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Impact of a self management mobile application on quality of life and limb circumference in women with breast cancer related lymphedema

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Breast cancer-related lymphedema (BCRL) adversely affects the daily performance and quality of life (QoL) in affected patients. This study aimed to determine the Impact of a self-management mobile application on quality of life and limb circumference in women with BCRL. This randomized clinical trial was conducted on 180 patients with BCRL in Shiraz, Iran, from May 2023 to January 2024. The participants were randomly assigned to the intervention ($n = 90$) and control ($n = 90$) groups. The control group received the normal treatments at the lymph clinic. In addition to the usual clinic treatments, the intervention group had access to a mobile application for 3 months. The primary outcomes were QoL, assessed using the Lymphedema Life Impact Scale (LLIS), and the difference in arm circumference, measured using a standard tape. After the intervention, the mean (SD) LLIS score in the intervention group was 29.1 (10.7), which was significantly lower than the control group with 39.3 (15.5). This difference was statistically significant ($p < 0.001$), indicating a substantial improvement in QoL in the intervention group compared to the control group. Additionally, the intervention group showed a lower mean (SD) arm circumference difference of 2.18 (1.4) compared to the control group with 3.78 (2.6). This result also was statistically significant ($p < 0.001$). Therefore, we recommend using the application to support self-management among women with BCRL.

Keywords Breast cancer, Lymphedema, Lymphedema management, Self-management, Mobile applications, Smartphone

Abbreviations

BCRL	Breast cancer-related lymphedema
CDT	Complex decongestive therapy
SPSS	Statistical package for the social sciences
QoL	Quality of life
LLIS	Lymphedema life impact scale
BMI	Body mass index
RCT	Randomized clinical trial
QUIS	Questionnaire for user interaction satisfaction

Over the past decade, tremendous advances in the diagnosis and treatment of breast cancer have dramatically improved patient survival[1]. However, the disease and its treatments have unique challenges for breast cancer survivors[2]. Among these, breast cancer-related lymphedema (BCRL) is considered a critical chronic complication that leads to various physical, emotional, and functional impairments[3] which can significantly affect the quality of life (QoL)[4]. The reported prevalence of BCRL varies across regions and studies, depending on diagnostic methods and population characteristics[5]. It is estimated that approximately 20–30% of women eventually develop

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BCRL after treatment for breast cancer[6]. A recent study reported a prevalence of approximately 30% in low- and middle-income countries[5]. Furthermore, a cross-sectional study in China found an alarming prevalence of 49%[7]. Recent estimates indicate that the prevalence of BCRL in Iran ranges from 4 to 21%[8].

It should be recognized that the high prevalence of BCRL reflects a serious impact on women's QoL, encompassing physical, emotional, and social dimensions[9]. Women with BCRL often experience decreased QoL due to physical limitations, discomfort, and psychological distress[10]. This deterioration is primarily caused by impaired mobility, swelling, and persistent emotional strain[11]. Research suggests that interventions adressing both physical symptoms and emotional needs can lead to significant improvements in the QoL of individuals with BCRL[12,13]. Therefore, effective long-term management is crucial for preventing lymphedema progression[14]. Nevertheless, access to specialized lymphedema care remains limited in some regions, due to a shortage of trained professionals and dedicated clinics[15]. This gap underscores the self-management strategies that empower patients to take an active role in their care[14].

Evidence suggests that supporting self-management behaviors is essential for optimal lymphedema control and improved QoL[16]. Self-management is a fundamental component of lymphedema care, requiring lifelong commitment to prevent disease progression[14]. However, adherence to self-management practices is generally poor among patients with BCRL and often declines over time[17]. Multidimensional factors encompassing clinical, psychological, technological, and socioeconomic aspects, frequently hinder optimal self-management[18–20]. Studies have identified barriers such as high treatment costs, limited access to care, insufficient patient education, and lack of ongoing support[15,18,19]. For example, although structured exercise programs are proven to improve BCRL outcomes, their real-world implementation is often constrained by limited resources and patient-specific challenges[21].

To address these challenges, various self-management strategies have been investigated, with several studies assessing the effectiveness of educational interventions in improving lymphedema-related outcomes. While these studies indicate that self-management techniques can reduce edema volume and improve QoL, their conclusions are limited by notable methodological shortcomings. Many lacked control groups or involved small sample sizes, undermining the strength and generalizability of their findings. Furthermore, reliance on traditional educational tools, such as booklets, often fails to ensure long-term engagement or provide real-time feedback. Moreover, QoL in these studies was frequently assessed using generic instruments that may not fully capture the specific physical and psychosocial burdens of BCRL. Therefore, there remains an urgent need for approaches that offer sustained support and interactive feedback to promote consistent adherence to self-management practices[22–24].

Within this context, m-health technologies offer novel opportunities to enabe caregivers to remotely monitor patients, provide educational resources, and facilitate communication between patients and healthcare teams[25]. M-health interventions, particularly mobile applications, are accessible and scalable, granting patients immediate access to education, support, and monitoring tools[26]. Given the crucial role of self-management in lymphedema care, these technologies hold considerable promise. However, there is a notable paucity of randomized controlled trials (RCT) evaluating the efficacy of mobile applications in managing BCRL[27]. Most existing studies are qualitative[28] or quasi-experimental[29] and lack control groups[24], highlighting the need for robust RCTs. While some research has examined the impact of these applications on patient-centered outcomes such as sexual life, body image[29], and lymphedema symptoms[27], their effects on overall QoL and lymphedema volume have not been explored in depth. Moreover, the applications assessed in previous studies frequently lack nurse support for continuous monitoring and personalized care. They also often fail to incorporate education based on the key principles of complex decongestive therapy (CDT), the gold standard of lymphedema management[30]. Furthermore, they frequently do not address important features such as feedback systems, peer support tools, adherence reminders, and progress tracking[24,28,29,31,32].

