



Arm Lymphedema Prevention Adherence Questionnaire: Validation and HAPA Model Application in Breast Cancer Postoperative Patients

Qiong Wu¹, Orawan Kaewboonchoo¹, Paul Ratanasiripong², Lalita Kaewwilai¹

¹Faculty of Public Health, Mahidol University, Bangkok, Thailand, 10400

²California State University, Long Beach, USA, CA 90840

Correspondence: Orawan Kaewboonchoo, Faculty of Public Health, Mahidol University, 420/1 Ratchawithi RD., Ratchathewi District, Bangkok 10400. Thailand, 10240, E-mail: orawan.kae@mahidol.ac.th

Received: November 30 2025; Revised: February 25 2026; Accepted: March 22 2026

Abstract

Objective: Arm lymphedema is a common, lifelong postoperative complication in breast cancer survivors, and adherence to prevention behaviors may help reduce its occurrence. This study aimed to validate the modified questionnaire on adherence to arm lymphedema prevention behaviors and examine the strength of the relationship between constructs of the Health Action Process Approach (HAPA) model and adherence to arm lymphedema prevention behaviors among breast cancer postoperative patients. **Methods:** A cross-sectional study was conducted from August to November 2024. Exploratory factor analysis (EFA) assessed construct validity, and Cronbach's α evaluated reliability. Path analysis using Structural Equation Modelling (SEM) tested the HAPA model and relationships among variables. **Results:** EFA supported a three-factor structure for the modified questionnaire with an overall Cronbach's α of 0.92. In the pre-intentional motivational phase, the path coefficients demonstrated a statistically significant effect of risk perception, outcome expectancy and action self-efficacy on behavioral intention. In the post-intentional volition phase, the path from behavioral intention and coping planning to adherence to arm lymphedema prevention behaviors showed significant effects. However, the effect of coping self-efficacy and action planning on adherence to arm lymphedema prevention behaviors was not significant. **Conclusion:** The modified questionnaire demonstrated good construct validity and reliability. Risk perception, outcome expectancy and action self-efficacy were key determinants of behavioral intention; behavioral intention and coping planning (excluding coping self-efficacy and action planning) influenced adherence. The results provide a basis for interventions to improve adherence to arm lymphedema prevention behaviors in postoperative

breast cancer patients, potentially reducing lymphedema incidence and improving postoperative quality of life.

Keywords: Adherence to arm lymphedema prevention behaviors, HAPA model, Structural equation modelling, Validation questionnaire sustainability

What was Known

- Arm lymphedema is a common, lifelong postoperative complication in breast cancer survivors, and the rate of adherence to prevention behaviors varies.
- The HAPA model incorporates various motivational and volitional constructs to describe the factors influencing the adoption and maintenance of health behaviors.

What's New and Next

- Provides a validated questionnaire to measure adherence to arm lymphedema prevention behaviors in postoperative breast cancer patients.

Identifies key HAPA model determinants of behavioral intention and adherence, informing intervention design

Introduction

Arm lymphedema is a common complication for postoperative breast cancer survivors within 10 years⁽¹⁾ which is also referred to as breast cancer-related arm lymphedema (BCRaL). In China, a 3-year incidence rate of breast cancer-related lymphedema (BCRL) was found to be 17.57% among patients who underwent breast surgery or breast reconstruction for breast cancer based on retrospective data from the electronic medical record system⁽²⁾. The prevalence of arm lymphedema among postoperative breast cancer survivors over a 10-year period was found to be 49.0%.¹ Lymphedema can not only cause significant physical disabilities, such as pain, tension, heaviness, and even impairment of spinal function^(3,4) but it can also lead to psychosocial problems, such as negative effects on work, home, and leisure activities, significantly decreasing the quality of life^(5,6). Moreover, women with arm lymphedema may experience increased psychological distress, including frustration, distress, depression, and anxiety⁽⁷⁾. Lymphedema cannot be cured and must be monitored throughout the patient's lifetime⁽⁸⁾. Therefore, it is necessary to reduce the risk of developing this condition through prevention.

Arm lymphedema prevention involves a comprehensive set of behaviors aimed at minimizing risk and managing symptoms. Risk-reduction behaviors include assistance care (e.g., avoiding blood pressure measurement and injections on the affected arm), limb care (e.g., avoiding tight objects, heat or sun exposure, trauma, and heavy lifting), skin care (e.g., maintaining cleanliness and moisturization, avoiding cuticle cutting, and using electric razors for hair removal), and lifestyle strategies (e.g., wearing protective gloves and loose clothing^(9,10,11,12)). Lymphedema management techniques include upper limb exercises, use of compression garments, self-lymphatic drainage, regular monitoring of limb changes, and arm circumference measurement^(13,14,15,16). Maintaining a healthy diet and appropriate weight is also recommended as part of overall lymphedema care⁽¹²⁾.

Despite the recognized benefits of arm lymphedema prevention behaviors, adherence remains suboptimal and varies widely across studies. Overall adherence to arm lymphedema self-management is approximately 40%⁽¹⁷⁾. Reported adherence rates differ by behavior, with higher adherence to assistance care (89.3%) than to limb care (61.2%) and exercise-related care (42.7%) among patients undergoing axillary surgery for breast cancer⁽⁹⁾. Among patients with breast cancer-related lymphedema (BCRL), only 19.5% adhered to all recommended self-management behaviors⁽¹³⁾ and 39.1% reported regular self-care practice⁽¹⁴⁾. Higher adherence is associated with greater limb volume reduction⁽¹⁸⁾, whereas poor adherence is linked to increased arm volume

and progression to more advanced stages of BCRL.⁽¹⁹⁾ These findings highlight the need to improve adherence to arm lymphedema prevention behaviors to reduce the incidence and severity of lymphedema.

Although the terms *adherence*, *compliance*, and *concordance* are often used interchangeably, they reflect different conceptual emphases. *Compliance* denotes passive obedience to medical instructions, whereas *adherence* emphasizes patients' active, autonomous engagement in agreed treatment plans, and *concordance* focuses on shared decision-making between patients and healthcare providers^(20,21,22,23,24). Accordingly, the term *adherence* was adopted in this study.

Adherence to arm lymphedema prevention behaviors was assessed using a modified version of the Lymphedema Self-Management Behavior Questionnaire (LSMBQ)⁽²⁵⁾. The original 22-item, six-dimension scale was adapted by removing the emotional and role management dimensions to align with the study aims, and by adding two researcher-developed items addressing arm exercise adherence and affected limb circumference measurement based on the literature. Because modifications to scale items may alter the underlying construct, validation of the modified LSMBQ was necessary; therefore, the primary aim of this study was to examine the construct validity of the revised instrument⁽²⁶⁾.

