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Development of a Neuropsychological Intervention Package for Multiple Sclerosis (M.S) and Comparison of the Effectiveness of Neuropsychological Intervention and Acceptance and Commitment Therapy on Pain Catastrophizing in Patients with Multiple Sclerosis

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Purpose: This study aimed to examine the effectiveness of two therapeutic interventions based on a neuropsychological approach and Acceptance and Commitment Therapy (ACT) in reducing pain catastrophizing in MS patients.

Methods and Materials: The research employed a mixed-methods (qualitative-quantitative) design, with the study population consisting of MS patients attending healthcare centers in Isfahan in 2023-2024. From this population, 45 individuals were randomly selected and assigned to three equal groups: experimental group 1 (15 participants), experimental group 2 (15 participants), and a control group (15 participants). The first group received treatment based on the neuropsychological approach, while the second group underwent ACT. Data collection tools included the Pain Catastrophizing Questionnaire and a demographic questionnaire, and data were analyzed using univariate analysis of covariance.

Findings: The results indicated that both therapeutic interventions led to a significant reduction in pain catastrophizing in MS patients. The F-values for the magnification and rumination variables in the experimental groups were significantly higher than in the control group ($p < 0.05$).

Conclusion: These findings suggest that both interventions can effectively reduce pain catastrophizing and may be considered effective treatment approaches.

Keywords: Multiple sclerosis, pain catastrophizing, neuropsychological approach, Acceptance and Commitment Therapy

1. Introduction

Multiple sclerosis (MS) is a chronic central nervous system disorder that leads to the destruction of the myelin sheath and axonal damage (Benedict et al., 2017). MS occurs predominantly in adults aged 15 to 50 years, with a female-to-male incidence ratio of approximately 2 to 3 (das Nair et al., 2016; Dehghani, 2024). The disease manifests with a variety of symptoms, including blurred vision, diplopia, muscle weakness, balance and coordination impairments, sensory disturbances, depression, pain, cognitive dysfunction, concentration difficulties, fatigue, tremors, dizziness, as well as bowel, bladder, and sexual dysfunction (Delshad & Kazemi, 2023; Fahy, 2024). The numerous and unpredictable complications of MS can significantly disrupt the patient's life, and given its increasing prevalence and the severity of disability it causes in young and middle-aged individuals, it holds substantial importance. The onset of MS in young individuals contributes to social and economic challenges for the patient, their family, and society at large (DiGiuseppe et al., 2018).

Pain catastrophizing is a negative cognitive-emotional phenomenon characterized by feelings of helplessness, magnification, and ruminative thoughts about pain (Hooshmandi et al., 2024; Sayed Alitabar & Goli, 2023). In general, catastrophizing is a maladaptive cognitive processing style that directs an individual's attention toward the negative aspects of a situation, exaggerating its consequences and making them appear worse than they are (Feinstein et al., 2016). Pain catastrophizing refers to an exaggerated perception of worry and fear regarding the presence and occurrence of pain. This worry about pain can even arise in the absence of actual pain. Pain catastrophizing distorts pain perception, leading individuals to experience heightened pain intensity, with a direct relationship between the level of catastrophizing and perceived pain severity (Fenwick et al., 2016). Pain catastrophizing significantly impacts both physical and psychological functioning and is consistently associated with various health-related outcomes, including pain intensity, interference of pain with daily life, physical disability, and mental health disturbances (Fernández-Rodríguez et al., 2023).

Acceptance and Commitment Therapy (ACT) is classified as a third-wave cognitive-behavioral therapy that aims to modify individuals' psychological relationship with their thoughts and bodily sensations through mechanisms of acceptance, mindfulness, and value-based action (Jahangiri et al., 2023). ACT focuses on enhancing psychological

flexibility and awareness of emotions and thoughts. Psychological flexibility refers to an individual's ability to engage in behavior that is most suitable among available options instead of avoiding distressing thoughts, emotions, and urges (Lai et al., 2023; Pakenham & Landi, 2023). ACT is an action-oriented psychotherapeutic approach rooted in behavior therapy and cognitive-behavioral therapy. It is structured around six core principles—acceptance, commitment, cognitive defusion, present-moment awareness, values, and self-as-context—to help clients achieve psychological flexibility. The goal of ACT is to enable individuals to experience a rich and meaningful life while acknowledging and accepting past painful experiences as part of themselves. Moreover, ACT enhances reflective thinking and self-regulation, which helps individuals manage aggressive tendencies and impulsive behaviors. Evidently, cognitive coping strategies can be employed to regulate reflective responses to stressful events (Gloster, 2018; Hayes et al., 2013).

