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ORIGINAL ARTICLE

Adherence to prescribed exercise time and intensity declines as the exercise program proceeds: findings from women under treatment for breast cancer

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Abstract
Purpose Adherence to prescribed exercise is a challenge for cancer patients undergoing treatment. The changing pattern of exercise adherence over time cannot be fully understood by an overall measure of adherence. This study was aimed to identify the trajectory of exercise adherence and its predictors for women with breast cancer during their chemotherapy.

Methods Participants were 78 women with breast cancer assigned to the exercise arm of a randomized control trial. Based on the weekly adherence rates in time and intensity, patients were classified as good (>100 %), acceptable (80–100 %), and poor (<80 %) adherents. Data were analyzed using ordinal logistic hierarchical linear modeling.

Results The trajectories for both time and intensity adherence declined significantly. The decline in exercise-time adherence was significantly slower in women who reported higher interest in exercise. Women with higher perceived importance of exercise, early disease stage, and employed were more likely to be classified as good intensity adherents. Poorer weekly adherence for both exercise time and intensity was associated with higher fatigue level for that week.

Conclusions Adherence to exercise adherence in breast cancer patients declined as the dose of exercise prescription increased. Factors influencing overall adherence and adherence trend were identified.

Keywords Adherence · Home-based exercise · Breast cancer · Chemotherapy · HLM

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Introduction

For cancer patients undergoing treatment, exercise or physical activity has been shown to reduce symptoms such as fatigue [1], mood disorders [2], sleep disturbance [3], and physical function [4] and to improve quality of life [2]. Furthermore, women who exercised moderately after a breast cancer diagnosis were found to have a better survival rate than sedentary women [5]. A moderate-to-high intensity aerobic training is safe for breast cancer patients during chemotherapy [6].

Indeed, exercise has been shown in systematic reviews to benefit cancer patients during and after treatment [7–9].

Despite the benefits of exercise, many people do not adhere to recommended exercise prescriptions [10]. Among cancer survivors, the exercise adherence rate for both home-based and supervised exercise programs was 60 to 85 % [11]. Non-adherence to exercise interventions is a challenge for evaluating their efficacy [12–14].

Exercise adherence has been measured by two approaches: to determine overall performance or to average repeated measures of exercise-related behaviors over an exercise program. The most commonly used indicator of overall performance is the ratio of sessions attended/completed to sessions expected/prescribed [13, 15–20]. Exercise-related behaviors include exercise frequency, exercise duration, pedometer steps, intensity, etc. [21, 22]. For both the overall and averaged approaches, exercise adherence is treated as a time-invariant variable. Since exercise training is often prescribed with progressively increasing doses in both intensity and time, exercise adherence may change during the training period. Furthermore, for cancer patients under treatment, adherence to exercise may fluctuate with treatment side effects.

Changes in patterns of exercise adherence and its predictors in breast cancer survivors have been examined in only a few studies [23, 24]. For example, breast cancer survivors' adherence to a 12-week home-based exercise program was assessed by three indicators: total weekly exercise (minutes/week), number of steps/week, and meeting a negotiated weekly goal [23]. Participants' first two outcomes significantly increased during the program, but the percentage of those meeting the negotiated goal was >80 % only in the first 4 weeks [23]. In the second study, the adherence of female breast cancer patients receiving chemotherapy to the prescribed regimen of 10, 000 steps/day was measured in two ways: total number of steps/week and mean number of steps/day (on days with any steps recorded) [24]. During the 12-month study, the adherence rate was lower in the first 6 weeks, but increased at 3, 6, and 9 months before slightly dropping at 12 months [24].

Adherence has been defined as the extent to which a person's behavior corresponds with the agreed recommendation [25]. Therefore, the absolute amount of exercise activity, either steps or exercise time, does not reflect the concept of adherence. Only percentage of actual exercise activity over an expected exercise activity can better represent the essence of adherence. To develop effective strategies to improve breast cancer patients' exercise adherence, those at risk for poor adherence must be identified. This study examined female breast cancer patients' adherence to a 12-week home-based exercise intervention while undergoing chemotherapy. Specifically, the study had two purposes: (1) to examine the trajectory of exercise adherence in terms of time and intensity and (2) to explore predictors of the exercise adherence trajectory, in terms of intercept and slope.