Despite the critical role of self-management in lymphedema care, there remains a lack of accessible, multifaceted, and nurse-supported digital tools that meet patients' long-term needs, particularly in resource-limited settings. While lymphedema self-care is essential, many patients struggle to translate clinical recommendations into daily practice. Current interventions often lack interactivity, personalization, and integration of professional support, which are keys for sustained adherence and behavior change. Given the existing gap in evidence regarding holistic, patient-centered, and technology-based interventions for lymphedema and QoL enhancement, we intended to address these research needs. To this end, we conducted a RCT to determine the effectiveness of a newly developed self-management mobile application with established usability in patients with BCRL. The application provides continuous nurse support, peer support, and patient empowerment through individualized goal-setting. It also includes reminders, feedback functionalities, symptom tracking, and visualization of edema progression to facilitate patient compliance and sustained engagement in treatment. To obtain precise and condition-specific measurements, the study utilized the Lymphedema Life Impact Scale (LLIS), a validated tool designed to assess the experiences and challenges of patients with BCRL. Accordingly, this study aimed to determine the impact of a self-management mobile application on QoL and limb circumference in women with BCRL.

Methods

Design and participants

From June to November 2023, this RCT with a controlled pre/post-test design was conducted on 180 women referred to a lymphatic clinic affiliated with Shiraz University of Medical Sciences in Shiraz, Iran. This study hypothesized that the self-management mobile application would improve both QoL and limb circumference outcomes in women with BCRL at a three month follow up. Based on a previous single group pre–post study by Liang et al.[24], the mean (SD) scores for the general health domain of QoL were 56.64 (21.09) before and 62.93 (22.60) after the intervention. Therefore, the sample size calculation was based on the paired sample t-test. With a significance level of 5% and a power of 80%, the minimum required sample size was calculated using G*Power

version 3.1 and found to be 77 participants. To accommodate an anticipated attrition rate of 15%, the sample size was increased to 90 participants per group for this randomized controlled trial.

Inclusion criteria included women aged 18 years or older who were willing to participate in the study, had no psychiatric disorders, underwent breast cancer surgery with axillary lymph node dissection, and were at least six months post-surgery. Additional criteria included no neuromuscular disease affecting the hand or arm, having a minimum difference in arm circumference of two centimeters, not suffering from cardiac and renal diseases, owning a smartphone with either an Android or iOS, and the ability to use the smartphone for educational purposes. Exclusion criteria included active malignancy, recurrence of breast cancer, refusal to continue participation, receipt of chemotherapy or radiation therapy, participation in other educational programs related to lymphedema management during the study period, and failure to complete the study instruments.

Finally, a total of 180 eligible women were selected based on the inclusion and exclusion criteria. Participants were then randomly assigned in a 1:1 ratio to either the intervention group ($n=90$) or the control group ($n=90$) using block randomization with a block size of 4, generated by Random Allocation Software (version 2.0). The allocation sequence was concealed in opaque, sequentially numbered envelopes, which were opened by a blinded research assistant upon enrollment. At the end of the study, four individuals in the control group were excluded due to their unwillingness to participate in the post-test, following the per-protocol analysis approach. This led to a final sample size of 90 participants in the intervention group and 86 in the control group. Figure 1 shows the CONSORT diagram, illustrating the selection process and exclusions.

