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Original Contribution

The Effect of Regular Exercise on Quality of Life Among Breast Cancer Survivors

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The authors evaluated the effect of regular exercise during the first 36 months after cancer diagnosis on quality of life (QOL) in a population-based cohort study of 1,829 Chinese women diagnosed with breast cancer. The women were identified between 2002 and 2004 and were invited to participate in the study about 6 months after cancer diagnosis. Exercise was assessed approximately 6, 18, and 36 months after diagnosis, and a metabolic equivalent task (MET) score in hours per week was derived. A cumulative, weighted exercise-MET score was created for regular exercise during the 36-month postdiagnosis period. QOL was evaluated at 6 and 36 months postdiagnosis. Multiple linear regression and mixed models were conducted to evaluate the association between regular exercise and QOL, with adjustment for clinical prognostic factors and other potential confounders. Both exercise-MET scores measured during the first 6 or 36 months postdiagnosis and the weighted exercise-MET score over the 36-month postdiagnosis period were positively associated with total QOL score and physical, psychological, and social well-being scores assessed at 36 months postdiagnosis (all P for trend < 0.05). Compared with nonregular exercisers, women with higher exercise-MET scores ($\geq$8.3 MET-hours/week) were more likely to have higher scores for total QOL and specific QOL domains (all $P < 0.05$). The exercise-QOL association remained stable over time after cancer diagnosis. This study suggests that regular exercise after breast cancer diagnosis improves QOL.

breast neoplasms; cohort studies; exercise; quality of life

Abbreviations: ER, estrogen receptor; FACT-B, Functional Assessment of Cancer Therapy-Breast; MET, metabolic equivalent task; PR, progesterone receptor; QOL, quality of life.

Breast cancer is the most common cancer among women in the world (1). Approximately 4.4 million women worldwide are living with breast cancer (2, 3). In the United States, there are currently more than 2 million breast cancer survivors, and this population is growing (4). Women with breast cancer experience physical and psychological cancer-therapy-related sequelae, which may affect their quality of life (QOL) (5–7). An important goal for breast cancer patients and survivors is to improve their QOL by maximizing functions affected by the disease and cancer-related treatments (8, 9).

There has been considerable interest in whether lifestyle factors, including exercise, enhance QOL for women diagnosed with breast cancer (9–18). A growing number of clinical trials have demonstrated that short-term, structured exercise interventions may improve QOL for breast cancer patients and survivors (8, 19–27). However, 2 recent clinical trials have reported a null association between supervised exercise and QOL among breast cancer patients (28, 29). A few epidemiologic studies with relatively small sample sizes have examined the association between regular exercise participation and QOL among breast cancer patients or survivors in Western countries via mostly cross-sectional or retrospective study designs (9–14, 17, 18, 30). Evidence from population-based cohort studies with longitudinal assessments of exercise and QOL is lacking. As a result, it is unclear whether unsupervised exercise after cancer diagnosis is related to QOL and, if so, whether this association changes over time. Given that the number of breast cancer patients and survivors has been increasing worldwide,

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understanding whether and how exercise after cancer diagnosis affects QOL would have significant public health implications.

In this paper, we examine the effect of postdiagnosis exercise on QOL during the first 36 months after breast cancer diagnosis in a large, population-based cohort study in Shanghai, China. With detailed information on patients' sociodemographic and medical characteristics and exercise habits repeatedly collected via in-person interviews over time, our study design enabled a comprehensive evaluation of the association between regular exercise and QOL, both prospectively and at different time points.

MATERIALS AND METHODS

Study population

Participants came from the Shanghai Breast Cancer Survival Study, a large, population-based, prospective cohort study of breast cancer survivors conducted in Shanghai, China. Details on the study methods have been reported elsewhere (31, 32). Through the population-based Shanghai Cancer Registry, 2,600 women aged 20–75 years with incident breast cancer were identified between April 1, 2002, and March 31, 2004, and were invited to participate in the study approximately 6 months (range: 3–11) after cancer diagnosis (baseline survey). In-person interviews were completed for 2,230 cases (85.8%); 18 cases died before completing an in-person interview. With the use of structured questionnaires, study participants were followed through in-person interviews administered approximately 18 months (range: 12–25) and 36 months (range: 33–44) after cancer diagnosis. Of the 2,230 cases who completed the baseline interview, 61 (2.7%) died before the 18-month postdiagnosis interview, and 90 (4.0%) died after the 18-month but before the 36-month postdiagnosis interview. After women who refused to participate and those who could not be contacted were excluded, 1,829 women completed the 18-month postdiagnosis interview (82.0%) and 1,845 (82.7%) completed the 36-month postdiagnosis interview as of November 2008. In total, 1,829 cases completed all 3 interviews; these participants constitute the basis of the current study.

This study was approved by the institutional review boards of all institutions involved in the Shanghai Breast Cancer Survival Study. Written informed consent was obtained from all participants before interviews were conducted.

