



Original Article

Physical exercises for breast cancer survivors: effects of 10 weeks of training on upper limb circumferences

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Abstract. [Purpose] The aims of this study were to verify the effects on upper limb circumferences and total body extracellular water of 10 weeks of Nordic Walking (NW) and Walking (W), both alone and combined with a series of exercises created for breast cancer survivors, the ISA method. [Subjects and Methods] Twenty breast cancer survivors were randomly assigned to 4 different training groups and evaluated for upper limb circumferences, total body and extracellular water. [Results] The breast cancer survivors who performed NW, alone and combined with the ISA method, and Walking combined with the ISA method (but not alone) showed significantly reduced arm and forearm circumferences homolateral to the surgical intervention. [Conclusion] For breast cancer survivors, NW, alone and combined with the ISA method, and Walking combined with the ISA method should be prescribed to prevent the onset and to treat light forms of upper limb lymphedema because Walking training practiced alone had no significant effect on upper limb circumference reduction.

Key words: Lymphedema, Exercise training, Anthropometry

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INTRODUCTION

Both non-pharmacological and pharmacological treatments of breast cancer have negative side effects ranging from the kinesiological to psychological domain, depending on the interaction of treatment characteristics with the physio-pathological and psychological conditions of each subject^{1, 2)}. Upper limb lymphedema is a potential negative consequence of breast cancer surgery and radiation therapy that can appear during the months or even years after treatment ends.

A growing body of scientific literature emphasizes the psycho-physical importance of early physical exercise engagement of breast cancer survivors in order to facilitate an early recovery, and to prevent breast cancer recurrence and the onset of all sedentarism-related diseases³⁾. Currently, various forms of exercise are prescribed following breast cancer treatment. Although walking training, as the most accessible and low cost activity, is the most practised activity, proper exercises for breast cancer survivors should principally aim to correct faulty posture, balance muscle chain lengths, elasticity and strength, improve general physical fitness, prevent lymphedema, reduce mental distress, and activate the immune system⁴⁻⁶⁾. In order to achieve all or most of the described aims, it is very important to plan the correct training and if possible to choose a com-

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plete discipline. To furnish a wide-ranging healthy intervention, the recently introduced physical fitness discipline of Nordic Walking appears to be useful for breast cancer survivors. Nordic Walking is a form of brisk walking, utilizing a walking pole, which actively engages the trunk and upper limbs during walking, increasing their range of motion and increasing total body muscle endurance⁷⁻¹⁰, and it has positive effects on cardio-metabolic, postural and balance measures in both healthy and pathological conditions¹¹⁻¹³. In addition, due to its principal characteristics, it is conceivable to consider Nordic Walking as an effective discipline against lymphedema^{14, 15}. Indeed, during Nordic Walking practice there is an alternating open and close cycle of the hands, creating a “pumping effect”, theoretically favouring both lymphatic and blood circulation through upper limb muscle contraction, as reported for the Pole Walking technique^{7, 9, 16}. As Nordic Walking and Pole Walking are not the same discipline, they use different equipment and have a few but substantially different principal characteristics (Table 1), it is very important to verify the effectiveness of the Nordic Walking technique on the upper limb circumferences of breast cancer survivors. Taking into account that to maintain natural gait, while the hands are performing the Nordic Walking characteristic open-close cycle in an alternating manner (Fig. 1), could be too complex a task for novice Nordic Walkers with little previous experience of physical exercise, with a consequent delayed beneficial effect on upper limb circumferences, we designed a series of exercises, properly tailored for breast cancer survivors (i.e. the ISA method), to enhance the pump effect of the upper limbs and contrasting arthralgia. The aim of this study was to verify the effects of 10 weeks of Nordic Walking, Nordic Walking + ISA Method, Walking alone, and Walking + ISA Method on upper limb circumferences and total body water of breast cancer survivors.

SUBJECTS AND METHODS

Twenty breast cancer survivors (BCS) (mean age, 50.60 ± 3.60 years) were recruited by the Department of General Surgery Specialized in Senology of the “G. Bernabeo” Hospital (Ortona, Italy). The inclusion criteria were: age >40 ≤ 55 years; no past or current chemotherapy; no current radiotherapy; current hormonal therapy; cardiovascular and orthopaedic eligibility for Nordic Walking practice; no endocrine diseases; lymphedema lower than class 2 of the CEAP-L classification¹⁷; no dieting or use of nutritional supplements; no participation in any exercise programme during the six months prior to the study; and un-employed status. The Ethics Committee of the “G. d’Annunzio” University of Chieti-Pescara approved this study, and all of the participants gave their written informed consent.