The Health Action Process Approach (HAPA) model is a social-cognitive framework that explains health behavior change through two sequential phases: a pre-intentional motivational phase (risk perception, outcome expectancy, and action self-efficacy) and a post-intentional volitional phase (action planning, coping planning, and self-efficacy for coping and recovery), highlighting planning as the bridge between intention and behavior^(27,28,29,30). By distinguishing different stages and types of self-efficacy, the HAPA model helps explain how motivation is translated into sustained action and addresses the intention-behavior gap^(28,30). Given its successful application in predicting and explaining adherence across diverse health behaviors, including chronic disease management and preventive practices^(31,32,33), therefore, this study adopts the HAPA model to assess its applicability to adherence to arm lymphedema prevention behaviors and to examine the relationships between HAPA constructs and adherence outcomes.

Based on the above evidence, there's no validated measurement tool for arm lymphedema prevention adherence in this context and HAPA model application. This study aimed to assess the construct validity of questionnaire on adherence to arm lymphedema prevention behaviors, and

examine the strength of the relationship between the HAPA model constructs and adherence to arm lymphedema prevention behaviors among breast cancer postoperative patients.

Materials and Methods

1. Study Design

A cross-sectional research design was conducted in this study. This study was conducted at a public tertiary hospital in Shandong Province, China from August to November 2024. This hospital is an important medical center in the southern region of Shandong Province (Lunan region).

2. Participants

Participants were recruited from patients diagnosed with early stage of breast cancer and who had postoperative treatment at the hospital's breast cancer surgery departments. Inclusion criteria: patients who underwent breast cancer surgery with axillary lymph nodes dissected or had ≥ 5 sentinel lymph nodes removed; age ≥ 18 years old. Exclusion criteria: patients who received other treatments, such as chemotherapy or radiation therapy; have impaired cognitive performance. The sample size of this study was confirmed based on the estimated parameter-to-sample ratio (q:N), which ranges from 1:5 to 1:20⁽²⁶⁾. Based on the HAPA model, the number of parameters is 8, and the sample size ranged from 40 to 160. With a potential 20% drop-out rate, the sample size estimate was around 50 to 200. Finally, a total of 210 participants were recruited in the study.

3. Measurements

Demographic characteristics include age, height, weight, educational level, marital status, occupation, monthly family income, and surgical side. BMI was calculated using the formula: BMI = weight (kg)/height squared (m^2)

Adherence to arm lymphedema prevention behaviors was assessed using modified the Lymphedema Self-Management Behavior Questionnaire (LSMBQ) for the current study²⁵. LSMBQ includes lymphedema risk minimization behaviors and lymphedema care techniques. The LSMBQ consists of 22 items and 6 dimensions. The dimensions included disease information management (3 items), diet and exercise management (3 items), the affected limb protection management (6 items), promotion of lymph reflux management (3 items), emotional management (3 items), and role management (4 items). Each item was responded by a 5-point Likert rating from 0 (never) to 4 (always). The higher score indicates the better lymphedema prevention behavior. The LSMBQ

measures lymphedema risk minimization behaviors and lymphedema care techniques, but doesn't include the affected limb circumference measurement and arm exercise, only physical exercises like deep breathing exercises, resistance exercises and aerobic exercises. The LSMBQ was chosen after deleting the dimensions of emotional management and role management in this questionnaire due to not mention information about them in the present study based on the research aims, and two multiple questions were added, which developed by researchers based on a literature review, include statements such as 'I can adhere to do arm exercise in daily life, as recommended', and 'I can adhere to measure the circumference of the affected limb myself or family members, as advised recommended'.

Arm lymphedema risk perception was measured by 4-items scale, which was developed based on a risk perception questionnaire (in Chinese) in women with breast cancer-related lymphedema with 22 items⁽³⁴⁾. Based on the current research aims, 4-items scale were developed, including (1) *I believe I am at risk of developing arm lymphedema after surgery*, (2) *If I develop arm lymphedema, it will significantly impact my daily life*, (3) *I believe I can take steps to reduce my risk of developing arm lymphedema*, (4) *I understand what factors may increase my risk of developing arm lymphedema*. Each item is rated on a 5-point Likert scale from 1 (completely disagree) to 5 (completely agree). Scale mean scores were calculated. Higher score indicates a greater level of risk perception. Cronbach's α was 0.85.

Arm lymphedema outcome expectancies were measured by 4-items scale⁽³⁵⁾. The 4-items was: "If I regularly engage in lymphedema prevention behaviors, then..." (1) *I feel more in control of my arm health*, (2) *I experience less swelling and discomfort in my arm*, (3) *feel more confident in my appearance and arm function*, (4) *I feel stronger and more capable of managing my condition*. Each item is rated on a 4-point Likert scale from 1 (not at all) to 4 (*Exactly true*). Scale mean scores were calculated. Higher score indicates a greater level of outcome expectancies. Cronbach's α was 0.78.

The Perception, Intention, and Ability to Change (PIAC) scale was used to assess patients' arm lymphedema-related intentions⁽³⁶⁾. The PIAC scale consists of 9 items, two dimensions: perceptions/intentions (5 items) and ability/implementation (4 items). Each item uses a 5-point Likert rating from '0 = Never' to '4 = Always.' The scores for item 3 and 4 are reversed. The total score of the PIAC ranges from 0 to 36. Higher scores indicate a stronger intention to change behaviors. The PIAC has been used for cancer patients⁽³⁷⁾. The scale exhibits internal consistency

among its 9 items (Cronbach's $\alpha = 0.75$)⁽³⁶⁾. The modified PIAC with 7 items (deleting items 3 and 4) was used in this study, and the total scores from 0 to 28. Higher scores indicate a stronger intention to change behaviors. Cronbach's α was 0.88.

The General Self-Efficacy Scale (GSE) is used to test the patients' self-efficacy⁽³⁸⁾. The Simplified Chinese version of the General Self-Efficacy Scale was used in this current study to assess patients' arm lymphedema self-efficacy, which consists of 10 items and 2 dimensions: action self-efficacy (items 1, 6, 7, 8, and 9) and coping self-efficacy (items 2, 3, 4, 5, and 10)⁽³⁹⁾. Participants were asked to indicate their responses using a 4-point Likert-type scale ranging from '1= Not at all true' to '4= Exactly true'. The total score ranges from 10 to 40, with higher scores indicating greater self-efficacy. Cronbach's α was 0.86.

