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ORIGINAL ARTICLE

Progressive strength training to prevent LYmphoedema in the first year after breast CAncer – the LYCA feasibility study

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ABSTRACT

Background: Lymphoedema is a common late effect after breast cancer (BC) that has no effective cure once chronic. Accumulating evidence supports progressive strength training (PRT) as a safe exercise modality in relation to the onset and exacerbation of lymphoedema. In the 'preventive intervention against LYmphoedema after breast CAncer' (LYCA) feasibility study we examined the feasibility of a program of PRT in the first year after BC to inform a planned randomised controlled trial (RCT).

Material and methods: LYCA was a one-group prospective pilot trial inviting women operated with axillary lymph node dissection for unilateral primary BC. Participants exercised three times a week for 50 weeks (20 weeks supervised followed by 30 weeks home-based exercise). The program ensured slow individualised progression during the exercise program. The primary outcome was feasibility measured by eligibility and recruitment rates, as well as questionnaire-assessed satisfaction and adherence to exercise. Furthermore, we assessed arm interlimb volume difference by water displacement, muscle strength by dynamic and isometric muscle testing and range of movement in the shoulder by goniometry.

Results: In August 2015, eight of 11 eligible patients accepted participation. Two of them dropped out early due to other health issues. The remaining six participants had high exercise adherence through the supervised period, but only three maintained this through the home exercise period. Program satisfaction was high and no serious adverse events from testing or exercising were reported. One participant presented with lymphoedema at 50-week follow-up. Muscle strength markedly increased with supervised exercise, but was not fully maintained through the home exercise period. Range of shoulder movement was not negatively affected by the program.

Conclusion: Recruitment, testing, and exercise in LYCA was safe and feasible. At the 50-week follow-up, there was one case of lymphoedema. The LYCA program will be further tested in a full-scale RCT.

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The increasing survival rate after breast cancer (BC) proves that treatment has become more effective. However, BC survivors are at risk of several severely disabling late effects such as lymphoedema. The reported incidence of lymphoedema varies greatly due to differences in definition and methods of measurement [1]. Disipio and colleagues [2] report in a literature review of cohort studies that lymphoedema affects one in five BC survivors. In a Danish study of women participating in an exercise intervention, the point prevalence 4–26 months post-BC surgery for self-reported clinically diagnosed lymphoedema was 28%, but 44% in the subgroup operated with axillary lymph node dissection (ALND) [3]. The negative influence of lymphoedema on quality of life is well established [4–6]. Cure is not possible and patients are dependent on compression garments and manual lymphatic drainage to prevent progression of lymphoedema. Further, this group of BC survivors may experience symptoms including discomfort, pain, reduced upper limb function, skin problems and infections, which trickle down into many aspects of daily life. The most important risk factors for lymphoedema are obesity, ALND and radiotherapy. According to a Danish observational study, up to 65% of patients in this high-risk group will experience symptoms of lymphoedema at some stage after surgery [7].

Two randomised studies support the usefulness of early physiotherapy in women who have undergone ALND [8,9]. In a randomised controlled trial (RCT) comprising 120 women [8] significantly fewer BC survivors had developed lymphoedema at one-year follow-up compared with controls (7% vs. 25%; RR 0.28; 95% CI 0.1–0.8). The intervention involved

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Supplemental data for this article can be accessed here.

manual lymph drainage, scar tissue treatment, progressive shoulder strengthening, mobility exercises, and education in self-management. Another intervention study ($n = 65$) found lymphoedema in 11% of participants in the early physiotherapy group versus 30% in the control group despite this being a secondary endpoint [9]. It can be argued that these two studies lack specificity regarding the interventions and do not adhere to the principles of exercise [10]. Furthermore, six smaller randomised trials, most of them underpowered ($n = 30–42$), have investigated whether physiotherapy or exercise could reduce the risk of lymphoedema after BC, but results were inconclusive [11–16]. Evidence from these RCTs leaves us with uncertainty concerning the importance of exercise in prevention of lymphoedema. Promisingly, a secondary analysis of the Physical Activity and Lymphoedema trial comprising 154 women after ALND showed that slow progressive resistance training (PRT) reduced the likelihood of self-reported symptoms of arm swelling compared to controls (11% vs. 17%, $p = 0.03$), although this was not confirmed when arm volume was measured objectively [17].