After recruitment, the breast cancer survivors were visited by both cardiology and sports medicine specialists to verify their cardiovascular and orthopaedic eligibility for Walking and Nordic Walking practice through medical examination, echocardiography and the maximal stress test. After meeting the medical eligibility criteria, the participants were randomly assigned to one of four different workout groups, which performed Nordic Walking (NWg), Nordic Walking + ISA method (NW-ISAg), Walking (Wg) or Walking + ISA method (W-ISAg) workout. Before starting 10 weeks of supervised training, both NWg and NW-ISAg were introduced to Nordic Walking, through 10 lessons on the Nordic Walking technique. After

Table 1. Nordic Walking vs. Pole Walking characteristics

Nordic Walking	Pole Walking
<p>Equipment:</p> <ul style="list-style-type: none"> ○ light-weight poles come in fixed-length, 2 or 3 sections; ○ releasable hand strap system that attaches to the handle and is fixed to the pole whilst in use; ○ specially-designed, removable rubber tips and fixed steel tips are angled to assist with push-off; ○ poles are alternately used beside and behind the body in a pushing action; ○ the body’s natural gait pattern—called the reciprocal gait—is accentuated when using Nordic Walking poles; ○ to some extent, without losing the natural walking pattern, the stride lengthens, and spinal rotation is the key to achieving walking “with attitude”. This recruits more muscles but actually often lowers perceived exertion because more muscles are being used. 	<p>Equipment:</p> <ul style="list-style-type: none"> ○ poles are adjustable in length and divided into 3 sections; ○ baskets are interchangeable and useful for preventing poles from sinking into the ground; ○ adjustable, locking straps with a different variety of handle types, enable user to maintain contact with grips without causing hand strain; ○ concave, carbide flex tips are designed for optimal performance on a variety of non-paved surfaces; ○ rubber tips with a flat surface, enable the user to walk indoors or on pavements; ○ Pole Walkers use the poles to transfer body weight onto the pole which helps to share the load and provide stability with the principal aim to take some weight off the lower body joints and to cope with tough conditions underfoot; ○ in general, Pole Walkers are not seeking to gain such forward propulsion or increase stride in the way Nordic Walkers do and they plant the poles in front of them at a much more upright angle.

Created and adapted from the contents of Jayah Faye Paley’s blog <http://adventurebuddies.net/blog/2010/09/nordic-walking-poles-vs-trekking-poles-whats-the-difference/>

the 10 lessons, two Nordic Walking instructors of the International Nordic Walking Association (i.e. INWA) independently verified the proficiency of each participant. After NWg and NW-ISAg had completed the 10 lessons of Nordic Walking technique (T0), all the participants underwent anthropometry and body composition analysis, which were repeated at the end of the study (T1).

A resting 12-lead electrocardiogram (Stress ECG HD+, Cardioline, Trento, Italy) was recorded after 10 min supine rest. Because the majority of participants had never used a treadmill before, the eligibility for aerobic training was assessed through a graded maximal exercise test on a cycle ergometer (Cardioline xr50, Cardioline, Trento, Italy), supervised by a sports medicine specialist medical doctor. Participants performed a graded maximal exercise test, the Astrand protocol using 3-minute steps¹⁸), under continuous electrocardiogram monitoring (Stress ECG HD+, Cardioline, Trento, Italy), and blood pressure was measured at the end of each step. The test lasted until the doctor saw absolute or relative indications for clinical graded exercise test termination, according to the Italian Federation of Sports Medicine guidelines¹⁹).

A second level anthropometrist of the International Society for the Advancement of Kinanthropometry, following the Society's guidelines²⁰), measured weight, stretched stature and the following circumferences of the upper limbs: relaxed arm (the circumference at Acromiale-Radiale medio[®] point), maximal forearm (the maximal circumference of forearm), mid forearm (the circumference at mid-point between Radiale[®] and Stylium[®] points) and wrist (the wrist circumference at distal region of the Stylium[®] point). A stadiometer with a balance-beam scale (Seca 220, Seca, Hamburg, Germany) was used to measure weight and stretched stature; an anthropometric tape (Cescorf, Porto Alegre, Brazil) was used to measure circumferences and a segmometer (Cescorf, Porto Alegre, Brazil) was used to locate the Acromiale-Radiale medio[®] point and mid forearm. Anthropometric measures were reported to the nearest 0.1 kg and 0.1 cm.

