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The Role of Attachment Styles and Physical Activity in Predicting Quality of Life in Women with Breast Cancer: The Mediating Role of Resilience

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ABSTRACT

The present study aimed to examine the role of attachment styles and physical activity in predicting quality of life in women with breast cancer, with a particular focus on the mediating role of resilience. This applied study employed a descriptive-correlational design. The statistical population included all women with breast cancer who had active medical records at Imam Ali Hospital in Karaj, from which 85 participants were selected using convenience sampling. Inclusion criteria included confirmed diagnosis, age range of 20–50 years, and willingness to participate. Data were collected using the WHOQOL-BREF, Van Oudenhoven Attachment Styles Questionnaire, Connor–Davidson Resilience Scale (CD-RISC), and an international physical activity questionnaire. Data analysis was conducted using descriptive statistics, Pearson correlation, regression analysis, and structural equation modeling. The normality of the data was assessed using the Kolmogorov–Smirnov test, and analyses were performed using SPSS version 22 and AMOS software. The results of structural equation modeling indicated that attachment styles had a significant direct effect on quality of life ($\beta = 0.62$, $p < 0.001$) and an indirect effect through resilience. Physical activity also showed a significant direct effect on quality of life ($\beta = 0.58$, $p < 0.001$) as well as an indirect effect via resilience ($\beta = 0.55$, $p < 0.001$). Resilience had a significant positive effect on quality of life ($\beta = 0.64$, $p < 0.001$). Model fit indices confirmed an acceptable fit ($\chi^2/df = 2.11$, RMSEA = 0.03, GFI = 0.98). Overall, all hypothesized paths were statistically significant ($p < 0.001$). The findings suggest that attachment styles and physical activity are significant predictors of quality of life in women with breast cancer, both directly and indirectly through resilience. Enhancing resilience may strengthen the positive effects of adaptive attachment patterns and physical activity, thereby improving overall well-being.

Keywords: Attachment Styles, Physical Activity, Resilience, Quality of Life, Breast Cancer, Structural Equation Modeling

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Introduction

Breast cancer is one of the most prevalent and life-threatening diseases among women worldwide and has profound multidimensional effects on patients' physical, psychological, and social functioning. Beyond its medical consequences, breast cancer significantly disrupts individuals' daily functioning, emotional stability, and interpersonal relationships, ultimately influencing their overall quality of life. Quality of life, as a comprehensive and multidimensional construct, reflects individuals' perceptions of their physical health, psychological well-being, social relationships, and environmental conditions, and is increasingly

recognized as a critical outcome in cancer care and survivorship research (1, 2). Evidence indicates that despite advances in diagnosis and treatment, many women with breast cancer continue to experience reduced quality of life due to treatment side effects, emotional distress, fatigue, and changes in body image and social roles (3, 4). Therefore, identifying the psychological and behavioral factors that influence quality of life in this population has become a major focus in contemporary health psychology and psycho-oncology research.

Among the psychological determinants of quality of life, attachment styles have attracted considerable attention due to their fundamental role in shaping individuals' emotional regulation, interpersonal functioning, and coping strategies. Attachment theory posits that early interactions with caregivers lead to the formation of internal working models that guide individuals' expectations and behaviors in close relationships throughout life. These attachment patterns—commonly categorized as secure, fearful, dismissing (avoidant), and preoccupied—are associated with distinct emotional and behavioral responses to stress and adversity (5). Research has consistently shown that secure attachment is associated with better psychological adjustment, effective coping strategies, and higher levels of well-being, whereas insecure attachment styles are linked to maladaptive coping, increased psychological distress, and poorer quality of life outcomes (6, 7). In clinical populations, including individuals with chronic illnesses, attachment styles play a crucial role in how patients perceive and manage their illness, interact with healthcare providers, and seek social support (8). For example, individuals with secure attachment tend to exhibit higher levels of life satisfaction and better health-related quality of life, while those with insecure attachment may experience greater anxiety, loneliness, and dissatisfaction with life (9, 10). These findings suggest that attachment styles are important predictors of quality of life, particularly in populations facing significant health challenges such as breast cancer.