Taken together, studies involving participants at high risk [13–15] or low risk [16–21] of lymphoedema, and participants with manifest lymphoedema [18–21], have provided reassuring evidence regarding the safety of PRT. With this evidence in hand, we still lack a well powered study, testing if PRT can prevent lymphoedema.

The aim of the 'preventive intervention against LYmphoedema after breast CAncer' (LYCA) feasibility study was to test the feasibility of recruitment, testing, and PRT, and to examine the effect of the LYCA program on arm volume, muscle strength, and shoulder range of movement (ROM) to inform a larger randomised controlled design.

Methods

Participants, recruitment and design

In August 2015, eight participants were enrolled from Herlev Hospital. Inclusion criteria were: women aged 18–75, operated with ALND for unilateral primary BC, able to transport themselves to the hospital, and physically and mentally able to participate in the exercise intervention. Exclusion criteria were: previous ALND either side, primary breast reconstruction, metastatic disease, and history of lymphoedema. The study was approved by the Ethical Committee of the Capitol Region (ID: H-15002714) and all participants signed informed consent before entering the study. Nurses on the ward screened the operation lists for eligible patients on a daily basis. They informed eligible patients about the study before discharge on the day of surgery, and asked permission to contact them by telephone within the first two weeks. If patients accepted participation, they were baseline tested shortly after (2–3 weeks post-surgery) and commenced the 20-week supervised exercise in the Department of Physiotherapy at Herlev Hospital.

The LYCA pilot trial was a prospective single group study running before a planned RCT (clinicaltrial.gov. identifier: NCT02518477) with assessments at baseline and after 12, 20 and 50 weeks.

Intervention

Individualised exercise prescription was based on dynamic muscle testing at baseline assessing the maximum weight that could be lifted seven times (7RM test) (test protocol: Appendix 1). Exercise took place in the Physiotherapy Department at Herlev Hospital supervised by physiotherapists. The regime consisted of five modules of four weeks duration (Table 1), and each new module was initiated by a 7RM test to estimate maximal muscle strength. In the first module the prescribed load was 25 RM with 15–20 repetitions, in the second module 20 RM with 15–17 repetitions, and in the third module 15 RM with 10–12 repetitions. This meant that participants exercised just short of fatigue with a low load in the first three months of exercise. In the fourth and fifth modules the load alternated between 10 and 12 RM with 10–12 repetitions so that the exercise now reached fatigue level with a moderate load (75% of maximum). The exercise program covered all major muscle groups in the upper limbs, the large muscles of the lower limbs, and core strength and stability (see Appendix 2). Exercise sessions consisted of a 10–15-minute warm-up and mobility exercise, and 40 minutes of strength training. Participants chose a minimum of six strength exercises per session: three for the upper body, one for the lower body, and two for core, each performed in three sets per session. Every week participants exercised twice at the hospital and once at a self-selected location, for which they received a set of hand weights and elastic resistance bands. Cardinal symptoms of lymphoedema (heaviness, tightness, and swelling) were recorded weekly, and arm volume was measured at Weeks 12 and 20. If symptoms of swelling were present for two weeks or more, extra

Table 1. Overview of the exercise regime with time points of measurements for the LYCA feasibility study, Denmark, September 2015 to October 2016.

Time	Weeks 0–4	Weeks 4–8	Weeks 8–12	Weeks 12–16	Weeks 16–20	Weeks 20–50
Organisation	Supervised exercise in teams					Home exercise
Intensity	Submaximal (short of fatigue) Low load			Maximal (to fatigue) Moderate load		
Repetitions Load	15–20R 25RM	15–17R 20RM	10–12R 15RM	10–12R 12RM	10/12R 10/12RM	10–12R 10–12RM
Measure-ments	Week 0: Baseline test (MP, vol, ROM, Q)	Week 4: 7RM test	Week 8: 7RM test	Week 12: 7RM test, volume	Week 16: 10RM Week 20: MP, vol, Q	Week 26: booster session (arm volume) week 50: 50-week follow-up (MP, vol, ROM, Q)

MP: dynamic and isometric muscle power; Q: questionnaire; R: repetitions; RM: repetitions maximum; ROM: range of movement; vol: arm volume measured by water displacement.

volume measurements were made. Participants were informed about recommendations for physical activity and were encouraged to perform endurance exercise on alternate days.