Body extracellular water of the participants was assessed using a hand-to-foot electrical bioimpedance technique, and a 50-kHz frequency bioelectric impedance analyzer (BIA 101, Akern, Pontassieve, Italy). The test was performed 3 h after waking, and immediately after voiding, with the participants undressed in the supine position, the upper limbs separated from the trunk, and the lower limbs separated from each other.

All the training groups followed the same training schedule with different contents according to group membership. The 70 min of training, including 15 min of warm-up, 45 min of central phase and 10 min of cool down, was performed three times a week for 10 weeks. From the first to the fourth week, the participants trained at 10–11 on the Borg rating of perceived exertion (RPE) scale²¹), from the fifth to the eighth week at 12–13 RPE, and from the ninth to the tenth week at 13–14 RPE. The participants were familiarized with this scale before beginning the training, and also during the first week of training. The Borg scale is particularly useful for prescribing and monitoring exercise intensity in this population, as with the same external load it is possible to have a different internal load due to the side effects of pharmacological treatments (e.g. fatigue). Exercise trainers checked the exercise intensities of the participants through the talk test²²), and checked their compliance with the training sessions. Each group was conducted and supervised by exercise specialists. NWg and NW-ISAg were conducted and supervised by exercise specialists who were also instructors of the Italian Nordic Walking Association, and members of the same International Association (i.e. INWA). Considering the differences between the groups: I) NWg executed the traditional ANWI-INWA suggested exercises for warm-up and cool-down, including whole body mobilization exercises during warm-up, and stretching exercises during cool-down²³), and Nordic Walking in the central phase of the training session; II) Wg executed whole body mobilization exercises during warm-up and stretching exercises during cool-down^{23, 24}), and Walking in the central phase of the training session; III) NW-ISAg executed the ISA method during warm-up and both the ISA method and stretching exercises during cool-down, and Nordic Walking in the central phase of the training session; and IV) W-ISAg executed the ISA method during warm-up and both the ISA method and stretching exercises during cool-down, and Walking in the central phase of the training. During the training period, participants did not practice other forms of exercise and did not have lymphatic drainage.



Fig. 1. Hands coordination scheme during Nordic Walking practice

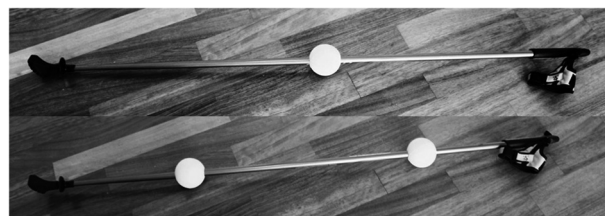


Fig. 2. ISA balls applied to Nordic Walking poles

The ISA method includes a series of dynamic exercises, propaedeutic for Nordic Walking, lymphedema and arthralgia, properly tailored for breast cancer survivors. It requires the use of ISA balls, foam balls of 6 or 7 cm diameter with different densities, that can be used both alone or with Nordic Walking poles (Fig. 2). This series of exercises has the following objectives: to gently warm-up joints, and to reduce muscular tensions and counteract or prevent upper limb lymphedema. The scheme of execution is the following: the protocol starts with warm-up exercises for the hand and wrist joints, that are executed using only ISA balls, followed by multi-joint exercises, actively involving wrists, elbows and shoulders using both Nordic Walking poles and ISA balls applied to them, and by neck exercises, that are executed using only Nordic Walking poles. The main task performed by participants in the workout with ISA balls, was to gently squeeze them, during the forward and the returning phases of each exercise, in order to promote the pumping effect in the upper limbs. Exercises were created according to anatomy training principles²⁵). After the neck and upper limb exercises, trunk and lower limb exercises were executed using only Nordic Walking poles. Lower limb exercises were executed following a distal to proximal order, from feet to hip joints. Proper breathing exercises, involving the diaphragm, were also executed. No compression sleeves were worn during the workouts.

