BMC Psychiatry

RESEARCH

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Characteristics of positive and negative effects on the quality of life of breast cancer patients

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Abstract

Background Postoperative and ongoing treatment of breast cancer is traumatic to women with breast cancer and may lead to positive and negative psychological diseases, which can affect the prognosis of patients with breast cancer. Positive affect (PA) and negative affect (NA) significantly impact the prognosis of postoperative breast cancer patients. However, the effects of specific emotions on patient prognosis and the relationships between them are still unclear.

Methods A case–control study was conducted to investigate the characteristics of PA and NA and their effects on Quality of Life (QoL) in breast cancer patients. 442 postoperative breast cancer patients and 444 healthy women were recruited from November to December 2021. For the observation group, participants were eligible if they (1) were aged between 16 and 80 years and (2) had a confirmed pathological diagnosis of breast cancer and (3) possessed the ability to read text, voluntarily agreed to participate, provided informed consent, and cooperated with the study procedures. The control group consisted of individuals without breast cancer who met all other criteria, as stated above. Patients were excluded from the study if they (1) had severe comorbid conditions causing functional impairment or life-threatening risks or (2) suffered from mental disorders or were unconscious at the time of the study. For the control group, individuals with a pathological diagnosis of breast cancer were also excluded. All other exclusion criteria were consistent with those for the observation group. The demographic information and clinicopathological information of the participants were collected. The Positive Affect and Negative Affect Scale (PANAS) is a scale containing 20 emotional scores related to emotion and is used to assess the level of positive and negative affect. The Quality of Life Questionnaire Core 30 (QLQ-C30) was used to assess the quality of life of cancer patients in 15 domains. SPSS 24.0 was used to analyze and process the data. Independent-sample *t*-tests, one-way ANOVA and Pearson correlation analysis, were used to analyze PA and NA in different treatment phases. Polynomial regression and response surface analysis were conducted to assess the relationships among PA, NA, and QoL. The results were considered statistically significant at $P < 0.05$.

Results Compared with healthy women, breast cancer patients had lower scores on "alert" and "distressed" but higher scores on "inspired," "scared," and "afraid." There were no significant differences in the relationships

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between PA and NA between patients and healthy women ($P > 0.05$). During the initial treatment phase, the highest proportion of patients had an NA greater than the PA (PA < NA). In the rehabilitation phase, the highest proportion of patients had PA greater than or equal to the NA (PA ≥ NA). The relationship between PA and QoL was an inverted U-shaped curve ($P < 0.05$), whereas the relationship between NA and QoL was a positive U-shaped curve ($P < 0.05$). There was an interaction effect between PA and NA ($P < 0.001$). The relationships among PA, NA, and QoL varied across treatment phases. In the initial treatment phase, the presence of both positive and negative affect improved QoL. In the endocrine therapy phase, excessive positive effects decrease QoL. During the rehabilitation phase, QoL improved as positive affect increased relative to negative affect.

Conclusion There are significant differences in the distributions of positive and negative effects in breast cancer patients at different treatment phases. The impact of PA and NA on QoL varies by treatment phase. Our findings have important implications for tailoring emotional interventions for breast cancer patients at different stages of treatment.

Keywords Breast cancer patients, Positive affect, Negative affect, Polynomial regression, Quality of life

Introduction

Breast cancer replaced lung cancer as the most diagnosed cancer globally in 2020 [1]. Nearly 2.3 million patients are newly diagnosed each year, representing 11.7% of all new cancer cases [1]. The burden of breast cancer is increasing worldwide. The survival and prognosis of female breast cancer patients are influenced by various factors, such as age of onset, cancer cell differentiation, and metastasis status [2–4]. Increasing evidence shows that psychological factors, particularly affect patient prognosis [5–7]. The incidence of emotional disorders in cancer patients in China is approximately 44.63% [8]. Many patients experience high negative affect (NA) after diagnosis, which can negatively affect subsequent treatment. Studies have consistently indicated that NA—such as anxiety, depression, anger, and fear—is associated with poor prognosis, lower survival rates, shorter survival times [9–12], and poorer quality of life (QoL), including more pain and insomnia [7, 10–12]. According to Lyu et al. [13] Yang et al. [14] reported that fear was associated with physical dysfunction and lower QoL in breast cancer patients. However, most research has focused on the NA and its impact on prognosis, with fewer studies examining positive affect (PA) in postoperative breast cancer patients. Recent research suggests that many patients experience both NA and PA after diagnosis and treatment. PA can arise from social support and personal adjustment [15, 16]. Notably, PA can reduce inflammatory activity in breast cancer survivors [17] and improve their quality of life [18].

Traditionally, PA and NA have been seen as two opposite ends of a single spectrum, known as the one-dimensional model of affect. This perspective was initially introduced by Osgood et al. in 1957, who used factor analysis to evaluate several emotional terms [19]. They identified an important dimension of affect, suggesting that it ranges from highly positive to highly negative, forming what became known as the bipolar model. According to this theory, PA and NA are distinct, independent dimensions, each with their own subcategories of affect.

In the one-dimensional model of affect, individuals experience their core affect in a bipolar manner, akin to a pendulum swinging between two distinct poles. At any given moment, a person can only feel one dominant affect, either positive or negative, but not both simultaneously. For example, it is not possible for someone to feel both anger or sadness and pleasure or joy at the same time. This model suggests a linear negative correlation between PA and NA, implying that the presence of one necessarily excludes the other [20]. This model has not been applied to breast cancer patients in published studies.

In 1965, Bradburn and Caplovitz introduced the bidimensional model of affect, challenging the traditional view that PA and NA are independent dimensions [21]. According to their model, PA and NA can occur either separately or simultaneously and are not mutually exclusive [22]. Studies have shown that individuals with high self-differentiation often experience both PA and NA concurrently in response to environmental stress, with a low correlation between these effects. Conversely, those with low self-differentiation display a strong negative correlation between PA and NA when exposed to similar stressors, indicating different affective responses to the same environmental challenges [23, 24]. Breast cancer is an experiential trauma for breast cancer patients. Physical defects after breast cancer surgery have a great impact on the psychology of patients, and postoperative chemotherapy and radiotherapy also cause psychological damage to women with breast cancer. Patients can experience PA and NA, which affect the prognosis of patients with breast cancer after surgery [25]. However, the effects of specific emotions on patient prognosis and the relationship between the two are unclear. No published models have been applied to clinical studies of this

disease. Research has identified specific neural substrates associated with the PA and NA. The amygdala is primarily activated in response to negative stimuli, whereas the nucleus accumbens in the anterior subcortex of the forebrain is actived during positive experiences [26, 27]. Furthermore, Bradburn's 1969 study on subjective well-being introduced the concept of affect balance (AB), defined as AB = PA—NA [28]. This metric was suggested to significantly influence personal subjective well-being and QoL, suggesting the need for simultaneous assessments of PA, NA, and AB. Additionally, Fredrickson et al. proposed the positive ratio (PR), which is the ratio of PA to NA (PA/NA) [29]. This index has been found to predict mental health outcomes, underscoring the importance of evaluating the interplay between PA and NA in understanding affective dynamics.

