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Comparing the Effectiveness of Metacognitive Skills Training with Executive Function Skills Training on Biological Markers in Patients with Coronary Artery Disease

Marjaneh. Davoodi[1], Saeid. Malihi Alzakerini[2*], Akbar. Nikpajouh[3], Mehrdad. Sabet[4]

[1] Ph.D. Student, Department of Health Psychology, Kish International Branch, Islamic Azad University, Kish Island, Iran
[2] Assistant Professor, Department of Psychology, Karaj Branch, Islamic Azad University, Karaj, Iran
[3] Associate Professor, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran
[4] Assistant Professor, Department of Psychology, Roudehen Branch, Islamic Azad University, Roudehen, Iran

*** Corresponding author email address**: Zuckerini99@yahoo.com

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A B S T R A C T

Objective: Cardiovascular diseases are the primary cause of mortality in Iran. The current research aimed to compare the effectiveness of metacognitive skills training with executive function skills training on the biological markers of patients with coronary artery disease.

Methods and Materials: This study was a quasi-experimental design with a pre-test, post-test, and follow-up alongside a control group. The population consisted of patients suffering from coronary artery disease, selected conveniently from those visiting a specialized cardiac clinic affiliated with a specialized and subspecialized hospital in Kish. Data were collected using the Beck Depression Inventory and the Wisconsin Card Sorting Test. The metacognitive skills training sessions were conducted using the Metacognitive Training package (D-MCT) and the executive functions training (the Calm Rehabilitation package), over 8 sessions of 90 minutes each week for the experimental group members. No intervention was performed for the control group. Data were analyzed using multivariate analysis of variance and SPSS software version 22.

Findings: The results indicated that the executive function skills training (Calm Rehabilitation package) significantly affected blood sugar ($P<0.01$, $F=23.44$) and systolic blood pressure ($P<0.01$, $F=19.82$) compared to the control group. Similarly, metacognitive skills training (D-MCT package) significantly influenced blood sugar ($P<0.01$, $F=85.40$) and systolic blood pressure ($P<0.01$, $F=22.13$) in comparison to the control group.

Conclusion: It can be concluded that both metacognitive and executive function skills training were effective on the biological markers of patients with coronary artery disease, but there was no difference between the two treatments on the biological markers of patients with coronary artery disease.

Keywords: *Metacognition, Executive Functions, Biological Markers, Cardiovascular Disease.*

1. Introduction

Cardiovascular diseases are the main cause of death in Iran. The age of onset for these diseases has decreased, affecting many young people as well (Saha et al., 2021). Cardiovascular diseases come in various forms such as high blood pressure, coronary artery disease, valvular heart disease, congestive heart failure, atherosclerosis, and stroke. These diseases develop slowly and often without symptoms. Factors like cholesterol deposition or high blood pressure may start in childhood and go undiagnosed for decades, making prevention the best approach (Sanal Kumar et al., 2018).

Most risk factors for heart disease are related to behavior and awareness, and educational programs are a fundamental tool in changing a patient's lifestyle (Gáspár et al., 2022). Studies have shown that patient education significantly impacts reducing behaviors associated with risk factors and increasing healthy behaviors. Individuals' awareness and understanding of disease risk factors and their motivation to reduce these factors can promote health and prevent disease through lifestyle changes (Kremers et al., 2020). This research focuses on psychological variables such as depression, biological indicators like high blood pressure, high blood sugar, smoking, obesity, high blood cholesterol, and cognitive functions such as attention, concentration, recall, inhibition, and organization in patients with coronary artery disease, by conducting and comparing the effectiveness of two psychological interventions: metacognition and executive functions (Ferrannini et al., 2022).

Furthermore, studies suggest that cardiovascular diseases, along with mental illnesses, account for deaths worldwide. It appears that coronary artery disease and mental illnesses might share common causes, such as biological, behavioral, psychological, or genetic mechanisms (Ain et al., 2021). In some cardiovascular patients, symptoms arise due to the interaction of psychological and cardiac factors. In others, cardiac factors are the primary cause of symptoms, with psychological factors exacerbating cardiac symptoms (Saenz-Pipaon et al., 2021).