After 20 weeks of supervised exercise, participants continued exercising on their own, reporting amount, frequency and progression by answering weekly mobile phone text messages (Appendix 3). During supervised exercise, participants were trained in testing their maximal muscle strength, which enabled them to perform monthly self-managed 10 RM muscle testing throughout the home exercise period when prompted by texting. Participants attended a booster session six weeks into the home exercise program to ensure compliance and adherence.

Outcomes

Feasibility outcomes

We determined the eligibility rate by dividing the number of patients meeting the inclusion/exclusion criteria by the number of patients operated with ALND, and the recruitment rate by dividing the enrolled patients by the number of eligible patients. We assessed program satisfaction by questionnaire after 12 weeks of exercise, when participants rated various aspects of testing and intervention. Intervention adherence was determined by calculating mean exercise sessions per week and categorised into high ($\geq$2 sessions per week), acceptable (1.5–2 sessions per week) and low ($<$1.5 sessions per week). Adherence to prescribed exercise volume was assessed by self-report in exercise diaries.

Physical measures

Interlimb volume difference (ILVD) was measured by water displacement. Measurements for each arm are repeated until two ipsilateral measurements did not diverge more than 1% of the smallest volume. The average of the two measurements for each arm was then inserted into the following formula:

$$\frac{\text{vol(affected arm)} - \text{vol(contralateral arm)}}{\text{vol(contralateral arm)}} \times 100$$

A change in ILVD, in which the affected arm increased more than 3% relative to the other arm, was defined as clinically relevant only if accompanied by an increased score on the numeric rating scale (NRS) for cardinal symptoms of swelling, and if two of four clinical criteria were fulfilled [(1–3) compared to unaffected arm]: (1) increased thickness of the skin; (2) decreased contours in the area of the medial epicondyle, wrist and hand; (3) decreased visibility of veins; and (4) pitting oedema.

Body mass index (BMI) (kg/m^{-2}) was calculated from self-reported height and measured weight at baseline.

Dynamic muscle strength for biceps curl, shoulder abduction, triceps push-down and leg press was assessed by 7RM test at baseline and at 12, 20 and 50 weeks of exercise.

Isometric muscle strength for horizontal and vertical shoulder adduction, shoulder flexion, and extension was assessed by handheld dynamometry at baseline and after 20 and 50 weeks of exercise.

Handgrip strength and shoulder ROM (flexion, abduction and external rotation) was measured by dynamometry and goniometry, respectively, both at baseline and 50 weeks.

Questionnaire data

Participants filled in questionnaires at baseline and after 20 and 50 weeks, reporting on demographics, pain and sensory disturbances; sensation of swelling, heaviness and tightness; physical activity (IPAQ); anxiety and depression (SCL-92 and MDI); health-related quality of life (EORTC-C30 and BR 25) and fatigue (FACIT-fatigue). For this feasibility study we performed data management on demographics solely from the questionnaire data.

Analysis

Data are presented as means (±SD) if not otherwise stated. No statistical testing was carried out due to the aim of assessing feasibility on this small sample size. The exercise program was considered feasible if no serious adverse effects were registered, if participants were satisfied with the program, and if adherence to the intervention was at least acceptable. We report the point prevalence of lymphoedema at 50 weeks, and use a diagram to describe change in ILVD over time. We report measures of muscle strength and summarise changes in shoulder ROM over time.

Result

Feasibility

Among 15 participants operated with ALND for BC at Herlev Hospital between 10 August and 3 September 2015, four patients were ineligible due to age $>$75, resulting in an eligibility rate of 73%. The remaining 11 patients were invited and eight accepted participation in the pilot trial, resulting in a recruitment rate of 73%. One participant dropped out at Week 2 due to a frozen shoulder on the contralateral side needing individual physiotherapy and another at Week 14 due to prolonged hospitalisation for heart problems. The remaining six participants were followed through 50 weeks, leaving us with a drop-out rate of 25%.