Statistical analysis was performed using the SAS 9.2 software (SAS Institute Inc., Cary, USA). Although non-parametric tests were performed because of the small sample size, some data are presented as means \pm standard deviation in order to better comprehend the results. Considering the whole sample, the Kruskal-Wallis test was used to verify whether the groups differed in basal characteristics. Considering each group separately, the Mann-Whitney test was used to verify whether circumferences of the upper limb, homolateral with surgical intervention for breast cancer, significantly differed from those of the opposite side. The Wilcoxon test was used to verify, separately in each group, the significance of changes in the outcome measures at the end of the training period. A value of $p < 0.05$ was considered significant.

RESULTS

Table 2 shows the homogeneity of the groups, which had the same starting values, except for the relaxed arm circumferences, which were higher in the NWg. As NWg had higher relaxed arm circumference than the other groups, and not only on the side homolateral to the surgical treatment, the observed difference was not due to a different grade of lymphedema but to a difference in the group's characteristic. Table 3 shows that all the upper limbs homolateral to the surgical intervention for breast cancer had circumferences greater than those of the contralateral upper limb except the wrist circumferences, which showed no significant difference. The Wilcoxon test showed that while Wg showed no significant changes in any of the outcome measures, and increased both total body water and mid-forearm circumference, the other groups exhibited significant reductions (Table 4). Both NWg and NW-ISAg showed significantly reduced relaxed arm and maximum and mid-forearm circumferences homolateral to the surgical intervention. NW-ISAg also showed significant reductions in extracellular water, the extracellular to total body water ratio and the wrist circumference homolateral to the surgical intervention (Table 4). In contrast to Wg, which showed no significant reductions in arm circumferences, W-ISAg showed a significant reductions in the extracellular to total body water ratio, relaxed arm circumference, and both maximum and mid-forearm circumferences homolateral to the surgical intervention (Table 4). No significant changes were observed in the limb contralateral to the surgical intervention.

Table 2. Anthropometric and hydration differences of the groups

	NWg	NW-ISAg	Wg	W-ISAg
Age (years)	52.6 \pm 2.1	48.4 \pm 1.5	49.2 \pm 5.7	52.2 \pm 2.5
Weight (kg)	78.3 \pm 12.5	60.5 \pm 7.4	65.1 \pm 10.7	64.2 \pm 5.1
TBW (lt)	35.8 \pm 4.1	32.8 \pm 4	32.3 \pm 3.1	33.5 \pm 1
ECW (lt)	19.1 \pm 3.2	17.1 \pm 1.3	16.9 \pm 1.6	17.8 \pm 2.2
ECW/TBW (%)	53 \pm 5.8	52.7 \pm 4.2	52.2 \pm 1.5	53.2 \pm 5.4
Relaxed arm circ. (cm) #	34.6 \pm 3.3*	29.2 \pm 2*	30.6 \pm 2.4*	30.6 \pm 1.7*
Max forearm circ. (cm) #	24.3 \pm 2.3	22.9 \pm 2.2	23.1 \pm 1.9	23.5 \pm 0.6
Mid forearm circ. (cm) #	23.7 \pm 2.2	21.5 \pm 2.2	22.4 \pm 1.4	22.1 \pm 0.7
Wrist circ. (cm) #	17 \pm 1.5	15.5 \pm 0.9	15.8 \pm 0.7	16.1 \pm 0.6
Relaxed arm circ. (cm)°	33.7 \pm 3.1*	28.5 \pm 1.8*	29.9 \pm 2.4*	29.6 \pm 1.5*
Max forearm circ. (cm)°	24.02 \pm 2.26	22.48 \pm 2.11	22.7 \pm 1.7	22.4 \pm 1.1
Mid forearm circ. (cm)°	23.26 \pm 2.04	21 \pm 2.31	21.7 \pm 1.1	20.7 \pm 0.7
Wrist circ. (cm)°	16.42 \pm 1.15	15.54 \pm 1.21	15.9 \pm 0.5	16.1 \pm 0.7

NWg: Nordic Walking group; NW-ISAg: Nordic Walking + ISA Method group; Wg: Walking group; W-ISAg: Walking + ISA Method group; TBW: total body water; ECW: extracellular water; circ.: circumference; Max: Maximum; #homolateral to the surgical intervention for breast cancer; °contralateral to the surgical intervention for breast cancer; * $p < 0.05$