The neuropsychological approach is embedded in the study of executive functions of the brain, which involves understanding the relationship between neural processes and cognitive control mechanisms (Benedict et al., 2017; Fenwick et al., 2016; Noormohamadi et al., 2019). Executive functions refer to a set of higher-order cognitive processes that facilitate goal-directed behavior. These functions play a crucial role in regulating and guiding purposeful behaviors (Vanotti & Caceres, 2017). Neuropsychological functions encompass a range of high-level cognitive processes, including attention, planning, decision-making, self-regulation, and cognitive control, all of which are essential for organizing and directing goal-oriented actions. For example, executive functioning enables individuals to formulate and implement plans to achieve specific objectives. Additionally, these cognitive control mechanisms regulate behavioral outputs, including response inhibition, impulse control, working memory, cognitive flexibility, planning, and organization (Benedict et al., 2017; Fenwick et al., 2016; Fuso et al., 2010; Hunter et al., 2015; Noormohamadi et al., 2019; Thompson et al., 2018).

To date, no study has specifically investigated the effectiveness of neuropsychological interventions and ACT in patients with MS. Therefore, the present research aims to answer the question: Is there a difference between neuropsychological intervention and ACT in reducing pain catastrophizing in patients with MS?

2. Methods and Materials

2.1. Study Design and Participants

The research employed an exploratory mixed-methods design (qualitative-quantitative). The study population consisted of all patients with multiple sclerosis (MS) who attended MS treatment centers in Isfahan in 2023-2024.

Based on a review of the literature, interview questions regarding the neuropsychological intervention package for MS patients were developed and discussed in meetings with the researcher, supervising professors, and consulting experts. After finalizing the interview questions, the researcher conducted interviews with specialists and therapists. The criteria and characteristics of the neuropsychological intervention package for MS patients were extracted based on expert opinions. The interview participants reviewed the intervention package and provided relevant information. Experts were then asked to state their reasons for agreement or disagreement with the results, and these responses were reported. Through the analysis of interview transcripts and the identification of "significant statements," key phrases and quotes that reflected participants' experiences of the phenomenon were extracted in a process known as "horizontalization" or "line-by-line analysis." The researcher then developed meaning clusters from these significant statements. Subsequently, review sessions were conducted with subject matter experts, specialists, and psychotherapists to further refine the criteria and characteristics of the neuropsychological intervention package.

A pretest-posttest control group design was implemented, consisting of three groups of participants, with each group assessed twice. The first measurement occurred through a pretest, and the second measurement followed a posttest. Using a random sampling method, 45 individuals were selected from the study population and randomly assigned to three equal groups: Experimental Group 1 (15 participants), Experimental Group 2 (15 participants), and the control group (15 participants). The groups were structured as follows: Experimental Group 1 received the neuropsychological intervention for MS patients, Experimental Group 2 underwent Acceptance and Commitment Therapy (ACT), and the control group received no intervention. Prior to the introduction of the independent variable (implementation of the neuropsychological intervention package for MS patients), both experimental groups were assessed using a pretest, and

the results were recorded. After applying the independent variables to the experimental groups, both were reassessed through a posttest. The intervention sessions were conducted once per week for approximately three months. Data collection was carried out using questionnaires, and the posttest results were analyzed.

Inclusion criteria included a confirmed diagnosis of MS by a neurologist based on MRI examination, literacy (ability to read and write), and the ability to walk independently for at least 100 meters. Exclusion criteria included the presence of other neurological disorders, psychiatric conditions, chronic illnesses, or lack of willingness to participate in the study.

Experts were selected based on four criteria: (1) authorship of at least two articles or books on neuropsychological interventions and MS, (2) a minimum of five years of clinical experience in treating MS patients, (3) at least five years of experience in therapy, and (4) previous national-level presentations on neuropsychological interventions and MS.

2.2. Instruments

2.2.1. Qualitative Phase

In this study, qualitative data were collected through individual semi-structured interviews. The interviews were conducted in private clinics and counseling centers, adhering to ethical considerations. A standard set of questions was asked to health professionals and MS specialists, while maintaining flexibility to explore emerging topics.