The mean age at baseline of the eight women included was 57 (±7.5), and mean BMI was 24 kg/m^{-2} (±2.8). Three participants had BC on the dominant side and five had been operated with mastectomy. Five participants were never smokers, three were previous smokers, and none current smokers (baseline characteristics) (Table 2).

Four of six participants returned forms assessing program satisfaction 12 weeks into the intervention (one was not present at the time, and one had dropped out). Replies with regard to timing of invitation and exercise commencement and contents of tests and intervention were positive (evaluation questionnaire with answers: Appendix 4).

Participants reported no pain or discomfort from testing or exercising in the questionnaire, while during exercise sessions one participant reported pain in the shoulder on the affected side during the abduction exercise, possibly arising from sub-acromial impingement or overuse. Pain subsided within three weeks of adding slight elbow flexion and external shoulder rotation to the exercise.

Regarding adherence to supervised exercise, five participants had 'acceptable' and one had 'high' adherence. Adherence to home exercise was high for three participants and low for one. The remaining two participants had high adherence as long as they exercised, but discontinued after three and 12 weeks, respectively. Deviation from the prescribed exercise volume was reported by one participant, who had a peripherally inserted central catheter (PICC-line) in the contralateral arm. This was due to instructions from the Oncology Department not to exercise the contralateral arm in the eight-week period with the PICC-line.

Table 2. Baseline characteristics of participants in the LYCA feasibility study, Denmark, September 2015 to October 2016.

	Mean (SD)/*n*
N	8
Age (years)	57.4 (±7.5)
BMI (kg/m^{-2})	24 (±2.8)
Dominant limb affected (*n*)	3
Mastectomy (*n*)	5
Seroma (*n*)	8
Times seroma emptied	3.9 (±2.0)
Pre-diagnosis physical activity:	
Adherence to guidelines (*n*)	1
Low/moderately active 30 mins/day (*n*)	3
Less than low/moderately active 30 mins/day (*n*)	4
Smoking	
Never smoker (*n*)	5
Previous smoker (*n*)	3
Smoker (*n*)	0
Living with partner (*n*)	7
Education[a]	
Higher (*n*)	1
Medium (*n*)	5
Short (*n*)	2
Time from operation to baseline test (days)	17.4 (3.5)
Interlimb volume difference (%)	0.2 (4.5)
Pain on average in the last 24 hours (0–10)[b]	1.4 (±1.3)

[a]Education: higher: graduate; medium: vocational/undergraduate; short: mandatory school only;
[b]pain measured by numeric rating scale, where 0 is 'nothing' and 10 is 'a lot'.

Arm volume

The change in ILVD is reported in Figure 1. One of six patients had subjective and objective symptoms of lymphoedema at 50-week follow-up, with 5% increase in ILVD and three of four clinical criteria for lymphoedema fulfilled. She had discontinued the program after 12 weeks of home exercise. Three participants had increased ILVD and symptom score during the program, but at 50 weeks these had returned to baseline levels. One participant did not have volume measured at baseline or 50 weeks due to complications with the equipment, but at no stage through the intervention did she experience symptoms of lymphoedema.

Body composition and muscle strength

All dynamic muscle tests showed an increase from baseline to 50 weeks. The largest increase was seen for elbow flexion, with 4.5 kg (±1.6) at baseline to 7.2 kg (±1.5) at 20 weeks, and 5.5 kg (±1.1) at 50 weeks on the affected side. Similarly, for isometric muscle strength, we found an increase from baseline to 50 weeks for four tests (shoulder flexion, extension, vertical adduction, and horizontal adduction). However, for grip strength we found a decrease bilaterally from 48.7 N (±15.9) to 27.4 N (±3.8). There was minimal difference between arms in all measurements of strength at 50-week follow-up. All data on muscle strength is reported in Table 3. Self-administered monthly 10 RM strength tests for shoulder abduction and biceps curl, reported by text message, showed maintained muscle strength through the home exercise period.