The Action and Coping Planning Scale (ACPS) was used to assess patients' engagement in arm lymphedema-related action planning and coping planning⁽⁴⁰⁾. The ACPS consists of 10 items with action planning and coping planning as two dimensions. Each item is rated on a 5-point Likert scale from 1 (completely disagree) to 5 (completely agree). The total score ranges from 10 to 50, with higher scores indicating greater action planning and coping planning. The modified ACPS was used to assess patients' engagement in arm lymphedema-related action planning and coping planning. Cronbach's α was 0.92.

4. Data Collection

Convenience sampling was used for participant recruitment due to its accessibility⁴¹. First, the researcher explained the purpose, methodology, content, and data collection process of the survey to the participants. Then, participants who agreed to take part in the study were asked to complete a self-report questionnaire immediately. The survey took approximately 10–15 minutes to complete. It was anonymous, and participants were allowed to withdraw during the survey.

5. Data analysis

Data analysis was conducted using IBM SPSS 26 and Amos 28. Mean and standard deviation (SD) were used to report continuous data, while percentages were used for categorical data. The correlation between the measured variables was determined using the Pearson's correlation coefficient. Exploratory factor analysis (EFA) was used for the modified scale to ensure that the additional items aligned with the original scale. Values for Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (preferably significant) were used to assess the suitability of data for factorization. Parallel analysis was conducted to determine the

number of factors to extract, and an oblimin rotation was applied to allow for correlated factors. Items with factor loadings ≥ 0.40 were considered acceptable. Cronbach's α technique was used for reliability analysis.

Path analysis using structural Equation Modelling (SEM) was used to test the HAPA model and explore the strength of relationships between multiple variables. SEM was performed using the maximum likelihood (ML) estimation method. The normed chi-square (χ^2/df), root mean square error of approximation (RMSEA), goodness of fit index (GFI), comparative fit index (CFI), adjusted goodness of fit index (AGFI), and TLI were used to assess the model overall fitness. The acceptable fit indices for the model were evaluated using the following criteria: $\chi^2/\text{df} < 3$, RMSEA < 0.08 , both GFI, AGFI, CFI, TLI > 0.90 . Statistical significance was set at $p < 0.05$.

Result

Table 1 Descriptive statistics for demographic characteristics (N=201)

	n	%		n	%
Educational level			Marital status		
Elementary school or below	78	38.8	Married	178	88.6
Junior high school	89	44.3	Single/ Divorced/ Widow	23	11.4
Senior high school	17	8.5	Family Income (monthly/yuan)		
University/college	17	8.5	≤ 3000	107	53.2
Occupation			3000-4000	66	32.8
Government employee	10	5.0	≥ 4000	28	13.9
Private sector worker	22	10.9	Surgical Side		
Self-employed	152	75.6	Right side	96	47.8
Retired	17	8.5	Left side	83	41.3
			Both sides	22	10.9

1. Characteristics of participants

Of the 210 questionnaires administered, 9 questionnaires had more than 50% of missing data. 201 participants completed all questionnaires. The participation rate was 95.7%. Participants' demographic characteristics are presented in Table 1. Participants' average age was 52.76 years (SD = 9.43, range 24–81 years), and most were married (88.6%). Most participants completed Junior high school (44.3%) and elementary school or below (38.8%). The majority (75.6%) were self-employed, while government employees accounted for the smallest proportion at 5.0%. Only 13.9% of participants has a family monthly income $\geq$ 4000 yuan, and 53.2% had surgery on the right side. Participants' average BMI was 24.93 (SD=3.38, range 16.61–33.06 kg/m²), with height ranging from 145 to 186cm and weight from 42 to 90kg.

2. Psychometric Properties

The original and modified scale of LSMBQ were shown in Appendix. Items 16–22 in the emotional management and role management dimensions of original scale were deleted, and new items 16 and 17 were added based on the research purpose.

Exploratory factor analysis (EFA) was conducted using Principal Axis Factoring to explore the structure of the modified LSMBQ. The Kaiser–Meyer–Olkin (KMO) was 0.91 and Bartlett's test of sphericity was 1,743.30 ($p < 0.001$), which confirmed that the data were suitable for factor analysis. Three factors, which accounted for 60.37 % of the cumulative total variance explained, were extracted for the 17-item scale. The eigenvalues, total variance explained and the number of factors is shown in Table 2. The Scree plot (Fig. 1) also indicated a three-factor model, which was confirmed with parallel analysis. Table 3 presents the factor loadings on each factor. Six items loaded on factor one (lymphedema care techniques management), and items loadings for factor one ranged between 0.47 and 0.69. Six items loaded on factor two (disease information, diet and exercise management), and items loadings for factor one ranged between 0.51 and 0.75. The remaining five items loaded in factor three (lymphedema risk minimization behaviors) with factor loadings ranging between 0.47 and 0.71. The Cronbach' α for factor one was 0.86, 0.82 for factor 2, and 0.86 for factor 3 suggesting that internal consistency was good. The overall Cronbach's α for the modified LSMBQ was 0.92, indicating good reliability.

Table 2 Eigenvalues and Total Variance Explained**Total Variance Explained**

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.637	44.921	44.921	7.173	42.195	42.195	3.247	19.099	19.099
2	1.505	8.854	53.775	1.024	6.023	48.219	2.901	17.063	36.162
3	1.121	6.597	60.372				2.700	15.883	52.044
4	0.946	5.564	65.936						
5	0.757	4.450	70.386						
6	0.714	4.197	74.584						
7	0.622	3.658	78.242						
8	0.580	3.414	81.656						
9	0.464	2.727	84.383						
10	0.454	2.669	87.052						
11	0.424	2.491	89.543						
12	0.411	2.416	91.959						
13	0.325	1.910	93.869						
14	0.315	1.854	95.723						
15	0.286	1.679	97.403						
16	0.245	1.444	98.846						
17	0.196	1.154	100.000						

Extraction Method: Principal Axis Factoring.