Data collection

Through in-person interviews, we collected information on cancer diagnosis, cancer-related treatments, relapse/metastasis, disease status, comorbidity, demographics, menstrual and reproductive history, family history of breast cancer, complementary and alternative medicine use, regular exercise participation, usual dietary intake, tea consumption habits, alcohol consumption habits, cigarette smoking habits, and QOL. Anthropometric measurements, including height, weight, waist circumference, and hip circumference, were taken by trained interviewers, all of whom were retired medical professionals. All measurements were taken twice according to a standard protocol, and the averages of these measurements were used in this study. Body mass index and waist-to-hip ratio were calculated on the basis of these measurements.

Disease- and treatment-related information was collected, including stage of tumor-node metastasis at the time of primary diagnosis, estrogen receptor (ER) and progesterone receptor (PR) status, type of surgery, chemotherapy, radiotherapy, immunotherapy, and tamoxifen use. Additionally, medical charts were reviewed to verify diagnosis, treatment, and disease-stage information. ER and PR status was included in the analyses in the following joint categories: ER+/PR+ (receptor positive), ER−/PR− (receptor negative), and ER−/PR+ or ER+/PR− (receptor mixed). The Charlson comorbidity index was created based on a validated comorbidity scoring system (33), and the diagnostic codes were obtained from the *International Classification of Diseases*, Ninth Revision, Clinical Modification (34).

Exercise assessment

At each interview, participants were asked whether they participated in recreational exercise regularly (at least twice a week) (yes/no). If the participant answered yes, she was then asked to report as many as 5 of the most common activities she participated in regularly. At baseline, participants reported regular exercise activities that took place during the 6 months preceding the interview. At subsequent interviews, participants reported activities since the last interview (i.e., for the preceding 12 months and 18 months). No women reported participating in more than 4 types of regular exercise during the first 18 months after cancer diagnosis, and only 0.1% of study participants engaged in 5 types of regular exercise according to the 36-month postdiagnosis interview. Information on frequency and duration was obtained for all reported activities.

Each activity was assigned a metabolic equivalent task (MET) score based on the method proposed by Ainsworth et al. (35). A MET score in hours per week (MET-hours/week) for each activity was derived by multiplying the number of hours per week the participant reported engaging in that activity by the MET score assigned to the activity. The values from individual activities were summed to derive a total exercise-MET score. A cumulative, weighted MET score for regular exercise over the 36-month postdiagnosis period was created by using the total exercise-related MET score derived from each interview weighted by the duration of regular exercise. The validity of the exercise assessment in this study was evaluated previously and was proven to be excellent (36).

QOL assessment

The General Quality of Life Inventory-74 was used to assess QOL at the baseline and 36-month postdiagnosis interviews. The inventory was based on the World Health Organization's Quality of Life Assessment Instrument and was modified for use in the Chinese population. Details about the General Quality of Life Inventory-74 assessment have been described in our previous studies (31, 32).

The inventory comprises 74 items that can be grouped into 20 facets and covers the following 4 domains: 1) physical well-being, 2) psychological well-being, 3) social well-being, and 4) material well-being. In this study, we focused on the first 3 domains (physical, psychological, and social well-being). Participants' responses were converted to scores on a 0–100 scale for each domain and each facet, with higher scores reflecting better QOL. A total QOL score was also calculated. The QOL assessment questionnaire has been demonstrated to have a satisfactory level of reliability and validity (37, 38) and has been used in epidemiologic surveys of breast cancer patients and survivors (31, 32).

Statistical analysis

Differences in sociodemographic and medical characteristics by regular exercise participation at baseline and follow-up interviews were evaluated by using Student's *t* test and/or the χ^2 test. Pearson correlation coefficients between total QOL score and domain-specific scores assessed 6 and 36 months after cancer diagnosis were calculated. The primary outcomes of this analysis were total QOL; physical, psychological, and social well-being domains; and selected facets of QOL (e.g., psychological distress). Mean differences and 95% confidence intervals for QOL scores across exercise levels were calculated by using multiple linear regression analyses with adjustment for potential confounders, including age at diagnosis, marital status, income, education, comorbidity, menopausal status, menopausal symptoms, body mass index, waist-to-hip ratio, tea consumption, chemotherapy, disease stage, ER/PR status, and recurrence/metastasis. Other factors such as time interval from diagnosis to study enrollment and cigarette smoking were not significantly related to QOL in univariate analyses and were not included in our multivariate models.

We categorized women who reported regular exercise participation into low- and high-exercise-level groups using an established exercise guideline (39) cutpoint of 500 MET/minutes per week or 8.3 MET-hours/week (low-level group: <8.3 MET-hours/week; high-level group: ≥8.3 MET-hours/week). Those who reported no regular exercise participation served as the reference group in the analyses. Analyses stratified by baseline QOL, ER/PR status, tumor-node metastasis stage, and comorbidity were performed, and interaction terms were added in the corresponding models to evaluate their potential interactive effects with regular exercise on QOL.