Materials and methods

Sample and setting

The study sample was from the intervention arm of a randomized control study examining the effect of home-based walking-exercise program on sleep disturbance and other symptoms for women with breast cancer receiving chemotherapy. Participants for the original study were recruited from women treated at Chang Gung Memorial Hospital in northern Taiwan who met the following criteria: (1) diagnosed with stage I–III breast cancer, (2) reporting insomnia, fatigue, pain, or depressive symptoms after the first cycle of chemotherapy, and (3) willing to be randomly assigned to an intervention or control group. Women were excluded if they had diagnosed sleep disorders, a psychiatric diagnosis, cardiovascular problems, muscle-skeletal problems, or conditions judged by their treating physicians as not suitable for exercise.

Among 492 patients assessed for eligibility in the original study, 221 were disqualified and 112 refused to participate. Of the remaining 159 patients, 81 were randomly allocated to the exercise group, but 3 dropped out before the intervention, leaving 78 who received the exercise intervention (Fig. 1). Among these 78 patients, 64 completed the 12-week exercise program and 14 dropped out for various reasons: not feeling well physically (n=8), unwilling to exercise (n=2), dislike of brisk walking (n=1), and unknown reasons (n=3). Those who withdrew and those who completed the 12-week program did not differ significantly at baseline on fatigue, performance status, and distance walked in 6 min. The sample for the current analysis included the 78 women who participated in the exercise intervention for at least 1 week. The study was approved by the hospital's Institutional Review Board, and all participants provided their written informed consents.

Exercise intervention

The exercise intervention was a 12-week home-based aerobic-walking program that followed ACSM guidelines of progressive increase of exercise prescription through three stages: initial, improvement, and maintenance stage [26]. Since the participants in this study were cancer patients under treatment, a moderate exercise intensity was set with 30–70 % heart rate reserved (HRR), which was 10–15 % lower than suggested by ACSM. The suggested exercise frequency was 3 times/week

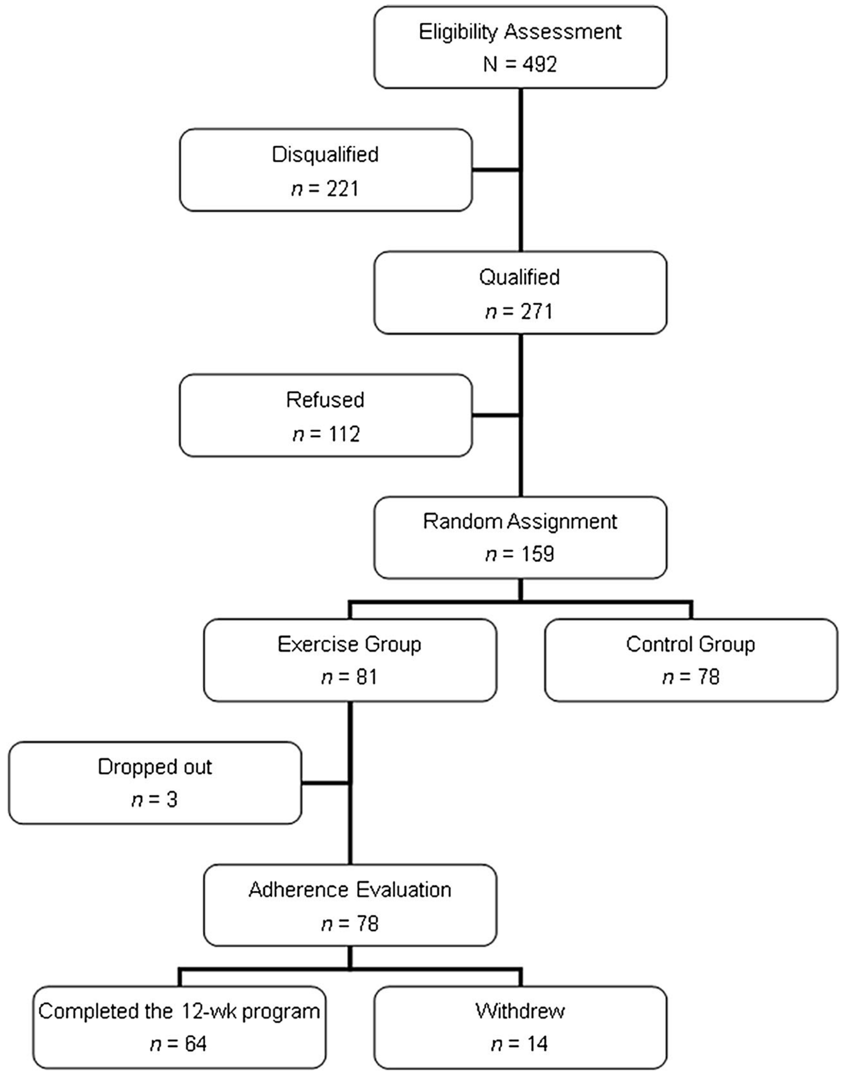

Fig. 1 Flow chart of subject recruitment

for the first 6 weeks and 5 times/week for the second 6 weeks. Exercise duration was also increased gradually, from 15 to 25 min/session for weeks 1 to 4, to 25–35 min/session for weeks 5 to 8, and 35–40 min/session for weeks 9 to 12 (Table 1).