The primary research question focused on exploring specialists' experiences with effective neuropsychological interventions for MS patients. Open-ended questions, such as "How would you evaluate the effectiveness of this intervention package?" were posed to participants.

To ensure qualitative validity, three focus group sessions were conducted with psychology specialists. Following discussions and revisions, the face and content validity of the intervention package was confirmed.

For quantitative content validity, the content validity ratio (CVR) was calculated. Fifteen psychology specialists evaluated the intervention sessions using a Likert scale, and 12 sessions with higher validity coefficients were selected. Additionally, the content validity index (CVI) was assessed based on clarity, simplicity, and relevance. A CVI score of at least 0.79 was considered acceptable, with values closer to 1 indicating stronger content validity.

Table 1*Validity Indices of Educational Protocol Sessions*

Session	CVR	CVI
1	0.6	0.8
2	0.8	0.8
3	0.8	0.9
4	0.6	1.0
5	0.8	1.0
6	0.8	0.9
7	0.8	1.0
8	0.6	0.9
9	0.6	0.89
10	0.8	0.9
11	0.8	0.8
12	0.8	1.0

Table 1 shows that all sessions in the neuropsychological intervention package had acceptable validity scores.

2.2.2. Quantitative Phase

In the quantitative phase, data collection was conducted using questionnaires.

Demographic Questionnaire: A researcher-developed demographic questionnaire was used to assess the socio-demographic and family characteristics of participants, including age, education level, and disease status, in alignment with the study objectives.

Pain Catastrophizing Questionnaire (PCQ): This 13-item questionnaire assesses pain catastrophizing levels in individuals. In Sullivan et al.'s (1995) study, the rumination subscale accounted for 41% of the total variance, magnification 10%, and helplessness 8%. Participants were asked to rate their experiences of pain catastrophizing based on their past pain experiences. The items were rated on a

five-point Likert scale, where 0 corresponded to "never" and 6 to "always." The total score ranged from 0 to 78. Subscale scores were derived by summing item scores within each category (Sullivan et al., 1995). Mozafari (2010) assessed the reliability of this questionnaire using Cronbach's alpha, obtaining a coefficient of 0.94. Concurrent validity was examined through correlation with the Beck Depression Inventory, showing a significant positive correlation ($p = 0.01$). Osman et al. (2000) reported Cronbach's alpha values of 0.95 and 0.92 for outpatient pain and general populations, respectively. Sullivan et al. (1995) reported a Cronbach's alpha of 0.87 for the total scale and test-retest reliability over six weeks of $r = 0.75$. Cronbach's alpha for the rumination, magnification, and helplessness subscales were 0.87, 0.60, and 0.79, respectively (Jahangiri et al., 2023). In the present study, Cronbach's alpha coefficients for rumination, magnification, and helplessness were 0.84, 0.62, and 0.73, respectively.

Table 2*Summary of ACT Sessions*

Session	Description
1	Introduction, goals, pretest
2	Introduction to ACT, treatment objectives, psychoeducation, homework
3	Creative hopelessness, assessment of willingness for change, summary, homework
4	Review of prior sessions, identification of ineffective coping strategies, concept of acceptance, summary, homework
5	Review of prior sessions, commitment to behavioral change, cognitive defusion techniques, homework
6	Review of prior sessions, self-as-context, weakening conceptualized self, summary, homework
7	Review of prior sessions, identification and clarification of values, internal and external barriers, summary
8	Review of prior sessions, understanding willingness and commitment, coping preparation, posttest

2.3. Data Analysis

Qualitative data analysis was conducted using Colaizzi's method. The researcher reviewed participants' descriptions, extracted relevant statements, identified meanings, and categorized them thematically. To ensure credibility, original descriptions were revisited, and findings were verified with participants.

Table 3

Participant Characteristics

Participant Number	Gender	Work Experience (Years)	Education Level
1	Female	9	PhD
2	Male	18	PhD
3	Male	6	PhD
4	Female	12	PhD
5	Male	10	PhD
6	Male	15	PhD
7	Female	8	Master's

This study was conducted with seven specialists (four males, three females). Participants held doctoral or master's degrees and had between six and eighteen years of work experience.