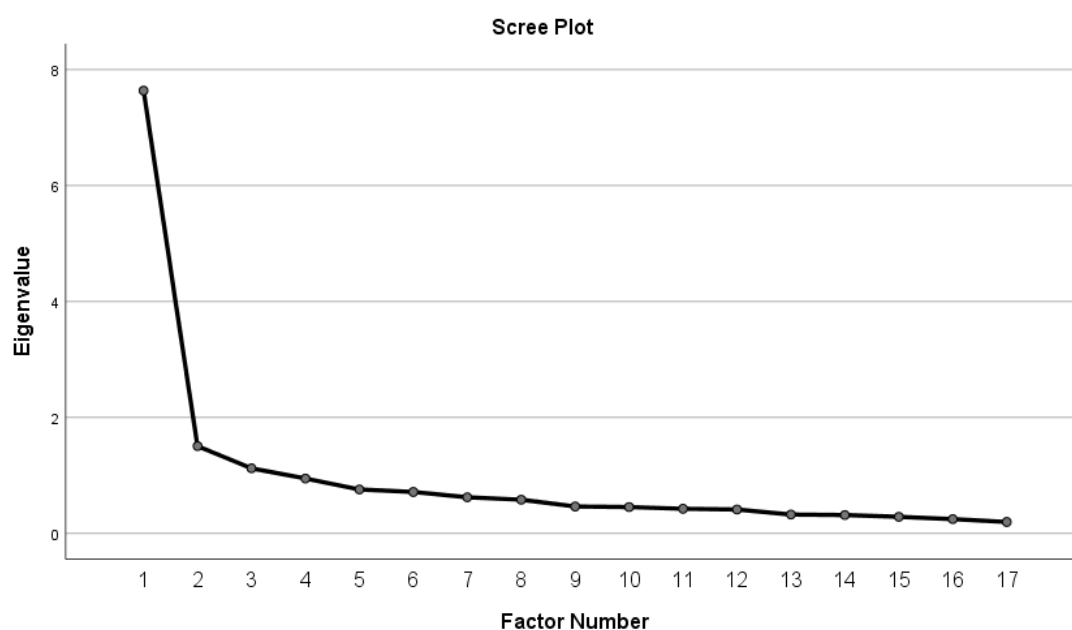


Figure 1 Scree plot of factors

Table 3 Factor Loadings

Items	Factor		
	1	2	3
1	0.238	0.571	0.173
2	0.163	0.588	0.166
3	0.315	0.513	0.080
4	0.162	0.755	0.242
5	0.155	0.547	0.366
6	0.206	0.549	0.330
7	0.275	0.367	0.479
8	0.277	0.406	0.571
9	0.340	0.289	0.603
10	0.289	0.234	0.717
11	0.372	0.224	0.665
12	0.475	0.157	0.389
13	0.689	0.249	0.245
14	0.600	0.196	0.243
15	0.675	0.183	0.240
16	0.697	0.271	0.278
17	0.692	0.275	0.236

3. Correlation and path analysis

The participants' score for adherence to arm lymphedema prevention behaviors, arm lymphedema-related intentions, action self-efficacy, coping self-efficacy, action plan, and coping planning were 36.28 ± 12.46 , 16.73 ± 5.39 , 12.82 ± 3.00 , 11.92 ± 3.21 , 13.80 ± 3.98 , and 13.50 ± 3.81 . There are significant relationships between observed variables ($r=0.143-0.665$, all $p < 0.05$) (Table 4).

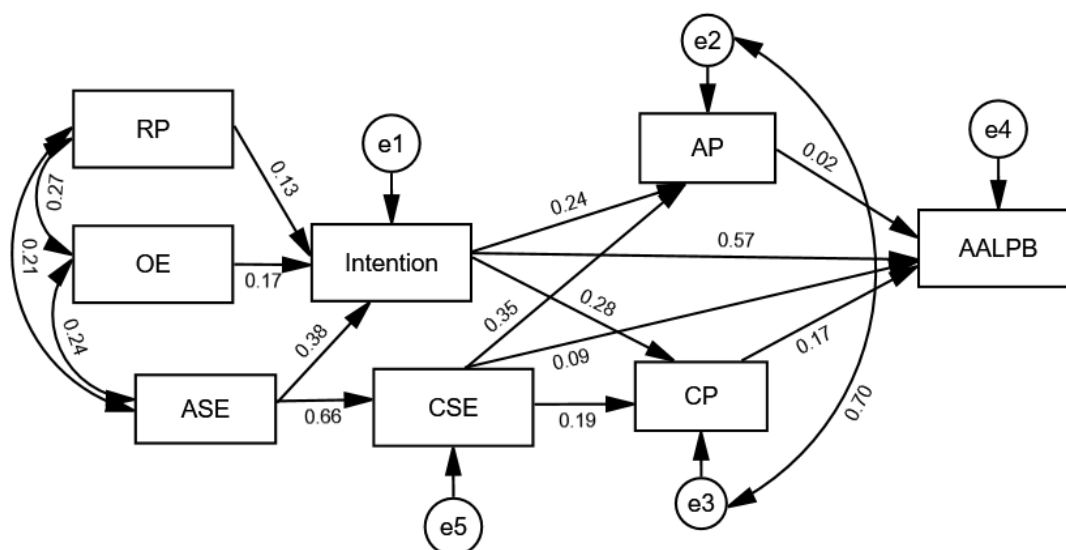
Table 4 Descriptive statistics and correlations among variables

	M $\pm$ SD	1	2	3	4	5	6	7	8
1. Adherence to arm lymphedema prevention behaviors	36.28 $\pm$ 12.46	1							
2. Arm lymphedema risk perception	10.81 $\pm$ 3.21	0.321**	1						
3. Arm lymphedema outcome expectancies	10.65 $\pm$ 2.51	0.343**	0.270**	1					
4. Arm lymphedema-related intentions	16.73 $\pm$ 5.39	0.665**	0.257**	0.294**	1				
5. Action self-efficacy	12.82 $\pm$ 3.00	0.432**	0.213**	0.242**	0.451**	1			
6. Coping self-efficacy	11.92 $\pm$ 3.21	0.358**	0.151*	0.257**	0.365**	0.661**	1		
7. Action planning	13.80 $\pm$ 3.98	0.397**	0.169*	0.259**	0.365**	0.423**	0.435**	1	
8. Coping planning	13.50 $\pm$ 3.81	0.414**	0.143*	0.271**	0.350**	0.328**	0.294**	0.748**	1