We also applied mixed models to examine whether the exercise-QOL association changed over time. Because QOL was measured only twice (at the 6- and 36-month postdiagnosis interviews) and regular exercise was assessed at 3 time points (at the 6-, 18-, and 36-month postdiagnosis interviews) in our study, the data were analyzed in 2 ways. The first approach was to use the exercise data collected at only the 6- and 36-month postdiagnosis interviews. The second approach was to average the exercise-related MET score based on information collected at the 18- and 36-month postdiagnosis interviews (weighted by the time intervals). The time was set to 0 for the baseline interview (6 months postdiagnosis) and to 1 for the 36-month postdiagnosis interview. Interaction terms for exercise with time were examined by using the mixed models to evaluate whether the exercise-QOL association changed over time. We also analyzed the 3 exercise measurements with an imputed 18-month postdiagnosis QOL score based on QOL assessed at the 6- and 36-month postdiagnosis interviews. These analyses produced similar findings; results from the first approach are presented in this paper.

Tests for trend in the analyses were performed by entering the categorical variables as continuous parameters in the corresponding models. All tests were performed by using Statistical Analysis Software (SAS, version 9.1; SAS Institute, Inc., Cary, North Carolina). The significance levels were set at $P < 0.05$ for 2-sided analyses.

RESULTS

The median follow-up period after breast cancer diagnosis was 36.2 months (range: 32.7–44.4). There were no significant differences in sociodemographic or medical characteristics between all participants enrolled ($n = 2{,}230$) and those included in the current study ($n = 1{,}829$). Approximately 69%, 75%, and 74% of women reported exercising regularly 6, 18, and 36 months after diagnosis, respectively. Baseline QOL scores for total QOL and the physical, psychological, and social well-being domains were significantly associated with scores 36 months after diagnosis. The corresponding correlation coefficients were 0.61 for total QOL, 0.52 for physical well-being, 0.49 for psychological well-being, and 0.55 for social well-being (all $P < 0.001$).

Table 1 summarizes participant characteristics by regular exercise participation status at each follow-up survey. The mean age at diagnosis was 53.7 years (standard deviation, 10.2). At baseline, women who reported regularly exercising, compared with nonregular exercisers, were a significantly younger age at menarche, had a lower waist-to-hip ratio, had a higher income, had less comorbidity, consumed more tea, and had a higher QOL. At the 18-month postdiagnosis survey, regular exercisers were more likely than nonregular exercisers to be younger at cancer diagnosis, have higher educational attainment, have a higher income, and have a higher QOL, and they were more likely to be postmenopausal. No significant differences were found regarding other characteristics. Similar results were observed when comparisons were made based on regular exercise participation at the 36-month postdiagnosis interview.

Multiple linear regression models with adjustment for lifestyle, clinical, and sociodemographic variables indicated that baseline exercise was significantly and positively associated with concurrent physical, psychological, and social well-being, as well as with total QOL (trend test: all $P < 0.05$; data not shown in tables). The baseline exercise-related MET score and the weighted exercise-related MET score over the 36-month postdiagnosis period were both significantly and positively related to QOL 36 months after diagnosis (trend test: all $P < 0.05$; Table 2). Further adjustment for baseline QOL attenuated the association of the baseline exercise-related MET score with QOL at the follow-up survey. However, the weighted 36-month exercise-related MET score was still significantly and positively

Table 1. Baseline Characteristics[a] of Study Participants by Regular Exercise Participation Status[b] 6, 18, and 36 Months After Cancer Diagnosis, Shanghai Breast Cancer Survival Study, China, 2002–2008