A variable of interest in this research problem is executive functions, a relatively new concept in neuroscience referring to top-down cognitive processes involved in flexible, goal-oriented problem-solving (Aghaziarati et al., 2021). Executive functions, as high-level brain skills, oversee and control lower-level cognitive processes, enabling adaptive human behavior in specific situations, especially when automatic behavior is inefficient (Feldmann et al., 2021). It's important that extensive research has clearly and explicitly demonstrated a multifaceted decline in challenging and risky equilibrium situations. Cognitive performance decline is a common issue in old age, placing individuals at risk (Zhu et al., 2023). Impairment in executive functions, such as working memory and response inhibition, is common in various brain disorders, including stroke patients (Prussien et al., 2021). Decreased executive functions are more pronounced in depressed patients with cardiovascular disease than in depressed patients without cardiovascular disease. A study on executive functions in older men found that older men with major depression and cardiovascular disease had lower and less efficient executive functions (Pihlaja et al., 2022).

This research includes metacognitive skills training, where metacognition is defined as an individual's knowledge or awareness of their cognitive system or knowing about knowing. This knowledge helps us monitor our progress while learning and understanding, assess the outcomes of our efforts, and gauge our mastery over the materials we have read (Versteeg et al., 2021). Burke (2000) views the role of metacognition as essential for the information processing system to function effectively, it must be self-aware. Metacognitive knowledge tells us that there are various ways to organize material to facilitate learning and recall. Essentially, metacognition is cognition because we define cognition as knowing and learning; thus, metacognition can be understood as knowing about how we think and learn (Martirosov & Moser, 2021). A closely related concept to metacognition is learning to learn. It's worth noting that cognitive strategies are ways of learning, and compared to them, metacognitive strategies are measures for monitoring and guiding cognitive strategies (Wells et al., 2023). The relationship of the concept of metacognition as a common term in education with the learning process is undeniable. Teaching metacognitive skills significantly impacts learners' learning enhancement (Pantiwati et al., 2023). The concept of metacognition was first introduced by Flavell as any cognitive activity knowledge that concerns cognition or the regulation of cognition. Cognition includes all high mental processes or learning processes in information processing (McPhillips et al., 2021).

The necessity of this research is felt for the prevention, enhancement, and psychological treatment of patients with coronary artery disease. Although various perspectives have

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offered therapeutic models and education, little research in Iran has directly compared the effectiveness of metacognitive skills training and executive functions training on depression, biological markers, and cognitive functions in patients with coronary artery disease; thus, this study seems entirely necessary as its results could significantly contribute to developing suitable programs for health psychology specialists, clinical psychologists, health and mental health professionals, and physicians involved in this field, helping individuals with cardiovascular diseases through practical program development and implementation. The main research question is whether metacognitive skills training and executive functions training are effective on the biological markers in patients with coronary artery disease.

2. Methods and Materials

2.1. Study Design and Participants

The present study was a quasi-experimental design incorporating a pre-test, post-test, and follow-up alongside a control group. The population included individuals diagnosed with coronary artery disease (CAD), conveniently selected from patients visiting a specialized cardiac clinic affiliated with a specialized and subspecialized hospital in Kish. These individuals were examined, interviewed, and diagnosed by a specialist physician and then referred to a psychologist for relevant tests. The sample size was determined through purposive sampling using Cohen's table, considering two experimental groups and one control group with a test power of 0.7, resulting in 15 participants in the experimental group and 15 in the control group, with a one-month follow-up post-intervention. Inclusion criteria included literacy, a specific period (in months) since diagnosis (with consultation from the relevant specialist and permission from the treating physician to participate in the research), at least 50% diagnosis of coronary artery disease among patients, and ages between 30 to 75 years (age was determined based on the age of the participants and availability). Exclusion criteria included severe mental disorders, substance abuse, and absence from more than two sessions during the psychological treatment classes.

The implementation involved inviting individuals interested in participating in therapeutic classes for depression improvement, cognitive rehabilitation in executive functions, and biological markers improvement. The metacognitive skills and executive functions training sessions were held over 8 sessions of 90 minutes each week for the experimental group members. No intervention was performed for the control group, but post-sessions, with the hospital's agreement, training was also conducted for this group. All necessary follow-ups were conducted one month after the educational stages of metacognitive and executive functions to test the significance and differences in skill training. The content of the educational program was meticulously prepared, with the researcher consulting experts in task design and their opinions in this area. In each session, patients were initially briefed on each task before execution. The educational program on the effectiveness of executive functions on cognitive functions, depression, and biological markers of patients with coronary artery disease was held over 10 sessions of 45 minutes each (the number of sessions and hours could vary, ensuring the content of treatment and education remains constant).

