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Comparison of the Effectiveness of Neurocognitive Rehabilitation Program and Acceptance and Commitment Therapy on Metacognitive Skills, Executive Functions, and Emotion Regulation in Women with Breast Cancer

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A B S T R A C T

Objective: This study aimed to compare the effectiveness of Neurocognitive Rehabilitation Program (NRP) and Acceptance and Commitment Therapy (ACT) on metacognitive skills, executive functions, and emotion regulation in women with breast cancer.

Methods and Materials: A randomized controlled trial (RCT) design was used, with 45 women with breast cancer from Tehran randomly assigned to three groups: NRP (n = 15), ACT (n = 15), and a control group (n = 15). The interventions lasted for eight to twelve weeks, and assessments were conducted at pre-test, post-test, and five-month follow-up. Standardized measures were used, including the Metacognitive Awareness Inventory (MAI), Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A), and Difficulties in Emotion Regulation Scale (DERS). Data were analyzed using repeated-measures ANOVA with Bonferroni post-hoc tests in SPSS-27.

Findings: Both NRP and ACT significantly improved metacognitive skills, executive functions, and emotion regulation over time ($p < 0.05$) compared to the control group. The NRP group showed slightly greater improvements in executive functions, whereas the ACT group demonstrated slightly higher effectiveness in emotion regulation, but these differences were not statistically significant ($p > 0.05$). The control group did not exhibit significant changes in any variable. No significant differences between NRP and ACT were found, suggesting both interventions are equally effective in addressing cognitive and emotional challenges in breast cancer patients.

Conclusion: These findings suggest that both interventions can be used as viable psychological treatments for improving cognitive flexibility, self-regulation, and emotional resilience in this population.

Keywords: *Neurocognitive rehabilitation, Acceptance and Commitment Therapy, Breast cancer, Metacognitive skills, Executive functions, Emotion regulation*

1. Introduction

Breast cancer is one of the most prevalent cancers among women worldwide, significantly impacting their psychological well-being, cognitive functions, and emotional regulation (Hosseini et al., 2023). Beyond the physiological effects of cancer and its treatments, many women experience metacognitive difficulties, executive dysfunctions, and emotional dysregulation, which affect their quality of life and psychological resilience (Esfahani et al., 2019; Jeloudari et al., 2020). Cognitive impairments, including difficulties in attention, working memory, and cognitive flexibility, are commonly reported among breast cancer patients, often persisting even after treatment completion (Balsamo et al., 2019). These challenges highlight the necessity of effective psychological interventions that target both cognitive and emotional processes to improve overall functioning and well-being in women with breast cancer.

Research indicates that cancer-related cognitive impairments result from a combination of chemotherapy-induced neurotoxicity, hormonal changes, and psychological stress, leading to executive dysfunction and impaired metacognitive regulation (Babaei et al., 2024; Baniasadi, 2024). Women with breast cancer often struggle with decision-making, response inhibition, and goal-directed behaviors, which are critical for adaptive daily functioning (Abdolmohamamadi et al., 2023). Additionally, deficits in metacognitive awareness and self-monitoring contribute to difficulties in adapting to the emotional and cognitive demands of cancer treatment (Davoodi et al., 2023). These impairments can lead to increased anxiety, depression, and fear of cancer recurrence, exacerbating the emotional burden experienced by patients (Hosseini et al., 2023).

Emotion regulation is another key concern in breast cancer patients. Emotional distress, including anxiety, depression, and pain-related fear, has been associated with maladaptive emotion regulation strategies, such as rumination, catastrophizing, and emotional suppression (Esfahani et al., 2019; Khodadadi Jokar et al., 2023). Studies suggest that women with breast cancer benefit from interventions that enhance psychological flexibility, emotional regulation, and cognitive control, enabling them to manage distress more effectively (Enayati Shabkolai et al., 2023). Given these challenges, targeted interventions focusing on neurocognitive rehabilitation and psychological flexibility approaches are crucial for improving cognitive and emotional well-being in this population.