In addition to psychological factors, behavioral variables such as physical activity have been identified as key contributors to quality of life in both healthy and clinical populations. Physical activity has been widely recognized for its beneficial effects on physical health, mental well-being, and functional capacity. In the context of chronic illness, including cancer, regular physical activity has been associated with reduced fatigue, improved mood, enhanced cognitive functioning, and better overall quality of life (11, 12). Empirical studies have demonstrated that individuals who engage in higher levels of physical activity report better health-related quality of life compared to those with sedentary lifestyles (13, 14). Furthermore, physical activity may exert its positive effects on quality of life through various psychological mechanisms, such as reducing depressive symptoms and enhancing self-efficacy and emotional regulation (15). In populations with chronic conditions, including neurological and oncological disorders, physical activity has been shown to play a protective role against cognitive decline and psychological distress, thereby contributing to improved quality of life outcomes (11, 16). Despite these well-documented benefits, the role of physical activity in predicting quality of life among women with breast cancer, particularly in interaction with psychological factors such as attachment styles, requires further investigation.

Another critical factor that has gained increasing attention in recent years is resilience, defined as the ability to adapt positively in the face of adversity, stress, or trauma. Resilience is considered a dynamic process that involves the interaction of individual, social, and environmental resources, enabling individuals to maintain or regain psychological well-being despite challenging circumstances. In the context of chronic

illness, resilience plays a crucial role in determining how individuals cope with disease-related stressors and maintain their quality of life (17). Research has shown that higher levels of resilience are associated with lower levels of psychological distress, greater emotional stability, and improved quality of life among patients with various medical conditions, including cancer (18). Moreover, resilience has been identified as a key mediator in the relationship between psychological and behavioral factors and health outcomes. For instance, resilience can buffer the negative effects of stress and enhance individuals' capacity to utilize adaptive coping strategies, thereby improving their overall well-being (19). Interventions aimed at enhancing resilience, such as resilience training and acceptance-based therapies, have also been shown to significantly improve quality of life in different populations, highlighting the practical importance of this construct (20).

Recent research has increasingly emphasized the mediating role of resilience in the relationship between various predictors and quality of life. For example, resilience has been found to mediate the effects of fatigue, stress, and psychological distress on quality of life in patients with chronic illnesses (18). Similarly, in cancer populations, resilience has been identified as a key mechanism through which social support, coping strategies, and psychological flexibility influence quality of life (21). These findings suggest that resilience not only directly impacts quality of life but also serves as a pathway through which other variables exert their effects. Given the significant role of resilience in promoting adaptation and well-being, it is essential to examine its mediating function in the relationship between attachment styles, physical activity, and quality of life in women with breast cancer.

Despite the growing body of research on quality of life in cancer patients, there remains a gap in understanding the combined effects of psychological and behavioral factors within an integrated framework. Most previous studies have examined these variables in isolation, without considering their potential interactions and underlying mechanisms. For instance, while attachment styles have been linked to quality of life and psychological outcomes, and physical activity has been shown to enhance well-being, few studies have simultaneously investigated these variables in a single model. Moreover, the mediating role of resilience in this context has not been sufficiently explored, particularly in women with breast cancer. Given the complex and multifaceted nature of quality of life, adopting a comprehensive approach that considers multiple influencing factors and their interrelationships is ضروری for advancing both theoretical understanding and clinical practice.

Furthermore, cultural and contextual factors may influence the relationships among attachment styles, physical activity, resilience, and quality of life. Studies conducted in different populations have highlighted variations in the strength and direction of these relationships, underscoring the importance of examining these variables within specific cultural contexts (12, 13). In Iran, where social, familial, and cultural dynamics play a significant role in individuals' coping processes, understanding the interplay between psychological and behavioral factors is particularly relevant for developing culturally sensitive interventions aimed at improving quality of life among cancer patients.