** $P < 0.01$, * $P < 0.05$

The SEM model demonstrated a good fit to the data ($\chi^2/df=2.18 < 3$, RMSEA=0.077 < 0.08, GFI=0.97, AGFI=0.91, CFI=0.97, TLI=0.94, all > 0.90, refer to Fig. 2). The path analysis examined the effects among variables, the standardized estimates for each path are seen in Table 5. The path from outcome expectancies to intention was significant ($\beta = 0.17$, $p = 0.010$). The path from risk perception to intention was significant ($\beta = 0.13$, $p = 0.042$). The path from action self-efficacy to intention had a positive effect ($\beta = 0.38$, $p < 0.001$). The path from action self-efficacy to coping self-efficacy had a positive effect ($\beta = 0.66$, $p < 0.001$). The path from intention to coping planning was significant ($\beta = 0.28$, $p < 0.001$), and to action plan had a positive effect ($\beta = 0.24$, $p < 0.001$). The path from intention to arm lymphedema prevention behaviors was significant ($\beta = 0.57$, $p < 0.001$), indicating a strong positive relationship between the two constructs. The path from coping self-efficacy to action plan was significant ($\beta = 0.35$, $p < 0.001$). The path from action planning to arm

lymphedema prevention behaviors was not significant ($\beta = 0.02$, $p = 0.805 > 0.05$), indicating no direct effect. In addition, the path from coping self-efficacy to arm lymphedema prevention behaviors was not significant ($\beta = 0.09$, $p = 0.102$). However, the path from coping self-efficacy to coping planning was significant ($\beta = 0.19$, $p = 0.005$), and the path from coping planning to arm lymphedema prevention behaviors was significant ($\beta = 0.17$, $p = 0.024$). A path from coping self-efficacy through coping planning to arm lymphedema prevention behaviors was observed.



Note: OE: outcome expectancies; RP: risk perception;

ASE: action self-efficacy; CSE: coping self-efficacy; AP: action planning;

CP: coping planning; AALPB: arm lymphedema prevention behaviors

Figure 2 Path diagram of the tested model (Standardized path coefficient)

Table 5 The results of the path analysis among variables

	Path		Standardized	Estimate	S.E.	C.R.	P
Intent	<--	OE	0.166	0.356	0.139	2.565	0.010
Intent	<--	RP	0.131	0.219	0.108	2.036	0.042
Intent	<--	ASE	0.383	0.687	0.114	6.017	***
CSE	<--	ASE	0.661	0.706	0.057	12.446	***
CP	<--	Inten	0.281	0.198	0.048	4.116	***
AP	<--	Inten	0.239	0.176	0.048	3.683	***
CP	<--	CSE	0.192	0.227	0.081	2.813	0.005
AP	<--	CSE	0.350	0.432	0.080	5.383	***
AALP	<--	Inten	0.566	1.299	0.128	10.158	***
AALP	<--	AP	0.020	0.063	0.254	0.247	0.805
AALP	<--	CP	0.175	0.571	0.252	2.263	0.024
AALP	<--	CSE	0.094	0.361	0.221	1.637	0.102

$P < 0.001$

Discussion

This study focuses on construct validity and reliability of questionnaire and examine the strength of the relationship (path analysis using SEM) between the HAPA model constructs and adherence to arm lymphedema prevention behaviors among breast cancer postoperative patients. The modified LSMBQ showed acceptable construct validity with three domains. Significant associations were found between HAPA constructs and adherence behaviors, with risk perception, outcome expectancy, and action self-efficacy predicting intention, and behavioral intention and coping planning predicting adherence.

The AALPB questionnaire was developed from the LSMBQ and consists of 17 items with three dimensions. The disease information, diet and exercise management domain (items 1–6) is derived from the combination of disease information management and diet and exercise management in the original LSMBQ scale. This domain demonstrates the need for breast cancer patients after surgery to understand basic BCRL knowledge and how to manage their condition through diet and physical activity to prevent lymphedema. The lymphedema risk minimization behaviors domain (items 7–11) is derived from the affected limb protection management section in the original LSMBQ, with item 12 removed. This domain describes the need for breast cancer patients after surgery to learn about protective measures for minimizing the risk of lymphedema. The lymphedema care techniques management domain (items 12–17) is derived from promotion of lymph reflux management in the original LSMBQ, with item 12 added and two additional new items. Item 12, *"I observe minor changes in the affected limb, such as swelling, pain, numbness,*

stiffness, heaviness, redness and fever and skin breakage, and actively report the changes in time” involves recognizing swelling and other symptoms, which requires professional knowledge and specialized techniques (such as circumference measurement), it is better to move item 12 into this domain. Therefore, the modified LSMBQ is suitable for adherence to arm lymphedema prevention behaviors, and the total score ranges from 0 to 68.

The finding of this study was statistically significant correlations between HAPA model constructs (risk perception, outcome expectancy, intention, self-efficacy, and planning) and adherence to arm lymphedema prevention behaviors in breast cancer surgery patients, which was in line with the results of a previous study⁽⁴²⁾. In addition, a prior study pointed that perceived risk and expected outcome had a significant positive relationship with patient adherence to diet, which could also support these findings⁽⁴³⁾.

In the pre-intentional motivational phase, the path coefficients demonstrated a statistically significant effect of risk perception, outcome expectancy and action self-efficacy on behavioral intention, which aligned with a prior study⁽⁴⁴⁾. The finding that risk perception predicted intention was consistent with several previous studies^(42,45,46). One possible reason is that perceived risk could influence individuals' decision-making⁽⁴⁷⁾. Therefore, once patients understand the risk of arm lymphedema after surgery, they may be more likely to form stronger behavioral intentions to engage in preventive behaviors. The finding that outcome expectancy predicted intention was in line with two previous studies, which confirmed that increments in outcome expectancies can cause significant increases in behavior intentions^(48,49). Moreover, social cognitive theory also supports the current findings, suggesting that individuals are more likely to form intentions to engage in a behavior if they believe it will lead to desirable outcomes.⁵⁰ The result of action self-efficacy could predict behavioral intention suggested that it is essential for breast cancer surgery patients to first be confident in their ability to set goals. In addition, risk perception had little effect on intention in the current study, which have been reported by previous studies applying the HAPA model in different behaviors^(44,51,52,53).

In the post-intentional volition phase, the path from behavioral intention and coping planning to adherence to arm lymphedema prevention behaviors showed significant effects. This finding is consistent with a previous study, which pointed that behavioral intention and coping planning are two important factors associated with adherence⁽⁵⁴⁾. When patients intend to follow arm lymphedema prevention guidelines, they are more likely to stick the recommendations. Coping planning is designed to consider daily activities, such as establishing a routine for arm

exercise and arm circumference measurement. This further provides additional strategies to overcome the gap between intention and behaviors. In addition, the effect of coping self-efficacy and action planning on adherence to arm lymphedema prevention behaviors was not significant. These findings were not consistent with previous studies. One study indicated that coping self-efficacy significantly predicted medication adherence behavior,⁽⁵⁵⁾ and another study suggested that action planning appears useful in increasing exercise adherence⁽⁵⁶⁾. Moreover, action planning is important for the beginning of behaviors.⁵⁷ These differences may be due to cultural context, and difference in target participants and constructs measurements. For example, people in Chinese culture pay less attention to individual self-efficacy and place more focus on external family support, especially when setbacks occur. This could lead to lower individual coping skills and the tendency to give up on behaviors. However, a path from coping self-efficacy through coping plan to arm lymphedema prevention behaviors was observed. It demonstrated that the role of coping self-efficacy was to promote coping planning convert into arm lymphedema prevention behaviors.