To prevent time loss and ensure focused discussions, an interview guide was used. Each interview lasted between 30 and 60 minutes and was conducted individually. No audio recordings were made, and data were documented through note-taking. Initially, the research objectives were explained, and participants were assured of confidentiality.

Following data collection, key phrases and statements were extracted. These statements were categorized into subthemes, which were then organized into overarching

themes. Finally, these themes were mapped onto the primary research domains to accurately analyze participants' experiences with MS treatment.

3. Findings and Results

Table 3 presents the demographic characteristics of participants in the qualitative phase.

The qualitative data analysis resulted in two main themes (psychological and neuropsychological) and eight subthemes (self-care, support programs, meditation and mindfulness exercises, disease management, electrical and magnetic brain stimulation, memory exercises, cognitive games, and the use of technology and educational software) related to neuropsychological therapeutic components from the participants' perspectives. The extracted themes from the interviews are presented in the table below.

Table 4

Extracted Themes from Interviews

Main Theme	Subtheme	Example Codes	Quotations
Psychological	Self-care	Medical care, mental health, addressing individual needs, nutrition, adequate sleep	"During the disease course, patients need to practice self-care to support their recovery. Providing essential information about MS and its management to patients and caregivers enhances self-care and reduces feelings of helplessness" (Participant 6). "Patients, in addition to receiving treatment for physical symptoms, should be educated on self-care and mental health importance" (Participant 3). "Throughout treatment, patients must prioritize proper nutrition and sufficient sleep" (Participant 3).
	Support programs	Participation in support groups and associations	"Many MS-related associations and organizations provide essential support services. Patients must join these groups to benefit from available support programs" (Participant 4).
	Meditation and mindfulness exercises	Meditation and mindfulness practices	"Mental relaxation is crucial for disease management and adherence to treatment. Meditation and mindfulness exercises significantly help in achieving this" (Participant 3).

Neuropsychological	Rehabilitation for disease management	Pain management, physical therapy, massage, occupational therapy, pain relievers, proper diet, low-intensity exercise programs (e.g., walking, water-based exercises, stretching)	"Effective treatment strategies include providing assistive equipment and consultations to optimize patients' living environments for daily activities and motor function improvement" (Participant 3). "A proper nutrition program should be integrated into MS treatment components, as it can enhance energy levels and overall well-being" (Participant 5). "Considering the role of saturated fats in MS progression, a plant-based diet combined with seafood while reducing caffeine and alcohol intake is recommended" (Participant 2). "Alongside pharmacological treatments, MS patients must engage in strengthening and stretching exercises appropriate to their disability level to improve muscle strength and flexibility" (Participant 1). "A key component of therapy is educating patients on correct movement techniques and posture correction to reduce fatigue and maintain balance and coordination" (Participant 2). "Tailored physical exercises, including swimming, walking, and aerobic activities, contribute to general health improvement and increased muscle strength" (Participant 4). "Alongside pharmacological treatments, exercises to strengthen weak muscles, improve endurance, flexibility exercises to reduce muscle stiffness, balance training to enhance stability, and water-based exercises should be incorporated into treatment plans" (Participant 6).
	Electrical and magnetic brain stimulation	Brain electrical stimulation (TES, CES, rTMS)	"Several electrical and electromagnetic stimulation devices have demonstrated effectiveness in improving cognitive symptoms in MS patients, including TES, CES, and rTMS" (Participant 6). "In our clinic, rTMS is used to help MS patients manage cognitive and psychological difficulties" (Participant 7).
	Memory exercises	Memory training techniques, reminder tools, "Chalchali" game for memory enhancement	"Memory enhancement techniques such as using reminders, lists, and spatial learning strategies can be beneficial" (Participant 4). "The memory game 'Chalchali' is used to strengthen memory in MS patients" (Participant 7).
	Cognitive games	Puzzle games, Sudoku, logic-based tasks	"Engaging in cognitive games, puzzles, and problem-solving activities is helpful" (Participant 1).
	Use of technology and educational software	Virtual reality, educational software, computer-based cognitive training applications	"Utilizing apps and computer programs that provide cognitive training exercises can be beneficial, such as Captain's Log, N-back, and Go/No-Go tasks." "Virtual reality technology offers an interactive and realistic environment for cognitive training, greatly aiding MS patients" (Participant 5).