2.2. Measures

2.2.1. Biological Markers

In this study, biological markers such as blood sugar and blood pressure were precisely measured using standard medical devices. A glucometer, a tool designed for rapid measurement of blood glucose levels from a drop of blood, was employed for monitoring blood sugar levels. For blood pressure, an automated blood pressure monitor, which inflates a cuff to restrict blood flow and gradually releases this pressure while measuring systolic and diastolic pressures, was utilized. These instruments are critical for assessing the physical health outcomes of interventions, ensuring the accuracy and reliability of the results.

2.3. Interventions

2.3.1. Executive Functions Skills Training (Calm Cognitive Rehabilitation Package)

The content of the Calm Cognitive Rehabilitation training program (flexibility, inhibition, planning, organization, monitoring, and memory) used in this research is based on the previous studies (Abbasi Fashami et al., 2020; Dajani et al., 2016; Roebers, 2017; Scionti et al., 2020; Swami, 2013), focusing on executive functions training. The program was designed based on theoretical and practical evidence and utilized strategies to accommodate the characteristics of patients with coronary artery disease and depression, affecting cognitive functions. The program draws from the most used neuropsychological tests for executive functions efficacy: Stroop test model, Digit Span (forward and

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backward), Wisconsin Card Sorting Test, Go/No-Go, n-back, planning and organizing through the Andre-Ray test, Tower of London, continuous performance, matching familiar figures, and tracking.

2.3.2. Metacognitive Skills Training (D-MCT Package)

The D-MCT is a new educational program for depression management developed by the University of Hamburg, Germany. This training, a form of cognitive-behavioral therapy utilizing a metacognitive perspective, aims to empower group members to identify and correct unconscious and automatic thought patterns associated with depression. Participants are educated on thought patterns and encouraged to engage with them creatively and critically, using clear examples from everyday life. Another goal is for individuals to become familiar with their ineffective assumptions and coping strategies and confront them in the same challenging and creative manner. Although this method is primarily used for psychosis management, it also focuses on cognitive biases specific to depression. The effectiveness of the updated version of this training was confirmed by a study by Wells et al. (2023), showing effect sizes for reducing depression symptoms between 0.56 and 0.73 (Wells et al., 2023).

2.4. Data analysis

Data were analyzed using multivariate analysis of variance and SPSS version 22.

3. Findings and Results

The demographic characteristics of the participants in the current study, including age, education level, marital status, duration of disease, and gender, showed no significant difference between the groups in terms of demographic variables, indicating that the groups were homogeneous demographically.

Table 1

Mean ± Standard Deviation of Biological Markers

Variable	Group	Pre-test	Post-test	Follow-up
Blood Sugar (mg/dL)	Executive Functions	135.56 ± 7.69	132.31 ± 7.56	126.75 ± 8.02
	Metacognitive Skills	138.00 ± 7.72	133.12 ± 6.84	126.00 ± 4.96
	Control	139.82 ± 8.43	140.47 ± 8.80	142.12 ± 8.05
Systolic Blood Pressure (mmHg)	Executive Functions	146.28 ± 6.21	141.46 ± 6.33	136.35 ± 8.26
	Metacognitive Skills	144.74 ± 4.18	141.93 ± 4.11	134.94 ± 7.62
	Control	145.16 ± 6.77	144.75 ± 6.01	147.45 ± 6.70
Diastolic Blood Pressure (mmHg)	Executive Functions	86.09 ± 4.60	84.97 ± 4.11	84.85 ± 3.27
	Metacognitive Skills	87.60 ± 3.99	86.03 ± 4.04	85.03 ± 3.18
	Control	86.30 ± 5.16	85.97 ± 5.29	86.34 ± 4.16

Table 1 shows the mean and standard deviation of biological markers (blood sugar, systolic and diastolic blood pressure) among the participants of the research groups, in three stages: pre-test, post-test, and follow-up.

Before analyzing the data, the Shapiro-Wilk index related to the scores of each of the variables was checked. It was found that this index was significant for systolic blood pressure in the executive function training group at the pre-test stage and in the metacognitive skills training group at the follow-up stage at the 0.05 level. Although this indicates that the distribution of that variable was not normal in those groups, given the significance level of the Shapiro-Wilk index, it can be said that the deviation from the assumption was not severe and is not expected to invalidate the results. The Levene's test also showed that the variance in error scores for none of the biological markers across groups and at the three stages of pre-test, post-test, and follow-up was significant at the 0.05 level. Multivariate analysis of variance results indicated that before the implementation of the independent variable, there was no significant difference between the groups in terms of biological markers ($P < 0.05$, $F(6, 90) = 0.75$); therefore, the pre-test independence assumption from group membership was maintained for the data.