Characteristic	Total (N = 1,829)	Regular Exercise Participation After Diagnosis								
		6 Months			18 Months			36 Months		
		No (n = 566)	Yes (n = 1,263)	P Value[c]	No (n = 454)	Yes (n = 1,375)	P Value[c]	No (n = 475)	Yes (n = 1,354)	P Value[c]
Age at diagnosis, years	53.7 (10.2)	54.0 (10.4)	53.5 (10.2)	0.320	52.1 (10.8)	54.2 (10.0)	<0.001	52.7 (10.7)	54.0 (10.1)	0.023
Age at menarche, years	14.4 (1.6)	14.5 (1.7)	14.3 (1.6)	0.024	14.4 (1.6)	14.4 (1.6)	0.800	14.4 (1.6)	14.4 (1.6)	0.749
Married	87.2	86.0	87.7	0.343	85.2	87.8	0.161	84.6	88.0	0.057
Body mass index, kg/m^2	24.2 (3.4)	24.3 (3.5)	24.2 (3.3)	0.482	24.2 (3.6)	24.2 (3.3)	0.703	24.2 (3.5)	24.2 (3.3)	0.973
Waist-to-hip ratio	0.83 (0.05)	0.84 (0.05)	0.83 (0.05)	0.001	0.83 (0.06)	0.83 (0.05)	0.643	0.83 (0.06)	0.83 (0.05)	0.817
Educational level										
<High school	50.0	53.0	48.7	0.061	47.4	50.9	<0.001	50.5	49.9	0.005
High school	35.4	35.2	35.6		42.5	33.1		39.2	34.1	
>High school	14.5	11.8	15.8		10.1	16.0		10.3	16.0	
Income (yuan/month per capita)										
<1,000	66.3	70.1	64.6	0.019	72.0	64.4	0.010	72.6	64.1	0.003
1,000–1,999	24.9	23.5	25.5		21.4	26.0		20.6	26.4	
≥2,000	8.8	6.4	9.9		6.6	9.5		6.7	9.5	
Postmenopause[d]	78.4	78.8	78.2	0.755	69.4	81.3	<0.001	72.8	80.3	<0.001
Menopausal symptoms[d]	76.8	78.5	76.1	0.270	76.2	77.0	0.724	76.4	77.0	0.812
Comorbidity score ≥1[d]	18.9	21.7	17.6	0.036	21.6	18.0	0.087	18.1	19.1	0.624
Alcohol consumption	2.4	2.5	2.4	0.899	2.4	2.4	0.978	2.5	2.4	0.842
Tea consumption	22.7	18.6	24.5	0.005	22.5	22.8	0.896	24.4	22.1	0.295
Cigarette smoking	2.2	2.8	1.9	0.210	3.3	1.8	0.061	3.4	1.8	0.041
Recurrence/metastasis[d]										
Yes	3.7	4.1	3.5	0.502[e]	4.2	3.5	0.479[e]	5.2	3.3	0.055[e]
No	93.0	91.5	93.6		91.6	93.4		90.7	93.7	
Unknown	3.4	4.4	2.9		4.2	3.1		4.2	3.1	
Mastectomy	95.1	94.7	95.3	0.615	94.5	95.3	0.506	94.7	95.2	0.688
Chemotherapy	91.9	93.1	91.3	0.189	90.8	92.2	0.321	91.8	91.9	0.953
Radiotherapy	28.4	33.2	26.3	0.002	28.9	28.3	0.817	28.8	28.3	0.817
Immunotherapy	13.3	14.0	13.1	0.593	13.7	13.2	0.819	12.6	13.6	0.583
Tamoxifen use	58.9	55.7	60.3	0.060	60.8	58.3	0.341	59.0	58.9	0.974
ER/PR status										
ER+/PR+	52.2	55.1	50.8	0.216[e]	55.1	51.2	0.403[e]	53.3	51.8	0.838[e]
ER−/PR−	26.2	24.2	27.1		25.8	26.3		26.5	26.1	
ER+/PR−, ER−/PR+	20.0	18.9	20.4		18.3	20.5		19.2	20.2	
Unknown	1.7	1.8	1.7		0.9	2.0		1.1	1.9	
TNM stage										
0–I	36.4	34.1	37.4	0.196[e]	35.0	36.8	0.671[e]	36.6	36.3	0.793[e]
IIA	34.1	32.9	34.6		35.5	33.6		34.5	33.9	
IIB	18.8	21.0	17.7		19.4	18.6		18.5	18.8	
III–IV	6.9	7.8	6.5		6.0	7.2		8.0	6.5	
Unknown	3.9	4.2	3.8		4.2	3.9		2.3	4.5	
Total QOL score	59.3 (7.9)	57.5 (8.3)	60.1 (7.6)	0.001	58.5 (8.4)	59.6 (7.8)	0.020	58.1 (8.3)	59.8 (7.8)	<0.001

Abbreviations: ER, estrogen receptor; PR, progesterone receptor; TNM, tumor-node metastasis; QOL, quality of life.

[a] Values are presented as mean (standard deviation) or percentage.

[b] Women were asked whether they regularly (at least twice a week) participated in exercise and were categorized as regular exercisers if they answered yes and as nonregular exercisers if they answered no.

[c] For tests of differences between women with and without regular exercise participation.

[d] Information 36 months after cancer diagnosis.

[e] For the χ^2 test, the "unknown" group was excluded.

Table 2. Linear Regression Models[a]: Adjusted Mean Differences in Total QOL Score and Scores in 3 QOL Domains Across Exercise Levels, Shanghai Breast Cancer Survival Study, China, 2002–2008