DISCUSSION

Taking into account that our pilot study was conducted on a restricted sample and that our results need further confirmation, our study provides interesting preliminary results for optimizing recovery from breast cancer treatment. According to our results, Walking training does not seem capable of reducing upper limb circumferences and extracellular body water, so

Table 3. Analysis of upper limb differences of the groups

	Homolateral upper limb	Contralateral upper limb
NWg		
Relaxed arm circ. (cm)	34.6 ± 3.3*	33.7 ± 3.1*
Max forearm circ. (cm)	24.3 ± 2.3*	24.02 ± 2.2*
Mid forearm circ. (cm)	23.7 ± 2.2*	23.26 ± 2*
Wrist circ. (cm)	17 ± 1.5	16.4 ± 1.1
NW-ISAg		
Relaxed arm circ. (cm)	29.2 ± 2*	28.5 ± 1.8*
Max forearm circ. (cm)	22.9 ± 2.2*	22.4 ± 2.1*
Mid forearm circ. (cm)	21.5 ± 2.2*	21 ± 2.3*
Wrist circ. (cm)	15.5 ± 0.9	15.5 ± 1.2
Wg		
Relaxed arm circ. (cm)	30.6 ± 2.4*	29.9 ± 2.4*
Max forearm circ. (cm)	23.1 ± 1.9	22.7 ± 1.7
Mid forearm circ. (cm)	22.4 ± 1.4*	21.7 ± 1.1*
Wrist circ. (cm)	15.8 ± 0.7	15.9 ± 0.5
W-ISAg		
Relaxed arm circ. (cm)	30.6 ± 1.7*	29.6 ± 1.5*
Max forearm circ. (cm)	23.5 ± 0.6*	22.4 ± 1.1*
Mid forearm circ. (cm)	22.1 ± 0.7*	20.7 ± 0.7*
Wrist circ. (cm)	16.1 ± 0.6	16.1 ± 0.7

Homolateral upper limb, circumferences taken on the upper limb homolateral to the surgical intervention for breast cancer; Contralateral upper limb, circumferences taken on the upper limb contralateral to the surgical intervention for breast cancer; Max: Maximum; NWg: Nordic Walking group; NW-ISAg: Nordic Walking + ISA Method group; Wg: Walking group; W-ISAg: Walking + ISA Method group; circ., circumference; *p<0.05

Table 4. Analysis of variables modifications of the groups

	NWg T ₀	NWg T ₁	NW-ISAg T ₀	NW-ISAg T ₁	Wg T ₀	Wg T ₁	W-ISAg T ₀	W-ISAg T ₁
Weight (kg)	78.3 ± 12.5	78.8 ± 11.9	60.5 ± 7.4	60.2 ± 6.6	65.1 ± 10.7	65.2 ± 11.2	64.2 ± 5.1	64.4 ± 5.1
TBW (lt)	35.8 ± 4	35.4 ± 3.9	32.8 ± 4.1	32.7 ± 3.7	32.3 ± 3.1	33.1 ± 3.4*	33.5 ± 1	34.3 ± 1.1
ECW (lt)	19.1 ± 3.2	18.5 ± 2.7	17.1 ± 1.3	16.8 ± 1*	16.9 ± 1.6	17.2 ± 2.3	17.8 ± 2.2	17.4 ± 1.8
ECW/TBW (%)	53 ± 5.8	52.1 ± 4.1	52.7 ± 4.2	51.7 ± 4.2*	52.2 ± 1.5	51.7 ± 3.1	53.2 ± 5.4	50.8 ± 4.9*
Relaxed arm circ. (cm) [#]	34.6 ± 3.3	34 ± 3.1*	29.2 ± 2	29.1 ± 2*	30.6 ± 2.4	30.6 ± 1.9	30.6 ± 1.7	29.7 ± 1.5*
Max forearm circ. (cm) ^{##}	24.3 ± 2.3	23.8 ± 2.3*	22.9 ± 2.2	22.2 ± 2.3*	23.1 ± 1.9	22.8 ± 1.9	23.5 ± 0.6	22.5 ± 0.8*
Mid forearm circ. (cm) ^{##}	23.7 ± 2.2	22.4 ± 1.7*	21.5 ± 2.2	20.9 ± 2*	22.4 ± 1.4	23.2 ± 1.8*	22.1 ± 0.7	20.9 ± 0.7*
Wrist circ. (cm) ^{##}	17 ± 1.5	16.8 ± 1.6	15.5 ± 0.9	15.4 ± 0.9*	15.8 ± 0.7	15.2 ± 0.6	16.1 ± 0.6	16.3 ± 0.6
Relaxed arm circ. (cm) [°]	33.7 ± 3.1	33.8 ± 2.9	28.5 ± 1.8	28.2 ± 1.7	29.9 ± 2.4	30.1 ± 1.9	29.6 ± 1.5	29.5 ± 1.5
Max forearm circ. (cm) [°]	24 ± 2.2	24 ± 2.5	22.4 ± 2.1	22.3 ± 2.3	22.7 ± 1.7	23.6 ± 1.5	22.4 ± 1.1	21.9 ± 0.8
Mid forearm circ. (cm) [°]	23.2 ± 2	23.2 ± 2.2	21 ± 2.3	21 ± 2.3	21.7 ± 1.1	21.8 ± 1.2	20.7 ± 0.7	20.3 ± 0.7
Wrist circ. (cm) [°]	16.4 ± 1.1	16.4 ± 1.2	15.5 ± 1.2	15.5 ± 0.9	15.9 ± 0.5	15.8 ± 0.5	16.1 ± 0.7	16.3 ± 0.6