In summary, the literature suggests that attachment styles and physical activity are important predictors of quality of life, and resilience may play a key mediating role in these relationships. However, there is a need for empirical studies that integrate these variables within a comprehensive model to better understand their combined effects, particularly in women with breast cancer. Therefore, the present study aims to

investigate the role of attachment styles and physical activity in predicting quality of life in women with breast cancer, with a particular focus on the mediating role of resilience.

Methods and Materials

Study Design and Participants

The statistical population of this study consisted of all women diagnosed with breast cancer who had active medical records at Imam Ali Hospital in Karaj. According to the report of the Deputy of Treatment at Karaj University of Medical Sciences, the total population included 107 patients. From this population, 85 individuals were selected as the final sample using a convenience sampling method. It is noteworthy that due to the physical condition and health limitations of patients with breast cancer, only a portion of the population was willing and able to participate in the study. The inclusion criteria consisted of a confirmed diagnosis of breast cancer by a specialist physician, having an active medical record at the hospital, being within the age range of 20 to 50 years, absence of severe comorbid conditions such as epilepsy as determined by a psychiatrist, a duration of 2 to 6 months since diagnosis, willingness to participate in the study, and having at least basic literacy skills. The exclusion criteria included incomplete questionnaire responses, withdrawal of consent during the study, or exclusion based on medical judgment by the hospital physician.

Data Collection

The World Health Organization Quality of Life Questionnaire (WHOQOL-BREF) was used to assess quality of life. This instrument consists of 26 items and has been widely validated across different cultures and countries since 1996. It is scored on a five-point Likert scale ranging from “very low” to “very high.” The questionnaire measures four domains including physical health, psychological health, social relationships, and environmental conditions. Previous studies have reported high internal consistency for this instrument, with reliability coefficients reaching 0.95. The Persian version of the questionnaire has been standardized and psychometrically validated, confirming its suitability for use in Iranian populations.

Attachment styles were measured using the Van Oudenhoven Attachment Styles Questionnaire developed in 2003. This instrument includes 21 items and assesses four attachment dimensions: secure, fearful, dismissing (avoidant), and preoccupied. The overall Cronbach’s alpha coefficient for the questionnaire has been reported as 0.78, with subscale reliabilities of 0.74 for secure, 0.68 for fearful, 0.55 for dismissing, and 0.80 for preoccupied attachment styles. In Iranian samples, the reliability of the instrument has been reported as 0.72 using Cronbach’s alpha, and its validity has been supported through split-half methods, indicating acceptable psychometric properties.

Resilience was assessed using the Connor-Davidson Resilience Scale (CD-RISC), developed in 2003. This 25-item scale measures resilience on a five-point Likert scale ranging from 0 to 4, with total scores ranging from 0 to 100. Higher scores indicate greater resilience. The scale has demonstrated strong psychometric properties, including adequate internal consistency, test-retest reliability, and convergent and divergent validity. Although exploratory factor analysis has identified five underlying factors, the total resilience score is typically used due to more robust reliability evidence. The Persian version of the scale has also demonstrated acceptable reliability, with Cronbach’s alpha coefficients reported around 0.73 to 0.75, and construct validity supported through factor analysis.

Physical activity was measured using an international physical activity questionnaire designed to assess levels of physical engagement. This instrument includes 16 items organized into three domains: leisure-time physical activity, sports activity, and occupational physical activity. Responses are rated on a five-point Likert scale ranging from 1 to 5. Previous studies have reported reliability coefficients around 0.74 and validity coefficients approximately 0.51. In Iranian samples, the instrument has demonstrated acceptable validity (0.54) and reliability (Cronbach's alpha = 0.78). Additional studies using split-half methods have reported validity coefficients of 0.48 and reliability estimates of 0.76, supporting its adequacy for research purposes.

Data Analysis

Data analysis was conducted at both descriptive and inferential levels. Descriptive statistics included measures such as mean, standard deviation, frequency, and percentage. To test the research hypotheses, Pearson correlation coefficient, regression analysis, and structural equation modeling (SEM) were employed. The normality of the data distribution was assessed using the Kolmogorov–Smirnov test. All statistical analyses were performed using SPSS software version 22 and AMOS software for structural modeling.