The results provide a basis for interventions to improve adherence to arm lymphedema prevention behaviors in postoperative breast cancer patients, enhancing self-efficacy, planning, and maintenance of preventive behaviors, potentially reducing lymphedema incidence and improving postoperative quality of life.

The findings of this study provide practical guidance for improving adherence to arm lymphedema prevention behaviors among breast cancer surgery patients. Interventions should not only focus on increasing patients' knowledge, but also target key motivational and volitional determinants identified by the HAPA model. Specifically, healthcare professionals should enhance patients' risk perception, positive outcome expectancies, and action self-efficacy to facilitate the formation of behavioral intention. In addition, coping planning should be emphasized during postoperative education and follow-up, helping patients anticipate potential barriers and develop feasible strategies to maintain preventive behaviors in daily life. Incorporating HAPA-based approaches into routine clinical care may contribute to sustained adherence and reduced risk of arm lymphedema.

This study has several strengths and limitations. This study has several strengths. First, a theory-driven approach was adopted by applying the HAPA model to examine adherence to arm lymphedema prevention behaviors, providing a comprehensive understanding of both motivational and volitional determinants. Second, a modified version of the LSMBQ was validated

using exploratory factor analysis, offering a tailored instrument for assessing adherence in this population. Third, the use of structural equation modeling allowed for simultaneous examination of multiple relationships among theoretical constructs. However, all questionnaires used for measuring variables were not developed based on the HAPA model. It is essential to develop a HAPA model-based questionnaire specifically tailored for BCRaL. Moreover, data were collected through self-report questionnaires, which may potentially cause biases. Future studies are encouraged to incorporate objective measures or multi-source data to further strengthen the validity of findings.

Conclusion

The modified questionnaire demonstrated good construct validity and reliability for measuring adherence to arm lymphedema prevention behaviors. The HAPA model constructs could be helpful in determining the predictors of adherence to arm lymphedema prevention behaviors among breast cancer postoperative patients. Risk perception, outcome expectancy and action self-efficacy were the determinants for behavioral intention; behavioral intention and coping planning (excluding coping self-efficacy and action planning) were the key determinants for adherence to arm lymphedema prevention behaviors.

Ethical Approval Statement

This study was reviewed and approved by the Ethical Review Committee for Human Research (COA. No. MUPH 2024-087).

Author Contributions

QW contributed to the study's conceptualization, developed the methodology, data collection, data analysis, and results discussion, as well as prepared the manuscript. OK, PR and LK contributed to the study conceptualization, reviewed, and edited the article, provided supervision, and validated the research. All authors read and reviewed the article before submission for publication.

Acknowledgements

The researcher would like to express sincere gratitude to the faculty members, research participants and the staff who assisted with data collection during the study.

Source of Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. Liu YF, Liu JE, Mak YW, 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*. 2021; 51: 101909. DOI: 10.1016/j.ejon.2021.101909
2. Zhuang L, Chen Q, Chen H, et al. Breast cancer-related lymphedema and recurrence of breast cancer: Protocol for a prospective cohort study in China. *PLoS One*. 2023; 18(5): e0285772. Published 2023 May 16. DOI: 10.1371/journal.pone.0285772
3. Togawa K, Ma H, Smith AW, et al. Self-reported symptoms of arm lymphedema and health-related quality of life among female breast cancer survivors. *Sci Rep*. 2021; 11(1): 10701. Published 2021 May 21. DOI: 10.1038/s41598-021-89055-0
4. Babasaheb SS, Rajesh KK, Yeshwant KS, Patil S. Analysis of Spinal Dysfunction in Breast Cancer Survivors with Lymphedema. *Asian Pac J Cancer Prev*. 2021; 22(6): 1869–73. Published 2021 Jun 1. DOI: 10.31557/APJCP.2021.22.6.1869
5. McLaughlin SA, Brunelle CL, Taghian A. Breast Cancer-Related Lymphedema: Risk Factors, Screening, Management, and the Impact of Locoregional Treatment. *J Clin Oncol*. 2020; 38(20): 2341–50. DOI: 10.1200/JCO.19.02896
6. Jørgensen MG, Toyserkani NM, Hansen FG, Bygum A, Sørensen JA. The impact of lymphedema on health-related quality of life up to 10 years after breast cancer treatment. *NPJ Breast Cancer*. 2021; 7(1): 70. Published 2021 Jun 1. DOI: 10.1038/s41523-021-00276-y
7. McWayne J, Heiney SP. Psychologic and social sequelae of secondary lymphedema: a review. *Cancer*. 2005; 104(3): 457–66. DOI: 10.1002/cncr.21195
8. Fu MR. Breast cancer-related lymphedema: Symptoms, diagnosis, risk reduction, and management. *World J Clin Oncol*. 2014; 5(3): 241–47. DOI: 10.5306/wjco.v5.i3.241
9. Fabro EAN, Macedo FO, Costa RM, et al. Guidelines for the prevention of secondary lymphedema following breast cancer treatment: adhesion and associated factors. *Mastology*. 2021; 31:1–9.

