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ORIGINAL ARTICLE

Validation of an information–motivation–behavioral skills model of upper limb functional exercise adherence among Chinese postoperative patients with breast cancer

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Abstract

Background The adherence to postoperative upper limb functional exercise in breast cancer (BC) patients is poor which can lead to adverse health outcomes. Effective intervention content to improve adherence is still unclear. The information–motivation–behavioral skills (IMB) model is a theoretical model that has been widely used to promote health behavior in many disease populations and may, therefore, help to explain and promote adherence to functional exercise. In this study, we validated the IMB model in a sample of postoperative BC patients.

Methods A cross-sectional study of 165 postoperative patients with BC was performed in a hospital. We collected information on demographics, functional exercise knowledge (information), personal and social motivation (motivation), objective skills and self-efficacy (behavioral skills), and functional exercise adherence (behavior). Measured variable path analyses were applied for the IMB framework.

Results The IMB elements explained 37.9% of the variance in adherence. As predicted, behavioral skills had a direct effect on adherence ($\beta = 0.509$; $P < 0.05$) and mediated the effects of knowledge (indirect effect 0.092, $P < 0.05$) and motivation (indirect effect 0.251, $P < 0.05$) on adherence.

Conclusions Behavioral skills have a direct effect on functional exercise adherence and a mediating effect on the influence of knowledge and motivation on adherence. Thus, these factors represent key determinants of exercise adherence. The IMB model could be applied to the upper limb exercise adherence of postoperative BC patients. These findings indicate that the promotion of exercise adherence interventions may benefit from targeting patients' exercise adherence-related knowledge, motivation, and behavioral skills.

Keywords BC · Upper limb functional exercise · Information–motivation–behavioral skills model

Introduction

Breast cancer (BC) is the most common female malignant tumor globally, the prevalence of which continues to rise [1, 2]. Due to improvements in early screening, diagnosis and treatment, the survival rates for BC patients have greatly improved. In China, the 5-year survival rate for BC is 73.0% [3]. At present, surgery is the most effective BC treatment. However, a series of postoperative complications, including limb dysfunction and edema, have a significant negative impact on the functional activities of patients and their subsequent quality of life [4, 5]. Early postoperative upper limb functional exercise have been shown to improve skin adhesion and edema of the upper limbs, which has a positive effect on promoting upper limb functional recovery and

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improving the quality of life of patients [6, 7]. Nevertheless, several studies have shown that the adherence to postoperative upper limb functional exercise is low, which mainly manifests as an inability to complete the exercise program over extended periods of time, or failing to achieve the required exercise intensity and frequency [8, 9]. Therefore, it is very important to effectively improve the upper limb functional exercise adherence of patients with BC. Previous studies [10, 11] have found that there are many factors affecting the adherence, such as disease severity, adverse effect of chemotherapy, self-efficacy, social support, and cognition. However, we still need a synthesis method to investigate the effect of potential factors on upper limb functional exercise adherence, and use the structural equation model to verify the coefficient and path between these factors.

Conceptional framework

The information-motivation-behavioral skills (IMB) model [12] is a relatively mature theory of behavior change. It has been confirmed in AIDs patients in several cross-sectional studies [13, 14]. Intervention measures based on the IMB model have successfully improved adherence and the clinical effects of drug use [15, 16]. In addition, as a health behavior model, the IMB has been widely used in various health fields, including BC screening and breast self-examination [17–19]. The model may, therefore, also be applicable to the intervention of the adherence of upper limb functional exercise in postoperative patients with BC.

The IMB model identifies three key factors for the formation and maintenance of health behaviors; (1) accurate information that can be easily translated into health behavior; (2) personal and social motivation to act on such information; and (3) behavioral skills to implement health behavior [20]. These refer to accurate information related to healthy behaviors for which we used upper limb functional exercise knowledge as an indicator. Motivation consists of two components, personal and social motivation. Personal motivation is a function of one's beliefs regarding the consequences of a behavior and the evaluation of these consequences. Social motivation is based on an individuals' perception of social normality and social support for anticipating behavior. Behavioral skills include objective skills to effectively implement preventive behavior and self-efficacy. In this study, information, motivation, and behavioral skills were used as factors that influence the adherence of patients with BC to upper limb functional exercise after surgery.