All exercise instructions were provided by a coach with professional training on sports. The coach first instructed patients about the benefit of exercise followed by a demonstration of brisk walking. An exercise manual using both simple wording and pictures was used to assist the instruction. Content of this exercise manual includes purposes and potential benefits of exercise, the step-by-step procedure of the brisk walking with pictures, methods of monitoring heart-rate, indicators for stopping exercise, and contact information. A progressive weekly goal based on individual patient's age and rest heart rate was planned for

Table 1 Exercise frequency, intensity, and duration by stage

Stage		Week	Frequency (sessions/week)	Intensity (% of HRR)	Duration (minutes/session)
I. Initial	I	1–4	3	30–40	15–25
II. Improvement	IIa	5–6	3	40–50	25–35
	IIb	7	5	40–50	25–35
	IIc	8	5	50–60	25–35
III. Maintenance	III	9–12	5	60–70	35–40

HRR heart rate reserve

each participants. Participants were taught to record their walking time, frequency, duration, HR before and after walking, maximum HR during walking, exertion level and any injuries or adverse events on a diary. During the weekly follow-up phone call, the same coach would usually remind patient to do exercise and make sure if the goal for that week was reached. Patients would be asked if they had any difficulty adhering to the prescribed exercise dose and if they experienced any uncomfortable situation during the exercise. The instructor often provided positive reinforcement for those who reached the goal and encouragement for those who did not reach the goal. To ensure the feasibility and standardization of the instruction, the coach performed several mock instructions under the guidance of the second author.

Measures

The primary outcomes were exercise adherence rates on two elements: time and intensity. We conceptualized four types of predictors: demographics, disease/treatment characteristics, exercise behavior and attitude factors, and physical factors (fatigue and physical status).

Exercise time and intensity

Data of actual exercise time, heart rate during exercise were self-recorded by participants using a researcher-developed exercise diary. This diary included each participant's weekly prescription for exercise frequency, duration, and target heart rate. Participants monitored their heart rate using a FDA-approved sports pulse ring that detects heart rates of 30–250 beats/min. In this study, this sports pulse ring had an error <3 %.

Exercise behavior and attitudes

Data were collected at baseline on previous regular exercise habits (yes/no), degree of interest in exercise, and perceived importance of exercise using a researcher-developed questionnaire. Interest in exercise and perceived importance of exercise were measured on a 0 (not at all) to 10 (extremely interested/important).

Fatigue

Baseline fatigue was measured by the Brief Fatigue Inventory (BFI) [27]. The first part of the BFI assesses fatigue intensity at the time of assessment, as well as average and worst during the past 24 h. The second part of the BFI assesses fatigue interference with six aspects of life. Both intensity and interference items are measured on a 0 (no fatigue/interference) to 10 (worst fatigue imaginable/extreme interference) scale. The BFI has demonstrated satisfactory validity and reliability in cancer patients [27]. Average fatigue intensity was used in the current study. In each exercise day during the 12-week intervention, patients recorded their fatigue level on a 0 (not at all) to 10 (extremely) scale in a researcher-developed exercise diary. Average weekly fatigue was used in the analysis.

Physical status

Physical status was assessed by performance on two measures: the Karnofsky Performance Scale (KPS) [20] and the six-minute walking test (6MWT) [28]. The KPS score ranges from 0 % (dead) to 100 % (normal, no complaints; no evidence of disease). The 6WMT measures the distance (in meters) that the subject can walk in 6 min. Both methods have been widely used in cancer patients with satisfactory reliability and validity [20, 28, 29].

Demographic and disease/treatment characteristics

Demographic (age, marital status, educational level, religious affiliation, menopause status, and employment status) and disease/treatment (disease stage, surgery type, chemotherapy regimen, and other adjuvant therapy) characteristics were collected from patients or medical records using a researcher-developed questionnaire.

