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Investigating the Effectiveness of Mindfulness Skills on Cognitive Flexibility and Working Memory in Ninth-Grade Students

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A B S T R A C T

Objective: The present study aimed to investigate the effectiveness of mindfulness skills training on cognitive flexibility and working memory.

Methods and Materials: The research method was quasi-experimental with a pretest-posttest and follow-up design with a control group. The statistical population of this research included all ninth-grade secondary school students in the city of Jajarm during the academic year 2023-2022, who were enrolled in public, non-public (non-profit), exemplary public, Martyr, and gifted schools. A total of 60 subjects were selected through cluster sampling and randomly assigned to two equal groups of 30 participants (an experimental group and a control group). Data were collected using the Working Memory Test by Daneman and Carpenter (1980) and the Cognitive Flexibility Questionnaire by Dennis and Vander Wal (2010). Data analysis was performed using SPSS software and multivariate analysis of covariance (MANCOVA).

Findings: The results indicated that mindfulness skills training had a significant effect on the cognitive flexibility of ninth-grade students ($P < .05$), and it also had a significant effect on the working memory of ninth-grade students ($P < .05$).

Conclusion: In conclusion, this study demonstrates that mindfulness skills training significantly enhances cognitive flexibility and working memory in ninth-grade students. These findings underscore the potential benefits of integrating mindfulness practices into educational programs to support students' cognitive development and adaptive functioning in academic and everyday environments.

Keywords: *Mindfulness skills, cognitive flexibility, working memory*

1. Introduction

One of the greatest challenges in the education of adolescents is the teaching process aimed at enhancing effective student learning (Dawson & Guere, 2018). Today, with a greater emphasis on technology, life success significantly depends on students' abilities to plan, organize, prioritize information, distinguish main ideas from details, flexibly change approaches, monitor progress, and reflect on their activities, all of which are key components of

executive functions of the brain (Meltzer, 2007). Executive functions refer to the processes necessary for the conscious control of one's thoughts, emotions, and behaviors, playing a crucial role in managing daily life and enabling appropriate responses to environmental stimuli and adaptation to surroundings. These cognitive processes are associated with the prefrontal cortex, which is the most significant neural area involved in adaptive behavior, social behavior, cognitive flexibility, and goal achievement (Farajzadeh, 2020; Kahaki, 2024). Executive functions develop throughout childhood and adolescence and are highly influential in academic success (Khatri, 2024; Latzman et al., 2012). These functions comprise skills that help individuals focus on critical aspects of a task and plan for its completion (Hart & Jacobs, 2010; Rahmani et al., 2024).

Executive functions include various components, such as self-regulation, planning, inhibition, impulse control, initiation and monitoring of activities, response inhibition, attention, problem-solving, working memory, and cognitive flexibility (Hill, 2004). Cognitive flexibility encompasses behaviors grounded in personal values, and possessing it enables a person to commit to valued actions beyond mere avoidance of distressing thoughts, feelings, memories, or impulses (Farajzadeh, 2020). Cognitive flexibility refers to the ability to select the most appropriate action among options, rather than performing actions solely to avoid discomfort. Humans must enhance adaptability across personal, familial, and social domains, with environmental adaptation being the most critical individual activity (Azizian et al., 2017). High cognitive flexibility is a sign of a healthy lifestyle and the ability to adapt behaviorally and attitudinally to one's environment (Azunny et al., 2020).

Another crucial executive function is working memory, a cognitive process essential for thinking and learning (Alidousti & Asgari, 2016). Transient working memory requires attention and temporary information storage, whereas executive working memory necessitates more substantial mental manipulation of that information (Janeh et al., 2012). The term "working memory" refers to a system responsible for the temporary manipulation and storage of information, serving as a flexible workspace for supporting daily cognitive activities that require both information processing and storage. It has recently been established that working memory can be improved through adaptive training tasks that enhance its capacity (Deng et al., 2020). Furthermore, one out of every ten students suffers from working memory issues. If no intervention is provided, these students may face academic difficulties over time. Conventional individual education programs for students with learning difficulties often fail to bring them to the same level as their peers (Gabriely et al., 2020).

A concept that enhances cognitive flexibility is mindfulness. Mindfulness is described as the process of paying attention to moment-by-moment experiences and as a combination of self-regulation of attention with curiosity, openness, and acceptance of experiences (Janz et al., 2019). Mindfulness is not about understanding the past or correcting incorrect ways of thinking but rather focuses on awareness of underlying triggers for cognition and emotions, exposing the hidden themes of life without judgment or blame (Aghababayi, 2017). It recognizes that emotions consist of thoughts, physical sensations, raw feelings, and impulses, and they often indicate broader issues in how we relate to ourselves, others, and the world, merely serving as signals to be observed non-judgmentally in the present moment. Mindfulness trains the mind, acting like a microscope that reveals the deepest patterns of thought; when the mind engages in observation, thoughts and emotions spontaneously dissolve (Badleh Shamushki et al., 2021).