10. Sherman KA, Miller SM, Roussi P, Taylor A. Factors predicting adherence to risk management behaviors of women at increased risk for developing lymphedema. *Support Care Cancer*. 2015; 23(1): 61-69. DOI: 10.1007/s00520-014-2321-1
11. Li M, Huang W, Zhang X, et al. Illness perceptions and adherence to breast cancer-related lymphedema risk management behaviours among breast cancer survivors. *Eur J Oncol Nurs*. 2022; 58: 102144. DOI: 10.1016/j.ejon.2022.102144
12. Tsuchiya M, Masujima M, Kato T, et al. Knowledge, fatigue, and cognitive factors as predictors of lymphoedema risk-reduction behaviours in women with cancer. *Support Care Cancer*. 2019; 27(2): 547-55. DOI: 10.1007/s00520-018-4349-0
13. Alcorso J, Sherman KA, Koelmeyer L, Mackie H, Boyages J. Psychosocial factors associated with adherence for self-management behaviors in women with breast cancer-related lymphedema. *Support Care Cancer*. 2016; 24(1): 139-46. DOI: 10.1007/s00520-015-2766-x
14. Deveci Z, Karayurt Ö, Eyigör S. Self-care practices, patient education in women with breast cancer-related lymphedema. *Turk J Phys Med Rehabil*. 2021; 67(2): 187-95. Published 2021 May 25. DOI: 10.5606/tftrd.2021.5022
15. Torgbenu E, Luckett T, Buhagiar MA, Phillips JL. Guidelines Relevant to Diagnosis, Assessment, and Management of Lymphedema: A Systematic Review. *Adv Wound Care (New Rochelle)*. 2023; 12(1): 15-27. DOI: 10.1089/wound.2021.0149
16. Davies C, Levenhagen K, Ryans K, Perdomo M, Gilchrist L. Interventions for Breast Cancer-Related Lymphedema: Clinical Practice Guideline From the Academy of Oncologic Physical Therapy of APTA. *Phys Ther*. 2020; 100(7): 1163-79. DOI: 10.1093/ptj/pzaa087
17. Ridner SH, Dietrich MS, Kidd N. Breast cancer treatment-related lymphedema self-care: education, practices, symptoms, and quality of life. *Support Care Cancer*. 2011; 19(5): 631-37. DOI: 10.1007/s00520-010-0870-5
18. Boris M, Weindorf S, Lasinkski S. Persistence of lymphedema reduction after noninvasive complex lymphedema therapy. *Oncology (Williston Park)*. 1997; 11(1): 99-114.
19. Vignes S, Porcher R, Arrault M, Dupuy A. Factors influencing breast cancer-related lymphedema volume after intensive decongestive physiotherapy. *Support Care Cancer*. 2011; 19(7): 935-40. DOI: 10.1007/s00520-010-0906-x
20. Sackett DL, Haynes RB. Compliance with therapeutic regimen. 1976.

21. Horne R, Weinman J, Barber N, et al. Concordance, adherence and compliance in medicine taking. London: NCCSDO; 2005:6.
22. Bassett SF. Bridging the intention–behavior gap with behavior change strategies for physiotherapy rehabilitation non-adherence. *N Z J Physiother.* 2015; 43(3): 105–11.
23. Bailey DL, Holden MA, Foster NE, Quicke JG, Haywood KL, Bishop A. Defining adherence to therapeutic exercise for musculoskeletal pain: a systematic review. *Br J Sports Med.* 2020; 54(6): 326–31. DOI: 10.1136/bjsports-2017-098742
24. Mir T. Adherence versus compliance. *HCA Healthc J Med.* 2023;4. DOI: 10.36518/2689-0216.1513.
25. Wei X, Lu Q, Shen A, et al. Development and psychometric evaluation of a lymphoedema self-management behaviour questionnaire for breast cancer patients. *Eur J Cancer Care (Engl).* 2022; 31(6): e13743. DOI: 10.1111/ecc.13743
26. Gunawan J, Marzilli C, Aungsuroch Y. Establishing appropriate sample size for developing and validating a questionnaire in nursing research. *Belitung Nurs J.* 2021;7(5):356–360. Published 2021 Oct 28. DOI: 10.33546/bnj.1927
27. Schwarzer R. Self-efficacy in the adoption and maintenance of health behaviors: theoretical approaches and a new model. In: Schwarzer R, ed. *Self-Efficacy: Thought Control of Action.* Washington, DC: Hemisphere Publishing Corporation; 1992: 217–42.
28. Schwarzer R, Luszczynska A. How to overcome health-compromising behaviors: the Health Action Process Approach. *Eur Psychol.* 2008; 13(2): 141–51.
29. Schwarzer R, Lippke S, Luszczynska A. Mechanisms of health behavior change in persons with chronic illness or disability: the Health Action Process Approach (HAPA). *Rehabil Psychol.* 2011; 56(3): 161–70. DOI: 10.1037/a0024509
30. Scholz U, Keller R, Perren S. Predicting behavioral intentions and physical exercise: a test of the health action process approach at the intrapersonal level. *Health Psychol.* 2009; 28(6): 702–8. DOI: 10.1037/a0016088
31. Ranjbaran S, Shojaeizadeh D, Dehdari T, Yaseri M, Shakibazadeh E. Using health action process approach to determine diet adherence among patients with Type 2 diabetes. *J Educ Health Promot.* 2020; 9:170. Published 2020 Jul 28. DOI: 10.4103/jehp.jehp_175_20
32. Sadeghi S, Kaveh MH, Jahromi SE, et al. Development, reliability and validity of Health Action Process Approach questionnaire for predicting treatment adherence among Iranian hemodialysis patients. *J Nephropathol.* 2021; 10(1).

33. Malik K, Amir N, Kusumawardhani AAAA, et al. Health Action Process Approach (HAPA) as a Framework to Understand Compliance Issues With Health Protocols Among People Undergoing Isolation at Emergency Hospital for COVID-19 Wisma Atlet Kemayoran and RSCM Kiara Ultimate Jakarta Indonesia. *Front Psychiatry*. 2022; 13:871448. Published 2022 May 26. DOI: 10.3389/fpsyt.2022.871448
34. Ma ZY, Yao SS, Shi YY, et al. Development of a risk perception questionnaire for women with breast-cancer-related lymphedema and its reliability and validity (in Chinese). *J Nurs*. 2023; 30(4): 1–5.
35. Klusmann V, Musculus L, Sproesser G, Renner B. Fulfilled Emotional Outcome Expectancies Enable Successful Adoption and Maintenance of Physical Activity. *Front Psychol*. 2016; 6: 1990. Published 2016 Jan 6. DOI: 10.3389/fpsyg.2015.01990
36. Büssing A, Poier D, Lauche R, Dobos G, Cramer H. Validation of an Instrument to Measure Patients' Intentions and Ability to Change Attitudes and Behavior. *Complement Med Res*. 2017; 24(4): 246–54. DOI: 10.1159/000477720
37. Ruhe S, Orawa H, Hübner J, Büntzel J; Working Group “Prevention and Integrative Oncology” (PRIO) within the German Cancer Society DKG. Hidden resources for cancer patients: interactions between spirituality, religiosity, and selected factors influencing patient self-care. *Oncology*. 2025:1–14. DOI: 10.1159/000543312.
38. Schwarzer R, Jerusalem M. Generalized Self-Efficacy Scale. In: Weinman J, Wright S, Johnston M, eds. *Measures in Health Psychology: A User's Portfolio. Causal and Control Beliefs*. Windsor, UK: NFER-NELSON; 1995: 35–7.
39. Zeng G, Fung SF, Li J, et al. Evaluating the psychometric properties and factor structure of the General Self-Efficacy Scale in China. *Curr Psychol*. 2020:1–11.
40. Wee ZQC, Dillon D. Increasing Physical Exercise through Action and Coping Planning. *Int J Environ Res Public Health*. 2022; 19(7): 3883. Published 2022 Mar 24. DOI: 10.3390/ijerph19073883
41. Simkus J. Convenience sampling: definition, method and examples. Published October 6, 2022.
42. Mohammadi Zeidi I, Morshedi H, Shokohi A. Predicting psychological factors affecting regular physical activity in hypertensive patients: Application of health action process approach model. *Nurs Open*. 2020; 8(1): 442–52. Published 2020 Oct 8. DOI: 10.1002/nop2.645