Range of shoulder movement: Shoulder abduction seemed to be the most restricted direction of shoulder movement post-operatively. At 50 weeks, all participants except one had

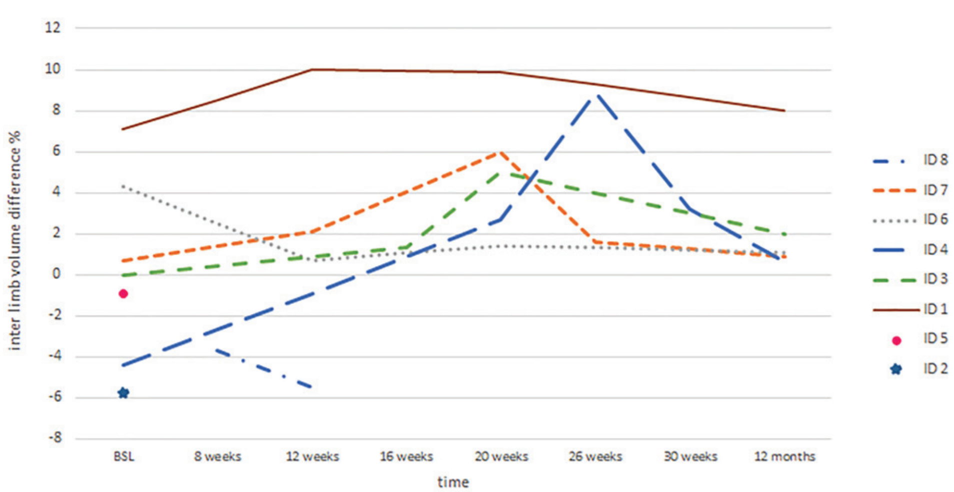

Figure 1. Change in interlimb volume difference over time after ALND for 8 participants in the LYCA Feasibility Study, Denmark, September 2015 to October 2016. Participants 5 and 2 only have baseline measures due to drop-out. Participant 8 has incomplete volume measurements due to problems with water displacement equipment and catheter in situ. Negative values of interlimb volume difference indicate that the operated side has lower volume than the opposite side.

Table 3. Mean muscle strength with standard deviations (SD) among 8 participants in the LYCA feasibility study, Denmark, September 2015 to October 2016.

Time Test	Baseline Ipsilateral mean (SD) $n=8$	Baseline Contralateral mean (SD) $n=8$	20 weeks Ipsilateral mean (SD) $n=6$	20 weeks Contralateral mean (SD) $n=6$	50 weeks Ipsilateral mean (SD) $n=6$	50 weeks Contralateral mean (SD) $n=6$
Dynamic (7RM)						
Shoulder abduction (kg)	3.4 (±0.9)	4 (±0.9)	5.5 (±0.8)	5.7 (±0.5)	4.3 (±1.0)	4.4 (±0.6)
Elbow flexion (kg)	4.5 (±1.6)	5.1 (±0.8)	7.2 (±1.5)	7.2 (±1.5)	5.8 (±1.3)	5.5 (±1.1)
Triceps (kg)	46.2 (±10.6)		60 (±7.1)		50 (±3.2)	
Leg press (kg)	91.3 (±14.6)		128.3 (±22.3)		103 (±24.0)	
Isometric (dynamometry)						
Shoulder adduction (Newton)	82.6 (±30.3)	87.9 (±32.7)	109.7 (±36.1)	104.2 (±28.7)	114.8 (±32.0)	120.5 (±25.4)
Shoulder horizontal adduction (Newton)	67.7 (±30.8)	73.5 (±22.5)	84.8 (±15.4)	80.5 (±17.8)	93.3 (±26.6)	91 (±20.8)
Shoulder flexion (Newton)	90.3 (±24.3)	91.1 (±20.3)	123.7 (±17.2)	127.3 (±21.2)	107.8 (±18.1)	109.7 (±9.2)
Shoulder extension (Newton)	63.3 (±15.2)	64 (±13.7)	72.5 (±18.1)	75.5 (±19.3)	65.3 (±8.2)	65 (±8.3)
Handgrip strength (Newton)	48.7 (±15.9)	47.9 (±12.7)	–	–	27.4 (±3.8)	27.6 (±4.9)

n does not add up as 2 participants dropped out before 20 weeks. Handgrip strength was not tested at 20 weeks.

recovered to above 115° of abduction. Shoulder flexion and external rotation were not markedly restricted at 50-week follow-up.

