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The Efficacy of Motor-Based Cognitive Rehabilitation in Inhibitory Control, Cognitive Flexibility, and Obsessive-Compulsive Symptoms of Adolescents with Obsessive-Compulsive Disorder

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This study was conducted to investigate the efficacy of motor-based cognitive rehabilitation in inhibitory control, cognitive flexibility, and obsessive-compulsive symptoms of adolescents with obsessive-compulsive disorder. The current study is semi-experimental research using a pre-test-post-test and a 3-month follow-up with a control group design. Thirty male and female individuals aged 14 to 18 years' old who had been diagnosed with obsessive-compulsive disorder and were seeking treatment at counseling and psychological services centers in Ahvaz participated in the study. Participants met the inclusion criteria were selected using a convenience sampling and randomly assigned to either the experimental or control group. The mean and standard deviation age of the participants in the experimental group was 16.5±1.20, while in the control group, was 16.6±1.19. Before the intervention, participants were evaluated using appropriate instruments, including the Go/No Go Test, Wisconsin Card Sorting Test, and Yale-Brown Obsessive-Compulsive Scale. After the evaluation, the participants in the experimental group underwent 12 sessions of cognitive rehabilitation treatment. Each session lasted 45 minutes. The participants in the control group did not receive any intervention. Participants were re-evaluated immediately after completing the intervention sessions and again three months later. MANCOVA and separate ANCOVAs analyses showed that motor-based cognitive rehabilitation can lead to improvements in inhibitory control, cognitive flexibility, and a reduction in obsessive-compulsive symptoms ($p < .05$). Based on the research results, motor-based cognitive rehabilitation can be used as a treatment for obsessive-compulsive disorder.

Keywords: inhibitory control, cognitive flexibility, obsessive-compulsive disorder, cognitive rehabilitation, adolescents.

Obsessive-compulsive disorder (OCD) is a condition currently defined by the American Psychiatric Association (2022) as a disorder characterized by obsessive thoughts (repetitive, irrational thoughts, urges, or imaginings and disturbing) or compulsions (repetitive behaviors or mental states). These symptoms are known to significantly affect the quality of life of sufferers and are often associated with other neurodevelopmental or psychiatric conditions (American Psychiatric Association, 2022). Obsessive-compulsive disorder (OCD) is a prevalent, chronic, and debilitating disorder. According to the American Psychiatric Association (2022), its prevalence in the general population is estimated to be between 1.1- 1.8%. It has been reported that this disorder can affect up to 3% of children and adolescents (Savert, 2013). In Iran, the prevalence of this disorder in children and adolescents has been reported to be between 3-4% (Mohammadi et al., 2021).

Several factors contribute to the development of OCD, among which cognitive deficits are considered to be one of the most significant. Numerous studies have demonstrated a broad spectrum of cognitive impairments, particularly in executive functions, among individuals with obsessive-compulsive disorder. These impairments play a significant role in both the onset and worsening of symptoms, and are influential in the pathophysiology of the disorder (Rosa-Alcázar et al., 2020; Martínez-Esparza et al., 2021; Yazdi Ravandi et al., 2018; Levy, 2018). Executive functions have established a strong link between brain structures, particularly the prefrontal cortex, and psychological functions. This connection has aided experts in the field to gain a better understanding of psychopathology. Executive functions encompass a broad range of cognitive abilities that are accountable for formulating, commencing, and arranging behavior aimed at achieving goals, as well as supervising behavior (Rao et al., 2008). On the other hand, various research findings have led to the hypothesis that individuals with obsessive-compulsive disorder (OCD) may have physiological defects or failures, particularly abnormalities or malfunctions in different areas of the brain. These areas include the Orbitofrontal Cortex (OFC), Anterior Cingulate Cortex (ACC), and Striatum, which may experience dysfunction (American Psychiatric Association, 2022; Whiteside et al., 2004; Abramowitz et al., 2009; Mataix-Cols et al., 2003). Furthermore, numerous studies have demonstrated deficits in the dorsolateral prefrontal cortex (DLPFC) among individuals with obsessive-compulsive disorder (Li et al., 2020; Boedhoe et al., 2018). These deficits in the DLPFC have been found to be associated with impairments in executive functions. Numerous studies have demonstrated that individuals with obsessive-compulsive disorder exhibit a range of executive function deficits, such as impairments in inhibitory control (Chamberlain et al., 2005; Norman et al., 2019). Inhibition refers to the mental processes involved in intentional and voluntary control, which enable individuals to prevent irrelevant information from interfering

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with ongoing responses or response patterns. It also allows them to suppress relevant prior information that is currently useless (Carlson & Wang, 2007). Recent research indicates the very important role of the dorsolateral prefrontal cortex (DLPFC) in inhibitory control (Nejati et al., 2018). Chamberlain et al. (2005) argue that obsessive-compulsive disorder is associated with a deficiency in behavioral inhibition, which is linked to compulsions, and a deficiency in cognitive inhibition, which is linked to obsessive thoughts.