However, previous studies have focus only on comparative studies and reported that female patients with breast cancer have anxiety and depression problems [25, 30–32], but in-depth research and discussion have not been conducted. The main reasons are that there is no quantitative treatment, no phased exploration of the differences in emotional problems and their impact on the prognosis of patients, no application of professional psychological models for assessing emotional problems, and no phased exploration of the differences in emotional problems and their impact on the prognosis of patients. Thus, our study focused on the PA and NA of postoperative breast cancer patients in China receiving antitumor treatments. We began by comparing the PA and NA profiles of these patients with those of nontumor healthy women. We subsequently analyzed the differences in PA and NA between healthy individuals and patients, as well as among patients across various treatment stages. Finally, we utilized polynomial regression and response surface analysis to explore the impact of PA and NA on the quality of life (QoL) of postoperative breast cancer patients.

Methods

Participant selection

A case–control clinical study and questionnaire survey were used in this study. The observation group included postoperative breast cancer patients, whose data were collected through convenient sampling from the "Breast Cancer Support Group," a public welfare organization, from October 2020 to March 2021. For the control group, data on healthy women were obtained via the WeChat and Moments social platforms between November and December 2021. The Ethics Committee of the Sixth Hospital of Peking University accepted and oversaw this procedure (Approval No. 2020–22). The entire experimental process was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent in accordance with the National Health and Medical Research Council guidelines. Ethical guidelines and legal data protection requirements will be strictly adhered to ensure that the rights and interests of the study participants are fully protected.

Convenience sampling methods have some limitations on the negative side of generality, such as limited representativeness, limited scope of application, and suitability for initial understanding and exploration, and some limitations on bias, such as selection bias, nonrepresentativeness bias, and information bias. However, by expanding the sample size and ensuring the randomness of sampling, its representativeness can be improved and bias can be reduced to a certain extent.

Inclusion and exclusion criteria

Inclusion criteria

For the observation group, participants were eligible if they (1) were aged between 16 and 80 years and (2) had a confirmed pathological diagnosis of breast cancer and (3) possessed the ability to read text, voluntarily agreed to participate, provided informed consent, and cooperated with the study procedures.

The control group consisted of individuals without breast cancer who met all other criteria as stated above.

Exclusion criteria

Patients were excluded from the study if they (1) had severe comorbid conditions causing functional impairment or life-threatening risks or (2) suffered from mental disorders or were unconscious at the time of the study.

For the control group, individuals with a pathological diagnosis of breast cancer were also excluded. All other exclusion criteria were consistent with those for the observation group.

Measurements

The researchers developed a general information questionnaire to collect demographic data from the participants. This included details on age, educational level, place of residence, occupational status, marital status, religious beliefs, and personal income.

Clinical and pathological measurements

The clinical and pathological questionnaire was designed by the researchers and reviewed by the breast cancer specialists to investigate the clinical and pathological information of the participants, including the stage of disease, breast surgical approach, lymphatic surgical approach, treatment approach, treatment phase, and menstrual status. A specialized questionnaire was developed by the researchers and validated by breast cancer specialists to gather clinical and pathological data

from the participants. This information included disease stage (ranging from stage 0 to IV), type of breast surgery (breast-conserving surgery or mastectomy), lymphatic surgery method (sentinel lymph node biopsy or clearance), treatment approach (surgery, chemotherapy, radiotherapy, endocrine therapy, or a combination thereof), treatment phase (preoperative chemotherapy, perioperative, postoperative chemotherapy, radiotherapy, endocrine therapy, or rehabilitation), and menstrual status (normal, paramenia, or menopause).

Positive Affect and Negative Affect Scale (PANAS)

Developed by Watson et al. [33], the PANAS is a tool designed to measure the levels of positive and negative affect in individuals. The scale was crafted after evaluating 60 affect-related words in the general population, 20 of which were selected to constitute the final scale. These 20 items are evenly divided into two subscales: one for positive affect and the other for negative affect, each with ten items. The items are rated on a five-point scale ranging from 1 ("almost none") to 5 ("very strong"), allowing each subscale to score between 10 and 50 points, with higher scores indicating more intense emotions. In 2003, Huang et al. [34] adapted the PANAS for the Chinese population, ensuring its suitability through translation and revision. The Chinese version demonstrated robust internal consistency, with Cronbach's alpha coefficients of 0.85 and 0.83 for each subscale and test–retest reliability scores of 0.47, confirming its reliability and validity. This tool has been effectively used to assess affect in breast cancer patients, showing strong validity and reliability in this specific population [35].

Quality of Life Questionnaire Core 30 (QLQ-C30)

The QLQ-C30, developed by the European Organization for Research and Treatment of Cancer (EORTC), is a standardized instrument for assessing QoL in cancer patients [36]. This scale includes 30 items distributed across 15 domains. These domains consist of five functional domains (physical, role, cognitive, emotional, and social functions), four symptomatic domains (fatigue, pain, nausea and vomiting), six single-item measures (shortness of breath, insomnia, loss of appetite, constipation, diarrhea, and economic difficulties), and one general health item. The Chinese versions of the QLQ-C30, versions 2.0 and 3.0, were adapted by Wan et al., who reported test–retest reliability scores above 0.73 and Cronbach's alpha coefficients exceeding 0.5, confirming their reliability and validity [37]. Further modifications by EORTC experts introduced a method for calculating the total QoL score, which is derived from the mean score of 13 items excluding "economic difficulties" and "general health". Before the total scoreis calculated, the scores from the symptomatic domains are reversed. This total QoL score has been validated for measuring QoL across cancer populations [38].

Study process

Participants were recruited online through the "Breast Cancer Mutual Aid Circle." Upon recruitment, breast cancer patients provided oral informed consent and received comprehensive information about the study's objectives and methods. They were introduced to the structure and content of the questionnaire and were reassured of the strict confidentiality of their responses. The participants were also reminded of the importance of providing honest answers to ensure the validity and reliability of the study's data. Once they provided informed consent, individuals were considered participants and proceeded to complete the questionnaires. These included the general information questionnaire, clinical and pathological questionnaire, PANAS, and QLQ-C30 using "Questionnaire Star," all in one session. The confidentiality of participant information was rigorously maintained throughout the study.

Statistical analysis

SPSS 24.0 was used to analyze and process the data. An independent-sample t test was applied to compare PA and NA between breast cancer patients and healthy women. One-way ANOVA was used to compare the relationships between PA and NA across patients at different treatment stages. Furthermore, Pearson correlation analysis was employed to assess the relationships among PA, NA and QoL. The results were considered statistically significant at $P < 0.05$.