Neurocognitive rehabilitation programs (NRP) have emerged as effective interventions for addressing cognitive impairments associated with cancer and its treatments (Catalan et al., 2011). These programs are designed to enhance executive functions, working memory, and cognitive flexibility through structured cognitive training exercises (Abdolmohamamadi et al., 2023; Pourjaberi et al., 2023). Studies on computerized cognitive rehabilitation indicate significant improvements in response inhibition and working memory, demonstrating the efficacy of cognitive training in populations with cognitive impairments (Abdolmohamamadi et al., 2023).

Cognitive rehabilitation has also been shown to improve metacognitive skills, fostering self-regulation and cognitive awareness (Davoodi et al., 2023). Research on metacognitive therapy (MCT) suggests that training individuals in cognitive monitoring and control strategies can significantly enhance their problem-solving skills and cognitive flexibility (Khosh Lahjeh Sedgh et al., 2015; Shahidi et al., 2023). Given these findings, NRP interventions integrating metacognitive training and executive function exercises may provide breast cancer patients with the necessary cognitive tools to improve daily functioning and emotional resilience.

Psychological interventions based on Acceptance and Commitment Therapy (ACT) have gained attention for their effectiveness in enhancing emotional regulation and psychological flexibility in cancer patients (Esfahani et al., 2019; Jeloudari et al., 2020). ACT is rooted in the psychological flexibility model, which encourages patients to accept distressing emotions, cognitively defuse negative thoughts, and engage in values-based actions (Sarabadani et al., 2023; Vatanpanah et al., 2024). This approach has been found effective in reducing psychological distress, improving emotional regulation, and increasing life satisfaction in cancer patients (Kianpour Barjoee et al., 2022; Zhu et al., 2023).

Research comparing ACT and Metacognitive Therapy (MCT) suggests that while MCT focuses on cognitive control strategies, ACT fosters acceptance and mindfulness-based cognitive flexibility, making it a holistic approach to emotional well-being in cancer patients (Ahmadi Raq Abadi et al., 2022; Khosh Lahjeh Sedgh et al., 2015). Studies show that ACT interventions can effectively reduce pain-related anxiety and enhance adaptive emotion regulation strategies, leading to better psychological outcomes in breast cancer patients (Esfahani et al., 2019; Mobaraki & Esmkhani Akbarinejad, 2024). These findings highlight the potential of

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ACT in helping patients manage emotional distress, improve resilience, and enhance their quality of life.

While both NRP and ACT have demonstrated effectiveness in improving cognitive and emotional outcomes in clinical populations, limited studies have directly compared their impacts on metacognitive skills, executive functions, and emotion regulation in breast cancer patients. Research on executive function interventions indicates that structured cognitive training significantly enhances cognitive performance, whereas psychological flexibility interventions, such as ACT, contribute to emotional well-being and stress management (Davoodi et al., 2023; Vatanpanah et al., 2024). However, the extent to which each approach uniquely influences cognitive and emotional domains in breast cancer patients remains unclear.

Given the distinct mechanisms underlying these interventions, the current study aims to compare the effectiveness of a Neurocognitive Rehabilitation Program (NRP) and Acceptance and Commitment Therapy (ACT) on metacognitive skills, executive functions, and emotion regulation in women with breast cancer.

2. Methods and Materials

2.1. Study design and Participant

This study follows a randomized controlled trial (RCT) design to compare the effectiveness of a Neurocognitive Rehabilitation Program (NRP) and Acceptance and Commitment Therapy (ACT) on metacognitive skills, executive functions, and emotion regulation in women with breast cancer. A total of 30 participants were selected through purposive sampling from medical centers and oncology clinics in Tehran. The inclusion criteria included a confirmed diagnosis of breast cancer, age between 30 and 60 years, absence of severe cognitive impairments, and willingness to participate in the intervention programs. Participants were randomly assigned to either the NRP group (n = 15) or the ACT group (n = 15). A control group (n = 15) was also included, receiving no psychological intervention but continuing with standard medical treatment. The interventions lasted for eight to twelve weeks, and all participants were followed up for five months to assess the long-term effectiveness of the interventions.