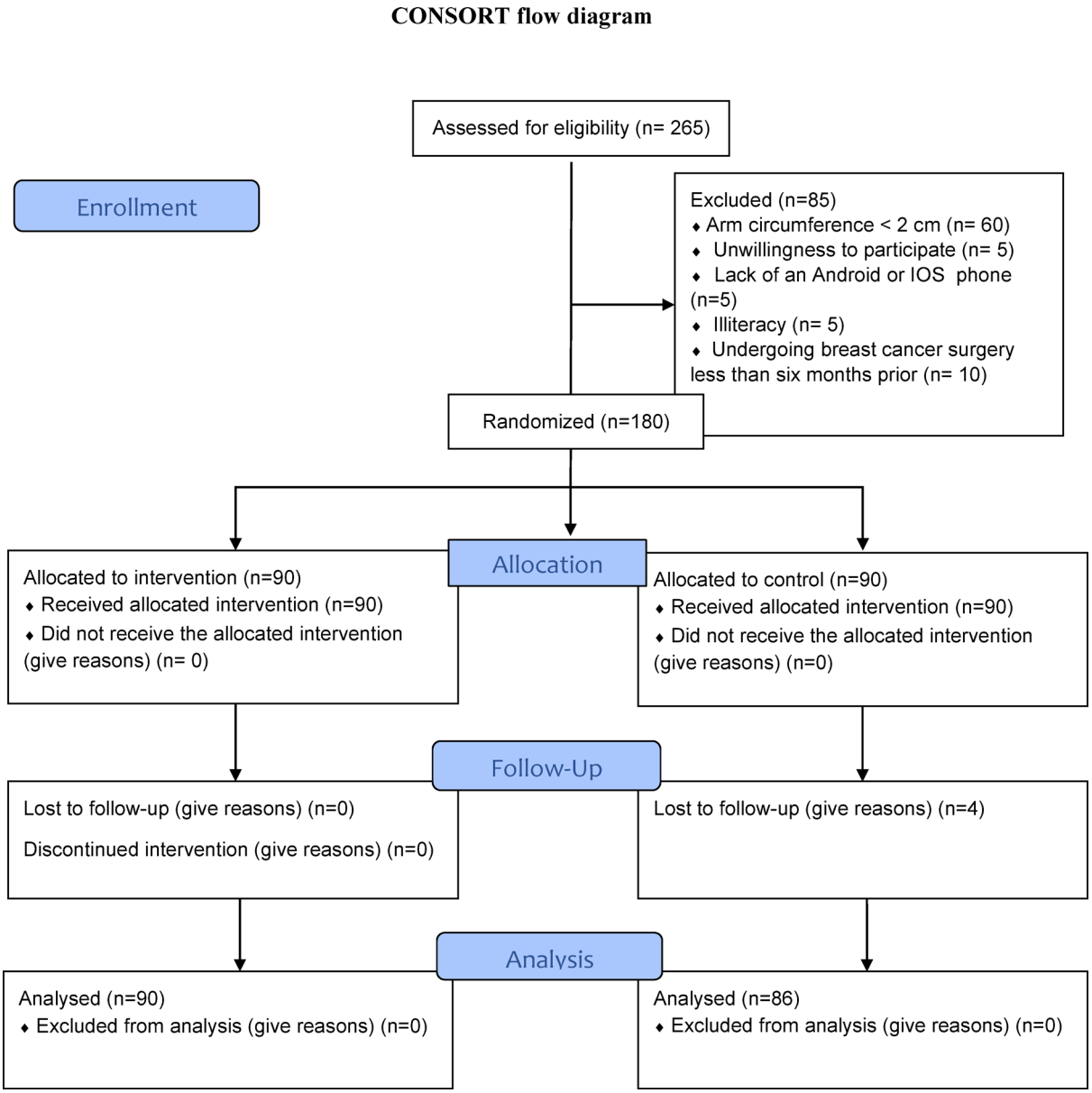

Fig. 1. CONSORT flow diagram.

Intervention

In this study, the control group received standard lymph clinic care, which included regular consultations with a lymph therapist, measurement of arm circumference, decongestive treatments provided by the clinic's physiotherapist, and provision of an educational booklet.

In addition to standard lymph clinic care, the intervention group received access to the "lymphedema self-management application" for three months. The application was conceptualized and designed in 2023 by the research team at Shiraz University of Medical Sciences, who were responsible for developing all educational content and defining the functional modules. In order to design the application, the content was initially developed based on clinical guidelines for CDT, expert consensus, and a comprehensive review of relevant scientific literature on patient self-care, lymphedema management, and existing digital health tools. A multidisciplinary expert panel reviewed and approved the content and structure, ensuring clinical and scientific accuracy. Following content finalization, software coding and technical implementation were outsourced under a contractual agreement to Aria Part E-commerce Company, which handled the programming of the application using Java for both Android and iOS platforms.

Upon launching the application, users are presented with a welcome message, an introduction, and a section for entering personal information. This is followed by access to the main menu, which includes the application's modules. The application consists of ten interactive modules designed to assist patients in managing their condition, with guidance provided by nurses. Specifically, the "lymphedema reduction skills" module features four educational videos on massage, self-bandaging, exercises, and skin care, each followed by a confirmation button ("I did the activity"). Moreover, the "arm circumference measurement" module instructs users on how to measure arm circumference and record their data over time. The "lymphedema information" module provides explanatory videos about the lymphatic system, symptoms, and risk management strategies. In addition, the "ask from the nurse" module enables users to submit questions and receive responses within 72 h, while the "online self-help group" module supports peer interaction and is facilitated by a nurse. The "lymphedema diary" allows patients to track their self-care activities, set goals, and visualize trends in exercise frequency, arm circumference, and mood. Through the "calendar" module, users receive twice-weekly reminders to perform their self-care tasks. At the end of the intervention period, the "application survey" module collects user feedback through ten structured questions. Finally, the "online exam" module reinforces learning by delivering monthly quizzes with multiple-choice questions, along with explanations about the correct answers. Each module includes a help icon for user guidance, and nurses have access to user data to monitor progress and provide personalized feedback.

The finalized version of the application underwent usability testing in a previous study involving 87 patients with BCRL. Usability was assessed using the Questionnaire for User Interaction Satisfaction (QUIS), version 5.5. Results showed that the overall usability mean score was 7.7 (1.0) out of 9, indicating a high level of usability. The highest-rated domain was screen layout, with a mean (SD) of 8.0 (1.0), while the lowest-rated domain was terminology and system information, with a mean (SD) of 7.3 (1.6). Within this domain, the lowest mean scores were observed for items related to error messages and task-related terminology, with mean (SD) values of 6.7 (2.1) and 6.9 (2.0), respectively. Notably, all usability dimensions scored above 7, reflecting consistently positive evaluations across all areas. No significant differences in usability scores were observed based on age, marital status, or type of surgery. However, urban residents rated the screen layout significantly higher than rural residents, with mean (SD) scores of 8.1 (1.0) and 7.8 (0.7), respectively ($P=0.025$). Furthermore, participants with academic education reported significantly higher total usability scores [mean (SD): 8.2 (0.6)] compared to those with primary [mean (SD):7.4 (1.0)] or secondary education [mean (SD): 7.5 (1.2) ($P=0.010$ and $P=0.005$, respectively)[33]. These findings support the application's suitability for diverse patient populations.

It is worth noting that Research Ethics Committee of Shiraz University of Medical Sciences has approved using the application for women with BCRL. The application can be accessed via https://bcrlselfmanagement.ir/, with required login credentials. Table 1 presents the modules and key features of the lymphedema self-management application.

The results showed no significant difference between the two groups concerning the LLIS total score or its dimensions before the intervention. After the intervention, the LLIS total score in both intervention ($P=0.001$) and control ($P=0.001$) groups significantly reduced compared to before the intervention. After the intervention, the total LLIS score and the scores of its three dimensions in the intervention group were significantly lower than the control group ($P=0.001$). The effect sizes associated with the differences in LLIS scores between the intervention and control groups following the intervention ranged from 0.657 to 0.780, indicating a moderate to large effect size (Table 3).