Discussion

The pilot trial had a high recruitment rate and both the test and exercise program were feasible with high satisfaction and no reports of serious adverse events. Two participants dropped out early, but adherence to supervised exercise was high for the remaining six participants. Unfortunately, two participants stopped exercising during home exercise, and one of these presented with lymphoedema at 50-week follow-up. The supervised exercise caused an increase in strength, although this could not fully be maintained through home exercise.

Arm volume

Among the participants in this study, one had clinical and subjective symptoms of lymphoedema at 50 weeks, whereas three others had experienced transient swelling during the intervention period but when assessed at 50 weeks this had been reversed. At 20–26 weeks of exercise there was a tendency towards a peak in ILVD in four of five patients with complete data on arm volume. This could be a symptom of accumulated treatment effects through the first 5–6 months, and with time and continued exercise ILVD decreased. Other studies have reported similar findings of transient swelling within the first year after BC surgery [22,23]. Kilbreath and colleagues [22] identified risk factors for swelling at different time points through the first 15 months after surgery, and at nine months after surgery the risk factors were taxane-based chemotherapy and increased ILVD 1 month post-operatively. Information on taxane-based chemotherapy will be available and investigated when the RCT is conducted.

When considering the mechanisms through which exercise could influence development of lymphoedema, such as the muscle pump and conditioning of the arm, we would expect them to have effect only for as long as the person continues to exercise. Of the two patients who discontinued exercise in the home exercise period, one got lymphoedema. Her increased ILVD and clinical signs of lymphoedema lasted approximately six months, which could be termed chronic lymphoedema, as also suggested by Kilbreath and colleagues [22].

Muscle strength and adherence to exercise

Adherence to exercise in the supervised period was high and muscle strength increased in all tests except in the handgrip test. The increase in muscle strength over 20 weeks is comparable with that seen in other studies of PRT after BC [17,24], although the supervised exercise applied in these studies was of shorter duration (eight and 13 weeks). According to the principles of exercise [10] we would expect diminishing returns from the exercise in the following period of home exercise, for instance as subjects become stronger, muscle strength increases less proportionately. However, only three of six participants had high adherence in the home exercise period, which had probably limited the mean strength increase at 50 weeks. The transition to home-based exercise was intended bridged by the use of one weekly exercise session at home during the supervised period and weekly mobile phone text messages were intended to contribute to continued commitment. However, the three patients with low exercise compliance reported that exercising was not a priority after returning to work.

We found a discrepancy between monthly self-managed strength test reports (elbow flexion and shoulder abduction) during the home exercise period and the 7RM strength tests in the same period. The self-managed testing showed maintained strength through this period, whereas the 7RM test at 50-week follow-up showed a decrease in strength. This discrepancy could be due to the unsupervised self-managed tests being imprecise and participants insufficiently instructed in avoiding compensations, causing quality to be low in both tests and exercises. Another reason could be that testers improved their ability to standardise the test and correct compensatory mechanisms from their experience in the first year, hence performing the test correctly at 50-week follow-up would require higher muscle strength.

The handgrip strength test diverges from the other muscle strength tests, showing a nearly halved strength bilaterally from baseline to 50-week follow-up. Handgrip strength has been widely used as a proxy for upper body strength [25], and although disputed in a study by Rogers and colleagues [26], this finding is rather puzzling. Our results suggest that the exercises in LYCA did not effectively improve handgrip strength but on the contrary caused deterioration. Not even an observational study on non-exercising BC survivors [27] reported such deterioration; here decreased handgrip strength was found in 40% of participants. The RCT will examine the possibility of measurement error and chance finding in handgrip strength.

Movement impairment

Several studies have documented impaired range of shoulder movement one year or more after BC surgery, with a prevalence ranging from 1.5% to 51% [7,28,29]. The group with the highest prevalence is often reported to be that receiving radiotherapy and ALND, as did the participants in this study. Among our participants, one had developed severe restriction (88°) of shoulder abduction after one year. The exercise program in LYCA does not seem to have caused worse outcomes for range of shoulder movement than could be expected in this population.