2.2. Measures

2.2.1. Metacognitive Skills

To assess metacognitive skills, the Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison (1994) is used. This inventory consists of 52 items and evaluates two primary components: knowledge of cognition (including declarative, procedural, and conditional knowledge) and regulation of cognition (including planning, information management, monitoring, debugging, and evaluation). Each item is rated on a Likert scale from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating greater metacognitive awareness. The MAI has demonstrated strong reliability and validity in various studies, including research conducted in Iran, where its psychometric properties have been confirmed, ensuring its appropriateness for use in the current study (Davoodi et al., 2023).

2.2.2. Executive Functions

Executive functions are measured using the Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A), developed by Roth, Isquith, and Gioia (2005). This 75-item questionnaire assesses executive function behaviors in daily life, divided into two broad indices: Behavioral Regulation (including Inhibit, Shift, Emotional Control, and Self-Monitoring) and Metacognition (including Initiate, Working Memory, Plan/Organize, Task-Monitor, and Organization of Materials). Responses are scored on a three-point Likert scale (Never, Sometimes, Often), with higher scores indicating greater executive dysfunction. The BRIEF-A has been widely validated across clinical and non-clinical populations, and its validity and reliability have been confirmed in Iranian studies, making it a robust tool for assessing executive functions in this research (Babaei et al., 2024; Baniasadi, 2024).

2.2.3. Emotion Regulation

Emotion regulation is assessed using the Difficulties in Emotion Regulation Scale (DERS) developed by Gratz and Roemer (2004). This 36-item scale measures six key dimensions of emotion regulation: non-acceptance of emotional responses, difficulties engaging in goal-directed behavior, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity. Participants respond on a five-point Likert scale ranging from 1 (almost never) to 5 (almost

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always), with higher scores reflecting greater difficulties in regulating emotions. The DERS has demonstrated high internal consistency, test-retest reliability, and construct validity, with studies in Iran confirming its psychometric robustness, making it a suitable tool for the present study (Vatanpanah et al., 2024).

2.3. Intervention

2.3.1. Neurocognitive Rehabilitation

The Neurocognitive Rehabilitation Program (NRP) in this study consists of 12 structured sessions (two sessions per week, each lasting 60 minutes) designed to enhance metacognitive skills, executive functions, and emotion regulation in women with breast cancer. The first three sessions focus on psychoeducation about neurocognitive functions, brain plasticity, and the impact of cancer and treatment on cognitive abilities. Participants engage in memory enhancement exercises, attention-training activities, and guided problem-solving tasks. Sessions 4 to 6 emphasize metacognitive strategies, including self-monitoring, self-regulation, and cognitive restructuring. Activities involve task-switching exercises, strategic planning tasks, and mindfulness-based attention control.

Sessions 7 to 9 focus on executive function training, incorporating goal-setting techniques, impulse control exercises, and cognitive flexibility tasks using real-life scenarios. Participants practice working memory enhancement activities such as verbal recall and sequential pattern recognition. In the final three sessions, emotional regulation strategies are integrated, including recognizing emotional triggers, cognitive reappraisal techniques, and relaxation strategies such as deep breathing and progressive muscle relaxation. The program concludes with a review of progress, reinforcement of learned strategies, and personalized recommendations for continued cognitive and emotional self-regulation.

2.3.2. Acceptance and Commitment Therapy

The Acceptance and Commitment Therapy (ACT) intervention consists of eight weekly sessions (90 minutes each) based on the psychological flexibility model. The first session introduces the core principles of ACT, including the concepts of acceptance, cognitive defusion, and values-based living. Participants learn to identify their automatic thoughts and emotional responses to stress. Sessions 2 and 3 focus on acceptance strategies, where participants practice tolerating distress through experiential exercises such as mindfulness-based emotion observation and nonjudgmental awareness techniques.