Objectives and research hypotheses

The purpose of this study was to test whether the IMB model can explain the upper limb functional exercise adherence behavior in postoperative BC patients. Based on the theoretical underpinnings of the IMB model, we hypothesized that upper limb functional exercise knowledge and motivation would affect upper limb functional exercise adherence behavior directly and indirectly through behavioral skills (Fig. 1).

Materials and methods

Participants and procedures

A cross-sectional, observational study was conducted. Participants were included if they met the following criteria: (1) BC diagnosed and treated with surgery; (2) ability to communicate normally; and (3) voluntary participation in the survey following explanations by staff. The exclusion criteria were as follows: (1) other malignant tumors; (2) mental disorders including depression and an inability to cooperate; and (3) other important organ disease that limit patient activity.

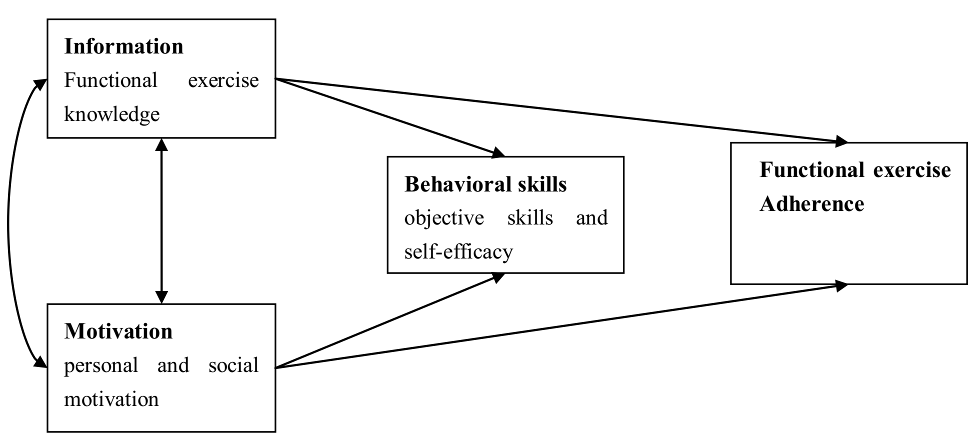

Fig. 1 Hypothesized IMB skills model of upper limb functional exercise adherence

Data were collected from May 2nd to November 30th 2016 at a hospital in Changchun, China. Convenience sampling was adopted. Overall, 165 of the 176 eligible participants (response rate = 93.8%) provided consent and completed the study. All questionnaires were collected by trained research assistants. All procedures were approved by the hospital nursing department and hospital ethics committee.

Measures

Demographic characteristics included age, gender, race, residence, occupation, education, marital status, and income. Clinical characteristics included a family history of BC, clinical stages of disease, operative site, operative method on the axillary lymph nodes, postoperative time, and chemotherapy times.

The upper limb functional exercise knowledge was assessed using the 15-item Upper Limb Functional Exercise Knowledge Questionnaire containing four dimensions: (1) the concept of upper limb dysfunction (three items); (2) the importance of upper limb functional exercise (two items); (3) the method of upper limb functional exercise (three items); and (4) the attention to upper limb functional exercise (seven items). Example questions included 'Do you think postoperative upper limb dysfunction is related to lymphatic, vascular and neurological injuries caused by mastectomy and axillary lymph node dissection?' that were designed to be "yes," "no," or "I don't know" (yes = 1; no or I don't know = 0). The overall scores ranged from 0 to 15, with higher scores indicating greater upper limb functional exercise knowledge.