Findings and Results

The demographic characteristics of the participants indicated that the majority of the sample fell within the 30 to 40-year age group (53%, n = 45), followed by those under 30 years of age (27%, n = 23), and those above 40 years (20%, n = 17). Regarding marital status, most participants were married (61.2%, n = 52), while 38.8% (n = 33) were single. In terms of educational attainment, the largest proportion of participants held a high school diploma (37.8%, n = 32), followed by those with below diploma or middle school education (27%, n = 23), bachelor's degree holders (25.8%, n = 22), and a smaller group with a master's degree or higher (9.4%, n = 8). Concerning occupational status, nearly half of the participants were housewives (49.4%, n = 42), followed by individuals engaged in self-employment (36.4%, n = 31), and a smaller proportion employed in governmental positions (14.2%, n = 12). Overall, the sample predominantly consisted of married women in the middle adulthood age range with moderate educational levels and a high representation of non-employed (housewife) individuals.

Table 1. Cronbach's Alpha Coefficients for Research Variables

Variables	Cronbach's Alpha
Secure Attachment Style	0.87
Fearful Attachment Style	0.85
Dismissing Attachment Style	0.89
Preoccupied Attachment Style	0.88
Physical Activity	0.84
Resilience	0.92
Quality of Life	0.81

The results presented in Table 1 indicate that all research variables demonstrated acceptable to excellent internal consistency reliability. The highest reliability coefficient was observed for resilience (α = 0.92), suggesting a very high level of internal consistency among its items. Attachment styles also showed strong reliability, with coefficients ranging from 0.85 to 0.89 across the four dimensions. Physical activity (α =

0.84) and quality of life (α = 0.81) also exhibited satisfactory reliability levels. Overall, these findings confirm that the measurement instruments used in the study possess adequate reliability for subsequent statistical analyses.

Table 2. Kolmogorov–Smirnov Test Results for Normality of Variables

Variable	Z Value	Significance Level (p)	Error Level	Hypothesis Status	Conclusion
Resilience	6.89	0.148	0.05	Ho Confirmed	Normal
Physical Activity	7.26	0.179	0.05	Ho Confirmed	Normal
Quality of Life	6.36	0.188	0.05	Ho Confirmed	Normal
Secure Attachment Style	6.32	0.157	0.05	Ho Confirmed	Normal
Fearful Attachment Style	4.42	0.159	0.05	Ho Confirmed	Normal
Dismissing Attachment Style	4.37	0.124	0.05	Ho Confirmed	Normal
Preoccupied Attachment Style	4.29	0.133	0.05	Ho Confirmed	Normal

As shown in Table 2, the results of the Kolmogorov–Smirnov test indicate that all study variables follow a normal distribution. For all variables, the significance values ($p > 0.05$) exceed the predefined error level of 0.05, leading to the confirmation of the null hypothesis (H_0) of normality. This suggests that there is no significant deviation from normal distribution for any of the variables, including resilience, physical activity, quality of life, and the four attachment styles. Therefore, the assumption of normality is met, justifying the use of parametric statistical tests such as Pearson correlation, regression analysis, and structural equation modeling in subsequent analyses.

Table 3. Goodness-of-Fit Indices for the Research Model

Fit Index	Acceptable Range	Obtained Value
Chi-Square (χ^2)	—	7.325
Significance Level (p)	< 0.05	0.000
χ^2/df Ratio	< 3	2.112
RMSEA	< 0.08	0.03
GFI	> 0.90	0.98
AGFI	> 0.90	0.89
PNFI	> 0.50	0.91
PCFI	> 0.50	0.84