Combining positive and negative emotions into a single variable is the conventional approach for studying mixed emotions. However, this method has drawbacks, including low reliability, reduced dimensionality of variables, challenges in interpretation, difficulties in coefficient interpretation, and limitations in terms of parameters. To address these shortcomings, polynomial regression and response surface analysis were utilized. In accordance with the model formula proposed by Edward and Parry [39], the formula (1), which is constructed through polynomial regression and response surface analysis is as follows:

$$\mathrm{QoL} = a_0 + a_1\mathrm{PA} + a_2\mathrm{NA} + a_3\mathrm{PA}^2 + a_4\mathrm{PA} * \mathrm{NA} + a_5\mathrm{NA}^2 + e \quad (1)$$

Among them, c represents quality of life, which serves as the dependent variable. PA and NA represent positive and negative affect, respectively, and serve as independent variables. *e* is the error term. The coefficients of the polynomial regression equation were tested via

the bootstrap method. A three-dimensional response surface map was then created using PA and NA as the x- and y-axes and QoL as the z-axis. Polynomial regression and response surface analysis are commonly used to analyz the relationship between mixed emotions and job satisfaction. Polynomial regression can effectively capture complex relationships between positive and negative affect and dependent variables in greater detail, including linear relationships, nonlinear relationships, and interactions between positive and negative affect. The interpretation of polynomial regression equations is more intricate and often supplemented by response surface analysis [40].

Sample size was estimated using Cohen's method. There are 5 polynomial variables and 5 covariates predicted *Qo*L with $R^2 = 0.477$. The effect size $f^2 = \frac{R^2}{1-R^2} = 0.795$, and the degrees of freedom for denominator was estimated to be $v = 21.92$. Therefore, the minimum sample size to achieve 90% power in the regression analysis $N = 10 + 22 + 1 = 33$. While a total of 442 participants in the observation group and 444 in the control group were included to expand the sample size and improve the reliability of the study data.

Results

Selection process and patient characteristics

The observation group received 455 questionnaires, 13 of which were excluded. A total of 442 valid questionnaires were ultimately included, with an effective response rate of 97.14%. There were 132 (29.9%), 182 (41.2%), and 108 (24.4%) patients with stage I or below, stage II, and stage III or above disease, respectively. Furthermore, 322 patients (72.9%) had a mastectomy, 274 (62.0%) had a sentinel lymph dissection, 209 (47.3%) received radiation, chemotherapy, or surgery, and 344 (75.6%) were menopausal. In terms of treatment stages, 158 (35.7%), 180 (40.7%) and 104 (23.5%) patients were in the initial stage of treatment (preoperative chemotherapy, perioperative, postoperative chemotherapy, or radiotherapy), endocrine therapy and rehabilitation after treatment, respectively.

The control group received a total of 488 questionnaires from healthy women. After 44 invalid questionnaires were removed, 444 questionnaires were ultimately included, resulting in an effective rate of 90.98%.

The demographic characteristics of the breast cancer patients and healthy controls were compared, revealing no significant differences in age or residence between the two groups. However, significant disparities were observed in the distributions of marital status, religious belief, educational level, occupational status, and personal income ($P < 0.05$), as indicated in Table 1.

Differences in positive and negative affect between breast cancer patients and healthy women

Compared with healthy women, breast cancer patients scored significantly lower on the "alert" dimension of PA ($P < 0.001$) and higher on the "inspired" dimension ($P < 0.05$). Compared with healthy women, breast cancer patients scored significantly lower on the "distressed" dimension ($P < 0.05$) and higher on the "scared" ($P < 0.001$) and "afraid" dimensions ($P < 0.001$). There was no significant difference in the total PA or scores between the two groups (Table 2, Figs. 1– 2).

Differences in PA and NA among patients with different ages and treatment stages of breast cancer

Multiple comparisons revealed that breast cancer patients aged 40 years and younger had significantly lower PA than other age groups did ($P < 0.01$), and significantly greater NA ($P < 0.001$). Patients in the rehabilitation stage had significantly greater PA than did those in the initial treatment and endocrine therapy stages ($P < 0.05$), whereas patients in the initial treatment stage had significantly greater NA than did those in the endocrine therapy stage and rehabilitation stage ($P < 0.05$), as shown in Table 3.

Differences in the relationships between PA and NA between patients and healthy women as well as between patients at different phases

To further investigate their relevancies, we conducted a chi-square test analysis to determine the relationship between PA and NA in breast cancer patients at different treatment stages. The results revealed significant differences in the distribution of PA-NA matching types among breast cancer patients at different treatment stages ($\chi 2 = 17.711,\ P < 0.01$). Bar charts were created to illustrate the proportions of different state affect matching types across each treatment stage. The specific results can be found in Table 4 and Fig. 3. Significant differences were found among breast cancer patients during different treatment phases: the initial treatment phase ($\chi^2 = 22.462,\ P < 0.001$), endocrine therapy phase ($\chi^2 = 3.950,\ P > 0.05$) and the rehabilitation phase ($\chi^2 = 11.539,\ P < 0.01$).

Relationships between PA, NA and QoL in breast cancer patients

Through Pearson correlation analysis, we found that in breast cancer patients, PA was significantly negatively correlated with NA ($r = -0.335,\ P < 0.01$), and QoL was significantly positively correlated with PA ($r = 0.485,\ P < 0.01$) and significantly negatively correlated with NA ($r = -0.535,\ P < 0.01$). The treatment stage of breast cancer patients showed a nonsignificant correlation with

Table 1 Demographic data in breast cancer patients and healthy women

		Female breast cancer patients ($n=442$)	Healthy women ($n=444$)	χ^2/t
Age		47.55 ± 10.07	46.12 ± 13.18	1.81
Place of residence	City	320 (72.4)	302 (68.0)	2.22
	Town	82 (18.6)	99 (22.3)	
	Village	40 (9.0)	43 (9.7)	
Marriage	Single	13 (2.9)	52 (11.7)	26.55***
	Married	378 (85.5)	350 (78.8)	
	Divorced or widowed	51 (11.5)	42 (9.5)	
Religious belief	No	331 (74.7)	397 (89.4)	33.45***
	Yes	111 (25.1)	47 (10.6)	
Education level	High school and below	191 (43.2)	164 (36.9)	12.24*
	College/Associate degree	87 (19.7)	108 (24.3)	
	University and above	164 (37.1)	172 (38.7)	
Employment status	Employed	221 (50.0)	254 (57.2)	6.57*
	Housewife	100 (22.6)	73 (16.4)	
	Retired	121 (27.4)	117 (26.4)	
Personal income	CNY ≤ 3000	75 (17.0)	89 (20.0)	11.56*
	CNY 3001 ~ 6000	153 (34.6)	155 (34.9)	
	CNY 6001 ~ 10,000	69 (15.6)	92 (20.7)	
	CNY ≥ 10,001	54 (12.2)	49 (11.0)	
	No fixed income	91 (20.6)	59 (13.3)	

* $P<0.05$, *** $P<0.001$

PA ($r=0.087$, $P>0.05$), a significant negative correlation with NA ($r=-0.138$, $P<0.01$), and a significant positive correlation with QoL ($r=0.254$, $P<0.01$). See Table 5 for details.