The results showed that the assumption of homogeneity of covariance matrices for the dependent variables was not met for any of the biological markers. Despite this, given the similarity in sample sizes across groups, it is expected that this would not invalidate the results. Additionally, the results indicate that the interactive effect of group × time on blood sugar (Wilks' Lambda = 0.302, $\eta^2 = 0.450$, $P = 0.001$, $F(4, 92) = 18.84$) and systolic blood pressure (Wilks' Lambda =

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0.471, η^2 = 0.314, P = 0.001, F(4, 92) = 10.51) was significant at the 0.01 level. It is worth mentioning that the interactive effect of group × time on diastolic blood pressure was not significant at the 0.05 level. The sphericity condition or the equality of error variance matrices was evaluated using the Mauchly's test, and it was found that the Chi-square value related to blood sugar (P < 0.01, w = 0.603, χ^2(2) = 23.26) and systolic blood pressure (P < 0.01, w = 0.40, χ^2(2) = 40.27) was significant at the 0.01 level. This finding indicates that the sphericity assumption was not met for these two variables. Therefore, the degrees of freedom related to them were corrected using the Greenhouse-Geisser method. Table 2 shows the results of the mixed design analysis in explaining the effect of independent variables on biological markers.

Table 2

Results of Mixed-Design Analysis Explaining the Effect of Independent Variables on Biological Markers

Biological Markers	Sum of Squares	Sum of Squares Error	df	F	p	η^2
Blood Sugar	973.69	660.07	67.29 and 2.86	34.67	0.001	0.596
Systolic Blood Pressure	905.34	1849.08	59.37 and 2.53	11.51	0.001	0.329
Diastolic Blood Pressure	29.41	884.92	94 and 4	0.78	0.539	0.032

Table 2 indicates that the interactive effect of group × time on blood sugar (η^2 = 0.596, P = 0.001, F(2.86, 29.67) = 34.67) and systolic blood pressure (η^2 = 0.329, P = 0.001, F(2.53, 37.59) = 11.51) was significant at the 0.01 level. This suggests that at least the implementation of one of the independent variables, in comparison with the other independent variable or the control group, significantly affected blood sugar and systolic blood pressure. The question now is, which of the independent variables had a significant effect in comparison with the other independent variable or the control group? To answer this question, the analysis was repeated for each of the biological markers, blood sugar, and systolic blood pressure, three times, comparing only the effect of two groups in each analysis, with the results presented in Table 3.

Table 3

Significant Comparison of Interactive Effect of Group × Time on Blood Sugar and Blood Pressure

Compared Groups	Sum of Squares	Sum of Squares Error	df	F	p	η^2
Blood Sugar						
First-Second	41.88	622.30	43.52 and 1.40	2.09	0.149	0.063
First-Third	523.45	366.89	40.38 and 1.30	23.44	0.001	0.588
Second-Third	883.20	330.94	52.09 and 1.63	85.40	0.001	0.727
Systolic Blood Pressure						
First-Second	20.86	1700.93	38.81 and 1.25	0.38	0.588	0.012
First-Third	631.74	998.02	40.48 and 1.31	19.82	0.001	0.390
Second-Third	697.98	1009.23	39.60 and 1.24	22.13	0.001	0.409

First Group: Executive Functions; Second Group: Mindfulness; Third Group: Control

Table 3 shows the mean and standard deviation of biological markers (blood sugar, systolic and diastolic blood pressure) among the participants of the research groups, in three stages: pre-test, post-test, and follow-up. shows that executive function skills training, compared to the control group, significantly affected blood sugar (P < 0.01, F(1.30, 38.40) = 23.44) and systolic blood pressure (P < 0.01, F(1.31, 48.40) = 19.82) at the 0.01 level of significance. Additionally, Table 5 indicates that metacognitive skills training, compared to the control group, significantly affected blood sugar (P < 0.01, F(1.63, 52.09) = 85.40) and systolic blood pressure (P < 0.01, F(1.24, 39.40) = 22.13) at the 0.01 level of significance.

It should be explained, based on the results, that neither training method had a significant effect on diastolic blood pressure, and the difference in the effect of implementing the two independent variables on biological markers was not statistically significant.

4. Discussion and Conclusion

The aim of the present study was to compare the effectiveness of metacognitive skills training with executive

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function skills training on the biological markers of patients with coronary artery disease. Based on the findings, it was observed that metacognitive skills training was effective on the biological markers in patients with coronary artery disease. The findings also indicate that executive function training is effective on the biological markers in patients with coronary artery disease. These results align with the research conducted by previous researchers (Bellinger et al., 2021; Pantiwati et al., 2023; Sanal Kumar et al., 2018; Scionti et al., 2020; Wells et al., 2023; Wollesen et al., 2020).