Procedure

At the second chemotherapy cycle, eligible and consented patients were assessed for baseline data. At the third chemotherapy cycle, the exercise coach instructed patients how to perform their home-based walking and how to use the pulse ring to monitor heart rate during exercise. The exercise coach called patients weekly to encourage adherence to the exercise program and to help them deal with exercise-related problems, if any. Patients were asked to record exercise-related information in the exercise diary throughout the 12-week exercise intervention period.

Statistical analysis

Exercise adherence was evaluated by two elements of the exercise prescription: time and intensity. The weekly total exercise time was obtained from the diary information of exercise duration/session and frequency/week. Adherence to the prescribed exercise time was defined by the ratio of actual exercise time/week to the prescribed minimal exercise time/week. Adherence to exercise intensity was defined by the ratio of the highest heart rate during exercise to the target heart rate. The target heart rate for each week was calculated for each patient based on their age using the following equation:

$$HR_{target} = ([HR_{max} - HR_{rest}] \times \text{percent intensity}) + HR_{rest}$$

where

HR_{target}	target heart rate
HR_{max}	maximal heart rate=200−age in years
HR_{rest}	heart rate at rest
$HR_{max}-HR_{rest}$	heart rate reserve (HRR)
Percent intensity	30 to 70 %

The obtained adherence ratios (rates) for time and intensity were further categorized into three ordinal groups: "good adherence" (>100 %), "acceptable adherence" (80–100 %), and "poor adherence" (<80 %).

The trajectory of exercise adherence and its predictors was examined by ordinal logistic hierarchical linear modeling (HLM). In this study, repeated measures of adherence were considered as being nested within individuals. Therefore, we used a multilevel analysis. Level I data contained information of within-person changes over time, while level II data comprised information about individual characteristics that could be used to predict the parameters estimated from level I. The analytic process was divided into three steps. First, an unconditional model was specified to determine the pattern of change in adherence over time. Second, univariate analysis was used to explore potential factors predicting adherence. The predictors explored in this step included demographic variables, disease and treatment variables, exercise behavior and attitude variables, and physical variables including fatigue. Third, significant factors identified were entered into multivariate analysis and final models with significant predictors of adherence, for both time and intensity, were formed. In these analyses, the weekly time- and intensity-adherence categories were time-variant dependent variables. Time (weeks) and weekly mean fatigue severity were considered level-I time-variant predictors. Personal and disease/treatment characteristics, exercise behavior and attitude, and physical variables were level-II time-invariant variables. For each week after the first week, patients with missing adherence data were compared to patients with valid data for their previous week's adherence rates to determine whether the data were missing at random.

Results

Sample characteristics

Participants' mean age was 48.27 years (SD=8.03). Most of the women were married (85.9 %) and were diagnosed

Table 2 Sample characteristics (n=78)

Variable	Mean (SD)	n (%)
Age (years)	48.27 (8.03)	
Height (cm)	155.58 (4.70)	
Weight (kg)	57.43 (10.66)	
Interest in exercise (0–10)[a]	5.83 (2.65)	
Perceived importance of exercise (0–10)	8.92 (1.68)	
Baseline 6 min-walking distance (m)	434.1 (78.76)	
Karnofsky performance status (0–100)	91.13 (4.23)	
Fatigue severity (BFI score, 0–10)	3.90 (2.22)	
Regular exercise before diagnosis		
Yes		35 (44.9)
No		43 (55.1)
Previous exercise frequency (days/week) (n=35)		
≤2		2 (5.7)
3–4		10 (28.6)
≥5		23 (55.7)
Marital status		
Never married		9 (11.5)
Married-partnered		67 (85.9)
Divorced/widowed		2 (2.6)
Menopause		
Yes		33 (42.3)
No		45 (57.7)
Religion		
None		22 (28.2)
Buddhism		38 (48.7)
Christianity/Catholicism		3 (3.9)
Taoism		15 (19.2)
Employment		
None		20 (25.6)
Full time		55 (70.5)
Part time		3 (3.8)
Working status after diagnosis		
Same		39 (50.0)
Shift to part time		3 (3.8)
Quit		19 (24.4)
Leave job temporarily		12 (15.4)
Other		5 (6.4)
Education level		
≤Elementary school		19 (24.4)
Junior high school		11 (14.1)
Senior high school		32 (41.0)
≥College		16 (20.6)
AJCC disease stage		
I		31 (39.8)
IIa		28 (36.4)

Table 2 (continued)