43. Qona'ah A, Fauziah N, Basuni HL. Correlation between risk perception and outcome expectancies on dietary compliance in diabetes mellitus patients. *Babali Nurs Res.* 2022; 3(3): 194-201.
44. Schwarzer R, Renner B. Social-cognitive predictors of health behavior: action self-efficacy and coping self-efficacy. *Health Psychol.* 2000; 19(5):487-95.
45. Bae SY, Chang PJ. The effect of coronavirus disease-19 (COVID-19) risk perception on behavioural intention towards 'untact' tourism in South Korea during the first wave of the pandemic (March 2020). *Curr Issues Tour.* 2021; 24(7): 1017-35.
46. Hardcastle SJ, Maxwell-Smith C, Hagger MS. Predicting physical activity change in cancer survivors: an application of the Health Action Process Approach. *J Cancer Surviv.* 2022; 16(6): 1176-83. DOI: 10.1007/s11764-021-01107-6
47. Stefani G, Cavicchi A, Romano D, Lobb AE. Determinants of intention to purchase chicken in Italy: the role of consumer risk perception and trust in different information sources. *Agribusiness.* 2008; 24(4): 523-37. DOI: 10.1002/agr.20177.
48. Maddux JE, Sherer M, Rogers RW. Self-efficacy expectancy and outcome expectancy: their relationship and their effects on behavioral intentions. *Cognit Ther Res.* 1982; 6:207-211.
49. Gellert P, Ziegelmann JP, Schwarzer R. Affective and health-related outcome expectancies for physical activity in older adults. *Psychol Health.* 2012; 27(7):816-28. DOI: 10.1080/08870446.2011.607236
50. Bandura A. *Social Foundations of Thought and Action: A Social Cognitive Theory.* Englewood Cliffs, NJ: Prentice-Hall; 1986.
51. Tang C, Raat H, Yan M, et al. Application of the health action process approach model for reducing excessive internet use behaviors among rural adolescents in China: a school-based intervention pilot study. *BMC Public Health.* 2021; 21(1): 986. Published 2021 May 26. DOI: 10.1186/s12889-021-10999-z
52. Zhang CQ, Zhang R, Schwarzer R, Hagger MS. A meta-analysis of the health action process approach. *Health Psychol.* 2019; 38(7): 623-37. DOI: 10.1037/hea0000728
53. Hattar A, Pal S, Hagger MS. Predicting Physical Activity- Related Outcomes in Overweight and Obese Adults: A Health Action Process Approach. *Appl Psychol Health Well Being.* 2016; 8(1): 127-151. DOI: 10.1111/aphw.12065

54. Lin CY, Updegraff JA, Pakpour AH. The relationship between the theory of planned behavior and medication adherence in patients with epilepsy. *Epilepsy Behav.* 2016; 61: 231-6. DOI: 10.1016/j.yebeh.2016.05.030
55. Ranjbaran S, Shojaeizadeh D, Dehdari T, Yaseri M, Shakibazadeh E. Determinants of medication adherence among Iranian patients with type 2 diabetes: An application of health action process approach. *Heliyon.* 2020; 6(7): e04442. Published 2020 Jul 14. DOI: 10.1016/j.heliyon.2020.e04442
56. Hilberdink S, Lens GL, Lefevre LJ, Peters GJ. OP0101-HPR action planning's parameters for effectiveness in increasing exercise adherence behaviour. *Ann Rheum Dis.* 2015; 74: 106-7.
57. Scholz U, Schüz B, Ziegelmann JP, Lippke S, Schwarzer R. Beyond behavioural intentions: planning mediates between intentions and physical activity. *Br J Health Psychol.* 2008; 13(Pt 3):479-94. DOI: 10.1348/135910707X216062

Appendix Original and modified scale of LSMBQ

No.	Original items	Modified items
1	I take the initiative to ask professionals for help when I have questions about disease	No change required
2	I take the initiative to exchange relevant information with other patients	No change required
3	I actively learn about knowledge related to lymphoedema, such as risk factors, signs and symptoms and self-management skills	No change required
4	I adhere to a balanced diet to maintain a healthy weight	No change required
5	I maintain good eating habits, such as a low-salt, high-protein diet and avoid tobacco and alcohol	No change required
6	I do suitable exercises, such as deep breathing exercises, resistance exercises and aerobic exercises	No change required
7	I keep the skin of the affected limb clean and moisturized	No change required
8	I protect the affected limb to avoid injury, such as avoiding sunburn, trauma or performing invasive treatment operations such as blood draws and injections	No change required
9	I avoid the affected limbs being stimulated by over cold or overheat, such as sauna or long hot bath	No change required

10	I avoid pressure on the affected limb, such as avoiding wearing tight clothing or jewelry, measuring blood pressure	No change required
11	I avoid overwork of the affected limb, such as excessive weight-bearing or long-term repetitive labor	No change required
12	I observe minor changes in the affected limb, such as swelling, pain, numbness, stiffness, heaviness, redness and fever and skin breakage, and actively report the changes in time	No change required
13	I do activities that promote the return of lymph fluid, such as raising the affected limb and doing concentric massage	No change required
14	I use compression garments as recommended, such as when travelling long distances or flying	No change required
15	I adhere to the advice of professionals to prevent and treat lymphoedema, such as manual lymphatic drainage and artificial compression	No change required
16	I self-regulate negative emotions through relaxation training	Deleted
17	I communicate with my family/friends/colleagues/fellow patients about my psychological feelings for comfort and help	Deleted

18	I communicate with medical staff about my psychological feelings for support and help	Deleted
19	I take on my due duties and responsibilities in my family	Deleted
20	I maintain a good relationship with my family, colleagues and friends	Deleted
21	I return to social and/or work before the illness	Deleted
22	I adjust and adapt to the new life as a patient	Deleted
		Add: 16. I can adhere to do arm exercise in daily life, as recommended
		Add: 17. I can adhere to measure the circumference of the affected limb myself through myself or family members, as advised recommended