QOL 36 Months After Diagnosis	Exercise-related MET Score 6 Months After Diagnosis[b]					Weighted Exercise-related MET Score During the 36 Months After Diagnosis[b]				
	<8.3 (n = 568)		≥8.3 (n = 695)		P for Trend	<8.3 (n = 565)		≥8.3 (n = 1,100)		P for Trend
	Mean Difference	95% CI	Mean Difference	95% CI		Mean Difference	95% CI	Mean Difference	95% CI	
Total QOL score	1.56	0.65, 2.46	1.70	0.83, 2.57	<0.001	1.17	−0.19, 2.53	2.29	1.01, 3.57	<0.001
Physical well-being	1.19	0.06, 2.33	1.83	0.74, 2.92	0.001	0.54	−1.16, 2.24	1.43	−0.18, 3.04	0.025
Psychosocial well-being	1.63	0.45, 2.80	1.62	0.49, 2.75	0.007	0.91	−0.86, 2.67	2.13	0.46, 3.80	0.002
Social well-being	1.37	0.27, 2.47	2.09	1.03, 3.16	<0.001	1.34	−0.31, 2.99	3.18	1.63, 4.74	<0.001
Further adjustment for QOL 6 months after diagnosis										
Total QOL score	0.50	−0.26, 1.26	0.33	−0.40, 1.06	0.404	0.49	−0.64, 1.62	1.15	0.08, 2.22	0.009
Physical well-being	0.22	−0.78, 1.23	0.61	−0.36, 1.58	0.213	0.23	−1.27, 1.74	1.05	−0.37, 2.47	0.041
Psychosocial well-being	0.80	−0.25, 1.86	0.52	−0.50, 1.53	0.354	0.41	−1.17, 1.99	1.20	−0.30, 2.69	0.039
Social well-being	0.69	−0.28, 1.65	0.74	−0.19, 1.66	0.131	0.86	−0.58, 2.30	1.87	0.50, 3.23	0.001

Abbreviations: CI, confidence interval; MET, metabolic equivalent task; QOL, quality of life.

[a] Models were adjusted for age at diagnosis, marital status, income, education, comorbidity, menopausal status, menopausal symptoms, waist-to-hip ratio, body mass index, tea consumption, chemotherapy, estrogen receptor/progesterone receptor status, tumor-node metastasis stage, and recurrence/metastasis. Participants in the nonregular exercise group served as the reference.

[b] The cutpoint (8.3 MET-hours/week) was based on the US Department of Health and Human Services national recommendation for recreational physical activity (39).

associated with the total QOL score and with scores for physical well-being, psychological well-being, and social well-being at follow-up (trend test: all $P < 0.05$).

Table 3 presents the associations between regular exercise and selected QOL facets. Compared with nonregular exercisers, women with higher exercise levels at baseline (≥8.3 MET-hours/week) reported higher capacity for daily living, less psychological distress, more positive feelings, better body image, higher work and study capacity, more recreational activity, better marriage and family relationships, and higher general QOL at the 36-month follow-up (trend test: all $P < 0.05$). Similar results were observed for analyses of the weighted exercise-related MET score. Although further adjustment for baseline QOL attenuated the associations, positive linear trends for associations of the weighted exercise-related MET score with QOL 36 months after diagnosis were observed for most facets, such as psychological distress ($P < 0.01$) and positive feelings ($P < 0.05$).

We also evaluated whether baseline QOL modified the association between regular exercise and QOL at the 36-month follow-up (Table 4). Positive associations with baseline or weighted exercise-related MET scores were observed among women with low and high QOL at baseline (interaction term test: all $P > 0.05$). Similarly, we did not find any interaction of comorbidity, tumor-node metastasis stage, or ER/PR status with regular exercise that affected QOL among breast cancer survivors (data not shown).

Table 5 presents results of analyses using mixed models for regular exercise and QOL assessed 6 and 36 months after cancer diagnosis. Compared with nonregular exercisers, women who had a low level of regular exercise (<8.3 MET-hours/week) were more likely to have higher total QOL scores and higher scores for the physical, psychological, and social well-being domains (all $P < 0.01$). However, women who met recommended exercise levels (≥8.3 MET-hours/week) showed much more improvement in both their total QOL score and scores for each of the 3 domains (all $P < 0.001$). For analyses over time, the total QOL score and scores for the 3 QOL domains increased significantly over the 36-month postdiagnosis period (test for time: all $P < 0.05$). The positive association between regular exercise and QOL remained stable over time after cancer diagnosis (interaction term test for time: all $P > 0.05$; data not shown). Similar results were found for most selected QOL facets (data not shown).

DISCUSSION

In this population-based cohort study, we found that regular-exercise level after breast cancer diagnosis was significantly and positively related to QOL assessed 6 and 36 months after diagnosis among breast cancer survivors, even after controlling for baseline QOL. Women who met exercise recommendations (≥8.3 MET-hours/week) had higher total QOL scores and higher scores for physical, psychological, and social well-being domains after cancer diagnosis, and this association remained stable over time. The exercise-QOL association varied little by baseline QOL, disease stage, ER/PR status, or the existence of comorbidity. To our knowledge, this is one of the largest and most comprehensive population-based cohort studies to prospectively evaluate the association of regular exercise with QOL among breast cancer survivors.