Another executive function that is commonly reported to be deficient in individuals with obsessive-compulsive disorder is cognitive flexibility (Dittrich & Johansen, 2013; Rosa-Alcázar, 2020). Cognitive flexibility refers to the capacity to modify one's pattern of activity in order to effectively adjust to the demands of a particular task or situation (Cepeda et al., 2001). Obsessive-compulsive disorder is characterized by repetitive and inflexible maladaptive behavioral and cognitive patterns that indicate a lack of cognitive flexibility or a failure to exhibit it (Gruner and Pittenger, 2017). Numerous studies have demonstrated behavioral and neurological abnormalities associated with cognitive flexibility in individuals diagnosed with obsessive-compulsive disorder. Studies have shown that certain areas of the brain are activated when a person engages in tasks related to cognitive flexibility. These regions include the dorsolateral prefrontal cortex (DLPFC), basal ganglia, anterior cingulate cortex (ACC), and posterior parietal cortex (Leber et al., 2008). Since many of the brain regions mentioned, particularly the Dorsolateral Prefrontal Cortex (DLPFC) and the Anterior Cingulate Cortex (ACC), are also affected in individuals with obsessive-compulsive disorder, the cognitive inflexibility observed in these patients can be attributed to these neurological impairments. Bradbury et al. (2011) suggest that individuals with obsessive-compulsive disorder may have a deficiency in cognitive flexibility, which could explain the significance they place on obsessive thoughts. According to Chamberlain et al. (2005), obsessive thoughts and compulsions are believed to arise from cognitive inflexibility. On the other hand, the lack of cognitive flexibility of these patients can be attributed to the lack of inhibitory control, because when we want to go from one stimulus to another, we need to inhibit the first stimulus. Based on the above information, it can be concluded that cognitive deficits, particularly a lack of inhibitory control and cognitive flexibility, may contribute to the development, onset, and worsening of both mental symptoms (obsessions) and practical symptoms (compulsions) of obsessive-compulsive disorder. Therefore, it is anticipated that addressing these cognitive deficits could significantly decrease the specific symptoms of obsessive-compulsive disorder, including obsessions and compulsions. In other words, improving cognitive functions may reduce obsessive-compulsive symptoms that are related to cognitive deficiencies. Obsessive-compulsive disorder (OCD) can have a debilitating impact on adolescents, affecting their personal, academic, and social abilities, as well as their families. If left untreated during childhood and adolescence, and without necessary interventions, OCD can have negative effects on an individual's future and adulthood. According to the American Psychiatric Association (2022), the likelihood of this disorder resolving without treatment is low. Additionally, if the disorder develops during childhood or adolescence, it may persist throughout life. Therefore, it is crucial to implement appropriate interventions during this period. Researchers and therapists have utilized a wide range of medicinal and non-medicinal treatments to address obsessive-compulsive disorder and its related symptoms and issues. The significant side effects of drugs, drug dependency, parental disapproval of their child's drug use, and other related factors have resulted in the adoption of non-drug treatments in numerous cases. Among these treatments, we can name Exposure and Response Prevention (ERP) and Cognitive Behavioral Therapy (CBT) (Abramowitz, 1997; McLean et al., 2001). While behavioral and cognitive-behavioral treatments have shown significant success in treating obsessive-compulsive disorder, the process of these treatments may not be clear and objective for everyone. High levels of anxiety experienced by teenagers, particularly in early adolescence, when exposed to anxiety-inducing stimuli during exposure and response prevention therapy, can diminish their motivation to continue with the treatment process. As a result, many researchers have turned to more diverse and innovative treatments, such as Cognitive Rehabilitation Therapy. This approach not only addresses the limitations of other treatments, particularly the issue of objectivity, but also seeks to broaden the range of treatment options for obsessive-compulsive disorder. Cognitive Rehabilitation Therapy is a process that aims to improve a damaged nervous system through specific therapeutic techniques. This therapy creates functional changes by rewarding, promoting, and relearning previously learned abilities or new patterns to enhance cognitive functions (Stringer, 2003). In this treatment method, the therapist considers the information obtained during the evaluation session and designs tasks to enhance the cognitive functions of the brain. These tasks become progressively more challenging as the patient advances through the treatment. This

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treatment can be used from childhood through old age (Jackson et al., 2012).