NWg: Nordic Walking group; NW-ISAg: Nordic Walking + ISA Method group; Wg: Walking group; W-ISAg: Walking + ISA Method group; TBW: total body water; ECW: extracellular water; circ.: circumference; Max: Maximum; [#]homolateral to the surgical intervention for breast cancer; [°]contralateral to the surgical intervention for breast cancer; *p<0.05

it should not be used alone for the prevention/treatment of upper limb lymphedema. This result should be explained by the fact that there is a lack of active use of the upper limbs, whereas Nordic Walking actively uses the upper limbs as a propulsive means, one of its main features. Indeed, Pellegrini et al.²⁶⁾ showed that the muscle activities of the triceps brachii, latissimus dorsi, biceps brachii and anterior deltoideus muscles, were respectively 16-fold, 40-fold and 3-fold lower in Walking than in the Nordic Walking. Also, each muscle's activation is characterized by a cyclical pattern, with activation of different intensities, according to the phase of walking. The alternating active use of the upper limb muscles supports lymphatic and blood circulation, benefiting from the gravity effect helping to prevent or reduce upper limb swelling. An important result of the present preliminary study is that by coupling the ISA method with Walking training, it is possible to compensate for the lack of the upper limb "pumping effect", a typical negative characteristic of walking training. Indeed, after 10 weeks of training, while Wg showed no significant modifications, W-ISAg exhibited significant reductions in extracellular to total body water ratio, and arm and forearm circumferences. This result could be particularly useful for breast cancer survivors favoring Walking training but not Nordic Walking, and also for those who have to train indoors, using a treadmill, for any reason. In the present study, when the proper Nordic Walking technique was performed maintaining the natural gait with the hands performing an open and close cycle in an alternating manner, Nordic Walking alone was able to reduce the upper limb circumferences and extracellular body water. Therefore, even in the absence of the ISA method, when the proper Nordic Walking technique is practised for 10 weeks, reductions can be achieved in the upper limb circumferences homolateral to the breast cancer surgery site.

In conclusion, both a larger study and the use of a more accurate technique for quantifying lymphedema are necessary to confirm the present results. Furthermore, the present results may only be applicable to people with lymphedema lower than class 2 of the CEAP-L classification. However, the addition of the ISA Method, during both the warm-up and cool down phases, to 10 weeks of walking-based workout could be useful for the management of lymphedema, walking alone seems not to be of benefit. In order to choose a physical exercise having complete efficacy against breast cancer treatment effects on the side of treatment, particular attention should be paid to Nordic Walking. Nordic Walking has been reported to achieve balanced postural changes in breast cancer-related treatment postural disorders¹⁰⁾, increases in upper extremity strength⁸⁾, improvements in cardio-metabolic and respiratory measures and has been used in the prevention and treatment of upper limb lymphedema. However, in order to elicit beneficial effects, it is necessary to perform the proper technique and achieve consistency in training.

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