Polynomial regression analysis

Prior to performing polynomial regression analysis, the positive and negative emotion statuses of breast cancer patients were matched, and the proportions of consistency and inconsistency were calculated (Table 6). Both consistency and inconsistency of positive and negative affect exist, and the follow-up analysis was of practical value. To avoid the multicollinearity problem, the positive affect, negative affect and QoL life scores of breast cancer patients were centralized. The results suggested that the maximum value of the variance inflation factor (VIF) of the independent variable was 1.803 (< 10), indicating that there was no multicollinearity among the independent variables in the present study.

In the regression model, we examined QoL as the dependent variable, with PA and NA as independent variables. We added control variables progressively to explore both linear and curvilinear relationships between QoL and these affective states, along with their interaction. The findings showed that PA had an inverted U-shaped relationship with QoL, indicating that QoL increased with positive affect up to a point, after which it declined. Conversely, NA had a U-shaped relationship with QoL, where QoL decreased as NA increased but then improved at higher levels of NA. Additionally, there was a significant interaction effect between PA and NA on QoL outcomes (see Table 7).

Response surface analysis

Table 7 shows that the slope of the consistency line (S1) was −0.064 ($P<0.05$, 95% CI −0.253, 0.111), and its curvature (C1) was 0.026 ($P<0.05$, 95% CI −0.004, 0.050), indicating that neither of the bootstrap results were significant. This finding suggested that there was no significant difference in QoL between breast cancer patients with "low PA-low NA" and patients with "high PA-high NA".

The slope of the consistency line (S2) was 1.129 ($P<0.001$, 95% CI 0.984, 1.271), and its curvature (C2) was −0.027 ($P<0.001$, 95% CI −0.046, −0.010), indicating that the bootstrap results of both were significant. Furthermore, the inconsistency line was a U-shaped curve with downward openings with coordinates of (8.247, −8.247) and (−8.247, 8.247), and the Z-hat value was 18.621 (95% CI 16.051, 21.021). The bootstrap result was significant, suggesting that the QoL was considerably greater in breast cancer patients with "high PA-low NA" than in those with "low

Table 2 Comparison of positive and negative affects between breast cancer patients and healthy women

	Breast cancer patients (*n* = 442) Mean ± SD	**Healthy women (*n* = 444) Mean ± SD**	***t***	**|Cohen's *d*|**
Interested	3.01 ± 1.09	3.06 ± 1.19	−0.56	0.04
Excited	3.15 ± 1.03	3.06 ± 1.05	1.36	0.09
Strong	3.06 ± 1.08	3.06 ± 1.11	0.07	0.00
Enthusiastic	3.13 ± 1.15	3.24 ± 1.14	−1.43	0.10
Proud	2.78 ± 1.19	2.83 ± 1.18	−0.61	0.04
Alert	2.54 ± 1.14	2.84 ± 1.11	−4.03***	0.27
Inspired	2.88 ± 1.13	2.70 ± 1.18	2.25*	0.16
Determined	3.24 ± 1.10	3.10 ± 1.11	1.92	0.13
Attentive	3.11 ± 1.01	3.16 ± 0.98	−0.73	0.05
Active	3.13 ± 1.08	3.06 ± 1.10	0.96	0.06
Total positive affect score	**30.04 ± 8.10**	**30.11 ± 8.23**	**−0.12**	**0.01**
Distressed	2.59 ± 1.07	2.74 ± 1.17	−2.02*	0.13
Upset	2.23 ± 1.04	2.17 ± 1.14	0.82	0.05
Guilty	2.09 ± 1.10	1.95 ± 1.01	1.98*	0.13
Scared	2.18 ± 1.21	1.84 ± 1.06	4.53***	0.24
Hostile	1.68 ± 0.90	1.67 ± 0.95	0.16	0.01
Irritable	2.48 ± 1.08	2.34 ± 1.17	1.73	0.12
Ashamed	2.00 ± 1.06	2.05 ± 1.05	−0.73	0.05
Nervous	2.42 ± 1.09	2.32 ± 1.09	1.38	0.09
Jittery	1.94 ± 1.05	1.95 ± 1.03	−0.17	0.01
Afraid	2.30 ± 1.18	2.04 ± 1.04	3.58***	0.24
Total negative affect score	**21.90 ± 8.39**	**21.07 ± 7.64**	**1.55**	**0.10**