Various studies have shown that individuals with obsessive-compulsive disorder exhibit physiological and cognitive defects, particularly in inhibitory control and cognitive flexibility. It is also well-known that these cognitive defects play a significant role in the development, onset, and worsening of obsessive-compulsive symptoms. As no research has yet investigated the effect of cognitive rehabilitation on the improvement of cognitive defects and symptoms of obsessive-compulsive disorder (OCD) in Iranian adolescents, and few studies have been conducted in this field worldwide, particularly on children and adolescents, the present study aims to examine the effectiveness of motor-based cognitive rehabilitation in enhancing inhibitory control, cognitive flexibility, and OCD symptoms in adolescents with OCD. In pursuit of this objective, the question arises as to whether motor-based cognitive rehabilitation can improve inhibitory control, cognitive flexibility, and symptoms of obsessive-compulsive disorder in adolescents with OCD.

Method

The current study is a semi-experimental research using a pre-test-post-test design and a 3-month follow-up with a control group. The study's statistical population includes all males and females between the ages of 14 and 18 who have been diagnosed with obsessive-compulsive disorder and referred to counseling and psychological service centers in Ahvaz during the years 2021-2022. A sample of 30 adolescents with obsessive-compulsive disorder in Ahvaz who met the inclusion criteria conveniently participated in the study. In general, 30 individuals participated in the present study, consisting of 14 females and 16 males. One participant from the control group and two participants from the experimental group were excluded from the study due to reasons such as migration or failure to participate in more than two treatment sessions. The sample size was reduced to 27 individuals, consisting of 14 females and 13 males. The inclusion criteria were a diagnosis of obsessive-compulsive disorder based on DSM-5 criteria, absence of other psychological disorders or physical illness, age between 14 and 18 years, no concurrent psychological treatment or medication, high motivation for participation as determined through an initial interview, and tendency to participation in the research by signing a written consent form. Based on the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders by the American Psychiatric Association, the diagnosis of their disorder was confirmed. They were then randomly assigned to two groups: experimental and control, with 15 participants in each group. The exclusion criteria included inability to perform cognitive rehabilitation tasks, concurrent psychological or drug treatment, non-participation in more than two consecutive treatment sessions, and unwillingness to participation.

To conduct the current research, recruitment calls were initially published in schools, online channels, clinics, and counseling and psychotherapy centers in Ahvaz. After reviewing the requirements for participation, the researchers conducted interviews with potential participants to gather information and ensure they understood the conditions and duration of the intervention. Before initiating any intervention program, we obtained the ethical code related to the subject of the current research (EE/1400.2.24.37371/Scu.ac.ir) and all participants completed a personal informed consent form and were assured of the confidentiality of their information. The participants or their parents were then provided with explanations about the treatment methods being used, as well as the research procedures. Before administer the interventions, the participants underwent a pretest using the appropriate assessment tools. Then the experimental group participated 12 sessions of 45 minutes each of motor-based cognitive rehabilitation, while the control group did not receive any intervention. After completing the interventions, the participants recompleted the measurement tools as posttest. After three months following the second evaluation, a third evaluation or follow-up was conducted. After the ending of research administration, the control group, which had previously been on the waiting list, also received several sessions of Cognitive Rehabilitation Therapy for free.