The motivation was assessed using the Upper Limb Functional Exercise Motivation Questionnaire which measures the patients' attitude, beliefs and social support regarding postoperative upper limb functional exercise. The questionnaire consisted of nine items, including two dimensions: (1) personal motivation (six items, for example 'Do you think postoperative upper limb function exercise is important?') and (2) social motivation (three items, for example 'Does your family support your postoperative upper limb function exercise?'). Based on the Likert five-point scoring method, the total score was the sum of all the items (9–45 points). Higher scores indicated a more positive attitude and greater social support.

The behavioral skills were assessed using the Upper Limb Functional Exercise Behavioral Skills Questionnaire. This included seven items that measure objective skills (four items had questions such as 'Have you mastered the methods or techniques of upper limb function exercise?') and self-efficacy (three items with questions such as 'Whether you have the confidence to insist on upper limb function exercise every day?'). Based on the Likert five-point scoring method, the overall scores ranged from 7 to 35, with higher scores indicating greater objective skills and self-efficacy.

Upper limb functional exercise adherence was measured using the Upper Limb Functional Exercise Adherence Scale. The scale was compiled and confirmed by Lu [21], with good surface validity, structural validity, and internal consistency and reliability. The scale was also proven to be of good reliability and validity in studies by Pan and coworkers [22].The scale includes 18 entries that consist of three dimensions: (1) physical exercise adherence (nine items, for example 'Can you remember the specific methods and techniques of functional exercise'); (2) postoperative precaution adherence (five items, for example 'Can you protect the affected limb and try to avoid using the affected limb to move and lift heavy objects'); and (3) initiative to seek advice adherence (four items, for example 'When you find that the effect of functional exercise is not obvious, can you actively seek advice to improve its effects'). The score of each item ranged from "1 = cannot at all" to "4 = can do completely" with a total score ranging from 18 to 72. Higher scores indicated a higher level of adherence.

In addition to the Upper Limb Functional Exercise Adherence Scale, the remaining three questionnaires were designed by researchers following a review of the relevant literature [21, 23–26]. This study assessed the reliability and validity of the questionnaires. The results showed that knowledge, motivation and behavioral skills questionnaires of upper limb functional exercise had good content validity (average content validity was 0.96, 0.99, and 1.00, respectively). The internal consistency of the questionnaires was also acceptable and reliable, the Cronbach's a coefficient of the questionnaires being 0.836, 0.824, and 0.776, respectively. The entire content of the questionnaires were displayed in the electronic supplementary materials.

Statistical analysis

Epidata 3.1 software was used to set up a database for data entry and SPSS 21.0 software was used for statistical analysis. Categorical variables were described as percentages and continuous variables were described as the mean ± SD. Pearson's correlation analysis was used to explore the relationship between upper limb functional exercise knowledge, motivation, behavioral skills and adherence. Using a path analysis, we created inferential statistics on the influencing factors of upper limb functional exercise adherence and constructed a path diagram. The path coefficient of each variable in the path model was calculated using multiple regression analysis. A p value < 0.05 was deemed statistically significant.

Results

Patient characteristics

Overall, 164 participants were female (99.4%), the majority of whom were married (87.9%). Participants had an average age of 47.25 years (SD = 9.60, range 26–75). Ninety-six were treated with simple breast resection (58.2%) and 70.3% with axillary sentinel lymph node biopsy. All the patients were treated with chemotherapy, and the number of patients who received the first chemotherapy was higher, accounting for 52.7% (Table 1). Univariate analysis showed no significant difference in upper limb functional exercise adherence among patients with differing chemotherapy times or axillary lymph nodes operative methods, as shown in the electronic supplementary materials.

Upper limb functional exercise knowledge, motivation, behavioral skills, and adherence correlation analysis

Table 2 presents descriptive statistics for each variable and bivariate correlations between these variables. There was a significant positive correlation between knowledge, motivation, behavioral skills, and exercise adherence in postoperative BC patients ($P<0.01$). The correlation coefficient between behavioral skills and exercise adherence was the highest ($r=0.602$, $P<0.01$). Correlation analysis of knowledge and motivation showed a significant positive correlation ($r=0.439$, $P<0.01$).