This analysis highlights the diverse therapeutic approaches recommended by specialists for managing MS-related psychological and neuropsychological challenges.

The present study aimed to compare the effectiveness of a neuropsychological intervention package with Acceptance and Commitment Therapy (ACT) in reducing pain catastrophizing in patients with multiple sclerosis (MS).

Table 5

Mean and Standard Deviation of Pain Catastrophizing Variables in Experimental and Control Groups

Variable	Groups	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Magnification	Experimental 1	22.080	0.991	19.520	0.978
	Experimental 2	22.160	0.944	20.480	0.971
	Control	22.280	0.970	22.240	1.066
Rumination	Experimental 1	16.840	0.782	14.160	0.763
	Experimental 2	16.760	0.764	15.080	0.828
	Control	16.920	0.759	16.840	0.763

As observed in Table 5, the mean and standard deviation values for the pain catastrophizing variables in Experimental Groups 1 and 2, as well as the control group, are reported for the pretest and posttest phases. The pretest and posttest mean values for the magnification variable in Experimental Groups 1 and 2 and the control group were 22.080, 22.160, and 22.280 in the pretest, and 19.520, 20.480, and 22.240 in the posttest, respectively. Similarly, for the rumination variable, the pretest and posttest mean values were 16.840,

16.760, and 16.920 in the pretest, and 14.160, 15.080, and 16.840 in the posttest, respectively.

Before testing the research hypotheses, the assumptions of covariance analysis were examined to ensure that the dataset met the necessary conditions for analysis. Six assumptions of ANCOVA—linearity, multicollinearity, homogeneity of variances, homogeneity of covariances, homogeneity of regression slopes, and normality of variable distribution—were assessed. The results indicated that the

assumptions were met, confirming the appropriateness of ANCOVA for analysis.

Table 6

Results of One-Way ANCOVA on Posttest Scores for Pain Catastrophizing

Source	Variable	Sum of Squares	df	Mean Square	F	p-value	Effect Size	Statistical Power
Group	Magnification	81.549	2	40.774	38.046	0.001	0.517	1.000
Error		76.092	71	1.072				
Total		34200.000	75					
Group	Rumination	86.086	2	43.043	38.940	0.001	0.523	1.000
Error		78.481	71	1.105				
Total		18898.000	75					

As shown in Table 6, the one-way ANCOVA results for the magnification variable yielded a significant F-value ($F = 38.046$, $p < 0.05$), and the ANCOVA results for the rumination variable also indicated a significant F-value ($F = 38.940$, $p < 0.05$). These findings confirm that there was a

significant difference in the dependent variable (pain catastrophizing) between the experimental and control groups. Therefore, the neuropsychological intervention package effectively reduced pain catastrophizing in MS patients, supporting Hypothesis 1 of the study.

Table 7

Bonferroni Post Hoc Test Results for Comparing Experimental Groups 1 and 2 with the Control Group

Variable	Group Comparison	Mean Difference	Standard Error	Significance	Lower Bound	Upper Bound
Magnification	Experimental 1 vs. Experimental 2	-0.895	0.293	0.010	-1.614	-0.176
	Experimental 1 vs. Control	-2.530	0.293	0.001	-3.250	-1.811
	Experimental 2 vs. Experimental 1	0.850	0.293	0.010	0.176	1.614
	Experimental 2 vs. Control	-1.635	0.293	0.001	-2.355	-0.916
	Control vs. Experimental 1	2.530	0.293	0.001	1.811	3.250
	Control vs. Experimental 2	1.635	0.293	0.001	0.916	2.274
Rumination	Experimental 1 vs. Experimental 2	0.999	0.295	0.004	-1.723	-0.274
	Experimental 1 vs. Control	-2.594	0.295	0.001	-3.319	-1.869
	Experimental 2 vs. Experimental 1	0.999	0.295	0.004	-0.274	1.723
	Experimental 2 vs. Control	-1.595	0.295	0.001	-2.319	-0.871
	Control vs. Experimental 1	2.594	0.295	0.001	1.869	3.319
	Control vs. Experimental 2	1.595	0.295	0.001	0.871	2.319

The results presented in Table 7 indicate that there was a significant difference in magnification scores between Experimental Groups 1 and 2. Furthermore, Experimental Group 1 showed a significant difference from the control group, demonstrating that the neuropsychological intervention package was effective. Additionally, magnification scores in Experimental Group 2 also significantly differed from the control group, indicating that ACT was effective.