Instruments

Go/No Go Test

The Go/No Go Test was developed by Hoffman in 1985 to assess an individual's ability to inhibit responses. The go/no-go test involves two phases. In the "Go" phase, a stimulus is presented and the person must respond as quickly as possible in a way that is consistent with the stimulus. In the "No-Go" phase, a second stimulus is presented after the first, and the person must refrain from responding when the second stimulus appears. The ability of an individual to control his/her response during the No-Go phase is an indicator of his/her inhibitory control. This test has multiple versions. In this study, we utilized the second version of the Psychology Experiment Building Language (PEBL) software. In the go/no-go test of this software, there are two target stimuli, one of which appears on the screen each time. These two stimuli are the letters P and R. The test comprises two stages. In the first stage, 128 P stimuli and 32 R stimuli are presented. The participant is required to click on the screen when the letter "P" appears, but should refrain from responding if the letter "R" appears. During the second stage, the R stimulus appears 128 times and the P stimulus appears 32 times. Participants are instructed to click on the screen when they see the R stimulus, but to refrain from responding when they see the P stimulus. The number of incorrect responses to the stimuli (R in the first stage and P in the second stage), also known as commission errors, is considered the primary indicator for measuring inhibitory control. The construct validity of this test was investigated in the research conducted by Votruba and Langenecker (2013), and the results indicated that the test has good construct validity. The reliability and retest coefficient of this scale, as reported in Hopko et al.'s (2006) research, is above 0.80. The reliability of this test was reported as 0.87 in a study conducted by Ghadiri et al. (2005) in Iran, using the test-retest method.

Wisconsin Card Sorting Test (WCST)

The Wisconsin Card Sorting Test is one of the most commonly used tests for measuring executive functions and determining the role of the frontal lobe in the brain. This test is used to measure various cognitive functions, including cognitive flexibility (Greve, 2001). In this test, the examinees must maintain the rule they noticed in one stage of the test for consecutive periods. When the rule for sorting the cards changes, they must also adjust their sorting method accordingly. Based on the feedback they receive; the individuals know whether they have understood the rule correctly or not. There are multiple versions of the Wisconsin Card Sorting Test. In this study, we utilized the computerized version of the test along with the second edition of PEBL software. The test consists of 64 unique cards, each displaying

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four types of shapes: stars, triangles, circles, and crosses. The number of each shape on each card may vary between 1 and 4. Additionally, the shapes on each card are printed in one of four colors: red, blue, green, or yellow. Based on this, the test has three principles or rules: color, shape, and number. From the combination of these three principles, 64 unique modes are created, each of which is displayed once on the screen. The test output includes the number of correct responses, the number of completed categories, and the perseverative error. In this research, the perseverative error has been used as the primary indicator for measuring cognitive flexibility, which is an executive function. An error in persistence occurs when a subject persists in categorizing based on a previous rule, even after the categorization rule has changed. It can also occur when a subject categorizes cards based on an incorrect guess and insists on their incorrect answer despite receiving "wrong" feedback (Mueller and Piper, 2014). The validity of the Wisconsin Card Sorting Test (WCST) in Lezak's research (2004; cited by Lezak, 2005) was reported to be over .86, while its reliability was found to be 0.95 in Schretlen's (2010) study using the split-half method. The reliability of the Persian version of the mentioned test, as assessed by the test-retest method, has been reported to be .85 (Naderi et al., 1994).

Yale-Brown Obsessive-Compulsive Scale (Y-BOCS)

The Yale-Brown Obsessive-Compulsive Scale (Y-BOCS) was developed by Goodman et al. in 1989 to measure the severity of obsessions and compulsions. This scale is highly sensitive to therapeutic changes and is widely used to measure the effectiveness of pharmacological and non-pharmacological treatments for obsessive-compulsive disorder. The current scale consists of two parts. In the initial section, the participants are

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requested to identify the thoughts or actions that bring them the greatest discomfort. In the second part, which measures the severity of symptoms, the respondent is asked to rate the intensity and frequency of their obsessive thoughts and behaviors on a five-point Likert scale ranging from 0 to 4. According to Goodman et al. (1989), if an individual score less than 10 in the second part, their obsession is considered very mild. A score of 10 to 15 is relatively mild, 16 to 25 is moderate, and a score of more than 25 indicates severe obsessions. The concurrent validity of this scale was reported as .99 in Rajezi Esfahani et al.'s (2012) research, and its reliability was assessed using Cronbach's alpha method for the first and second parts, resulting in values of .97 and .95, respectively.