Table 3. Linear Regression Models[a]: Adjusted Mean Differences in Selected QOL Facets Across Exercise Levels, Shanghai Breast Cancer Survival Study, China, 2002–2008

QOL 36 Months After Diagnosis	Exercise-related MET Score 6 Months After Diagnosis[b]					Weighted Exercise-related MET Score During the 36 Months After Diagnosis[b]				
	<8.3 (n = 568)		≥8.3 (n = 695)		P for Trend	<8.3 (n = 565)		≥8.3 (n = 1,100)		P for Trend
	Mean Difference	95% CI	Mean Difference	95% CI		Mean Difference	95% CI	Mean Difference	95% CI	
Sleep and energy	1.77	−0.10, 3.64	1.28	−0.51, 3.08	0.186	1.00	−1.81, 3.80	2.24	−0.41, 4.89	0.043
Physical discomfort	1.56	−0.44, 3.56	2.24	−0.32, 4.16	0.024	2.65	−0.35, 5.65	2.10	−0.73, 4.94	0.457
Daily living capability	1.07	−0.31, 2.46	2.23	0.90, 3.56	0.001	−0.72	−2.80, 1.36	0.97	−1.00, 2.94	0.029
Psychological distress	2.53	1.03, 4.03	1.78	0.34, 3.22	0.023	1.71	−0.54, 3.96	3.36	1.24, 5.49	<0.001
Positive feelings	3.04	0.99, 5.09	2.26	0.29, 4.23	0.034	2.88	−0.20, 5.96	4.18	1.27, 7.09	0.005
Body image	0.80	−0.60, 2.19	1.93	0.59, 3.28	0.005	0.10	−2.00, 2.20	1.33	−0.66, 3.32	0.043
Social support	1.19	−0.89, 3.27	1.26	−0.74, 3.26	0.230	1.70	−1.42, 4.83	3.18	0.23, 6.13	0.016
Work and study capacity	1.59	0.22, 2.95	3.09	1.78, 4.40	<0.001	0.55	−1.51, 2.60	2.51	0.57, 4.45	<0.001
Recreational activity	2.43	1.10, 3.77	3.40	2.12, 4.68	<0.001	2.68	0.70, 4.67	5.99	4.11, 7.87	<0.001
Marriage and family	1.37	−0.23, 2.98	2.22	0.68, 3.76	0.005	1.65	−0.76, 4.05	3.38	1.11, 5.65	0.001
General QOL	1.67	0.20, 3.15	1.90	0.48, 3.32	0.010	0.95	−1.27, 3.16	2.56	0.46, 4.65	0.002
Further adjustment for QOL 6 months after diagnosis										
Sleep and energy	0.16	−1.52, 1.84	−0.61	−2.23, 1.01	0.434	−0.49	−3.00, 2.03	0.73	−1.66, 3.11	0.188
Physical discomfort	0.94	−0.95, 2.83	1.57	−0.24, 3.38	0.091	2.56	−0.26, 5.39	2.09	−0.58, 4.77	0.406
Daily living capacity	0.39	−0.88, 1.65	1.24	0.02, 2.46	0.043	−0.27	−2.16, 1.63	1.25	0.54, 3.04	0.014
Psychological distress	1.82	0.38, 3.25	1.07	−0.31, 2.45	0.162	1.22	−0.93, 3.36	2.59	0.56, 4.62	0.003
Positive feelings	2.26	0.34, 4.18	0.92	−0.93, 2.77	0.395	2.23	−0.65, 5.10	3.07	0.35, 5.79	0.031
Body image	0.25	−1.06, 1.55	1.06	−0.20, 2.32	0.094	−0.43	−2.39, 1.54	0.30	−1.56, 2.16	0.366
Social support	1.42	−0.49, 3.32	1.21	−0.62, 3.04	0.215	0.59	−2.27, 3.44	2.00	−0.71, 4.70	0.049
Work and study capacity	0.80	−0.47, 2.09	1.76	0.52, 2.99	0.005	0.94	−0.97, 2.86	2.14	0.34, 3.95	0.004
Recreational activity	1.79	0.46, 3.12	2.30	1.01, 3.60	0.001	2.34	0.38, 4.30	5.15	3.28, 7.01	<0.001
Marriage and family	0.84	−0.61, 2.29	1.36	−0.03, 2.76	0.058	1.38	−0.83, 3.52	2.28	0.22, 4.34	0.017
General QOL	0.49	−0.85, 1.83	0.53	−0.76, 1.81	0.436	0.57	−1.43, 2.57	1.62	−0.27, 3.51	0.028

Abbreviations: CI, confidence interval; MET, metabolic equivalent task; QOL, quality of life.

[a] Models were adjusted for age at diagnosis, marital status, income, education, comorbidity, menopausal status, menopausal symptoms, waist-to-hip ratio, body mass index, tea consumption, chemotherapy, estrogen receptor/progesterone receptor status, tumor-node metastasis stage, and recurrence/metastasis. Participants in the nonregular exercise group served as the reference.

[b] The cutpoint (8.3 MET-hours/week) was based on the US Department of Health and Human Services national recommendation for recreational physical activity (39).