* $P < 0.05$, *** $P < 0.001$

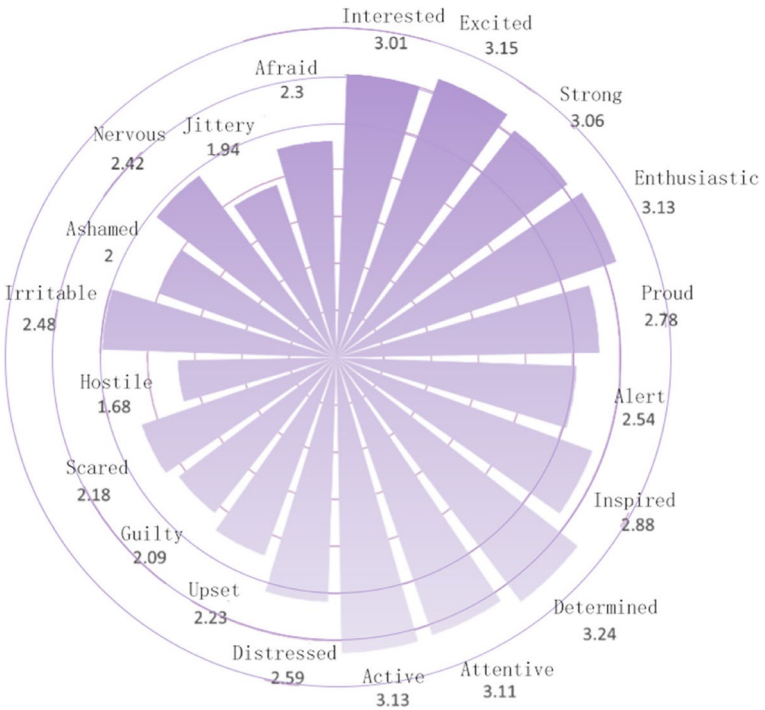

Fig. 1 Distribution chart for breast cancer patients

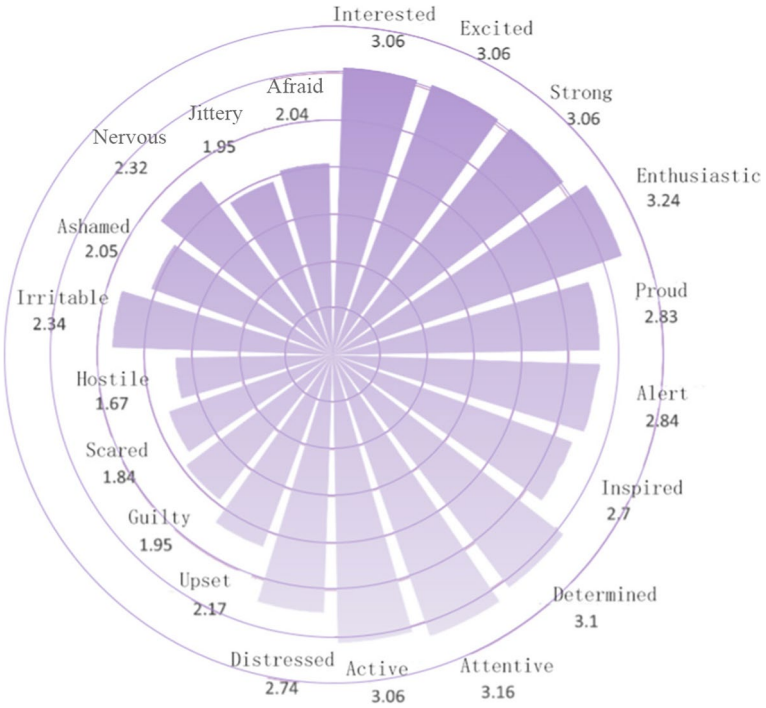

Fig. 2 Distribution chart for healthy women

Table 3 Comparison of PA and NA affects in breast cancer patients at different ages and treatment stages

		PA		NA	
		M	*SD*	*M*	*SD*
Age	①: ≤ 40	27.83	7.56	25.88	9.86
	②: 41 ~ 50	30.93	7.80	21.04	7.14
	③: 51 ~ 60	30.95	8.61	20.37	7.46
	④: ≥ 61	30.47	8.43	18.35	6.82
	F value	4.25**		15.05***	
	Pairwise comparison	①<②③④		①>②③④	
Treat stage	①: Initial treatment stage	29.37	7.99	23.47	8.52
	②: Endocrine therapy stage	29.64	7.59	21.02	8.09
	③: Rehabilitation stage	31.75	8.92	21.07	8.44
	F value	3.11*		4.34*	
	Pairwise comparison	①②<③		①>②③	

注：*$P < 0.05$ **$P < 0.01$, ***$P < 0.001$; *PA* positive affect, *NA* negative affect

PA-high Na". In addition, the critical value of the U-shaped curve of the inconsistency line -S2/(2*C2) = 22.44 was beyond the value range of PA and NA in this study, so it was not discussed. The response surface analysis results are shown in Fig. 4.

Table 4 Distribution difference of PA-NA matching types in breast cancer patients at different treatment stages

Matching type	Initial treatment stage *n* (%)	Endocrine therapy stage *n* (%)	Rehabilitation stage *n* (%)
PA > NA	46 (29.11)	70 (38.89)	48 (46.16)
PA = NA	37 (23.42)	57 (31.67)	28 (26.92)
PA < NA	75 (47.47)	53 (29.44)	28 (26.92)
χ^2	22.462***	3.950	11.539**

$N = 442$, **$P < 0.01$, ***$P < 0.001$. *PA* positive affect, *NA* negative affect

Regulatory effect of treatment stage on the relationship between positive and negative affect and QoL in breast cancer patients

Polynomial regression analysis

Breast cancer patients were grouped according to their treatment stage, and polynomial regression analysis was performed for positive and negative affect and QoL in each group. There was no multicollinearity among the independent variables (the highest VIF was 1.783, < 10).

As mentioned above, Model 1 adds the control variable, Model 2 adds the primary term of the independent variable, and Model 3 adds the secondary term and interactive term of the independent variable. The results revealed that there was a linear relationship

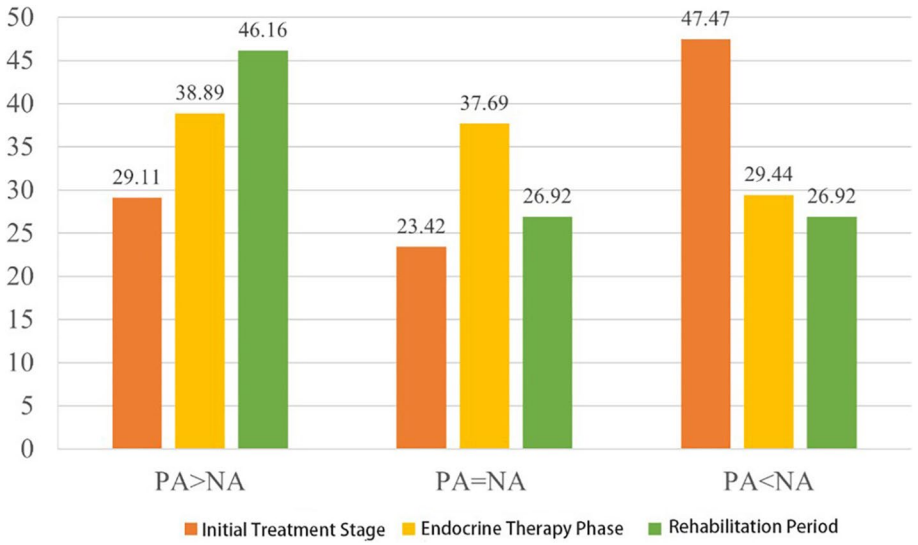

Fig. 3 Histogram of PA-NA matching types in breast cancer patients at different treatment stages. PA = positive affect, NA = negative affect

Table 5 Correlation analysis of treatment phases, affect and quality of life in breast cancer patients

	(*M* ± *SD*)	1	2	3	4
1. Treatment phases [a]	1.88 ± 0.76	1			
2. Positive affect	30.04 ± 8.10	0.087	1		
3. Negative affect	21.91 ± 8.39	−0.138**	−0.335**	1	
4. Quality of life	82.72 ± 11.37	0.254**	0.485**	−0.535**	1

* *P* < 0.05, ** *P* < 0.01, *** *P* < 0.001. Treatment phases[a]: 1 = the initial treatment phase, 2 = endocrine therapy phase, 3 = rehabilitation phase

Table 6 PA-NA matching types in breast cancer patients at different treatment phases

Matching type	*n* (%)	PA (*M* ± *SD*)	NA (*M* ± *SD*)
PA > NA	164 (37.10)	37.32 ± 5.86	15.74 ± 4.29
PA = NA	122 (27.60)	29.13 ± 4.42	20.71 ± 4.83
PA < NA	156 (35.30)	23.09 ± 5.47	29.31 ± 8.15

N = 442. *PA* positive affect, *NA* negative affect

between positive and negative affect and QoL at each treatment stage. An interaction was found between positive and negative affect in the initial treatment stage (β = 0.055, *P* < 0.001). There was a curvilinear relationship between positive emotion and QoL at the endocrine therapy stage (β = −0.030, *P* < 0.001). There was no curvilinear relationship or interaction effect between the rehabilitation stage and QoL (Table 8).