Exercise for Cognitive Improvement & Rehabilitation (Excir)

Exercise for Cognitive Improvement and Rehabilitation (Excir) was utilized as a cognitive rehabilitation therapy in this study. Excir, formerly known as Cortex, is a program that offers cognitive rehabilitation methods for individuals in need of cognitive improvement and rehabilitation. The Excir program presents targeted motor exercises that require cognitive functions to participants in a graded form, starting from easy levels and progressing to more difficult ones with increasing cognitive demands of the exercise. Each session includes motor exercises aimed at developing skills such as selective attention, sustained attention, alternating attention, working memory, inhibitory control, and cognitive flexibility. The previously established goals will change and become more diverse and challenging over the time (Najian and Nejati, 2017). The basic principles of this program are as follows:

1. Motor tasks are organized in a hierarchical manner and become progressively more challenging over the time based on user feedback.

2. Motor tasks are designed based on various functions, such as attention, inhibitory control, working memory, and cognitive flexibility.

3. Motor tasks can be repeated until the participant achieves the desired level of proficiency.

4. The decision to advance the program is based on the participant's performance, and the therapist's presence is necessary to enhance the quality of the assignment.

Table 1

Summary of Cognitive Rehabilitation Sessions

session	content of session
1-4	Sustained Jumping Task, Adjusted Hand Movement, Direction Selective Jumping, Walking with calculation
5-8	Selective Color Jumping, Patterned Walking, Opposite Hands Movements, Clap control
9-12	Selective Number Jumping, Coordinate Limbs Movements, Walking with calculation, Selective Color Jumping

Results

The mean (and SD) age of the participants in the experimental group was 16.5 (1.20), while in the control group, was 16.6 (1.19). Mean and standard deviation of variables separated for experimental and control groups are presented in Table 2.

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Table 2

Mean, Standard Deviation, Minimum and Maximum Scores of the Variables

Variable	Group	Stage	Mean	SD	Min	Max
Inhibitory Control	Control	Pre-test	12.28	2.26	9	16
		Post-test	11.64	2.53	8	16
		Follow-up	12.3	2.20	10	16
	Experimental	Pre-test	12.46	2.98	9	18
		Post-test	10.00	2.56	6	14
		Follow-up	11.07	2.90	7	16
Cognitive Flexibility	Control	Pre-test	12.85	2.10	9	17
		Post-test	12.57	2.24	9	16
		Follow-up	12.64	2.02	9	15
	Experimental	Pre-test	12.38	2.90	10	17
		Post-test	10.30	2.56	6	14
		Follow-up	10.76	2.55	7	16
OCD Symptoms	Control	Pre-test	22.85	5.48	16	32
		Post-test	23.00	5.64	15	33
		Follow up	23.35	5.27	16	32
	Experimental	Pre-test	21.46	6.02	16	34
		Post-test	19.53	5.81	13	32
		Follow-up	20.30	5.94	14	33

To data analyses, both multivariate and univariate covariance analyses were used. Prior to these analyses, the assumptions of the MANCOVA including normal distribution, homogeneity of variances, homogeneity of variance-covariance matrices, and homogeneity of the regression lines were examined. The results of the Kolmogorov-Smirnov test in the pre-test, post-test, and follow-up stages indicated that, with the exception of cognitive flexibility in the pre-test stage of the control group, all other data followed a normal distribution. Since the skewness and kurtosis values of this dataset fall within the range of -3.29 to +3.29 (applicable to samples with small size), it is appropriate to use parametric tests for analysis. To check the homogeneity of variances, Levene's test was used. The results obtained from Levene's Test indicate that the F value is not significant at the alpha level of 0.05 for all variables in both the post-test and follow-up stages, except for inhibitory control in the follow-up stage. Therefore, the assumption of homogeneity of variances is upheld. Box's M test was utilized to assess the homogeneity of the variance-covariance matrix in both the post-test and follow-up stages. The results of this analysis are presented in Table 3.

Table 3
Results of the Homogeneity of Variance-Covariance Matrices using Box’s M test

	Post-test	Follow-up
Box's M	7.509	6.247
F	1.087	.904
Degree of Freedom 1	6	6
Degree of Freedom 2	4451.763	4451.763
Significance level	.491	.368

The results presented in Table 3 indicate that there is no significant difference ($p>.05$) between the correlation matrices of the dependent variables among the research groups, and confirm the assumption of homogeneity of the variance-covariance matrix.

Based on the results presented in Table 4, it can be found that the F value of the interaction between the group and the pre-test scores with the post-test, as well as with the follow-up for all variables, is not statistically significant. Therefore, it can be concluding that the assumption of homogeneity of regression slopes for both post-test and follow-up stages is maintained.