Clinical trials have shown the importance of a short-term, structured exercise intervention to QOL among breast cancer patients and survivors (8, 19, 21, 23, 24, 40–42), although 2 recent randomized clinical trials reported no significant effect (28, 29). Courneya et al. (8) found that a 15-week exercise training intervention was linked to increased physical well-being and overall QOL assessed by the Functional Assessment of Cancer Therapy-Breast (FACT-B) instrument among 53 postmenopausal breast cancer survivors who had completed cancer-related therapies in Canada. Milne et al. (24) found that, for 58 women diagnosed with stage I–II breast cancer in Australia, combined aerobic and resistance exercise soon after adjuvant therapy improved QOL measured by the FACT-B. However, the randomized controlled trial in Canada showed that neither aerobic nor resistance exercise significantly improved cancer-specific QOL for 242 breast cancer patients receiving chemotherapy, although the supervised exercise program improved self-esteem and physical fitness (28). Collectively, clinical trials have provided some suggestive evidence that exercise may be an effective intervention to improve QOL for breast cancer patients and survivors.

The association of daily exercise participation with QOL among women with breast cancer has been previously evaluated in several small observational studies. In a 12-month follow-up study of 69 US women who had completed cancer-related treatments for stage 0–II breast cancer, Pinto et al. (10) found that exercise level was related to higher overall QOL and physical functioning as assessed by the Short Form-36. In a recent multiethnic cohort of 729 early-stage breast cancer survivors in the United States, meeting recommended levels of physical activity was associated with better vitality, social functioning, emotional

Table 4. Linear Regression Models[a]: Adjusted Mean Differences in Total QOL Score and Scores in 3 QOL Domains Across Exercise Level, Stratified by Total QOL Score 6 Months After Cancer Diagnosis, Shanghai Breast Cancer Survival Study, China, 2002–2008

QOL 36 Months After Diagnosis	QOL at 6 Months <Median (n = 914)					QOL at 6 Months ≥Median (n = 915)					*P* for Interaction
	Exercise-related MET Score[b]				*P* for Trend	Exercise-Related MET Score[b]				*P* for Trend	
	<8.3		≥8.3			<8.3		≥8.3			
	Mean Difference	95% CI	Mean Difference	95% CI		Mean Difference	95% CI	Mean Difference	95% CI		
Exercise-related MET score 6 months after diagnosis[b]											
Total QOL score	1.38	0.23, 2.53	1.46	0.36, 2.57	0.009	0.84	−0.34, 2.03	0.87	−0.27, 2.01	0.159	0.399
Physical well-being	1.14	−0.29, 2.57	1.72	0.34, 3.09	0.014	0.39	−1.21, 1.99	0.98	−0.57, 2.52	0.205	0.715
Psychosocial well-being	1.19	−0.42, 2.80	1.13	−0.41, 2.68	0.150	1.04	−0.48, 2.56	0.89	−0.58, 2.35	0.281	0.535
Social well-being	0.77	−0.70, 2.25	1.53	0.12, 2.94	0.034	1.20	−0.32, 2.72	1.67	0.21, 3.13	0.029	0.510
Exercise-related MET score during the 36 months after diagnosis[b]											
Total QOL score	1.02	−0.65, 2.69	2.41	0.83, 3.98	<0.001	0.48	−1.34, 2.31	1.10	−0.62, 2.83	0.111	0.502
Physical well-being	0.57	−1.52, 2.66	1.47	−0.51, 3.44	0.074	−0.22	−2.69, 2.26	0.41	−1.93, 2.75	0.444	0.655
Psychosocial well-being	1.15	−1.18, 3.49	2.47	0.26, 4.68	0.010	−0.22	−2.57, 2.12	0.54	−1.69, 2.76	0.317	0.674
Social well-being	0.97	−1.16, 3.10	3.36	1.35, 5.37	<0.001	0.81	−1.53, 3.16	1.89	−0.33, 4.11	0.033	0.641

Abbreviations: CI, confidence interval; MET, metabolic equivalent task; QOL, quality of life.

[a] Models were adjusted for age at diagnosis, marital status, income, education, comorbidity, menopausal status, menopausal symptoms, waist-to-hip ratio, body mass index, tea consumption, chemotherapy, estrogen receptor/progesterone receptor status, tumor-node metastasis stage, and recurrence/metastasis. Participants in the nonregular exercise group served as the reference.

[b] The cutpoint (8.3 MET-hours/week) was based on the US Department of Health and Human Services national recommendation for recreational physical activity (39).

roles, and global QOL for non-Hispanic, white, and black breast cancer survivors (18). A recent cross-sectional survey in the United States observed that cancer survivors (including breast cancer survivors) who met the physical activity guidelines proposed by the American Cancer Society had a higher QOL than those who did not (15). However, the response rate in this study was relatively low (32.7%). Aside from having small sample sizes (10, 11, 17, 30), several previous studies also suffer from having cross-sectional or retrospective study designs (11, 17, 30), low response rates (e.g., 53.4%) (11, 17), mixed types of cancer (17, 30), or a single QOL measurement at follow-up without considering baseline QOL (10, 12, 13, 18).

