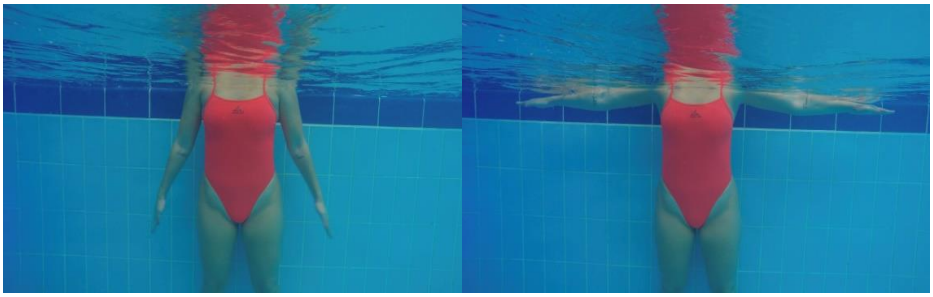

Figure 2. Abduction and adduction of the upper limbs in the frontal plane

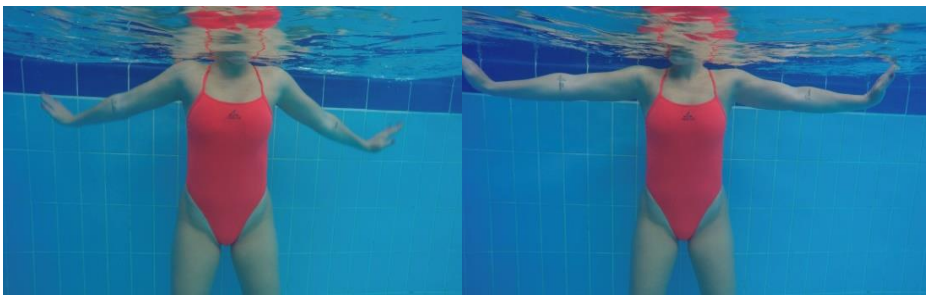

Figure 3. Circumduction performed in an anterior/posterior direction with small amplitude, with the upper limbs maintained at different degrees of abduction

Figure 4. Flexion and extension at the elbow joint

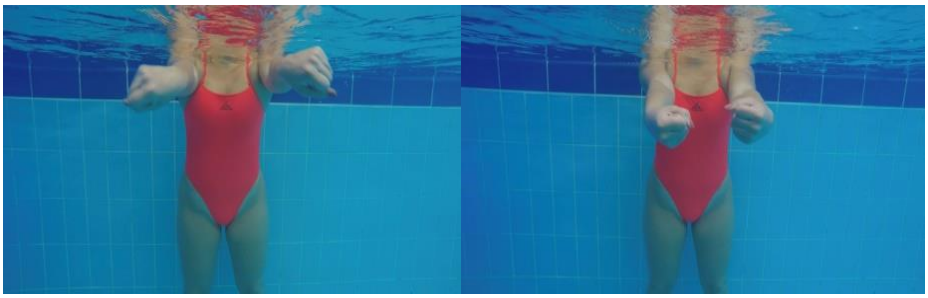

Figure 5. Wrist circumduction

Measurements/Assessments of the upper limb

The global functional assessment of the upper limb was performed using the three tests proposed by David Magee (Table 1) in order to identify the functional remaining. These tests are quantified on a scale of 0 to 4; during the assessment, the patient is placed on a chair without a backrest.

Table 1. *Global functional assessment*

Test 1 taking the hand to the back of the neck	0 - the fingers touch the back of the neck with full abduction and external rotation 1 - the fingers touch the back of the neck but the shoulder is not in complete abduction 2 - the fingers touch the back of the neck; the affected limb compensates for the movement through adduction 3 - the fingers do not touch the back of the neck 4 - the fingers do not exceed shoulder level
Test 2 touching the scapula with the hand by performing flexion, adduction and internal rotation	0 - the hand touches the spine of the opposite scapula with the shoulder in adduction and complete internal rotation 1 - the hand touches the spine of the opposite scapula through adduction, without internal rotation 2 - the hand exceeds the middle line of the torso 3 - the hand does not exceed the middle line of the torso 4 - the affected limb cannot be mobilised away from the body
Test 3 touching the scapula with the hand by performing extension, adduction and external rotation	0 - the hand touches the opposite scapula 1 - the hand touches the torso 6-15 cm below the opposite scapula 2 - the hand touches the opposite iliac crest 3 - the hand touches the buttocks on the same side 4 - the affected limb cannot be mobilised away from the body

Results

The results obtained from the individual initial evaluation (IE) and final evaluation (FE) were recorded in the evaluation form of each patient; the data can be found in Table 2.

Table 2. *Results of functional tests*

Patient	Test 1		Test 2		Test 3	
	IE	FE	IE	FE	IE	FE
1	3	1	3	1	3	1
2	4	1	3	1	3	1
3	3	0	2	1	3	1
4	3	1	2	0	2	1
5	4	1	2	1	2	0

Note: IE – initial evaluation; FE – final evaluation.