IMB path diagram of upper limb functional exercise adherence

Multivariate regression analysis of the knowledge, motivation and behavioral skills of upper limb functional exercise

Table 3 shows the coefficients of the multiple regression analysis. Both knowledge ($\beta=0.181$, $P=0.011$) and motivation ($\beta=0.493$, $P=0.000$) had a significant influence on behavioral skills, among which motivation had a greater influence.

Multivariate regression analysis of knowledge, motivation, behavioral skills and adherence of upper limb functional exercise

Table 4 shows the coefficients in this multiple regression analysis. The influence of knowledge and motivation on adherence was not statistically significant, with influence

Table 1 Characteristics of participants

Characteristic	Mean ± SD or *N* (%)
Age, years	47.25 ± 9.60
Gender	
Male	1 (0.6%)
Female	164 (99.4%)
Race	
Ethnic Han	145 (87.9)
Ethnic minorities	20 (12.1)
Marital status	
Married	2 (87.9)
Not married	145 (1.2)
Residence	
Town	103 (62.4)
Country	62 (37.6)
Education	
Illiteracy or elementary school	30 (18.2)
Junior high school	60 (36.4)
Senior high school	34 (20.6)
Technical school or college	41 (24.8)
Income (RMB)	
< 1000	45 (27.3)
1000–1999	38 (23.0)
2000–2999	43 (26.1)
3000–4999	26 (15.8)
≥ 5000	13 (7.9)
Main caregiver	
Parents	10 (6.10)
Husband	101 (61.2)
Children	45 (27.3)
Others	9 (5.5)
Family history of breast cancer	
Yes	7 (4.2)
No	158 (95.8)
Operative method	
Modified radical mastectomy	49 (29.7)
Simple mastocarcinomaectomy	96 (58.2)
Breast-conserving surgery	20 (12.1)
Axillary lymph nodes operative method	
Radical dissection	49 (29.7)
Sentinel lymph node biopsy	116 (70.3)
Surgical site	
Right	81 (49.1)
Left	81 (49.1)
Both sides	3 (1.8)
Postoperative time (day)	
< 10	34 (20.6)
10–30	55 (33.3)
31–60	24 (14.5)
61–90	14 (8.5)
> 90	38 (23.0)
Clinical stage	

Table 1 (continued)

Characteristic	Mean ± SD or N (%)
Stage I	22 (13.3)
Stage II	101 (61.2)
StageIII	42 (25.5)
Other chronic diseases	
Yes	45 (27.3)
No	120 (72.7)
Postoperative complications	
Yes	18 (10.9)
No	147 (89.1)
Chemotherapy times	
1	87 (52.7)
2	18 (10.9)
3	10 (6.1)
4	10 (6.1)
5	9 (5.5)
6	11 (6.7)
7	7 (4.2)
8	13 (7.9)

coefficients of 0.075 ($P = 0.287$) and 0.110 ($P = 0.164$), respectively. The influence of behavioral skills on adherence was significant (influence coefficient of 0.509, $P = 0.000$). The IMB constructs explained 37.9% of the variance in upper limb functional exercise adherence.

Direct and indirect effects of variables in upper limb functional exercise adherence IMB models

Table 5 shows the direct and indirect effects of variables in the IMB model of upper limb functional exercise adherence. Although knowledge and motivation had no significant direct effect on upper limb functional exercise adherence, both had significant indirect effects on adherence ($\beta = 0.092$, $p < 0.05$; $\beta = 0.251$, $p < 0.05$, respectively) through behavioral skills.