Variable	Mean (SD)	*n* (%)
IIb		9 (11.7)
IIIa		5 (6.5)
IIIc		5 (6.5)
Surgery type		
Mastectomy		34 (43.6)
Breast-conserving surgery		44 (56.4)
Lymph node dissection		
Yes		41 (52.6)
No		37 (47.4)
Comorbidity		
Yes		30 (38.5)
No		48 (61.5)
Chemotherapy regimen		
Cyclophosphamide, methotrexate, fluorouracil		21 (26.9)
CEF		26 (33.3)
CEF + taxane		30 (38.5)
Taxane only		1 (1.3)
Radiotherapy		
Yes		36 (46.2)
No		42 (53.8)
Hormone therapy		
Yes		48 (61.5)
No		30 (38.5)

BFI Brief Fatigue Inventory, *AJCC* American Joint Committee on Cancer, *CEF* cyclophosphamide, epirubicin, 5-fluorouracil

[a] Numbers in parentheses indicate possible range of scores

with stage I or IIa breast cancer (76.2 %). The average scores of interest in exercise and perceived importance of exercise were5.83 (SD=2.65) and 8.92 (SD=1.68), respectively. Detailed information regarding cancer treatment and physical functioning are presented in Table 2. No injury due to exercise was reported in the period of exercise intervention. Some adverse events occurred with low incidence, such as cold sweating (0.07 %), palpitation (0.07 %), dizziness (0.34 %), and shortness of breath (0.14 %).

Exercise-time adherence

The mean weekly total exercise time was 185.91 min, with the longest time in weeks 5 and 9 (206.58 and 207.21 min, respectively) and the shortest in week 1 and 4 (149.83 and 149.85 min, respectively) (Table 3). The mean time-adherence rate was 87.1 %, with the highest adherence in week 3 (99.4 %) and the lowest in week 11 (74.0 %). The proportion of good adherents (adherence rate>100 %) decreased over the exercise program (mean=69.0 %, range=40.8–92.3). In the last stage of the program (week 9–12), only 40.8–50.0 % of participants fully adhered to the prescribed exercise time (Fig. 2). The missing of exercise-time adherence was not associated with the time adherence rate at the previous week.

Exercise-intensity adherence

Participants' exercise intensity was represented by the highest HR achieved during exercise. The mean highest HR during exercise was 128.81 beats/min (range=78–186). Overall, the weekly highest HR during exercise showed an increasing trend, except for a slight drop in week 4 (Table 3). The overall mean intensity-adherence rate was high, 97.59 % (range=95.14–99.18). The proportion of good adherents (adherence rate>100 %) decreased over the exercise program (mean=73.1 %, range=45.8–94.2). The proportion of good adherents decreased notably after week 8, although most participants still had an 80 % adherence rate (Fig. 3). The missing of exercise-intensity adherence was not associated with the intensity adherence rate at the previous week.

Trajectory and predictors of adherence

Changes in adherence over time and factors predicting adherence were explored using ordinal adherence categories (poor, acceptable, and good) of time and intensity as the dependent variables. For time adherence, unconditional HLM results indicated that adherence declined as the exercise program progressed (coefficient=−0.342, $p<0.001$) (Table 4). Over time, the probability of being categorized as a good adherent decreased (odds=0.710, 95 % CI=0.662–0.762). However, the probability of this adherence declining with time was shown to be lower in multivariate analysis for patients with higher perceived interest in exercise (odds=1.038, 95 % CI=1.006–1.072). In addition, the probability of being categorized as a good adherent was lower in the corresponding week that patients had higher weekly fatigue severity (odds=0.770, 95 % CI=0.673–0.882) (Table 4). In other words, the weekly exercise-time adherence fluctuated with patients' level of fatigue in that week.

Intensity adherence was also shown by the unconditional model to decline as the program progressed (coefficient=−0.360, $p<0.001$). Overtime, the probability of being categorized as a good adherent decreased (odds=0.698, 95 % CI=0.627–0.776) (Table 5). The probability of being categorized as a good adherent was greater for patients who attached higher importance to exercise (odds=1.593, 95 % CI=1.013–2.504), were employed (odds=6.103, 95 % CI=1.037–35.925), and with early-stage disease (odds=0.426, 95 % CI=0.270–0.788).