Table 4

Investigation of the Assumption of Homogeneity of the Regression slopes

Stage	Variable	Source	Sum of squares	Degree of Freedom	Mean square	F	Sig.
Post-Test	Inhibitory Control	Pre-Test and Group	2.876	1	2.876	1.908	.180
	Cognitive Flexibility	Pre-Test and Group	.003	1	.003	.002	.967
	OCD Symptoms	Pre-Test and Group	1.684	1	1.684	.842	.368
Follow-Up	Inhibitory Control	Pre-Test and Group	.403	1	.403	.235	.632
	Cognitive Flexibility	Pre-Test and Group	.367	1	.367	.179	.676
	OCD Symptoms	Pre-Test and Group	.012	1	.012	.007	.936

Due to the assumptions are met, both multivariate and univariate covariance analysis were used to analyzing the data.

The results of the Wilks' Lambda test in the post-test stage indicate a significant difference in at least one of the dependent variables among the studied groups. Furthermore, based on the effect size in the post-test stage, it can be concluded that the independent variable accounts for 72% of the variance in the continuous variables. ($p < .05$; $F = 17.539$; Eta = .72).

The results of the Wilks' Lambda test during the follow-up phase indicate a significant difference in at least one of the dependent variables among the studied groups. Based on the effect size during the follow-up phase, it can be concluded that the independent variable accounted for 56% of the variance in the continuous variables. ($p < .05$; $F = 8.594$; Eta = .56).

Table 5

Results of Multivariate Analysis of Covariance (MANCOVA)

Stage	Index	Value	F	Hypothesis df	Error df	Sig.	Partial Eta	Observed Power
Post-Test	Wilks' Lambda	.275	17.539	3	20	.0001	.72	1
Follow-Up	Wilks' Lambda	.437	8.594	3	20	.001	.56	1

Based on the results of multivariate covariance analysis, it was determined that there is a significant difference between the control and experimental groups in terms of at least one of the dependent variables. However, the pattern of this difference is not clear. Therefore, univariate covariance analysis was used to examine the different patterns, and the results are presented in Table 6.

Based on the results presented in Table 6, it is evident that the F statistic, with a value of 10.486, is significant for inhibitory

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control during the post-test stage. This result indicates a significant difference in inhibitory control between the groups studied during the post-test phase. It is evident that the F statistic, with a value of 6.472, is significant for inhibitory control in the follow-up phase. This result indicates a significant difference in inhibitory control between the groups studied during the follow-up phase.

Based on the results presented in Table 6, it is evident that the F statistic (18.327) is significant for cognitive flexibility in the post-test stage. This result indicates a significant difference in cognitive flexibility between the groups studied during the post-test stage. It can also be observed that the F-statistic, with a value of 9.286, is significant for cognitive flexibility in the follow-up phase. This result indicates a significant difference in cognitive flexibility between the groups studied during the follow-up phase. Based on the results presented in Table 6, it is evident that the F statistic (13.253) is significant for obsessive-compulsive symptoms in the post-test stage. This result indicates a significant difference in obsessive-compulsive symptoms between the studied groups during the post-test stage. It can also be observed that the F-statistic, with a value of 9.372, for obsessive-compulsive symptoms during the follow-up phase is also statistically significant. This result indicates a significant difference in obsessive-compulsive symptoms between the groups studied during the follow-up stage.

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Table 6

Results of ANCOVA Analysis Comparison of Differences between Experimental and Control Groups in Inhibitory Control, Cognitive Flexibility and OCD Symptoms

Stage	Variable	Source	Sum of Squares	df	Mean square	F	Sig.	Partial Eta Squared	Observed Power
Post-Test	Inhibitory Control	Group	17.580	1	17.580	10.486	.004	.32	.872
	Cognitive Flexibility	Group	26.369	1	26.369	18.327	.0001	.45	.983
	OCD Symptoms	Group	25.099	1	25.099	13.253	.001	.37	.935
Follow-Up	Inhibitory Control	Group	11.574	1	11.574	6.472	.018	.22	.681
	Cognitive Flexibility	Group	18.573	1	18.573	9.286	.006	.29	.829
	OCD Symptoms	Group	17.441	1	17.441	9.372	.006	.29	.823