The findings presented in Table 3 indicate that the structural model demonstrates an overall acceptable to excellent fit with the observed data. The chi-square to degrees of freedom ratio ($\chi^2/df = 2.112$) falls well below the recommended threshold of 3, suggesting a good model fit. The RMSEA value of 0.03 indicates a very good fit, as it is substantially lower than the acceptable cutoff of 0.08. Additionally, the goodness-of-fit index (GFI = 0.98) exceeds the recommended value of 0.90, confirming strong model fit. Although the adjusted goodness-of-fit index (AGFI = 0.89) is slightly below the ideal threshold, it remains close enough to be considered acceptable. Furthermore, the parsimony-adjusted indices PNFI (0.91) and PCFI (0.84) are both above the minimum acceptable level of 0.50, indicating that the model achieves a good balance between fit and parsimony. Overall, these indices confirm that the proposed structural model is well-fitted to the data.

Table 4. Significance of Model Variables in the Structural Model

Variables	B	CR	t Value	Mean	Mean Difference	Significance Level
Quality of Life	0.67	2.62	3.60**	3.12	0.39	0.000
Resilience	0.64	2.82	3.90**	3.25	0.46	0.000
Attachment Styles	0.62	2.54	4.10**	4.35	0.86	0.000
Physical Activity	0.58	2.79	5.20**	4.36	0.83	0.000

As shown in Table 4, the structural model results reveal that all variables included in the model have statistically significant effects. The t-values for all variables exceed the critical threshold (|t| > 1.96), and all significance levels are below 0.001, indicating strong statistical significance. Among the variables, physical activity shows the highest t-value (t = 5.20), suggesting a relatively stronger contribution within the model, followed by attachment styles (t = 4.10), resilience (t = 3.90), and quality of life (t = 3.60). The standardized regression coefficients (B values) further indicate moderate to strong relationships among the constructs. These results confirm that attachment styles, physical activity, and resilience play significant roles within the structural model, supporting the hypothesized relationships and highlighting the mediating role of resilience in predicting quality of life among women with breast cancer.