Table 7 Polynomial regression analysis of mixed affect and quality of life in breast cancer patients

	QoL		
	Model 1	Model 2	Model 3
Constant	0.548	3.174	3.386*
Control variable			
Age	0.749**	−1.411**	−0.415**
Educational level	−0.879	−0.743	−0.752
Occupational status	−1.672	−0.816	−0.685
Religious belief	−1.222	−0.516	−0.603
Treatment stage	3.731***	2.931***	2.973***
Independent variable			
PA		0.474**	0.533***
NA		−0.587**	−0.596***
PA^2			−0.011*
PA*NA			0.027***
NA^2			0.011*
F	7.413***	49.396***	39.296***
R^2	0.078	0.443	0.477
ΔR^2		0.365***	0.033***
Consistency line (PA = NA)			
Slope (S_1)	−0.064*		
Curvature (C_1)	0.026*		
Inconsistency line (PA = −NA)			
Slope (S_2)	1.129***		
Curvature (C_2)	−0.027***		

N = 442, * *P* < 0.05, ** *P* < 0.01, *** *P* < 0.001. *PA* positive affect, *NA* negative affect, *QoL* quality of life

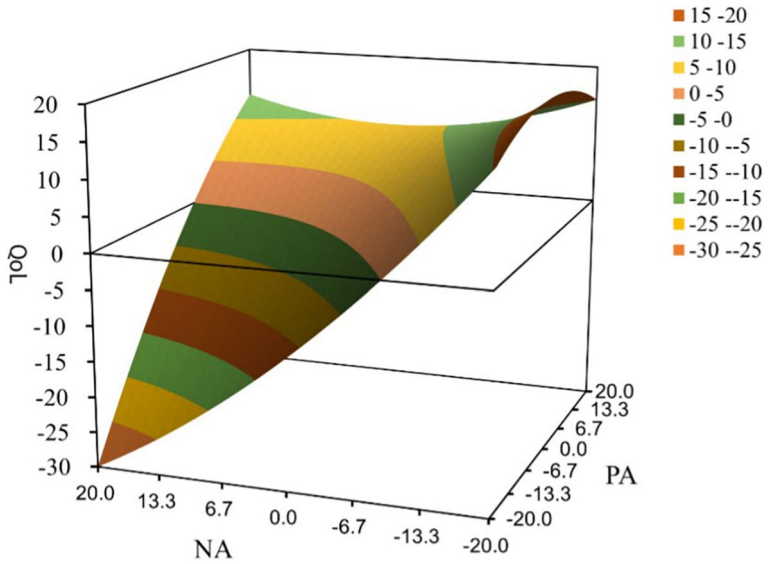

Fig. 4 3D response surface analysis of the relationship between mixed affect and quality of life in breast cancer patients. PA = positive affect, NA = negative affect, QoL = quality of life. The data interval of the ordinate represents the QoL data and the value of the original data after centralized processing

Table 8 Polynomial regression analysis of mixed affect and quality of life in breast cancer patients

Variables	The initial treatment phase ($n=158$)			Endocrine therapy phase ($n=180$)			Rehabilitation phase ($n=104$)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	3.022	3.022	1.669	7.115	8.709*	8.855*	0.882	5.984	6.873
Control variables	–	–	–	–	–	–	–	–	–
Independent variables									
PA		0.602**	0.677***		0.562**	0.606***		0.283**	0.307**
NA		−0.604**	−0.620***		−0.491**	−0.560***		−0.615**	−0.575**
PA^2			0.008			−0.030***			0.002
PA*NA			0.055***			0.013			0.009
NA^2			0.007			0.016			0.002
F	1.163	17.102***	15.052***	0.643	20.059***	17.318***	1.697	16.364***	10.706***
R^2	0.018	0.402	0.476	0.015	0.407	0.474	0.056	0.500	0.504
ΔR^2		0.384***	0.074***		0.392***	0.067***		0.445***	0.003
Consistency line (PA = NA)									
Slope	0.057*			0.046*			−0.268		
Curvature	0.701**			−0.001			0.013		
Inconsistency line (PA = − NA)									
Slope	1.296***			1.165***			0.882***		
Curvature	−0.040**			−0.045**			−0.005		

$^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$. PA = positive affect, NA = negative affect. '–' indicates NaN value

Response surface analysis

Combined with the slope and curvature analysis of consistency and inconsistency lines at different treatment stages in Table 8 a 3D response surface diagram was drawn, as shown in Fig. 5.

In the initial treatment stage, the slope of the consistency line was 0.057 ($P<0.05$, 95% CI −0.312, 0.445), and the Bootstrap result were not significant. The curvature was 0.701 ($P<0.01$, 95% CI 0.028, 0.107) with a significant Bootstrap result. Hence, the consistency line was a U-shaped curve with an upward opening,

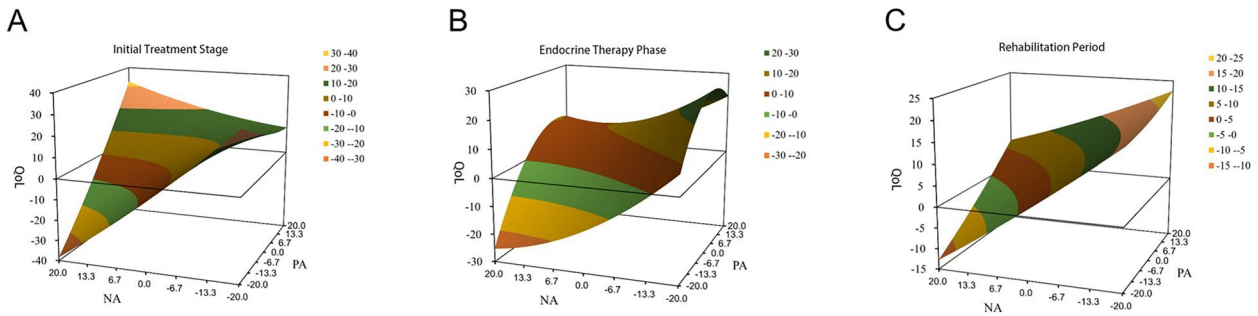

Fig. 5 3D response surface map of the relationship between mixed affect and quality of life in breast cancer patients at different treatment stages. PA = positive affect, NA = negative affect, QoL = quality of life. The data interval of the ordinate represents the QoL data and the value of the original data after centralized processing

and the coordinates were (8.257, 8.257) and (−8.257, −8.527), respectively, and the Z-hat value was 1.011 (95% CI −5.749, 7.483). Bootstrap result was not significant, and there was no discernible difference in the QoL life between "high PA-high NA" and "low PA-low NA" patients. The slope of the inconsistency line was 1.296 ($P < 0.001$, 95% CI 1.017, 1.569), and the curvature was −0.040 ($P < 0.01$, 95% CI −0.064, −0.008), with both bootstrap results being significant. This illustrated that the inconsistency line was a U-shaped curve with a downward opening and a falling orientation initially. The coordinates were (8.257, −8.257) and (−8.257, 8.527), respectively, and the Z-hat value was 21.236 (95% CI 16.039, 25.991). The Bootstrap result was significant, and the QoL life of "high PA-low NA" was significantly higher than that of "low PA-high NA" patients. The response surface map was a slot plane, and the highest Z value was on the consistency line.