Table 3 Weekly exercise time and intensity and corresponding adherence rate over 12 weeks

	Exercise time											
Week	1	2	3	4	5	6	7	8	9	10	11	12
(*n*)	(48)	(52)	(53)	(46)	(55)	(56)	(49)	(50)	(53)	(51)	(49)	(52)
Exercise time (min)[a]												
Mean	149.83	188.02	184.92	149.85	206.58	190.54	184.08	182.28	207.21	199.24	185.02	203.37
(SD)	(105.82)	(116.08)	(105.07)	(118.62)	(164.86)	(134.59)	(115.11)	(126.88)	(158.3)	(136.16)	(139.72)	(122.80)
Time adherence (%)												
Mean	97.82	97.01	99.37	92.08	91.42	96.07	82.68	81.94	75.68	76.57	74.02	80.00
(SD)	(9.90)	(11.67)	(4.58)	(18.61)	(21.87)	(11.75)	(27.35)	(25.52)	(30.67)	(28.46)	(30.55)	(26.41)
	Exercise intensity											
Week	1	2	3	4	5	6	7	8	9	10	11	12
(*n*)	(47)	(51)	(52)	(46)	(54)	(50)	(47)	(49)	(48)	(47)	(45)	(48)
Highest HR[b]												
Mean	126.73	127.42	129.22	124.75	126.40	128.37	127.98	127.90	131.79	131.45	131.83	131.83
(SD)	(18.63)	(15.93)	(15.83)	(15.43)	(14.66)	(14.55)	(12.27)	(12.70)	(12.68)	(11.36)	(10.10)	(12.38)
Intensity adherence (%)												
Mean	98.53	98.89	98.90	98.81	97.67	98.72	99.18	97.16	95.14	95.79	96.44	95.86
(SD)	(4.52)	(3.68)	(4.08)	(3.63)	(5.27)	(4.15)	(1.94)	(4.13)	(6.25)	(4.78)	(4.29)	(5.54)

[a] Exercise time = the weekly total exercise minutes

[b] Highest HR = the highest heart rate during exercise

Additionally, the probability of being categorized as a good adherent was lower in the corresponding week that a patient had higher weekly fatigue (odds=0.836, 95 % CI=0.710–0.983) (Table 5). Thus, weekly exercise-intensity adherence also fluctuated with patients' level of fatigue that week.

Discussion

This study found that two aspects of exercise adherence (i.e., time and intensity) to a home-based walking-exercise program decreased over the 12-week program. Predictors of time adherence were fatigue and interest in exercise, and predictors of