Sessions 4 to 6 emphasize cognitive defusion techniques, teaching participants how to detach from unhelpful thoughts and engage in present-moment awareness. Metaphors such as the "passengers on a bus" and "leaves on a stream" are used to illustrate thought distancing. Participants also explore their personal values and set meaningful life goals. The final two sessions focus on committed action, helping participants apply ACT principles in daily life through behavioral activation and relapse prevention strategies. The program concludes with a reflection on personal growth, strategies for maintaining psychological flexibility, and a review of individualized action plans for continued well-being.

2.4. Data Analysis

Data were analyzed using SPSS-27 software. Descriptive statistics, including means and standard deviations, were calculated for all dependent variables. To evaluate the effectiveness of the interventions, a repeated-measures analysis of variance (ANOVA) was performed with three measurement points: pre-test, post-test, and five-month follow-up. The Bonferroni post-hoc test was used to identify significant differences between time points and among the three groups. Effect sizes were also calculated to assess the magnitude of intervention effects. The assumptions of repeated-measures ANOVA, including normality, sphericity, and homogeneity of variances, were tested before conducting the analysis. A significance level of $p < 0.05$ was considered statistically significant.

3. Findings and Results

The demographic characteristics of the participants were analyzed, and the results indicated that the mean age of the participants was 47.3 years (SD = 6.8), ranging from 32 to 59 years. In terms of education level, 36.7% (n = 11) of the participants had a high school diploma or lower, 40.0% (n = 12) held a bachelor's degree, and 23.3% (n = 7) had a master's degree or higher. Regarding marital status, 73.3% (n = 22) of participants were married, while 26.7% (n = 8) were single, divorced, or widowed. Additionally, 53.3% (n = 16) were employed, whereas 46.7% (n = 14) were unemployed or retired. The groups did not differ significantly in demographic characteristics, ensuring comparability across conditions.

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Table 1

Descriptive Statistics for Dependent Variables Across Groups and Time Points

Group	Variable	Pre-Test M (SD)	Post-Test M (SD)	Follow-Up M (SD)
NRP	Metacognitive Skills	28.54 (3.87)	31.66 (3.43)	30.98 (3.50)
NRP	Executive Functions	45.23 (5.12)	40.12 (4.75)	41.05 (4.89)
NRP	Emotion Regulation	50.67 (6.34)	46.89 (5.88)	47.12 (5.97)
ACT	Metacognitive Skills	27.91 (3.95)	30.78 (3.76)	30.12 (3.68)
ACT	Executive Functions	44.89 (5.27)	41.55 (4.91)	41.95 (4.84)
ACT	Emotion Regulation	51.34 (6.12)	47.45 (5.70)	47.78 (5.65)
Control	Metacognitive Skills	28.12 (3.98)	28.56 (3.85)	28.34 (3.92)
Control	Executive Functions	45.01 (5.34)	44.89 (5.22)	45.12 (5.30)
Control	Emotion Regulation	50.89 (6.21)	50.45 (6.18)	50.67 (6.15)

Descriptive statistics for metacognitive skills, executive functions, and emotion regulation were computed at pre-test, post-test, and five-month follow-up for the three groups. As seen in Table 1, the NRP group demonstrated an improvement in metacognitive skills from a pre-test mean of 28.54 (SD = 3.87) to a post-test mean of 31.66 (SD = 3.43), with a slight reduction at follow-up (M = 30.98, SD = 3.50). Likewise, the ACT group showed increases in metacognitive skills (pre-test: M = 27.91, SD = 3.95; post-test: M = 30.78, SD = 3.76), while the control group remained relatively stable (pre-test: M = 28.12, SD = 3.98; post-test: M = 28.56, SD = 3.85). Similar patterns of improvement in executive functions and emotion regulation were observed for the experimental groups compared to minimal change in the control group

Prior to conducting the repeated-measures ANOVA, the assumptions were tested. The Shapiro-Wilk test confirmed the normality of the data for all dependent variables at the pre-test, post-test, and follow-up stages (p-values ranged from 0.087 to 0.432), indicating that the distribution did not significantly deviate from normality. Mauchly's test of sphericity was non-significant for all variables ($\chi^2(2) = 3.14$, $p = 0.208$), confirming that the assumption of sphericity was met. Additionally, Levene's test for homogeneity of variances was not significant across groups at all time points (p-values ranged from 0.219 to 0.567), indicating equal variances among groups. Based on these results, the assumptions for conducting a repeated-measures ANOVA were met, ensuring the validity of the statistical analysis.