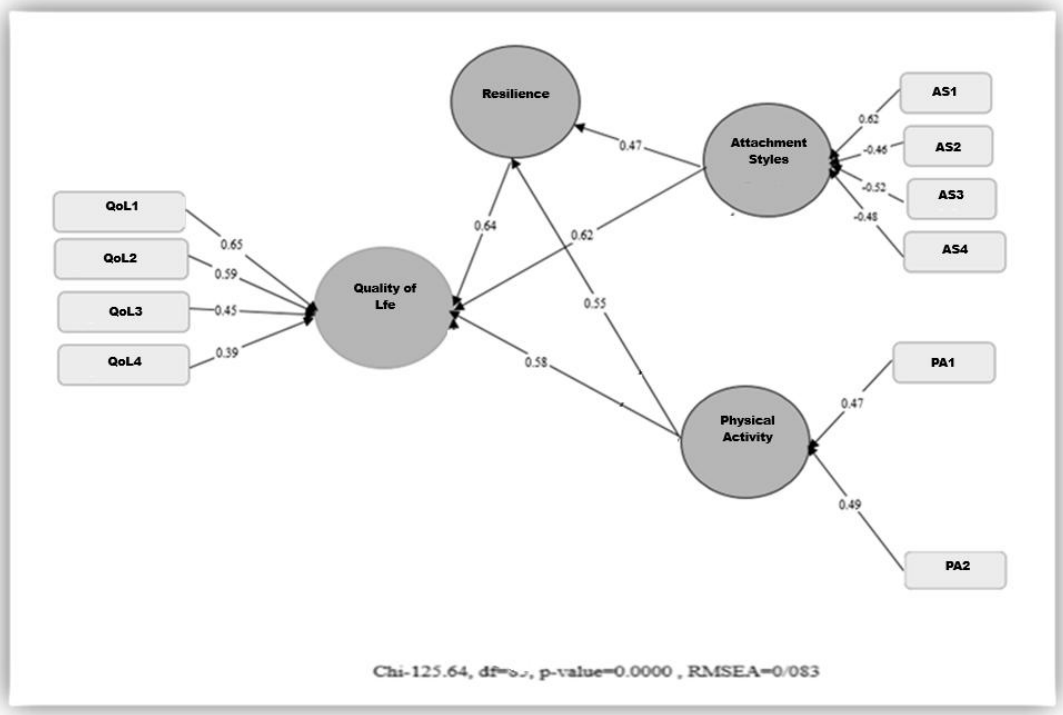

Figure 1. Final Structural Model

The structural model illustrated in Figure 1 demonstrates the relationships among attachment styles, physical activity, resilience, and quality of life in women with breast cancer. The results indicate that attachment styles have both a direct effect on quality of life (β = 0.62) and an indirect effect through resilience (β = 0.47 to resilience and β = 0.64 from resilience to quality of life), confirming the mediating role of resilience. Physical activity also shows a direct effect on quality of life (β = 0.58) as well as an indirect effect through resilience (β = 0.55 to resilience), further supporting the proposed mediation pathway. The measurement model demonstrates acceptable factor loadings for all observed indicators, with quality of life indicators ranging from 0.39 to 0.65, attachment style indicators ranging from 0.45 to 0.62, and physical activity indicators around 0.47 to 0.49, indicating adequate construct validity. Additionally, the overall model fit indices reported in the figure (χ^2 = 125.64, p = 0.000, RMSEA = 0.083) suggest an acceptable fit of the model to the data. Overall, the figure supports the hypothesized structural relationships, highlighting that both attachment styles and physical activity significantly influence quality of life, with resilience functioning as a key mediating mechanism.

Discussion and Conclusion

The present study aimed to investigate the role of attachment styles and physical activity in predicting quality of life among women with breast cancer, with a particular emphasis on the mediating role of resilience. The findings indicated that both attachment styles and physical activity had significant direct effects on quality of life, while resilience played a meaningful mediating role in these relationships. Specifically, attachment styles were significantly associated with quality of life, such that more adaptive (secure) attachment patterns were linked to higher levels of quality of life, whereas maladaptive attachment styles were associated with lower well-being. These findings are consistent with previous research demonstrating that attachment orientations influence emotional regulation, coping strategies, and interpersonal functioning, all of which are central to individuals' perception of their quality of life (6, 7). Individuals with secure attachment tend to experience greater psychological stability, more effective stress management, and stronger social support networks, which in turn enhance their overall quality of life, whereas insecure attachment patterns are often associated with increased anxiety, emotional dysregulation, and poorer psychosocial outcomes (9, 10).

The results also demonstrated that physical activity significantly predicted quality of life, both directly and indirectly through resilience. Participants who reported higher levels of physical activity tended to exhibit better quality of life outcomes, which aligns with a substantial body of literature highlighting the positive impact of physical activity on physical health, mental well-being, and functional capacity. Physical activity has been shown to reduce fatigue, enhance mood, and improve cognitive functioning, thereby contributing to better quality of life among individuals with chronic illnesses, including cancer (11, 12). Furthermore, consistent with previous findings, physical activity appears to influence quality of life through psychological mechanisms such as reduced depression and increased self-efficacy, suggesting that its benefits extend beyond purely physiological effects (15). Studies have also indicated that regular engagement in physical activity is associated with higher levels of happiness and lower levels of psychological distress, particularly among women and older adults (13, 14). Therefore, the present findings reinforce the importance of promoting physical activity as a key component of supportive care for women with breast cancer.

A central contribution of this study lies in the identification of resilience as a mediating variable in the relationship between attachment styles, physical activity, and quality of life. The results showed that resilience significantly mediated these relationships, indicating that individuals with more adaptive attachment styles and higher levels of physical activity were more likely to exhibit greater resilience, which in turn enhanced their quality of life. This finding is consistent with theoretical perspectives that conceptualize resilience as a dynamic process that enables individuals to adapt positively to adversity and maintain psychological well-being despite challenging circumstances. Previous research has demonstrated that resilience is strongly associated with improved quality of life and reduced psychological distress in patients with chronic conditions, including cancer (17, 18). Moreover, resilience has been identified as a key mechanism through which psychological and behavioral factors exert their influence on health outcomes. For instance, resilience has been shown to mediate the effects of stress, fatigue, and emotional distress on quality of life, highlighting its role as a protective factor in the face of illness-related challenges (19).