The results showed no significant difference between the two groups in terms of the mean arm circumference difference before the intervention ($P=0.622$). Nevertheless, the arm circumference difference in both intervention ($P=0.001$) and control ($P=0.001$) groups significantly reduced compared to before the intervention. Furthermore, the arm circumference difference of the intervention group was significantly lower than the control group ($P=0.001$). The effect size associated with the difference in arm circumference between the intervention and control groups following the intervention was 0.780, indicating a moderate to large effect size (Table 3).

The application was installed on the smartphones of participants in the intervention group, and its use was thoroughly explained. In addition, the researcher encouraged participants to contact her if they encountered any problems or had any questions about the application.

Data collection

Demographic information, the Lymphedema Life Impact Scale (LLIS), and a standard tape measure to assess arm circumference differences were used to collect study data. The primary outcomes were QoL, assessed using the LLIS, and the difference in arm circumference, measured using a standard tape. All participants completed

Modules	Key features
Lymphedema reduction skills	Four educational videos on: 1. Self-bandaging (26 min) 2. Self-lymphatic massage (13 min) 3. Lymphatic exercises (4 min) 4. Skin care tips for BCRL (13 min)
Arms circumference difference measurement	An educational video on lymphedema self-measurement (5 min)
	Arm circumference difference recording form
Lymphedema information	Three educational videos on: 1. Lymphatic system and lymphatic dysfunction (4 min) 2. Lymphedema manifestations (3 min) 3. Lymphedema risk management (14 min)
Ask from the nurse	A space for recording patients' questions and providing responses within 72 h
Online self-help group	A virtual peer support group held once a week at a scheduled time
Application survey	Ten closed-ended questions designed to assess users' opinions about the application
Lymphedema diary	A dedicated page for documenting daily performance in self-management activities
	A text box for setting self-management goals
	A text box for documenting favorable events of the week
	A video on the Simonton relaxation technique (3 min)
	Three charts related to: 1. Frequency of performing complex decongestive therapy techniques 2. Changes in arm circumference difference 3. Changes in emotions
Calendar	Specification for setting the day and time of reminder notifications with minimal clicks
Online exam	Nine monthly multiple-choice questions with explanations based on educational videos content
Settings	A place for updating username and password

Table 1. The lymphedema self-management application: modules and their key features.

Variables		Total ($n=176$)	Intervention ($n=90$)	Control ($n=86$) #	
		n (%)	n (%)	n (%)	*P*-value*
Marital status	Single	6 (3.4)	2 (2.2)	4 (4.7)	0.735*
	Divorced	13 (7.4)	7 (7.8)	6 (7)	
	Widowed	26 (14.8)	15 (16.7)	11 (12.8)	
	Married	131 (74.4)	66 (73.4)	65 (75.7)	
Educational level	Primary	72 (40.9)	42 (46.7)	30 (34.9)	0.061*
	Secondary	53 (30.1)	20 (22.2)	33 (38.4)	
	Academic	51 (29)	28 (31.1)	23 (26.7)	
Occupation	Employed	29 (16.5)	15 (16.7)	14 (16.3)	0.943*
	Housekeeping	126 (71.6)	65 (72.2)	61 (70.9)	
	Retirement	21 (11.9)	10 (11.1)	11 (12.8)	
Type of surgery	Modified radical mastectomy	95 (54)	45 (50)	50 (58.1)	0.279*
	Breast conversation	81 (46)	45 (50)	36 (41.9)	

Table 2. Comparison of qualitative demographic and clinical characteristics of the participants between the intervention and control groups. *The p-values were derived from Pearson's Chi-square test. #The control group size reduced to 86 due to the exclusion of four participants who did not complete the post-test, following the per-protocol analysis approach.

the LLIS at baseline and again three months post-intervention. Arm circumference measurements were also recorded at each time point. In addition, at the fourth and eighth weeks post-intervention, the researcher contacted participants in the intervention group to monitor their use of the application, identify any issues they encountered, and encourage continued engagement with the application.

The demographic form included questions about age, body mass index (BMI), education level, marital status, and occupation. It also asked about the type of surgery they had and the length of time between the surgery and the onset of their lymphedema.

LLIS

The LLIS was developed by Weiss et al. (2015) at Missouri State University. This comprehensive instrument specifically assesses the degree of impairment in QoL related to BCRL in three dimensions, which are physical, psychosocial, and functional. The questionnaire consists of 18 items. The items are scored on a Likert scale from 1, indicating no impairment, to 5, indicating severe impairment. The physical dimension consists of eight items

Lymphedema life impact scale dimensions	Evaluation time	Group				*P*-value (between-groups)	Cohen's d effect size
		Intervention $n=90$		Control $n=86$			
		Mean	SD	Mean	SD		
Physical	Before intervention	20.1	6.5	20	6.6	0.967**	0.006
	After intervention	12.8	5.1	17.6	7.2	0.001**	0.761
P-value (within-groups)		0.001*		0.001*			
Psycho-social	Before intervention	9.1	4	9.1	4	0.962**	0.005
	After intervention	6.2	3	8.7	4.5	0.001**	0.666
P-value (within-groups)		0.001*		0.174*			
Functional	Before intervention	15.4	4.6	14.5	4.9	0.234**	0.179
	After intervention	10	3.7	12.9	4.9	0.001**	0.657
P-value (within-groups)		0.001*		0.001*			
Total	Before intervention	44.6	12.7	43.7	13.8	0.665**	0.065
	After intervention	29.1	10.7	39.3	15.4	0.001**	0.767
P-value (within-groups)		0.001*		0.001*			
Arm circumference difference	Before intervention	5.3	2.7	5.5	2.6	0.622**	0.075
	After intervention	2.2	1.4	3.8	2.6	0.001**	0.780
P-value (within-groups)		0.001*		0.001*			