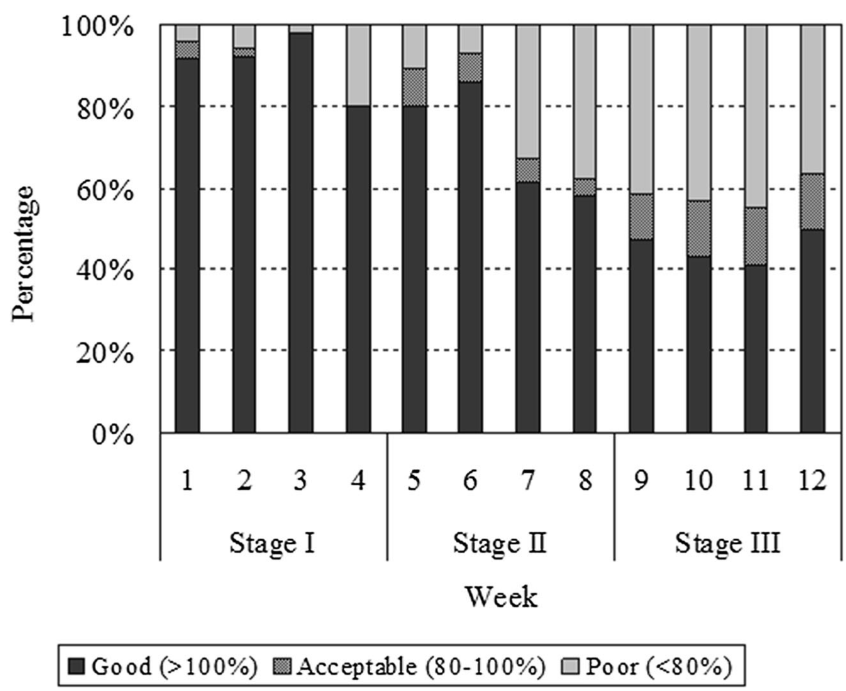

Fig. 2 Percentage of good, acceptable, and poor time adherence over 12 weeks

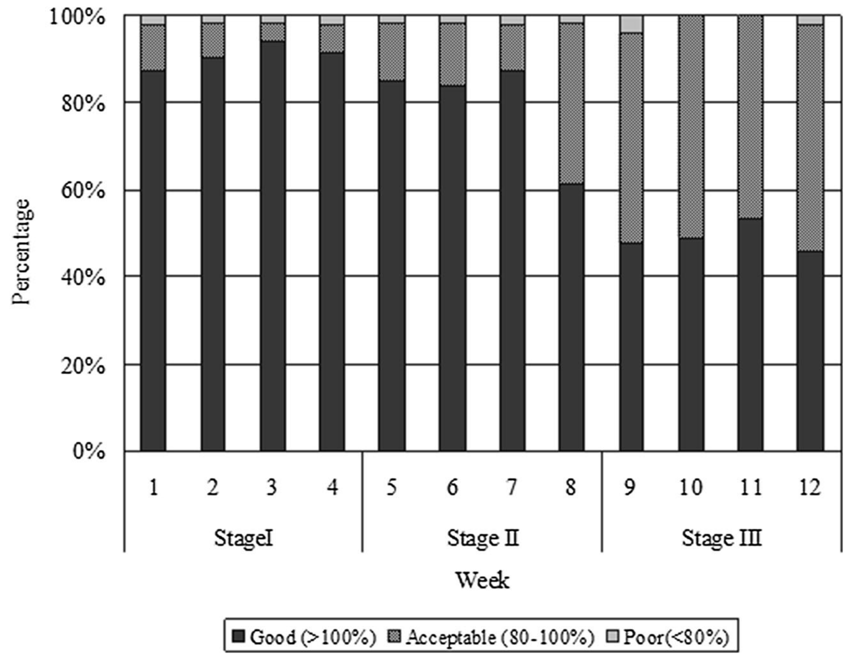

Fig. 3 Percentage of good, acceptable, and poor intensity adherence over 12 weeks

Table 4 Models of time adherence

Unconditional model					
Fixed effect	Coefficient	Odds ratio	95.0 % confidence interval Lower	Upper	*p*
For intercept					
Intercept	3.266	26.218	14.158	48.553	<0.001
For week slope, B1					
Intercept	−0.342	0.710	0.662	0.762	<0.001
For threshold					
d(2)	0.614	1.848	1.588	2.151	<0.001
Multivariate prediction model					
Fixed effect	Coefficient	Odds ratio	95.0 % confidence interval Lower	Upper	*p*
For intercept					
Intercept	4.244	69.690	1.669	2909.777	0.027
Education (years)	0.119	1.127	0.931	1.364	0.217
Exercise preference	−0.146	0.864	0.645	1.158	0.323
Employment	−1.359	0.257	0.043	1.524	0.132
Disease stage	0.022	1.023	0.636	1.644	0.925
Type of surgery	1.361	3.899	0.775	19.622	0.097
For week slope					
Intercept	−0.426	0.653	0.441	0.968	0.034
Education (years)	−0.011	0.990	0.970	1.010	0.300
Interest in exercise	0.037	1.038	1.006	1.072	0.023
Employment	0.066	1.068	0.860	1.327	0.543
Disease stage	−0.026	0.974	0.930	1.020	0.261
Type of surgery	−0.109	0.897	0.743	1.083	0.253
For weekly fatigue severity					
Intercept	−0.261	0.770	0.673	0.882	0.000
For threshold					
d(2)	0.695	2.003	1.653	2.427	0.000

Table 5 Models of intensity adherence

Unconditional model					
Fixed effect	Coefficient	Odds ratio	95.0 % confidence interval Lower	Upper	*p*
For intercept					
Intercept	3.998	54.515	22.001	135.079	<0.001
For week slope, B1					
Intercept	−0.360	0.698	0.627	0.776	<0.001
For threshold					
d(2)	4.727	112.915	36.039	353.778	<0.001
Multivariate prediction model					
Fixed effect	Coefficient	Odds ratio	95.0 % confidence interval Lower	Upper	*p*
For intercept					
Intercept	1.746	5.732	0.241	136.340	0.275
Exercise importance	0.465	1.593	1.013	2.504	0.044
Employment	1.809	6.103	1.037	35.925	0.046
Disease stage	−0.854	0.426	0.230	0.788	0.008
For week slope					
Intercept	−0.354	0.702	0.454	1.085	0.109
Exercise importance	−0.012	0.988	0.938	1.041	0.651
Employment	−0.189	0.828	0.654	1.048	0.115
Disease stage	0.058	1.060	0.994	1.129	0.073
For weekly fatigue severity					
Intercept	−0.179	0.836	0.710	0.983	0.031
For threshold					
d(2)	5.165	175.123	43.595	703.475	0.000

intensity adherence were fatigue, perceived importance of exercise, employment status, and disease stage.