Amendments

Minor amendments to the RCT protocol were made and attention was drawn to possible problems on the basis of experiences with the present study. The abduction exercise caused one of the participants to experience pain, but the exercise was adjusted and pain was eliminated. Following the baseline testing of the participants, we also improved the standardisation of the dynamic muscle testing by further specifying the test protocol to avoid uncertainty in the measurements.

A weakness of the intervention is that we focus only on one aspect of rehabilitation, namely the progressive strength training, leaving stretching, endurance training or other rehabilitation needs to usual care in the community centre. Some participants indicate in the questionnaire that they could have wished for the individual treatment available at the community centre. Due to problems overcoming the logistic and time issues participation brings, some abstained from receiving the community-based rehabilitation. In addition to affecting the individual recovery of each patient, this could affect the adherence and drop-out rate, as well as the recruitment of participants to the current study. To accommodate this in the RCT we will allow for exercising with the LYCA program at the community centre some of the time, as long as monitoring and progression are not disrupted. A problem with the home exercise is the low adherence. To overcome this we shall increase the information about and explanation of the importance of continued exercise in the RCT, and offer guidance by telephone if needed.

Conclusion

LYCA is feasible and acceptable, with no serious adverse events registered through the baseline testing and intervention, although the pilot study gave rise to improvements in the RCT protocol. The supervised exercise program characterised by high adherence was successful in increasing muscle strength among participants, but adherence and muscle strength decreased somewhat through the home-based exercise period. One participant presented with lymphoedema at 50-week follow-up. We shall further explore the findings in this study in an RCT.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Ethics

Ethical approval was obtained from the participating hospitals and the regional Ethical Committee system, Protocol number: H-15002714. Data is filed in accordance with Danish Data Protection Board, and the study was registered in Clinicaltrials.gov (NCT02518477) before inclusion of the first patient. Standard compression garments were kindly supplied by JUZO [30], to eliminate differences in the delivery of this first line of lymphoedema treatment in the municipalities involved.

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References

[1] Hayes S, Janda M, Cornish B, et al. Lymphedema secondary to breast cancer: how choice of measure influences diagnosis, prevalence, and identifiable risk factors. Lymphology. 2008;41:18–28.
[2] DiSipio T, Rye S, Newman B, et al. Incidence of unilateral arm lymphoedema after breast cancer: a systematic review and meta-analysis. Lancet Oncol. 2013;14:500–515.
[3] Bloomquist K, Karlsmark T, Christensen KB, et al. Heavy resistance training and lymphedema: prevalence of breast cancer-related lymphedema in participants of an exercise intervention utilizing heavy load resistance training. Acta Oncol. 2014;53:216–225.
[4] Hormes JM, Bryan C, Lytle LA, et al. Impact of lymphedema and arm symptoms on quality of life in breast cancer survivors. Lymphology. 2010;43:1–13.
[5] Vassard D, Olsen MH, Zinckernagel L, et al. Psychological consequences of lymphoedema associated with breast cancer: a prospective cohort study. Eur J Cancer: 1990. 2010;46:3211–3218.
[6] Chachaj A, Malyszczak K, Pyszel K, et al. Physical and psychological impairments of women with upper limb lymphedema