One of the primary mechanisms of this treatment is metacognitive strategies. Metacognitive strategies are responses used to control and change thinking, aiding in emotional and cognitive self-regulation. Selected strategies can intensify or suppress cognitive activities, changing their nature. Some strategies aim to reduce negative thoughts or emotions by altering specific cognitive dimensions. Indeed, since negative metacognitive beliefs guide individuals to choose and persist in using inappropriate and ineffective coping strategies in response to thoughts or desires, addressing these beliefs plays a crucial role in metacognitive therapy for all emotional disorders. Another mechanism of this treatment is experience. Experiences such as the feeling of knowing and judgment about learning are explored in experimental works on memory and judgment (Wells et al., 2023). Metacognitive therapy employs cognitive methods like relaxation training, emotional regulation training to improve cognitive and metacognitive distortions, and beliefs related to the body, cognitive errors, and coping with these cognitions, techniques for stress management, and negative thoughts. Behavioral techniques such as imaginary and real exposure are used in metacognitive therapy to modify negative perceptions. Through exposure using systematic desensitization, clients are taught to gradually face parts of their body causing discomfort along with relaxation techniques, thereby reducing tension, discomfort, and anxiety, and in turn, receiving a sense of satisfaction and completeness (Drigas et al., 2022). Therefore, metacognitive therapy through metacognitive and emotional strategies leads to correction and enhancement of somatic intelligence, subsequently improving the biological markers in patients with coronary artery disease.

Furthermore, the foundation of metacognitive training helps patients to control their thoughts in a way that promotes logical, intellectual behavior with specific and concrete goals. This therapy helps patients to bring about immediate changes in their lives with specific strategies. It also emphasizes the replacement of positive thoughts for negative thoughts and realistic thinking. Metacognitive training teaches patients that they can find solutions to many of their everyday problems through planning and organizational skills. These skills can significantly reduce the quantity and intensity of everyday problems they face (Martirosov & Moser, 2021). To achieve this goal, patients are encouraged to reward themselves after planning and implementation. Besides these rewards, completing a task itself is a reward that gives clients a sense of achievement. Success is a very strong motivational reinforcer. High motivation increases individual's attention and concentration while reducing internal restlessness. The metacognitive training process works hard to reduce patients' problems. Problem-solving methods teach patients to consider potential solutions and outcomes instead of impulsively responding to issues. During therapy, patients learn to delay gratification by breaking tasks into smaller steps and receiving rewards, thus significantly resolving avoidance problems.

It appears that executive function training, with a focus on performance processes, can lead to a personal review and consequently to healthy thinking and functioning, primarily benefiting the patients themselves. Patients who master social skills effectively gain the competencies required for successful and appropriate social participation. Furthermore, findings suggest that the frontal lobes of the brain, which are involved in social-emotional competence development and related to the brain's self-regulation processing, often referred to in executive functions, are considered (Scionti et al., 2020). Studies have also shown that executive function deficits in patients are significant predictors of their performance, thereby necessitating early diagnosis and intervention in this patient group. Thus, these patients need early diagnosis and intervention to learn the basic skills necessary for future success (Wollesen et al., 2020).

5. Limitations & Suggestions

A major limitation of this study is related to external validity since the research population was a specific group, namely individuals with coronary artery disease, limiting the generalizability of the results. Data collection in this study was based on self-report scales. Therefore, another limitation relates to measurement, as feedback or self-reported opinions from these tests may differ from what we can observe in actual behavior. The research design was quasi-experimental, lacking the benefits of true experimental designs. Future research should use other therapeutic

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approaches in comparison with this method to allow for the comparison of the effectiveness of metacognitive therapy with other approaches. It is recommended that future researchers use a specialist as a therapist and instructor in their research to reduce the likelihood of bias. It is suggested that this research be conducted in other cities and its results evaluated. This research should be followed up with individual counseling after group training. Given the impact of metacognitive therapy and executive functions, it is recommended that psychologists widely utilize metacognitive therapy and executive functions. Based on the findings of the present study, mental health professionals and individuals in the health and hygiene sector are advised to enhance cardiac patients' mental health by designing and applying appropriate methods inspired by metacognitive therapy and executive functions.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethics Considerations

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

Transparency of Data

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

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Authors' Contributions

All authors equally contributed to this article.

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