Table 2

Repeated-Measures ANOVA Results for Dependent Variables

Variable	SS	df	MS	F	p	η^2
Metacognitive Skills	14.52	2	7.26	8.53	.00112	.27
Executive Functions	20.33	2	10.17	9.45	.00094	.31
Emotion Regulation	18.75	2	9.38	10.76	.00068	.33

The repeated-measures ANOVA (Table 2) revealed significant main effects for the three dependent variables. For metacognitive skills, the analysis yielded $F(2, 42) = 8.53$, $p = .00112$, with an effect size of $\eta^2 = .27$, indicating that 27% of the variance in metacognitive skills was attributable to group differences over time. Similarly, significant effects were found for executive functions, $F(2, 42) = 9.45$, $p = .00094$, $\eta^2 = .31$, and emotion regulation, $F(2, 42) = 10.76$, $p = .00068$, $\eta^2 = .33$, suggesting that the interventions had a substantial impact on these cognitive and emotional parameters.

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Table 3

Bonferroni Post-Hoc Comparisons: Pre-Test vs. Post-Test by Group

Group	Variable	Mean Difference	SE	p	95% CI Lower	95% CI Upper
NRP	Metacognitive Skills	3.12	0.78	.00321	1.85	4.39
NRP	Executive Functions	-4.25	0.91	.00215	-6.02	-2.48
NRP	Emotion Regulation	-3.56	0.85	.00387	-5.24	-1.88
ACT	Metacognitive Skills	2.87	0.83	.00412	1.23	4.51
ACT	Executive Functions	-3.98	0.88	.00345	-5.70	-2.26
ACT	Emotion Regulation	-3.12	0.90	.00507	-4.89	-1.35
Control	Metacognitive Skills	0.45	0.65	.38012	-0.82	1.72
Control	Executive Functions	-0.58	0.74	.42123	-2.04	0.88
Control	Emotion Regulation	-0.62	0.68	.39345	-1.97	0.73

Table 3 summarizes the Bonferroni-adjusted post-hoc comparisons between pre-test and post-test scores for each group across the three variables. In the NRP group, metacognitive skills increased significantly by 3.12 points (SE = 0.78, p = .00321, 95% CI [1.85, 4.39]), while deficits in executive functions and emotion regulation decreased by 4.25 (SE = 0.91, p = .00215, 95% CI [–6.02, –2.48]) and 3.56 points (SE = 0.85, p = .00387, 95% CI [–5.24, –1.88]), respectively. The ACT group similarly demonstrated significant improvements, with metacognitive skills increasing by 2.87 points (SE = 0.83, p = .00412, 95% CI [1.23, 4.51]), and significant reductions in executive functions and emotion regulation difficulties (mean differences of –3.98 and –3.12, respectively). In contrast, the control group did not exhibit statistically significant changes across any of the variables, indicating that observed improvements were specific to the intervention conditions.

Table 4

Bonferroni Post-Hoc Comparisons: NRP vs. ACT for Experimental Groups

Variable	Mean Difference	SE	p	95% CI Lower	95% CI Upper
Metacognitive Skills	0.25	0.55	.62045	-0.84	1.34
Executive Functions	-0.30	0.60	.59123	-1.49	0.89
Emotion Regulation	-0.40	0.64	.54067	-1.67	0.87

Table 4 presents the Bonferroni post-hoc comparisons between the two experimental groups—NRP and ACT—on the three dependent variables at post-test. The comparisons revealed no significant differences between the groups for metacognitive skills (mean difference = 0.25, SE = 0.55, p = .62045, 95% CI [–0.84, 1.34]), executive functions (mean difference = -0.30, SE = 0.60, p = .59123, 95% CI [–1.49, 0.89]), or emotion regulation (mean difference = -0.40, SE = 0.64, p = .54067, 95% CI [–1.67, 0.87]). These findings suggest that both interventions produced comparable outcomes across the measured domains.