In the endocrine therapy phase, the slope of the consistency line was 0.046 ($P < 0.05$, 95% CI −0.263, 0.285), and the curvature was −0.001 ($P > 0.05$, 95% CI −0.049, 0.039), with neither of the Bootstrap result being significant. This indicated that the consistency line was a horizontal line, and there was no significant difference in the QoL life between "high PA-high NA" and "low PA-low NA" patients. The slope of the inconsistency line was 1.165 ($P < 0.001$, 95% CI 0.938, 1.366), and the curvature was −0.045 ($P < 0.01$, 95% CI −0.063, −0.018). Both Bootstrap results were significant, indicating that the inconsistency line was a U-shaped curve with an opening downward, and the coordinates were (7.840, −7.840) and (−7.840, 7.840), respectively. The Z-hat value was 18.325 (95% CI 14.175, 22.135) and the Bootstrap result was significant, suggesting that the QoL life of patients with "high PA-low NA" was significantly higher than that with "low PA-high NA". The response surface map was a ridge plane, and the highest Z value was on the inconsistency line.

In the rehabilitation period, the slope and curvature of the consistency line were not significant ($P > 0.05$), indicating that there was no obvious difference in QoL life between "high PA-high NA" and "low PA-low NA" patients. The slope of the inconsistency line was 0.882 ($P < 0.001$, 95% CI 0.596, 1.173) and the Bootstrap result was significant. The curvature was −0.005 ($P > 0.05$, 95% CI −0.039, 0.018) and the Bootstrap result was not significant. It showed that the inconsistency line was a straight line with a positive slope, and the QoL life of patients with "high PA-low NA" was considerably higher than that with "low PA-high NA".

Discussion

Characteristics and distribution of positive and negative affect in patients with breast cancer

In this study, 442 breast cancer patients were selected as the observation group and 444 healthy women were selected as the control group through a case–control study. Polynomial regression and response surface analysis were used to explore the positive and negative emotional characteristics of breast cancer patients and their associations with QoL.

Our results suggest that the positive and negative effects in breast cancer patients are not significantly different from those in healthy women. Positive emotion and negative emotion were matched and classified into three categories, e.g., PA > NA, PA = NA, and PA < NA. According to the comparison of the positive and negative emotion types between breast cancer patients and healthy women, there was no discernible variation in the distribution proportion of positive and negative emotion types. The distributions of positive and negative effects in breast cancer patients at different stages of treatment were compared, and the distributions of positive and negative effects in breast cancer patients were significantly different in the initial treatment phase, the endocrine treatment phase and the rehabilitation phase.

In the initial treatment phase, the proportion of breast cancer patients with "PA < NA" was significantly greater than that of patients in the other two treatment phases, and the proportion of patients with "PA > NA" was significantly lower than that of patients in the other two phases. Patients with "PA > NA" or "PA = NA" were substantially more common in the endocrine therapy phase than in the other two phases. In the rehabilitation phase, patients with "PA > NA" were significantly more common, while "PA < NA" was less common than in the other two treatment phases. One possible explanation for this might be that breast cancer patients undergoing the initial treatment phase often experience a difficult course of therapy, and sudden alterations in their condition can elicit intense negative effects. Nonetheless, patients in the rehabilitation period can find a more positive meaning from the disease and achieve posttraumatic growth, thus experiencing a greater level of positive affect. In addition, according to the dynamic affect model (DAM), when breast cancer patients are in the initial phase of treatment, they are under greater pressure and have a lower capacity for emotional differentiation and a relatively simple emotional structure. There is also a significant negative correlation between positive and negative affect in this period. Consequently, the "PA < NA" type of positive and negative affect is more common. However, during the rehabilitation phase, patients experience less stress and have a greater capacity for emotional differentiation. Their positive and negative effects are relatively independent, indicating a relatively positive correlation. Therefore, the "PA > NA" type is more prevalent. This finding is consiste with the two-dimensional theory of emotion. Positive and negative affect are in different dimensions, and an increase in positive emotional experience does not always follow a decrease in negative emotional experience. Positive and negative affect can exist simultaneously [41].

This is different from previous research results. Voogt et al. [42] reported that patients with advanced breast cancer had fewer positive emotional experiences than healthy women did, while their negative emotional experiences were similar to those of controls. The absence of positive affect rather than an increase in negative affect was the primary cause of psychological suffering in patients with metastatic breast cancer. Additionally, Markovitz et al. [43] reported that patients with breast cancer suffer more negative emotional experiences than positive emotional experiences. The inconsistencies in this study may be due to the different ways of measuring positive and negative affect. The present study employed the PANAS to assess affect, whereas Markovitz utilized the CES-D, which includes 6 negative and 4 positive affects. Compared with the CES-D, both negative and positive affect in the PANAS are high-arousal affect. Accordingly, varying experiences of high- and low-arousal affect may be experienced by breast cancer patients, which leads to divergent findings. Another possible reason for the discrepancy might be the variations in the samples. The participants in this study were selected from the Breast Cancer Mutual Aid Circle, an online resource that offers individuals emotional and informational assistance. Thus, there was little emotional difference between healthy women and those with breast cancer since adequate social support could help patients adjust to alterations in their disease. Furthermore, all disease stages were included in this analysis, whereas the study conducted by Voogt et al. [42] primarily consisted of patients with advanced breast cancer. The discrepancy in research outcomes may be due to a reduced positive emotional experience among individuals with advanced breast cancer.

The effect of emotional complexity on QoL in breast cancer patients

This study applied polynomial regression analysis to show that there was a curve association and an interaction between positive and negative affect and QoL in breast cancer patients rather than a single linear relationship.

This finding is consistent with the results in patients with stomach cancer. Shrira et al. [44] revealed that cancer patients are in a chronic stress situation and that excessive positive affect might cause unrealistic fantasies and inappropriate medical decisions in gastric cancer patients, leading to a reduction in disease adaptation. A certain level of negative affect might be beneficial for allowing gastric cancer patients to adapt to the disease. Therefore, the interaction effect of positive and negative effects on QoL in breast cancer patients has certain adaptive significance. According to the DAM, the decreased independence of positive and negative affect in breast cancer patients under stressful situations can promote better adaptation to the disease and treatment process and thus a greater quality of life.