Table 3. Within-group and between-group comparison of the quality of life and arm circumference difference in the intervention and control group, before and after the intervention. *The p-values were derived from paired t-test. **The p-values were derived from independent t-test. #The control group size reduced to 86 due to the exclusion of 4 participants who did not complete the post-test, following the per-protocol analysis approach.

and is scored from 8 to 40. The psychosocial dimension consists of four items and is scored between 4 and 20. The functional dimension has six items and this part scores between 6 and 30. The sum of the scores of all the 18 items is in the range of 18 to 90 and it makes up the total score. Also, a lower score on the instrument indicates less impairment, whereas a higher score reflects greater impairment in quality of life.

Weiss et al. validated the questionnaire through a comprehensive evaluation including content, construct, and criterion validity. Face validity was established by assessing the relevance of LLIS questions to patients' lymphedema experience, supported by expert ratings. The overall content validity index for the LLIS was 0.94, which indicates a strong consensus among experts that all questions were either relevant or highly relevant to the problems faced by patients with lymphedema. Construct validity was also confirmed by Pearson's correlation between LLIS scores and lymphedema symptoms ($r=0.706$ to 0.830). In addition, each domain of the LLIS showed significant correlations with the corresponding domains of the comparison instruments ($P<0.001$), confirming the criterion validity of the LLIS. The reliability of the scale was confirmed by intraclass correlations of the instrument dimensions with test-retest reliability ranging from 0.96 to 0.99. Cronbach's alpha values for internal consistency ranged from 0.84 to 0.92[34]. For the Persian version of the instrument, Haghighat et al. used a forward-backward translation procedure. They used confirmatory and exploratory factor analyses to confirm its construct validity. The LLIS showed strong internal consistency, with Cronbach's alpha of 0.96 for total score and 0.87, 0.85, and 0.88 for physical, psychosocial, and functional dimensions, respectively. In addition, the stability of the LLIS was estimated to be between 0.85 and 0.97 in a subgroup of 13 participants using the test-retest method[35].

A standard tape measure

In this research, all circumference measurements were conducted using a flexible and non-elastic tape, typically utilized to gauge lymphedema circumference in lymph clinics. Consequently, a uniform procedure for measuring arm circumference was implemented, consistent with earlier studies[36,37]. Measurements were made on both bare arms at the wrists and at 10, 20, 30, and 40 cm above the wrists. Participants were seated with their arms supported on a table, their shoulders flexed forward by about 30°, and their elbows flexed by 45°. A pen was utilized to mark the wrist and further measurement points at specified intervals from the wrist on the skin. The researcher subsequently placed the tape measure around the arm at the predetermined locations, making sure it was snug but not tight. She documented the circumference to the closest centimeter and maintained a thorough log of the measurements, noting the date and measurement locations, on a designated form. Bilateral arm measurements were documented to monitor changes in arm circumference during follow-up visits.

To assess tape measure reliability, the researcher and an assistant independently measured arm circumference in the same 10 patients. The Pearson correlation coefficients were 0.97, 0.95, 0.97, 0.99 and 0.97 at the wrists and at 10, 30 and 40 cm above the wrists, respectively ($P=0.001$). These results suggest a high level of reliability and consistency in the measurements obtained using the tape measure.

Data analysis

The data obtained in the research were analyzed by SPSS version 22 software (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). Data were analyzed using a per-protocol approach. Participants with incomplete post-test data ($n=4$ in the control group) were excluded from the final analysis. Based on the results of the Kolmogorov-Smirnov test, the data related to demographic information, clinical variables, QoL, and arm circumference difference were assumed to be normally distributed, so parametric tests were used. The Pearson's Chi-square test used to assess differences in the frequency of qualitative demographic and clinical variables between the two groups. Moreover, an independent sample t-test was utilized to evaluate the quantitative variables of age, BMI, and the time interval between surgery and the onset of lymphedema between the two groups. Furthermore, paired t-tests were conducted to compare pre- and post-intervention QoL and arm circumference difference within each group, while an independent sample t-test was used to compare these variables between the two groups. Cohen's d effect size was calculated for between-group changes. The effect sizes of 0.8, 0.5, and 0.2 were considered large, medium, and weak, respectively[38]. $P<0.05$ was considered statistically significant.

Results

Among the 180 enrolled patients, 176 completed the study. The mean (SD) age of the participants in the intervention group was 52.1 (10) years, and in the control group, it was 52.1 (8.5) years ($P=0.997$). The mean (SD) BMI was 27.3 (3.5) for the intervention group and 27.2 (3.7) for the control group ($P=0.821$). Additionally, the mean (SD) time interval between surgery and the onset of lymphedema was 18.9 (27.4) months for the intervention group and 19.6 (31.2) months for the control group ($P=0.874$). No statistically significant differences were observed between the intervention and control groups in terms of demographic and clinical characteristics (Table 2).

Discussion

This RCT was designed to assess the effectiveness of a self-management mobile application on lymphedema outcomes and QoL in women with BCRL. At the end of the intervention, there were significant improvements in QoL and arm circumference in participants. Significant differences between groups after intervention, with a high value of effect size, strengthen the clinical importance of the intervention. Although the lymphedema volume and quality of life improved for both groups, the intervention group showed significantly better improvement. Improvement in the control group indicated that the care provided in the clinic was effective. The significant difference in post-test scores for QoL and arm circumference in the intervention group compared with that of the control group, along with a large effect size, depicted that the intervention was significantly more effective than clinic care alone. This finding also provides evidence for the clinical significance of the results. Although in the control group, there were only moderate improvements regarding the severity of lymphedema, the intervention group demonstrated significant reductions from severe to mild levels. This suggests that the enhanced support and resources provided by the self-management application led to greater improvements.