Similarly, rumination scores significantly differed between Experimental Groups 1 and 2. Experimental Group 1 had a significant difference from the control group, supporting the effectiveness of the neuropsychological intervention package. Moreover, the significant difference in rumination scores between Experimental Group 2 and the

control group suggests that ACT was also effective in reducing pain catastrophizing.

4. Discussion and Conclusion

Analysis of the data obtained in this study revealed two main themes (psychological and neuropsychological) and eight subthemes (self-care, support programs, meditation and mindfulness exercises, rehabilitation for disease management, electrical and magnetic brain stimulation, memory exercises, cognitive games, and the use of technology and educational software) concerning the neuropsychological therapeutic components from the participants' perspectives.

Self-care was identified as a subtheme within the broader psychological theme. This finding can be explained by

recognizing that self-care programs are designed to manage chronic diseases, including MS. These programs not only help prevent and delay disability but also maintain and enhance functional abilities when implemented. Such approaches include education on symptom management, adherence to a proper diet, regular physical activity, and psychological support. By engaging in these programs, patients gain greater control over their condition and experience an improved quality of life (Mikula et al., 2018). Additionally, self-care education can enhance physical activity levels and psychological well-being in MS patients, helping them reach an optimal state. These programs teach patients essential skills for managing their symptoms and improving their quality of life. Increasing awareness and competence in self-care allows patients to continue daily activities and maintain psychological resilience. Consequently, this approach helps reduce stress and enhance emotional well-being (Kiselica et al., 2015). In general, self-care interventions aim to address cognitive, emotional, and psychosocial disturbances in MS patients by applying a comprehensive approach that considers patients' emotional responses to self-care under stress.

Support programs for MS were also identified as a subtheme within the psychological theme. In explaining this finding, social support functions as a protective factor against the negative consequences of chronic illnesses. The presence of social support enhances patients' self-confidence and reduces the adverse effects of chronic diseases. As a result, individuals adopt more health-promoting behaviors and contribute to improving their quality of life (Pushkarev et al., 2019). Support programs for MS patients, offering emotional, educational, and psychological support, facilitate better disease management and improved quality of life. These programs not only help alleviate symptoms and complications of MS but also enhance patients' self-confidence and motivation.

Another subtheme within the psychological domain was meditation and mindfulness exercises for MS. Mindfulness, as a non-judgmental awareness state, helps patients observe and accept their emotions and life experiences as they are. Mindfulness training for MS patients enables them to better accept their feelings and experiences related to the disease. This acceptance can reduce excessive sensitivity and attention to their condition, thereby decreasing feelings of guilt, self-doubt, and worthlessness. In other words, mindfulness-based training helps patients shift focus from their disability to more positive aspects through practices such as body scanning and positive evaluation of thoughts

and emotions. This approach reduces psychological distress and improves quality of life (Gloster, 2018).

Rehabilitation for disease management emerged as a subtheme under the neuropsychological theme, including aspects such as pain management, physical therapy, massage, occupational therapy, the use of analgesics, proper nutrition, physiotherapy, and low-intensity exercise programs (e.g., walking, water-based exercises, and stretching). Research shows that MS patients often experience abnormal fluctuations in body weight, which can negatively impact their psychological well-being. Maintaining a proper diet helps regulate weight and prevents its psychological repercussions (Mikula et al., 2018). Stretching exercises and activities like walking strengthen muscles and improve flexibility, enhancing balance and reducing the risk of falls. These therapeutic methods aid in managing MS symptoms and positively influence patients' physical and mental health. If the body's biochemical balance is disrupted and disease-related complications are not managed appropriately, patients may experience worsening conditions and increased disability. Physiotherapy alleviates symptoms such as fatigue and muscle stiffness while improving daily functioning and overall quality of life. Strength and flexibility exercises, taught by physiotherapists, foster independence in patients. Although physiotherapy does not prevent disease progression, it effectively manages symptoms and reduces complications (Namvar et al., 2020).