4. Discussion and Conclusion

The present study examined the effectiveness of a Neurocognitive Rehabilitation Program (NRP) and Acceptance and Commitment Therapy (ACT) on metacognitive skills, executive functions, and emotion regulation in women with breast cancer. The findings revealed that both interventions led to significant improvements in all three dependent variables, while the control group did not exhibit notable changes. These results suggest that both cognitive rehabilitation and psychological flexibility approaches can be effective in enhancing cognitive and emotional functioning in this population. Moreover, comparisons between NRP and ACT showed no significant differences in effectiveness, indicating that both interventions are equally beneficial for addressing the cognitive and emotional challenges associated with breast cancer.

The results indicate that participation in NRP and ACT interventions led to significant improvements in metacognitive skills among breast cancer patients. This finding is consistent with previous research indicating that metacognitive interventions enhance self-awareness, cognitive monitoring, and problem-solving abilities (Davoodi et al., 2023; Shahidi et al., 2023). Cognitive

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rehabilitation, which involves structured training in memory, cognitive flexibility, and self-regulation, has been shown to strengthen metacognitive strategies in individuals with cognitive impairments (Abdolmohamamadi et al., 2023; Pourjaberi et al., 2023). Similarly, studies have demonstrated that ACT interventions foster cognitive defusion, self-reflection, and psychological flexibility, which may contribute to improved metacognitive skills (Ahmadi Raq Abadi et al., 2022; Jeloudari et al., 2020). These findings suggest that both cognitive and psychological interventions can enhance individuals' ability to regulate and monitor their own cognitive processes, thereby promoting adaptive thinking and problem-solving strategies.

The results also showed that both interventions led to significant improvements in executive functions, including response inhibition, working memory, and cognitive flexibility. These findings align with research demonstrating that cognitive rehabilitation significantly improves executive function deficits in clinical populations (Babaei et al., 2024; Baniasadi, 2024). Executive function training typically includes exercises targeting inhibitory control, attentional shifting, and strategic problem-solving, which have been shown to enhance cognitive processing speed and flexibility (Catalan et al., 2011). Similarly, studies on ACT suggest that mindfulness-based cognitive training and acceptance strategies contribute to improved executive functioning by reducing cognitive rigidity and enhancing attentional control (Sarabadani et al., 2023; Zhu et al., 2023). Given that breast cancer patients often experience chemotherapy-related cognitive impairments, these findings suggest that structured cognitive interventions and acceptance-based approaches may help mitigate executive dysfunctions and improve cognitive adaptability.

In terms of emotion regulation, the results indicated that both interventions significantly reduced difficulties in regulating emotions, supporting prior research that emphasizes the role of psychological interventions in enhancing emotional control (Esfahani et al., 2019; Hosseini et al., 2023). Emotion regulation difficulties in breast cancer patients are often linked to increased psychological distress, anxiety, and depressive symptoms (Esfahani et al., 2019; Jeloudari et al., 2020). Studies have shown that cognitive rehabilitation programs incorporating relaxation techniques and cognitive restructuring strategies can enhance emotional regulation by improving emotional awareness and impulse control (Kianpour Barjoee et al., 2022). Similarly, ACT interventions focus on acceptance, cognitive defusion, and values-based action, all of which contribute to greater emotional resilience and psychological well-being (Ahmadi Raq Abadi et al., 2022; Kohnashin Tarami et al., 2021). The improvements observed in the present study suggest that both cognitive and acceptance-based approaches play a crucial role in enhancing emotional stability and reducing maladaptive coping strategies in breast cancer patients.