The dropout rate in this study (18 %) was higher than the 8.8 to 10.3 % rates reported in previous studies of exercise adherence with cancer patients [6, 30–32]. These differences may be due to exercise mode (supervised exercise) [6, 30], treatment phase (treatment completed) [31], and combining dietary consultation with exercise intervention and more frequent telephone reminders [32]. Supervised exercise often has a higher adherence rate than home-based exercise [33]. Treatment-related side effects may prevent patients from engaging in physical activity. Meta-analysis has shown that the effect of exercise in reducing fatigue was only significant for patients who completed or who were completing adjuvant treatment [8].

The decreasing exercise-time and exercise-intensity adherence reflects the exercise prescription, which gradually increased the frequency, duration, and percent of HRR over the 12-week program. Our results are consistent with previous reports that adherence decreased for sedentary adults [34] and breast cancer survivors [23] as prescription intensity increased. A higher requirement of exercise time was also found to be associated with a lower adherence [14]. The simultaneous increase of exercise intensity, frequency, and duration along the exercise program may have an additive effect in decreasing exercise adherence. Simultaneous increase of different aspects of exercise prescription has been used in newly diagnosed breast cancer patients with low non-adherence rate [35]. However, no detailed longitudinal adherence data were reported in that study. Future study may consider increase one exercise parameter at a time. Since the majority of our participants had good adherence during the first stage of the 12-week exercise program, the initial prescription for exercise time and HRR percentage may have been too weak and could have been stronger. In contrast, the decreased proportions of good adherents during the last stage of the exercise program suggest that the prescription was too strong for patients under chemotherapy.

We also found that changes in weekly time adherence and intensity adherence were associated with weekly fatigue. Participants who felt tired may not have been motivated to exercise or may have exercised less frequently for shorter durations and at lower intensity, as previously reported for patients receiving cancer treatment [36–38]. On the other hand, those with poor adherence may have experienced greater fatigue due to not exercising. The exercise intervention in the original trial was designed to reduce cancer-related symptoms, including fatigue. It is reasonable to hypothesize that participants with good exercise adherence experienced more benefit in symptom relief, in this case reduced fatigue. The causal relationship between fatigue level and exercise adherence needs to be further studied.

Exercise-time and exercise-intensity adherence were significantly predicted by participants' degree of interest in exercise and perceived importance of exercise, respectively. This finding is consistent with the theory of planned behavior where personal attitudes (e.g., interest in exercise) and subjective norm (e.g., perceived importance of exercise) toward a specific behavior (i.e., exercise adherence) influence the actual performance of that behavior [39]. An interesting note is that employment status was associated with better intensity adherence, but not with time adherence. One possible explanation is that employed patients may be in better physical condition, allowing them to have better adherence to the intensity requirement. However, employed patients may lack enough time to exercise at the required frequency or duration [13]. Disease stage was also found to predict intensity adherence, but not time adherence. Patients with early-stage disease may have better physical functioning, allowing them to have better intensity adherence. However, patients with better physical functioning do not necessarily have enough interest in exercise which, as shown in this study, is an important factor for time adherence.

Clinical implications

Our longitudinal adherence data can inform the design of future exercise programs for breast cancer patients undergoing chemotherapy. Specifically, the prescribed exercise time and intensity may be elevated during the initial stage and reduced during the last stage of the exercise program.

Limitations

First, our participants were breast cancer patients with self-reported insomnia, fatigue, pain, or depressive symptoms after the first chemotherapy cycle and sampled from a single hospital in Taiwan. This limitation prevents the generalizability of our findings to all women with breast cancer in Taiwan. Second, potential factors predicting adherence, such as change stage of behavior and self-efficacy, were not measured. Third, the psychometric properties of the single-item measurement of exercise belief and attitude need to be tested in the future study. Finally, non-adherence does not always represent performing less than the prescribed exercise; over-exercise can be a mode of non-adherence [40]. Future studies should sample breast cancer patients from hospitals throughout Taiwan, examine other potential predictors of exercise adherence, and over-exercise.

Conclusions

Both exercise-time and exercise-intensity adherence decreased as the prescription requirements increased. Poor exercise-time and exercise-intensity adherence was associated with chemotherapy-related fatigue. Greater exercise-intensity adherence was more likely in employed patients with early-stage disease. Exercise adherence was predicted by attitudes toward exercise.

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Conflict of interest There is no financial relationship to be claimed in this study. The authors have full control of all primary data and they agree to allow the journal to review their data if requested.

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