The mediating role of resilience observed in this study can also be interpreted in light of coping and adaptation theories. Individuals with secure attachment styles are more likely to develop adaptive coping

strategies, seek social support, and maintain a positive outlook, all of which contribute to higher levels of resilience. Similarly, engagement in physical activity may enhance resilience by improving physical strength, boosting self-confidence, and promoting emotional regulation. These processes collectively enable individuals to better manage the stressors associated with breast cancer, leading to improved quality of life. This interpretation is supported by empirical evidence indicating that resilience is influenced by both psychological characteristics and lifestyle factors, and that it plays a crucial role in determining how individuals respond to adversity (20, 21).

In addition, the findings of the present study are consistent with previous research emphasizing the importance of psychosocial interventions in improving quality of life among cancer patients. Interventions such as mindfulness-based therapies, resilience training, and acceptance-based approaches have been shown to significantly enhance psychological well-being and quality of life in this population (3, 4). These interventions often target key mechanisms such as emotional regulation, cognitive flexibility, and coping strategies, which are closely related to resilience. Furthermore, meta-analytic evidence suggests that holistic interventions, including spiritual and psychosocial approaches, can effectively improve both mental health and quality of life among cancer patients, underscoring the multifaceted nature of well-being in this population (2). Therefore, the current findings provide further support for the integration of psychological and behavioral interventions in cancer care.

Another important implication of the study is the confirmation of the interconnected nature of psychological and behavioral factors in shaping quality of life. The results highlight that quality of life is not determined by a single factor but rather emerges from the complex interplay of individual characteristics, lifestyle behaviors, and psychological resources. For example, attachment styles influence how individuals perceive and respond to stress, physical activity contributes to both physical and psychological health, and resilience serves as a central mechanism that integrates these influences and translates them into well-being outcomes. This integrated perspective is consistent with contemporary models of health that emphasize the interaction between biological, psychological, and social factors in determining health outcomes. Moreover, the findings suggest that interventions aimed at improving quality of life should adopt a comprehensive approach that addresses multiple dimensions of individuals' lives.

Despite the valuable insights provided by this study, several limitations should be acknowledged. First, the use of a cross-sectional design limits the ability to draw causal inferences about the relationships among attachment styles, physical activity, resilience, and quality of life. Although the structural model suggests directional relationships, longitudinal or experimental studies are needed to confirm causality. Second, the reliance on self-report measures may introduce response biases, such as social desirability or recall bias, which could affect the accuracy of the data. Third, the sample was selected using a convenience sampling method from a single hospital, which may limit the generalizability of the findings to other populations or settings. Finally, potential confounding variables, such as disease stage, treatment type, and socioeconomic status, were not controlled for in the analysis, which may have influenced the observed relationships.

Future research should address these limitations by employing longitudinal and experimental designs to examine the causal pathways among the variables studied. Researchers are encouraged to include more diverse and representative samples to enhance the generalizability of findings across different cultural and clinical contexts. Additionally, future studies could explore other potential mediators and moderators, such

as coping strategies, social support, and psychological flexibility, to gain a more comprehensive understanding of the mechanisms underlying quality of life in cancer patients. Incorporating objective measures of physical activity and clinical indicators of health status may also improve the robustness of future research.

From a practical perspective, the findings of this study highlight the importance of integrating psychological and behavioral interventions into the care of women with breast cancer. Healthcare providers should consider assessing patients' attachment styles and resilience levels as part of routine care, as these factors may influence their adaptation to illness and overall well-being. Interventions aimed at enhancing resilience, promoting physical activity, and improving interpersonal functioning may be particularly effective in improving quality of life in this population. Furthermore, multidisciplinary approaches that combine medical treatment with psychological support and lifestyle interventions are likely to yield the most beneficial outcomes for patients.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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