following breast cancer treatment. Psycho-Oncology. 2010;19: 299–305.
[7] Gartner R, Jensen MB, Kronborg L, et al. Self-reported arm-lymphedema and functional impairment after breast cancer treatment–a nationwide study of prevalence and associated factors. Breast. 2010;19:506–515.
[8] Torres Lacomba M, Yuste Sanchez MJ, Zapico Goni A, et al. Effectiveness of early physiotherapy to prevent lymphoedema after surgery for breast cancer: randomised, single blinded, clinical trial. BMJ (Clinical Research Ed). 2010;340:b5396.
[9] Box RC, Reul-Hirche HM, Bullock-Saxton JE, et al. Physiotherapy after breast cancer surgery: results of a randomised controlled study to minimise lymphoedema. Breast Cancer Res Treat. 2002;75:51–64.
[10] Hoffman J. Physiological aspects of sport training and performance, 2nd edition. Champaign (IL): Human Kinetics; 2014.
[11] Lauridsen MC, Christiansen P, Hessov I. The effect of physiotherapy on shoulder function in patients surgically treated for breast cancer: a randomized study. Acta Oncol. 2005;44:449–457.
[12] Sagen A, Karesen R, Risberg MA. Physical activity for the affected limb and arm lymphedema after breast cancer surgery. A prospective, randomized controlled trial with two years follow-up. Acta Oncol. 2009;48:1102–1110.
[13] Lee TS, Kilbreath SL, Refshauge KM, et al. Pectoral stretching program for women undergoing radiotherapy for breast cancer. Breast Cancer Res Treat. 2007;102:313–321.
[14] Ahmed RL, Thomas W, Yee D, et al. Randomized controlled trial of weight training and lymphedema in breast cancer survivors. J Clin Oncol. 2006;24:2765–2772.
[15] Courneya KS, Segal RJ, Mackey JR, et al. Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: a multicenter randomized controlled trial. J Clin Oncol. 2007;25:4396–4404.
[16] Beurskens CH, van Uden CJ, Strobbe LJ, et al. The efficacy of physiotherapy upon shoulder function following axillary dissection in breast cancer, a randomized controlled study. BMC Cancer. 2007;7:166.
[17] Schmitz KH, Ahmed RL, Troxel AB, et al. Weight lifting for women at risk for breast cancer-related lymphedema: a randomized trial. JAMA. 2010;304:2699–2705.
[18] McKenzie DC, Kalda AL. Effect of upper extremity exercise on secondary lymphedema in breast cancer patients: a pilot study. J Clin Oncol. 2003;21:463–466.
[19] Cheema B, Gaul CA, Lane K, et al. Progressive resistance training in breast cancer: a systematic review of clinical trials. Breast Cancer Res Treat. 2008;109:9–26.
[20] Schmitz KH, Ahmed RL, Troxel A, et al. Weight lifting in women with breast-cancer-related lymphedema. New Engl J Med. 2009;361:664–673.
[21] McClure MK, McClure RJ, Day R, et al. Randomized controlled trial of the Breast Cancer Recovery Program for women with breast cancer-related lymphedema. Am J Occup Ther. 2010;64:59–72.
[22] Kilbreath SL, Lee MJ, Refshauge KM, et al. Transient swelling versus lymphoedema in the first year following surgery for breast cancer. Support Care Cancer. 2013;21:2207–2215.
[23] Kim M, Shin KH, Jung SY, et al. Identification of prognostic risk factors for transient and persistent lymphedema after multimodal treatment for breast cancer. Cancer Res Treat. 2016;48:1330–1337.
[24] Kilbreath SL, Refshauge KM, Beith JM, et al. Upper limb progressive resistance training and stretching exercises following surgery for early breast cancer: a randomized controlled trial. Breast Cancer Res Treat. 2012;133:667–676.
[25] Cantarero-Villanueva I, Fernandez-Lao C, Diaz-Rodriguez L, et al. The handgrip strength test as a measure of function in breast cancer survivors: relationship to cancer-related symptoms and physical and physiologic parameters. Am J Phys Med Rehabil. 2012;91:774–782.
[26] Rogers BH, Brown JC, Gater DR, et al. Association between maximal bench press strength and isometric handgrip strength among breast cancer survivors. Arch Phys Med Rehabil. 2016. doi: 10.1016/j.apmr.2016.07.017.
[27] Rietman JS, Dijkstra PU, Debreczeni R, et al. Impairments, disabilities and health related quality of life after treatment for breast cancer: a follow-up study 2.7 years after surgery. Disabil Rehabilit. 2004;26:78–84.
[28] De Groef A, Van Kampen M, Dieltjens E, et al. Effectiveness of postoperative physical therapy for upper-limb impairments after breast cancer treatment: a systematic review. Arch Phys Med Rehabilit. 2015;96:1140–1153.
[29] Hayes SC, Johansson K, Stout NL, et al. Upper-body morbidity after breast cancer: incidence and evidence for evaluation, prevention, and management within a prospective surveillance model of care. Cancer. 2012;118(8 Suppl):2237–2249.
[30] JUZO. 2016. Available from: http://www.juzo.com/