Discussion

The results of the current study indicated that motor-based cognitive rehabilitation significantly improves inhibitory control in adolescents with obsessive-compulsive disorder. The results indicated a significant difference between the average scores of inhibitory control in the pre-test, post-test, and follow-up stages. The findings are consistent with previous research, such as Dousset et al. (2021), Qamari Givi et al. (2014), Nejati (2020), and Eivazi et al. (2023). Dousset et al. (2021) demonstrated that combining direct transcranial electrical stimulation with cognitive rehabilitation can enhance inhibitory control. Qamari Givi et al. (2014) demonstrated in their research that a cognitive rehabilitation program was effective in restoring executive functions, such as inhibitory control, in patients with obsessive-compulsive disorder. Nejati (2020) demonstrated in his research that cognitive rehabilitation can enhance the selective attention and inhibitory control of children diagnosed with attention deficit hyperactivity disorder. Eivazi et al. (2023) demonstrated in their research that cognitive rehabilitation can enhance the working memory and inhibitory control of children with dysgraphia. In order to explain this finding, it can be said that cognitive rehabilitation therapy is a treatment that improves the function and metabolism of the prefrontal lobe by forming new synapses and continuously stimulating brain structures. This therapy provides the basis for creating functional changes through reward, promotion, and relearning of previous abilities. Learning new patterns can improve cognitive functions (Stringer, 2013). Based on the principles of neuroplasticity and self-repair of the brain, it can be said that this treatment method, which involves repetition and the individual's effort to regulate their performance, through

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experience-dependent plasticity and both spontaneous and guided improvements, the brain gradually undergoes structural and functional changes in the neurons responsible for executive functions, ultimately exerting long-term effects. The reason for these effects is that cognitive rehabilitation tasks are designed to adjust the difficulty levels of the tasks from easy to difficult, which makes them suitable for different levels of individual development. Additionally, these tasks are designed to create engaging challenges that target executive functions and related areas of the brain. In other words, performing cognitive tasks that rely on the principle of neuroplasticity can elevate the metabolic rate of brain regions associated with those tasks. This, in turn, can alter the structure and function of these areas, leading to an enhancement in a person's cognitive abilities (Stringer, 2013). From another perspective, we understand that there exists a reciprocal relationship between the brain and behavior. In other words, every behavior that occurs originates from the brain, and conversely, when we acquire a behavioral skill, the corresponding brain structure also undergoes changes. When an individual performs a cognitive task repeatedly at varying levels of difficulty, the brain structures that are activated during the task and their metabolism gradually change based on the principle of neuroplasticity. One brain structure that is activated during various cognitive tasks and is considered the main part related to executive functions, particularly inhibitory control, is the dorso lateral prefrontal cortex (DLPFC). This area, essential for effective response inhibition, is activated during cognitive tasks, leading to an increase in metabolic rate. Over time, this can result in the gradual strengthening of a person's inhibitory control. Cognitive rehabilitation based on the principles of neuroplasticity and self-repair of the brain, by continuously stimulating areas with less brain activity, creates stable synaptic changes (Thorell et al., 2009). On the other hand, another explanation suggests that during the process of brain recovery, the principle of compensation comes into play. This means that other areas of the brain gradually assume the responsibilities of the damaged areas, and new pathways and neural circuits are formed. Cognitive rehabilitation tasks can also reduce the negative impact of structural brain defects by assisting the brain in identifying and creating new and alternative pathways (Powell, 2017).

The results of the current study indicate that motor-based cognitive rehabilitation has a significant impact on enhancing cognitive flexibility in adolescents diagnosed with obsessive-compulsive disorder. The results indicate a significant difference between the average scores of cognitive flexibility in the pre-test, post-test, and follow-up stages. The findings of other researchers, such as Alvarez et al. (2018), Von Ah and Crouch (2021), Ayers et al. (2020), and Qamari Givi et al. (2014), support the results of the present study. Alvarez et al. (2018) found that cognitive rehabilitation treatment had a positive effect on various cognitive functions, including planning, working memory, cognitive flexibility, information processing speed, and verbal fluency. Von Ah and Crouch (2021) demonstrated in their research that cognitive rehabilitation is effective in improving cognitive deficits, including cognitive flexibility, in individuals who have recovered from cancer. Ayers et al. (2020) demonstrated in their research on individuals with hoarding disorder that cognitive rehabilitation can enhance their cognitive flexibility. Qamari Givi et al. (2014) demonstrated in their research that the cognitive rehabilitation program effectively restored executive functions, including cognitive flexibility, in patients with obsessive-compulsive disorder. As explained in the findings related to