Our population-based cohort study with multiple exposure and outcome assessments showed that self-initiated exercise after cancer diagnosis, either a baseline assessment or a cumulative assessment up to 36 months after cancer diagnosis, was positively associated with QOL during the first 36 months after diagnosis, and the association persisted even after adjustment for baseline QOL. Our findings provide the strongest evidence to date that regular exercise may play an important role in improving QOL for breast cancer survivors.

The common physical and psychosocial sequelae of cancer-related treatments and experience include fatigue, sleep disturbance, depression, anxiety, and social isolation (5, 22, 43).

Table 5. Mixed Models[a]: Adjusted Mean Differences in Total QOL Score and Scores in 3 QOL Domains Across Exercise Levels, Shanghai Breast Cancer Survival Study, China, 2002–2008

QOL	Exercise-related MET Score <8.3[b]			Exercise-related MET Score ≥8.3[b]			*P* Value for Trend of Exercise	Time		
	Mean Difference	95% CI	*P* Value	Mean Difference	95% CI	*P* Value		Mean Difference	95% CI	*P* Value
Total QOL score	0.95	0.35, 1.54	0.002	1.79	1.25, 2.33	<0.001	<0.001	0.96	0.61, 1.30	<0.001
Physical well-being	1.19	0.39, 2.00	0.004	2.01	1.28, 2.75	<0.001	<0.001	2.63	2.15, 3.12	<0.001
Psychosocial well-being	1.21	0.36, 2.06	0.005	2.12	1.35, 2.89	<0.001	<0.001	0.62	0.10, 1.13	0.018
Social well-being	0.99	0.25, 1.74	0.009	2.21	1.54, 2.88	<0.001	<0.001	0.62	0.18, 1.06	0.006

Abbreviations: CI, confidence interval; MET, metabolic equivalent task; QOL, quality of life.

[a] Models were adjusted for age at diagnosis, marital status, income, education, comorbidity, menopausal status, menopausal symptoms, waist-to-hip ratio, body mass index, tea consumption, chemotherapy, estrogen receptor/progesterone receptor status, tumor-node metastasis stage, and recurrence/metastasis. Participants in the nonregular exercise group served as the reference.

[b] The cutpoint (8.3 MET-hours/week) was based on the US Department of Health and Human Services national recommendation for recreational physical activity (39).

Although exercise has been shown to be effective in combating breast-cancer-related fatigue and anxiety and to improve QOL outcomes in both clinical and epidemiologic studies (8, 13, 16, 19, 42, 44), including the current one, there is an important methodological concern with these findings. It is possible that cancer patients whose QOL is better to start with are more likely to participate in exercise, while women with a poorer QOL may avoid exercise—a typical example of reverse causality. To address this concern, we conducted analyses stratified by QOL scores and comorbidity assessed at baseline and by disease stage. We observed an association between regular exercise and QOL among women with a low or high QOL score at baseline, and the association varied little by comorbidity or disease stage. Further adjustment for baseline QOL did not eliminate the exercise and QOL association. These observations argue against reverse causation as the explanation.

Several biopsychosocial mechanisms have been proposed to explain the association of exercise with QOL in cancer patients and survivors. These mechanisms include cardiopulmonary adaptations, endorphins, mastery achievements, positive feedback, distraction, and social interaction (8, 22). Exercise may also influence QOL during cancer treatment by improving coping and adjustment to cancer (e.g., self-efficacy, social interaction) (22). Amelioration of therapy-related symptoms in cancer patients via exercise participation may reduce their impact on capacity for daily living, leisure activities, and interactions with others. Enhanced physical and social activities may improve psychological distress/well-being (e.g., anxiety, depression), thereby improving overall QOL (22).

It should be noted that our study has some limitations. First, we collected information on recreational exercise activities only. Physical activity from other sources, such as daily living and employment, could not be evaluated. Second, we used a generic health-related QOL measurement instead of a disease-specific QOL assessment (e.g., FACT-B). Some issues specific to women with breast cancer may not have been captured. However, to our knowledge, none of the disease-specific QOL assessments, including FACT-B, have been validated in our study population. The generic QOL measure that we used in this study has been validated in a Chinese population, and our previous study showed that this instrument is able to capture differences in QOL between breast cancer patients and the general population (31). Additional limitations include the possibility of residual confounding and the effect of study dropouts over the 36-month postdiagnosis period, although this rate was relatively low in our study (12%). Future research efforts should extend the longitudinal framework used in this study to investigate the long-term effect of regular exercise on QOL, as well as to evaluate the effect of overall physical activity, including physical activity resulting from regular exercise and other sources, on QOL among breast cancer survivors.

The number of breast cancer patients and survivors in the United States and many other countries in the world continues to increase. It has been well documented that breast cancer and cancer-related treatments negatively affect QOL, which in turn results in a poor prognosis for breast cancer patients. Our finding provides strong evidence that regular participation in moderate exercise improves the overall QOL and the physical, psychological, and social well-being of breast cancer survivors. Thus, programs aiming to promote regular exercise participation and exercise levels after breast cancer diagnosis should be developed and evaluated.

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