Table 3 Multivariate regression analysis of the knowledge, motivation and behavioral skills of upper limb functional exercise

Variable	*B*	Beta	*t*	*p*
Constant	9.498		4.504	0.000
Knowledge	0.223	0.181	2.575	0.011
Motivation	0.413	0.493	7.020	0.000

Dependent variable:upper limb functional exercise behavioral skills $R^2 = 0.354$

Table 4 Multivariate regression analysis of the knowledge, motivation, behavioral skills, and adherence of upper limb functional exercise

Variable	*B*	Beta	*t*	*p*
Constant	15.659		3.623	0.000
Knowledge	0.183	0.075	1.068	0.287
Motivation	0.182	0.110	1.399	0.164
Behavioral Skills	0.999	0.509	6.583	0.000

Dependent variable:upper limb functional exercise adherence $R^2 = 0.379$

Construct of the IMB model

The path coefficient and related statistics were added to the initial theoretical model to form the final IMB path diagram. As shown in Fig. 2, behavioral skills was significantly related to functional exercise adherence, and also mediated the effects of knowledge and motivation on adherence.

Discussion

The IMB model of adherence [12], which has been largely used to conceptualize HIV medication adherence [13, 14], was applied to conceptualize the determinants of upper limb functional exercise adherence among postoperative BC patients. To our knowledge, this is the first study to examine whether the IMB model can explain upper limb functional exercise adherence behavior among Chinese BC patients. Consistent with the IMB predictions, upper limb functional exercise knowledge and motivation were associated with

Table 2 Descriptive statistics and correlations between model variables

Measure	Descriptive statistics		α	Pearson correlation			
	Mean ± SD	Range		Knowledge	Motivation	Behavioral skills	Adherence
Knowledge	11.90 ± 2.91	0–15	0.751	1			
Motivation	39.60 ± 4.29	9–45	0.802	0.439[a]	1		
Behavioral skills	28.37 ± 3.59	7–35	0.746	0.397[a]	0.573 [a]	1	
Adherence	53.25 ± 7.06	18–72	NA	0.326[a]	0.435 [a]	0.602 [a]	1

[a] $P < 0.01$; *NA* not applicable

Table 5 Direct and indirect effects of variables in upper limb functional exercise adherence IMB model

Independent variable	Direct effect				Indirect effect			
	Adherence	Knowledge	Motivation	Behavioral skills	Adherence	Knowledge	Motivation	Behavioral skills
Knowledge				0.181[b]	0.092[b]			
Motivation				0.493[a]	0.251[b]			
Behavioral Skills	0.509[a]							

[a]$P<0.01$; [b]$P<0.05$

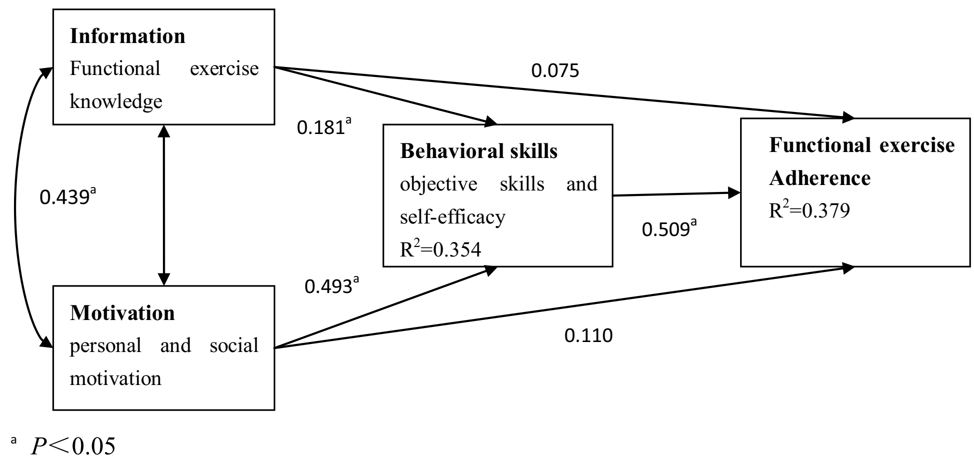

Fig. 2 Path analysis diagram of upper limb functional exercise adherence IMB

behavioral skills, which was in turn associated with exercise adherence. Thus, the IMB model was well positioned to explain the sample's upper limb functional exercise adherence behavior, accounting for 37.9% of the variability regarding this outcome.