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inhibitory control, the origins of inhibitory control and cognitive flexibility in the brain are remarkably similar. Both are considered components of cold executive functions. Therefore, when explaining the effectiveness of cognitive rehabilitation on cognitive flexibility, it is important to note that cognitive rehabilitation is founded on the principle of neuroplasticity. This means that performing cognitive tasks leads to the formation of new synapses and stimulation of brain structures, resulting in improved function and metabolism of the posterior lateral cortex of the prefrontal cortex. The prefrontal cortex plays a crucial role in facilitating functional changes through reward, reinforcement, and the acquisition of new abilities or patterns. This process enhances cognitive functions and leads to improved cognitive flexibility.

The results of the current study indicate that motor-based cognitive rehabilitation significantly reduces obsessive-compulsive symptoms in adolescents diagnosed with obsessive-compulsive disorder. The results indicate a significant difference between the average scores of obsessive-compulsive symptoms in the pre-test stage, post-test stage, and follow-up. The findings of other researchers, such as Kashyap et al. (2019), Mokhtari et al. (2022), and Jafari and Bayrami (2020), support the results of the present study. Kashyap et al. (2019) conducted research that demonstrated how cognitive rehabilitation therapy can effectively reduce the severity of anxiety symptoms, depression, and obsessive-compulsive symptoms while also improving executive functions. In Mokhtari et al.'s (2022) research, it was discovered that cognitive rehabilitation therapy can decrease the severity of obsessive-compulsive symptoms in adults diagnosed with obsessive-compulsive disorder. Furthermore, Jafari and Bayrami (2020) demonstrated in their research that cognitive rehabilitation can alleviate the severity of obsessive-compulsive symptoms in individuals diagnosed with obsessive-compulsive disorder. In explaining this finding, it can be said that executive function defects, such as inhibitory control and cognitive flexibility, are commonly observed in many patients with obsessive-compulsive disorder. As mentioned before, these defects can affect the development or exacerbation of obsessive-compulsive symptoms. Cognitive rehabilitation therapy can alleviate the symptoms caused by cognitive impairments through targeted interventions and exercises. As it has been noted, obsessive-compulsive disorder is characterized by a deficiency in behavioral inhibition, which is linked to compulsions, as well as a deficiency in cognitive inhibition, which is associated with obsessive thoughts. On the other hand, we know that the importance that a person with obsessive-compulsive disorder places on obsessive thoughts may be due to a deficiency in cognitive flexibility. Therefore, reducing obsessive-compulsive symptoms can be attributed to strengthening inhibitory control and cognitive flexibility. On the other hand, many studies have shown that individuals with obsessive-compulsive disorder exhibit dysfunction in the dorsolateral prefrontal cortex, which is a neurological anomaly. Cognitive rehabilitation can improve activity and metabolism in this brain region by engaging in challenging tasks. Based on the principle of neuroplasticity, cognitive rehabilitation can have a long-term effect on the brain region associated with obsessive-compulsive disorder (OCD). By increasing the metabolism of this area, we may observe a reduction in the severity of OCD symptoms in individuals with this disorder.

Based on the findings of the present study, it can be concluded that motor-based cognitive rehabilitation therapy can improve the

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inhibitory control and cognitive flexibility of adolescents with obsessive-compulsive disorder. Additionally, this therapy can reduce the severity of obsessive-compulsive symptoms in these individuals.

One limitation of the current study is the small sample size, which was due to the difficulty in accessing adolescents with obsessive-compulsive disorder. On the other hand, the present study was carried out on adolescents diagnosed with obsessive-compulsive disorder in Ahvaz City. Therefore, it is important to exercise caution when attempting to generalize the findings to other societies. On the other hand, despite our efforts to control for extraneous variables by utilizing a control group and selecting participants randomly, we should be cautious when attributing all observed changes solely to the independent variable, which in this case is cognitive rehabilitation therapy. Based on these limitations, it is suggested that future research should be conducted with a larger sample size, if possible. It is also recommended that future researchers conduct cognitive rehabilitation treatments in various communities, encompassing different geographic regions and age groups. On the other hand, it is suggested that future research should control for the role of gender and type of obsession. Based on the results of the present study, it is recommended that mental health professionals incorporate cognitive rehabilitation therapy into existing interventions for obsessive-compulsive disorder. We appreciate all the participants who took part in this study.

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