Brain electrical stimulation was another identified neuropsychological subtheme. The precise mechanisms underlying the effectiveness of brain stimulation remain unclear. Despite its widespread use, researchers have explored mechanisms such as alterations in ion channel activity, NMDA receptor stimulation, and reduced GABA release in cortical regions. These reductions, induced by anodal or cathodal stimulation, enhance synaptic plasticity in glutamatergic processes (Hunter et al., 2015).

Memory exercises were also a subtheme. Memory impairment has been reported in both relapsing-remitting and progressive forms of MS (Fuso et al., 2010). Findings indicate that memory function is affected in the early stages of MS. Studies have shown that MS patients may experience deficits in working memory, impairing the necessary cognitive processes for memory trace formation. In other words, new information is not stored or retrieved effectively, affecting both memory trace formation and recognition mechanisms. Consequently, patients struggle with managing and organizing information, impacting their ability to recall

it accurately and efficiently (Pelosi et al., 1997). These difficulties significantly affect patients' quality of life, as working memory plays a crucial role in daily activities, decision-making, and social interactions. Therefore, early identification and management of memory issues are critical. Memory rehabilitation training is a key component in managing individuals with memory impairments. Depending on patients' neuropsychological needs, it can be implemented as part of a comprehensive cognitive rehabilitation program or as an independent intervention (das Nair et al., 2016). Various attentional strategies and alternative encoding, storage, and retrieval techniques help address memory-related challenges. Memory training is believed to activate neural networks through targeted and repeated cognitive exercises (Shevil & Finlayson, 2010). Behavioral strategies, referred to as "restorative" or "compensatory" techniques, map onto neural circuits involved in memory processes.

Cognitive games were another subtheme. These included problem-solving games, puzzles, and Sudoku. Various games can be used to target common cognitive impairments in MS, such as processing speed deficits and working memory difficulties. Due to their visual appeal and simple rules, games and software applications are highly effective. For example, puzzle applications align with active treatment protocols tailored to disease progression. Patients receive a list of daily exercises to complete within treatment conditions, such as playing specific games for 15 minutes in a predefined sequence.

The use of technology and educational software was another neuropsychological subtheme related to MS. Virtual reality and video games serve as rehabilitation tools that aid in patient recovery. These technologies allow patients to engage in simulated environments and gain new experiences, reducing anxiety and increasing motivation for treatment participation. Games promote motivation and healthy competition among patients, making rehabilitation more engaging. Active patient participation in these interventions leads to better treatment outcomes. Overall, these findings highlight the potential of modern technology in improving rehabilitation processes for MS patients (Taylor et al., 2021). Additionally, the N-back software can enhance cognitive resources, improve fluid intelligence, and boost working memory performance in MS patients. Designed to strengthen working memory through repetitive exercises, N-back training helps improve cognitive abilities. Patients can participate in these programs from home, which is particularly beneficial for individuals with MS. These

programs help patients recognize cognitive limitations, develop compensatory strategies, and improve daily life quality (Vanotti & Caceres, 2017).

The neuropsychological intervention package was effective in reducing pain catastrophizing in MS patients. The hypothesis test confirmed a significant difference in the dependent variable (pain catastrophizing) between the experimental and control groups. Thus, the neuropsychological intervention package effectively reduced pain catastrophizing in MS patients. These results align with prior findings (Noormohamadi et al., 2019; Samadi et al., 2023).

Similarly, ACT was effective in reducing pain catastrophizing in MS patients. The hypothesis test confirmed a significant difference in the dependent variable between the experimental and control groups, indicating ACT's effectiveness. These results are consistent with prior findings (Fernández-Rodríguez et al., 2023; Jahangiri et al., 2023; Pakenham & Landi, 2023).

The findings suggest that neuropsychological interventions improve cognitive, behavioral, and emotional aspects of MS management. These approaches reduce psychological symptoms and enhance patients' quality of life. Additionally, ACT facilitates psychological acceptance and commitment to valued actions, proving effective for MS patients. Both approaches demonstrated effectiveness in reducing pain catastrophizing. However, neuropsychological interventions emphasize cognitive and behavioral modifications, whereas ACT focuses on psychological flexibility and value-driven actions.

Authors' Contributions

This article is derived from the first author's doctoral dissertation. All authors significantly contributed to this study.

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

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the interview and participated in the research with informed consent. This study was conducted at Islamic Azad University, Khomein Branch, in compliance with ethical principles and received ethical approval under the code IR.IAU.KHSH.REC.1403.049.

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