Test 1 – taking the hand to the back of the neck

In the first test, the average score decreased by 2.6, from 3.4 at the initial assessment to 0.8 at the final assessment. The average values show an improvement at group level, from "the fingers do not exceed shoulder level" to "the fingers touch the back of the neck with full abduction and external rotation". The minimum value decreased from 3 to 0, and the maximum value from 4 to 1. (Table 3)

Table 3. *Statistical Indicators – Test 1*

Evaluation	Average	Average difference	Median	Standard deviation	Min	Max	Range	Coefficient of variation
Initial	3.4	-2.6	3	0.55	3	4	1	14%
Final	0.8		1	0.44	0	1	1	50%

Test 2 – touching the scapula with the hand by performing flexion, adduction and internal rotation

The average score for functional test 2 decreased by 1.6, from 2.4 at the initial assessment to 0.8 at the final assessment. The average values show an improvement at group level, from "the hand does not exceed the middle line of the torso" to "the hand touches the spine of the opposite scapula with the shoulder in adduction and complete internal rotation". The minimum value decreased from 1 to 0, and the maximum value from 3 to 1. (Table 4)

Table 4. *Statistical Indicators – Test 2*

Evaluation	Average	Average difference	Median	Standard deviation	Min	Max	Range	Coefficient of variation
Initial	2.4	-1.6	2	0.54	1	3	1	20%
Final	0.8		1	0.44	0	1	1	50%

Test 3 – touching the scapula with the hand by performing extension, adduction and external rotation

The average score obtained in functional test 3 decreased by 1.8, from 2.6 at the initial assessment to 0.8 at the final assessment. The average values determined in the two evaluations show an improvement at group level, from "the hand touches the buttocks on the same side" to "the hand touches the torso 6-15 cm below the opposite scapula". The minimum value decreased from 1 to 0, and the maximum value from 3 to 1. (Table 5)

Table 5. *Statistical Indicators – Test 3*

Evaluation	Average	Average difference	Median	Standard deviation	Min	Max	Range	Coefficient of variation
Initial	2.6	-1.8	3	0.54	1	3	1	19%
Final	0.8		1	0.44	0	1	1	50%

Each patient performed three tests and we applied the Wilcoxon test to the entire sample to analyse group evolution and progress. The Z-value is -3.4078, and the p-value is 0.00064. The critical value for W at N = 15 (p = .05) is 25. The result is significant at $p < .05$. The effect size index (r = 0.87) shows a very strong impact (Predoiu, 2020) of the aquatic exercise programme on the upper limb function (on the side of the surgery). These data are presented in Table 6.

Table 6. *Wilcoxon test*

Average difference	Z-value	Standard deviation	p-value	r
1.6	-3.4078	17.61	.00064	0.87

Discussion and Conclusion

Hydrotherapy represents the external or internal use of water in any of its forms (water, ice, steam) for the purpose of promoting health or treating various conditions using different water temperatures and pools with a greater or lesser depth, the duration of a session being adapted to the specific condition and the somatic and functional characteristics of the person. Over time, it has proven to be one of the most widely used natural treatment modalities in ancient cultures, including India, Egypt, China, Greece and even the Roman Empire.

We noticed the existence of a small number of studies regarding the effects of hydrotherapy on several systems of the human body. Numerous scientists have developed studies to analyse the effects of swimming and hydrotherapy on the recovery of cancer patients, especially in breast cancer. Fernández-Lao et al. (2012) compared aquatic therapy with a land-based exercise programme aimed at reducing lymphoedema, increasing shoulder joint mobility, muscle strength and functional level in activities of daily living. According to these authors, the results are observed much faster when aquatic therapy is used; however, it is necessary to combine all the specific means of physical therapy in order to maximise the results and maintain them in the long term. In recent years, hydrotherapy has been proposed to shift from its use as an alternative method to its inclusion as a composite part of post-

surgical procedures in breast cancer because it has a positive impact on treating adverse effects (Mur-Gimeno et al., 2021), reduces fatigue and improves patients' quality of life (Wang et al., 2022). Thus, its benefits began to be researched and documented. The principles underlying hydrotherapy in the treatment of lymphoedema are represented by buoyancy, which facilitates the mobilisation of the upper limbs, the viscosity of water, which facilitates the toning of muscles that act as a pump on lymphatic vessels, and hydrostatic pressure, which exerts on the limbs a pressure similar to that of compression sleeves and thus achieves a real massage that leads to reducing the circumference of the affected segment. The treatment applied to lymphoedema is of the decongestive type and includes massage, water exercise, land-based exercise, lymph tape and multilayer compression bandaging (Marchica et al., 2021).

The introduction of aquatic physical therapy in the recovery protocol makes the means applied to patients with post-mastectomy lymphoedema more efficient (Ali et al., 2021); in certain situations, the results can be much more spectacular compared to the classic physiotherapy programme.

In the first test, the average values show an improvement at group level, from "the fingers do not exceed shoulder level" to "the fingers touch the back of the neck with full abduction and external rotation". The average value for functional test 2 decreased by 1.6, from 2.4 at the initial assessment to 0.8 at the final assessment. In the third test, the average values determined in the two evaluations show an improvement at group level, from "the hand touches the buttocks on the same side" to "the hand reaches 6-15 cm below the opposite scapula".

The effect of hydrotherapy as an adjuvant treatment in breast cancer associated with the population with lymphedema has been addressed in a small number of studies. Despite the pros and cons, we believe that hydrotherapy could be considered as part of the adjuvant treatment applied to people with breast cancer having both lymphoedema and decreased mobility and muscle strength.

Hydrotherapy has positive physiological and psychosocial effects as long as it is carried out within a group because it stimulates socialisation and, in particular, the acceptance of the condition that these people face. However, the literature is limited regarding the topic addressed in this paper. With the evolution of treatment methods, the survival rate after breast cancer diagnosis has increased. Thus, the attention of researchers and authors moved from mortality to morbidity and they began to analyse and promote physical activities that would help the socio-professional reinsertion of patients. In this context, hydrotherapy could play an important role in both the prevention and treatment of sequelae.

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Data Availability Statement: Data are available upon request to the contact author.

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