These findings also agree with the available literature supporting that self-management interventions are effective in lymphedema management. For instance, Liang et al. (2022) reported that an application-based intervention was associated with significant lymphedema volume reductions[24]. While Liang's application was limited to basic CDT modules, our intervention included added interactive features, namely real-time feedback from healthcare professionals and access to an online peer support group. Therefore, self-management interventions would seem to play a central role in enhancing BCRL management and subsequent alleviation of lymphedema. The confirmation of the findings from existing literature further underlines the relevance and applicability of the self-management mobile application in the context of managing the condition of lymphedema.

The findings of the present study indicated that, within three months after the intervention, the mobile-based approach was significantly more effective than routine treatment in improving QoL and its dimensions. These results confirm other studies, such as that concluded by Kaur et al. (2024), who mentioned that a mobile application designed for survivors of breast cancer improved their QoL. It seems that the structured support in the form of personalized education on the app, symptom tracking, and lifestyle recommendations helped the patients significantly in managing their symptoms effectively[39]. This suggests that such applications including varied dimensions of interaction, education, lifestyle modification, and symptom tracking, have the potential to enhance the recovery process in women after cancer treatment.

Importantly, both intervention and control groups experienced improvements in the physical and functional dimensions of QoL after three months. However, the special note is the substantial improvement in the psychosocial dimension among subjects in the intervention group compared to that of the control group. Our findings corroborate the notion that effective lymphedema management is as important for psychological health as it is for physical outcomes. This finding is supported by Jiakponna et al. (2024), who suggest that multimodal approaches, particularly those incorporating psycho-social support, have a greater impact on managing outcomes of chronic diseases[40]. Features such as an online self-help group and direct interactions with nurses, which our application integrated, might play a rather pivotal role in mitigating lymphedema's psycho-social burdens. While healthcare providers contributed essential medical guidance, the peer support provided practical demonstrations, real-life strategies, and mutual encouragement from persons with similar experiences. Indeed, studies have suggested that peer-led education and support, when combined with professional healthcare guidance, turn into an effective model for delivering self-management strategies[41].

On the other hand, it is important to acknowledge that not all studies have reported consistently positive results for mobile health interventions. For instance, Fu et al. did not find any clinically significant improvements in QoL and lymphedema volume with their web-based application[27]. This discrepancy may imply that the

design and content are important factors affecting the effectiveness of a digital intervention. The application developed by Fu et al. includes educational videos and guidelines about lymphedema management. whereas our application has much more comprehensive features, including real-time feedback, tailored reminders, and access to professional and peer support, likely account for the significant improvements observed compared to other digital interventions. As Garcia et al. (2023) suggested the effectiveness of mobile health apps is maximized when they incorporate interactive components that engage users in a meaningful way, deliver personalized content, and give feedback[42]. These aspects likely enabled patients to implement appropriate lymphedema management techniques to be more accurate and profound in these patients. It should also be noted that this effectiveness in our study, was achieved without additional costs or the need for more frequent visits to the clinic than usual. Hence, self-management strategies are critical as they empower patients to engage in daily care routines that reduce swelling and maintain function, ultimately improving their QoL (13).

Strengths and limitations

The strengths of this study include the novelty of the design for the mobile application, encompassing comprehensive patient care through education, behavioral support, and interactive elements. These features of a holistic approach in the management of BCRL provide versatility in the application and effectiveness not matched by conventional methods. The large sample size and random allocation of participants further give the study great internal validity, ensuring that the findings are robust and statistically sound. Moreover, the cross-platform compatibility of the application on both Android and iOS devices, with implemented secure personal logins, also allows the app usage from a wide range while not compromising privacy and security standards. These address major barriers of geographical distances and other time constraints that can be fostered for active patient involvement in self-management practices.

Despite all these strengths, there are a few limitations in the present study. The sample was drawn from a single treatment center, which may restrict the generalization of the findings. However, this center is a regional referral hub for many cities, and this diversity enhances the results' applicability to broader health settings. Furthermore, the nature of the intervention itself meant that participant blinding was not possible, as it would be immediately obvious who received the mobile application. While data collection, entry and analysis were blinded as far as possible, the lack of participant-level blinding is a potential source of bias. Moreover, since the intervention was delivered via a mobile application requiring internet access, its use was limited to participants with smartphones and connectivity. Future versions could include offline capabilities to enhance accessibility in low-connectivity settings. Further studies are needed to replicate these findings in diverse healthcare contexts to support broader generalization.

Conclusion

The findings of this study prove that the lymphedema self-management educational intervention with a smartphone-based intervention significantly improved lymphedema outcomes and QoL across all the dimensions in patients following breast cancer surgery. This technology appears to offer great possibilities in the facilitation of access to lymphedema management. Thus, these applications are suggested for use in lymphedema and breast cancer clinics and during the pre-and post-operative periods for teaching on prevention and management of BCRL. The results highlight the critical role of nurses in the provision of health services at the community level, particularly in the management of chronic disease conditions like lymphedema. Therefore, it is recommended that this nursing role be strengthened through the inclusion of educational content in the curriculum on strategies for self-management, as well as in-service training, particularly for oncology nursing specialists.