According to the 3D response surface analysis, when positive and negative affect were consistent, there was no discernible difference in QoL life between patients who had high and those who had low levels of positive and negative affect. These findings suggest that the impacts of positive and negative effects on the QoL of breast cancer patients are similar, which is inconsistent with previous research results. The emotion theory of Fredrickson et al. [29] states that negative affect has a stronger impact on individuals. To counteract the effects of negative affect, individuals must have a greater level of positive emotional experience to maintain improved mental health. The reason for this inconsistency may be that the study

conducted by Fredrickson et al. sampled the general population, whereas breast cancer patients experienced a greater level of stress. Positive and negative affect have different effects and functions in various stressful situations. When positive and negative affect are inconsistent, a higher level of positive affect than negative affect is associated with a greater QoL in breast cancer patients. This is consistent with prior studies. In stressful circumstances, affect is easily experienced as a single dimension, and those with greater emotional processing flexibility have greater independence between positive and negative affect [24]. Studies in the general population have demonstrated that individuals who are more psychologically resilient are able to maintain emotional health, experience more mixed affect, and have higher levels of emotional complexity than their less well-adjusted peers [45]. This study revealed that breast cancer patients tend to have a greater QoL when they have greater independence of positive and negative emotions, and greater positive affect than negative emotion.

Associations between positive and negative affect and QoL in breast cancer patients at different treatment stages

Polynomial regression analysis of breast cancer patients at different treatment phases revealed that the patients experienced the greatest stress at the initial treatment phase, and their negative and positive effects had the same effect on their QoL. There was only a linear relationship between positive and negative emotions and QoL, with no curve relationship. There was a significant positive interaction between positive and negative emotions, which implied that the improvement in one emotion could increase the positive predictive effect of the other emotion on QoL. Compared with breast cancer patients with inconsistent positive and negative affect, patients with simultaneously high or low positive and negative affect tended to have a greater QoL. There was no statistically significant difference in QoL between breast cancer patients with high PA-high NA and those with low PA-low NA. When positive and negative affect are inconsistent, the QoL of patients with "high PA-low NA" is greater than that of patients with "low PA-high NA". In the endocrine therapy phase, the stress experienced by patients was moderate, and the effect of negative affect on QoL was slightly greater than that of positive affect. The relationship between positive emotion and QoL life was curvilinear, whereas the relationship between negative emotion and QoL life was linear, and there was no interaction between positive and negative emotion. When positive and negative affect were consistent, there was no significant difference in QoL between patients with "high PA-high NA" and those with "low PA-low NA". When positive and negative affect are inconsistent, the QoL of "high PA-low NA" patients is greater than that of "low PA-high NA" patients and reaches the best value at a certain point. When the critical value is exceeded, the QoL of patients no longer increases but rather decreases. This condition was optimal at a certain point. When it exceeds the critical value, the QoL does not increase but rather decreases. During the rehabilitation period, patients experienced a low level of stress. The effect of negative affect on QoL was significantly greater than that of positive affect. The relationship between positive and negative affect and QoL was linear, with no interaction. Patients with "low PA-low NA" had a lower QoL life than those with "high PA-NA", whereas "high PA-low NA" patients tended to have a higher QoL life than "low PA-high NA" patients did.

Our study found that breast cancer patients have different psychological states at different stages, and rationality and PA and NA have a good effect on quality of life. There was an interaction effect between PA and NA. The relationships among PA, NA, and QoL varied across treatment phases.

Limitations

First, a questionnaire survey was employed in this study, and the limited number of items might restrict the measurement of the subjective emotional experiences of breast cancer patients. Therefore, we can increase the frequency of collecting emotional data through experience sampling programs in future research. On the other hand, we can also adopt more diverse methods, such as qualitative research and laboratory situational induction, to explore the relationship between emotional complexity and the QoL of breast cancer patients. Second, the PANAS and the QLQ-C30 were the main measurement tools applied in this study. Among them, positive and negative affect in PANAS are mostly high arousal affect and lack relatively low arousal affect. Previous studies have shown that breast cancer patients experience more low-arousal affect after diagnosis; thus, the measurement may be biased. Moreover, we found lower distress in breast cancer patients compared to controls. Under normal circumstances, it is indeed an unexpected finding that you should feel sad when you are told that you have cancer. We consider that the possible explanation is that you have carried out psychological construction to protect yourself against the attack of the disease and strive to achieve a more positive psychological state, so the above results will eventually be obtained. However, there is no literature and theoretical hypothesis support at present, and further research is needed.

Conclusion

In conclusion, our results revealed that the distributions of positive and negative emotional types in breast cancer patients were not significantly different from those in healthy women. In the initial treatment phase, there was no significant difference in the types or distributions of positive and negative affect between breast cancer patients and healthy women. However, the positive and negative emotional types varied among patients in different treatment stages. The proportion of negative affect greater than positive affect in the initial treatment phase was greater than that in the endocrine therapy and rehabilitation phases, and the proportion of positive emotion lower than negative emotion was lower than that in the other two phases. In addition, the relationships between positive and negative affect and QoL were distinct at different treatment phases. In the initial treatment phase, the consistent existence of positive and negative emotions could improve QoL. In the endocrine therapy phase, the QoL decreased when positive emotions were overwhelming. During the rehabilitation period, the QoL improved as the level of positive emotion relative to negative emotion increased. Our findings have important implications for tailoring emotional interventions for breast cancer patients at different stages of treatment. The emotions and QoL of breast cancer patients should be considered in clinical practice, and guidance and interventions, such as spiritual or traditional Chinese medicine, should be provided for alternative therapies according to the stage of treatment of patients [46]. Further studies are needed to explore the effects of different emotions on quality of life. And it is suggested to carry out randomized controlled clinical research on the intervention of patients with different emotional prescriptions to evaluate the effect of emotional intervention on the quality of life of breast cancer patients.

Abbreviations

PA	Positive affect
NA	Negative affect
QoL	Quality of life
AB	Affect balance
PR	Positive ratio
PANAS	The positive affect and negative affect scale
EORTC	European organization for research and treatment of cancer
QLQ-C30	Quality of life Questionnaire Core 30
CES-D	Center for epidemiologic studies depression scale
DAM	Dynamic affect model

Acknowledgements

We would like to acknowledge all the participates.

Authors' contributions

JZ and DY contributed equally to this study. JL and RW designed research; JZ and DY performed research; JZ, CC, and YW analyzed data; JZ, YL, and DY wrote the manuscript. All authors approved the final version of the paper.

Funding

This work was supported by the Beijing National Science Foundation (grant No. 7222236), the National Natural Science Foundation of China (grant No. 82271569) and the Capital Medical Development Research Fund (2022-1-4111).

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The Ethic Committee of the Sixth Hospital of Peking University accepted and oversaw this procedure (Approval No. 2020–22). The entire experimental process was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent in accordance with National Health and Medical Research Council guidelines.

Consent for publication

No applicable.

Competing interests

The authors declare no competing interests.

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Received: 3 August 2024 Accepted: 18 November 2024
Published online: 18 December 2024

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