The results showed that the majority of the 165 subjects were women with only one male included. This was due to the high incidence of BC among women with etiology and sex having a high correlation. The average age of the subjects was similar those reported in the previous studies in China [27, 28]. The majority of participants (77%) had less than 3-month postoperative time, which is a critical period for upper limb functional exercise of the upper limbs [29]. Investigating patients during this stage can fully reflects the knowledge, motivation, behavioral skills, and adherence status of the patients.

The results of the Pearson correlation analysis revealed a significant positive correlation between upper limb functional exercise knowledge, motivation, behavioral skills, and adherence. Among these, compared with knowledge and motivation, behavioral skills had the greatest influence on adherence, consistent previous studies [26]. A significant positive correlation between knowledge and motivation was observed, indicating that in the IMB model of upper limb functional exercise adherence, the knowledge and motivation is often covariant [13, 14]. This means that increased knowledge can lead to increased motivation, with positive individuals acquiring more knowledge. However, it should be noted that other studies [30, 31] have reported that motivation may exist in an inaccurate or incomplete information environment and vice versa.

In this study, upper limb functional exercise knowledge and motivation had a direct effect on behavioral skills, consistent with the IMB model. In addition, and consistent with other empirical tests of the IMB model of adherence [32, 33], motivation had a higher impact on behavioral skills than knowledge. These results show that, in comparison to improved knowledge, a lack of positive attitude, belief and good social support, leads to a loss of motivation to master the objective skills. Thus, the role of motivation during upper limb functional exercise should be emphasized. Clinical nursing staff should state its importance, establish the patient's confidence in rehabilitation, and improve their subjective initiative. Strengthening the encouragement and support of family members and medical staff to upper limb functional exercise would also be beneficial.

However, knowledge and motivation have no direct effect on upper limb functional exercise adherence, but can indirectly influence adherence through behavioral skills. These results differ from the initial IMB hypothesis but are consistent with the conclusions of the previous studies [34]. This indicates that although high levels of knowledge and motivation play an important role in the promotion of upper limb functional exercise, they are not necessary to improve adherence. Thus, by improving upper limb functional exercise skills and self-efficacy, and not simply enhancing the knowledge and motivation, the adherence to upper limb functional exercise can be improved.

Behavioral skills is a key influencing factor for adherence, the effects of which are direct, representing an important intermediate variable between upper limb functional exercise knowledge, motivation and adherence. Postoperative upper limb functional exercise in BC must follow certain principles in which a variety of behavioral techniques must be performed. Thus, clinical nursing staff should focus on the guidance and implementation of the specific functional exercise methods.

In summary, each factor individually cannot fully explain the existence, continuity, and complexity of adherence. As such, the upper limb functional exercise adherence IMB model can provide multi-variable interpretations of adherence, which can be applied to clinical nursing procedures to improve patient adherence to upper limb functional exercise following BC surgery.

Conclusions

In the upper limb functional exercise adherence IMB model, knowledge and motivation had a positive and direct effect on behavioral skills. The direct effect of motivation was greater than that of knowledge. knowledge and motivation had no direct effect on adherence. Behavioral skills had a direct effect on adherence and a mediating effect on the influence of knowledge and motivation on adherence, which is a crucial determinant for upper limb functional exercise adherence.

These results confirm that the IMB model can be applied to upper limb functional exercise in postoperative BC patients, and that clinical nursing staff can formulate targeted interventions in combination with the patients' needs using guidance of the theoretical model to improve upper limb functional exercise adherence.

Limitations

Firstly, the data obtained in this study were primarily self-reported knowledge, which is often influenced by subjective thinking. Secondly, this survey was a cross-sectional study but upper limb functional exercise is a continuous and dynamic process, and a longitudinal prospective investigation is needed. Thirdly, this study adopted a convenient sampling method meaning the scope of the research was limited. It is necessary to expand the sample size and validate the model universality in future studies.

Compliance with ethical standards

Conflict of interest The authors have no funding or conflicts of interest to disclose.

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