Given the confirmed efficacy of this approach in improving lymphedema outcomes and QoL for women with BCRL, it is recommended that similar interventions be integrated alongside in-person care in clinics, particularly for individuals facing financial constraints or living in remote areas without easy access tospecialized care. Future research should explore the long-term impacts of these interventions and examine their integration into diverse healthcare settings. In addition, future versions of the application could include offline functionality to improve accessibility for patients with limited internet access.

Data availability

Data is available from corresponding author upon reasonable request. Kindly contact zahrakhademian@yahoo.com.

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References

1. Bray, F. et al. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *Cancer J. Clin.* **68**, 394–424 (2018).
2. Sun, Y., Fu, M. R., Jiang, Y. & Little, A. S. Initiating and maintaining complete decongestive therapy Self-Management of lymphedema among breast cancer survivors: descriptive qualitative study. *Integr. Cancer Ther.* **23**, 15347354241226625 (2024).
3. Pappalardo, M., Starnoni, M., Franceschini, G., Baccarani, A. & De Santis, G. Breast cancer-related lymphedema: recent updates on diagnosis, severity and available treatments. *J. Personalized Med.* **11**, 402 (2021).
4. Jørgensen, M. G., Toyserkani, N. M., Hansen, F. G., Bygum, A. & Sørensen, J. A. The impact of lymphedema on health-related quality of life up to 10 years after breast cancer treatment. *NPJ Breast Cancer*. **7**, 70 (2021).
5. Torgbenu, E., Luckett, T., Buhagiar, M. A., Chang, S. & Phillips, J. L. Prevalence and incidence of cancer related lymphedema in low and middle-income countries: a systematic review and meta-analysis. *BMC Cancer*. **20**, 604. https://doi.org/10.1186/s12885-020-07079-7 (2020).