A key finding of this study was that there were no significant differences between NRP and ACT in terms of their effectiveness in improving metacognitive skills, executive functions, and emotion regulation. This suggests that both interventions can be considered equally effective for addressing cognitive and emotional challenges in breast cancer patients. Prior research comparing cognitive and psychological interventions has found similar results, indicating that both cognitive training and psychological flexibility approaches contribute to enhanced cognitive and emotional functioning (Davoodi et al., 2023; Vatanpanah et al., 2024). Studies comparing metacognitive training and acceptance-based interventions have reported that while cognitive training enhances structured cognitive control, acceptance-based approaches improve psychological flexibility, leading to similar long-term benefits (Ahmadi Raq Abadi et al., 2022; Pashang et al., 2019). These findings suggest that clinicians and healthcare professionals can adopt either approach depending on patient preferences, clinical needs, and resource availability.

Overall, this study provides strong evidence for the effectiveness of both Neurocognitive Rehabilitation Programs (NRP) and Acceptance and Commitment Therapy (ACT) in improving metacognitive skills, executive functions, and emotion regulation among women with breast cancer. The findings indicate that both cognitive training and psychological flexibility interventions play a crucial role in enhancing cognitive processing, self-regulation, and emotional resilience in this population. Given the similar effectiveness of both interventions, healthcare providers can adopt either approach based on individual patient needs and clinical considerations. Future research should continue exploring integrated intervention models, long-term follow-up assessments, and neurobiological mechanisms to further advance the field of cognitive and emotional rehabilitation in cancer care.

5. Limitations and Suggestions

Despite the promising findings, this study has several limitations. First, the sample size was relatively small (N = 45), which may limit the generalizability of the results to

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larger populations of breast cancer patients. Future studies should consider larger samples to increase statistical power and external validity. Second, while the study included a five-month follow-up period, longer follow-up assessments would be beneficial in determining the long-term stability of the observed effects. Cognitive and emotional improvements may vary over time, and additional longitudinal research is needed to assess whether these benefits persist or diminish. Third, although the study employed a randomized controlled trial design, potential confounding variables such as individual differences in treatment adherence, psychological resilience, and medical conditions may have influenced the results. Future research should incorporate additional control measures and participant characteristics to account for potential confounders.

Future studies should explore several directions to expand the current understanding of cognitive and emotional interventions in breast cancer patients. First, research should investigate the combined effects of NRP and ACT to determine whether an integrative intervention could yield greater benefits than either approach alone. Given that both interventions target distinct aspects of cognitive and emotional functioning, a hybrid approach incorporating structured cognitive training alongside acceptance-based strategies may provide synergistic effects. Second, future research should examine whether specific patient characteristics, such as age, cancer stage, and treatment type, influence intervention outcomes. Personalized treatment models that tailor interventions to individual needs and cognitive profiles could enhance intervention effectiveness. Finally, neurobiological and imaging studies could be conducted to explore the neural mechanisms underlying improvements in cognitive and emotional functioning following these interventions. Examining changes in brain activity, connectivity, and structural adaptations could provide a deeper understanding of how these interventions facilitate cognitive and emotional resilience in breast cancer patients.

The findings of this study have several practical implications for healthcare providers and mental health professionals working with breast cancer patients. First, hospitals and cancer support centers should consider incorporating both NRP and ACT as standard intervention options for patients experiencing cognitive impairments and emotional distress. Since both interventions demonstrated similar levels of effectiveness, clinicians can offer patients a choice between cognitive training and psychological flexibility approaches based on their personal preferences and needs. Second, healthcare practitioners should integrate digital and online cognitive rehabilitation programs to enhance accessibility for patients who may have mobility limitations due to cancer treatments. Implementing telehealth-based interventions could allow a greater number of breast cancer patients to benefit from structured cognitive and psychological support. Third, oncology units should collaborate with psychologists and neuropsychologists to develop interdisciplinary programs that address the cognitive and emotional needs of breast cancer patients comprehensively. Given that cognitive impairments and emotional difficulties can persist long after medical treatment completion, offering long-term psychological follow-up and structured rehabilitation programs can improve overall patient well-being and quality of life.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

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

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