6. Rosa, J. I., Salomé, G. M. & Miranda, F. D. Construction and validation of an algorithm to prevent and treat upper extremity lymphedema. *Fisioterapia Em Movimento*. **33**, e003367 (2020).
7. Liu, Y. et al. Prevalence and predictors of breast cancer-related arm lymphedema over a 10-year period in postoperative breast cancer patients: A cross-sectional study. *Eur. J. Oncol. Nurs.* **51**, 101909 (2021).
8. Haddad, P. et al. A multicentre cross-sectional study of arm lymphedema four or more years after breast cancer treatment in Iranian patients. *Breast Cancer*. **17**, 281–285 (2010).
9. Viruega, H. et al. Breast cancer: how hippotherapy bridges the gap between healing and Recovery—A randomized controlled clinical trial. *Cancers* **15**, 1317 (2023).
10. Eaton, L., Narkthong, N. & Hulett, J. Psychosocial issues associated with breast cancer-related lymphedema: a literature review. *Curr. Breast Cancer Rep.* **12**, 216–224 (2020).
11. Ramirez-Parada, K. et al. Upper-Limb disability and the severity of lymphedema reduce the quality of life of patients with breast cancer-related lymphedema. *Curr. Oncol.* **30**, 8068–8077 (2023).
12. Kheirkhah, M., Haghighat, S. & Omidi, Z. *Comparing the Effect of In-Person and Virtual Lymphedema Self-Management Education on Quality of Life of Women with Breast Cancer: A Randomized Clinical Trial* (2021).
13. Omidi, Z., Kheirkhah, M., Abolghasemi, J. & Haghighat, S. Effect of lymphedema self-management group-based education compared with social network-based education on quality of life and fear of cancer recurrence in women with breast cancer: a randomized controlled clinical trial. *Qual. Life Res.*. **29**, 1789–1800. https://doi.org/10.1007/s11136-020-02455-z (2020).
14. Torgbenu, E., Luckett, T., Buhagiar, M. A. & Phillips, J. L. Guidelines relevant to diagnosis, assessment, and management of lymphedema: a systematic review. *Adv. Wound Care*. **12**, 15–27 (2023).
15. Dorri, S., Olfatbakhsh, A. & Asadi, F. Informational needs in patients with breast cancer with lymphedema: is it important? *Breast Cancer Basic. Clin. Res.* **14**, 1178223420911033 (2020).
16. Togawa, K. et al. Self-reported symptoms of arm lymphedema and health-related quality of life among female breast cancer survivors. *Sci. Rep.* **11**, 10701 (2021).
17. Karaca-Mandic, P. et al. Lymphedema self-care: economic cost savings and opportunities to improve adherence. *Cost Eff. Resource Allocation: C/E* **21**. https://doi.org/10.1186/s12962-023-00455-7 (2023).
18. Zhao, H. et al. Breast cancer-related lymphedema patient and healthcare professional experiences in lymphedema self-management: a qualitative study. *Support. Care Cancer*. **29**, 8027–8044 (2021).
19. Wang, Y. et al. Factors influencing the Self-management of breast Cancer–Related lymphedema: A Meta-synthesis of qualitative studies. *Cancer Nurs.* https://doi.org/10.1097/NCC.0000000000001340 (2024).
20. Anik, A. R. et al. Non-invasive portable technologies for monitoring breast cancer related lymphedema to facilitate telehealth: A scoping review. *IEEE J. Biomedical Health Inf.* **27**, 4524–4535 (2023).
21. Bruce, J. et al. Exercise to prevent shoulder problems after breast cancer surgery: the PROSPER RCT. *Health Technol. Assess. (Winchester, Eng)*. **26**, 1–124 (2022).
22. Temur, K. & Kapucu, S. The effectiveness of lymphedema self-management in the prevention of breast cancer-related lymphedema and quality of life: A randomized controlled trial. *Eur. J. Oncol. Nurs.* **40**, 22–35 (2019).
23. Cansız, G., Dönmez, A. A., Kapucu, S. & Borman, P. The effect of a self-management lymphedema education program on lymphedema, lymphedema-related symptoms, patient compliance, daily living activities and patient activation in patients with breast cancer-related lymphedema: a quasi-experimental study. *Eur. J. Oncol. Nurs.* **56**, 102081 (2022).
24. Liang, X. et al. Self-administration of complex decongestive therapy facilitated by the mobile application WeChat improves lymphedema and quality of life in breast cancer survivors: an observational study. *Annals Translational Med.* **10**, 146. https://doi.org/10.21037/atm-21-6662 (2022).
25. Fu, M. R. et al. mHealth self-care interventions: managing symptoms following breast cancer treatment. *Mhealth* **2** (2016).
26. Kolanu, N. D., Syeda, Z. R., Joshi, N., Singh, P. & Erukulla, M. The differential impact of medical therapy and lifestyle modification on cardiovascular health and risk of adverse cardiovascular events: A narrative review. *Cureus* **16** (2024).
27. Fu, M. R. et al. A Web- and Mobile-Based intervention for women treated for breast cancer to manage chronic pain and symptoms related to lymphedema: results of a randomized clinical trial. *JMIR Cancer*. **8**, e29485. https://doi.org/10.2196/29485 (2022).
28. Harder, H. et al. A user-centred approach to developing bWell, a mobile app for arm and shoulder exercises after breast cancer treatment. *J. Cancer Surviv.* **11**, 732–742 (2017).
29. Aydin, A. & Gürsoy, A. Nurse-led support impact via a mobile app for breast cancer patients after surgery: a quasi-experimental study (step 2). *Support. Care Cancer*. **32**, 598 (2024).
30. Pirincci, C. S., Mete, O., Yasa, M. E. & Dalyan, M. A comparative evaluation of the efficacy of complete decongestive therapy in the treatment of unilateral breast cancer–related lymphedema with and without metabolic syndrome. *Support. Care Cancer*. **32**, 473. https://doi.org/10.1007/s00520-024-08676-z (2024).
31. Ahmadi, M., Shahrokhi, S. N., Khavaninzadeh, M. & Alipour, J. Development of a Mobile-Based Self-care application for patients with breast Cancer-Related lymphedema in Iran. *Appl. Clin. Inf.* **13**, 935–948. https://doi.org/10.1055/s-0042-1757295 (2022).
32. Miranda, F. D., Salomé, G. M., Costa, M. G. & Alves, J. R. Mobile app for patient education about breast cancer surgical treatment. *Fisioterapia Em Movimento*. **35**, e35128 (2022).
33. Hemati, M., Rivaz, M. & Khademian, Z. Lymphedema self-management mobile application with nurse support for post breast cancer surgery survivors: description of the design process and prototype evaluation. *BMC Cancer*. **24**, 973. https://doi.org/10.1186/s12885-024-12744-2 (2024).
34. Weiss, J. & Daniel, T. Validation of the lymphedema life impact scale (LLIS): a condition-specific measurement tool for persons with lymphedema. *Lymphology* **48**, 128–138 (2015).
35. Haghighat, S., Montazeri, A., Zayeri, F., Ebrahimi, M. & Weiss, J. Psychometric evaluation of the Persian version of the lymphedema life impact scale (LLIS, version 1) in breast cancer patients. *Health Qual. Life Outcomes*. **16**, 132. https://doi.org/10.1186/s12955-018-0958-z (2018).
36. Dylke, E. Measurement of breast cancer-related lymphoedema. *J. Physiotherapy*. **68**, 238–243 (2022).
37. Rafn, B. S., McNeely, M. L., Camp, P. G., Midtgaard, J. & Campbell, K. L. Self-measured arm circumference in women with breast cancer is reliable and valid. *Phys. Ther.* **99**, 240–253 (2019).
38. McLeod, S. *What Does Effect Size Tell You?*. https://www.simplypsychology.org/effect-size.html (2023).
39. Kaur, M. et al. Effect of mobile phone app-based intervention on quality of life in breast cancer survivors: A randomized controlled study. *Eur. J. Cancer* **200** (2024).
40. Jiakponna, E. C. et al. Psychosocial factors in chronic disease management: implications for health psychology. *Int. J. Sci. Res. Arch.* **12**, 117–128 (2024).
41. Sun, Y., Fu, M. R., Jiang, Y. & Little, A. S. Initiating and maintaining complete decongestive therapy Self-Management of lymphedema among breast cancer survivors: descriptive qualitative study. *Integr. Cancer Ther.* **23**, 15347354241226625. https://doi.org/10.1177/15347354241226625 (2024).
42. Deniz-Garcia, A. et al. Quality, usability, and effectiveness of mHealth apps and the role of artificial intelligence: current scenario and challenges. *J. Med. Internet Res.* **25**, e44030. https://doi.org/10.2196/44030 (2023).

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Author contributions

MH, ZKh, MR, and ST contributed substantially to the study's conception and design. MH collected data, which ZKh and MH analyzed and interpreted. MH conducted the intervention. ZKh and MH participated in drafting the manuscript. ZKh, MH, MR, and ST revised the manuscript critically for important intellectual content and finally approved it.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

This research was conducted with the approval of the Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.NUMIMG.REC.1401.084) and registered at the Iranian Registry of Clinical Trials under the code IRCT20220927056047N1, registered on 2022-12-10(https://www.irct.ir). All necessary permissions and approvals were obtained in compliance with the Helsinki Declaration and the other relevant ethical guidelines. Both verbal and written informed consent were obtained from all participants after providing comprehensive oral and written explanations regarding the study objectives, methodology, procedures, and their rights as participants. Participants' privacy and confidentiality were strictly maintained throughout the study, and all personal information was handled with the utmost care.

Additional information

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