Mindfulness, as a lifestyle practice, involves meditative exercises integrated into daily life, helping individuals become aware of dualistic mental states and use them cohesively. Through formal meditations (e.g., breathing meditation, mindful yoga, body scan) and informal practices (e.g., mindful eating, walking, showering) that break habitual patterns, individuals learn to be fully present in the "here" and "now." Failing to be in the moment creates a gap between the individual and reality, hindering the correct understanding of situations and the ability to give reasoned, mindful responses (Janssen et al., 2018). Additionally, according to Robazza and Ruiz (2018), mindfulness means paying attention purposefully, in the present moment, and non-judgmentally. Through mindfulness training, individuals learn to become aware of their mental state and focus attention differently (Robazza & Ruiz, 2018). The logic behind mindfulness is skill retention, allowing one to disengage from the automatic processes shaped by habitual rumination, thereby drawing attention to reality and expanding problem-solving options (Lee & Brown, 2022). Given the presented information, contradictory findings, and research gaps on this topic, this study aims to examine the impact of mindfulness skills on cognitive flexibility and working memory in ninth-grade students in Jajarm schools.

2. Methods and Materials

JAYPS Adolescent and Youth Psychological Studies
E-ISSN: 2981-2526

2.1. Study Design and Participants

The present study employed a quasi-experimental design with a pretest-posttest and follow-up phase, accompanied by a control group. The study included an experimental group and a control group, and both groups underwent pretests, posttests, and follow-up assessments. To ensure the stability of the learned skills during the training period and to provide participants with adequate time to experience their learning in real-life settings, a six-month interval was deemed necessary. The statistical population included all ninth-grade students in secondary school in the city of Jajarm during the 2023-2022 academic year, studying in public, non-public (non-profit), exemplary public, Martyr, and gifted schools. The total number of students was 593. To address the research questions and examine the effectiveness of mindfulness on the study's dependent variables, ninth-grade students in Jajarm were randomly selected using a cluster sampling method. A list of existing schools was prepared, and six schools were randomly chosen, selecting two classes from each school. Ultimately, 90 students were randomly selected and divided into an experimental group (60 students) and a control group (30 students). The experimental group received mindfulness training intervention. The control group received no intervention. The inclusion criteria were being a ninth-grade student (due to the researcher's access to this grade) and enrollment in Jajarm schools, while the exclusion criterion was missing more than three sessions.

2.2. Measures

2.2.1. Working Memory

The Working Memory Test by Daneman and Carpenter (1980) includes 27 sentences. The purpose of this test is to assess the ability to correctly determine the semantic truth or falsity of statements, as well as to evaluate working memory. The reliability of this test was reported as .88 in a preliminary study conducted by Dr. Hassan Asadzadeh on 84 psychology and education students at Allameh Tabataba'i University (Aghababayi, 2017). In the present study, the reliability, calculated using the Kuder-Richardson method, was .87, indicating high reliability for the test.

2.2.2. Cognitive Flexibility

The Cognitive Flexibility Inventory (CFI) was developed by Dennis and Vander Wal in 2010 and consists of 20 items. It is used to assess an individual's progress in developing flexible thinking, particularly in clinical and non-clinical settings, and for evaluating the effectiveness of cognitive-behavioral therapy for depression and other psychological disorders. In Iran, three subscales—alternatives, control, and alternatives for human behavior—were identified in a study by Shara et al. (2014). The inventory uses a 5-point Likert scale, ranging from "Strongly Disagree" (1) to "Somewhat Agree" (5). Dennis and Vander Wal (2010) reported a concurrent validity of -.39 with the Beck Depression Inventory (BDI-II) and a convergent validity of .75 with the Martin and Rubin Cognitive Flexibility Scale. In Iran, Shara and colleagues (2014) reported a test-retest reliability of .71 and a Cronbach's alpha of .90 for the entire scale (Saghebi et al., 2020). In the present study, Cronbach's alpha for the subscales—alternatives, control, and alternatives for human behavior—was .72, .55, and .57, respectively.

2.3. Intervention

2.3.1. Mindfulness Training

The mindfulness training protocol used in this study was adapted from the approach by Kabat-Zinn et al. (1992). The intervention consisted of 8 structured sessions (Gabriely et al., 2020; Janssen et al., 2018; Janz et al., 2019; Kazemi et al., 2019), each containing three phases. After obtaining participants' consent, the training was conducted by the researcher. Participants were randomly assigned to either the experimental or control group. The training comprised 8 group sessions, each lasting between 1 to 1.5 hours, and was carried out over a period of 1 to 1.5 months.

Session One: This session involved administering the pre-test, establishing rapport, and conceptualizing the issue. The first half-hour was dedicated to the pre-test. Following the pre-test, the method of mindfulness-based stress reduction and its impact on health and well-being were explained, supported by research evidence.

Session Two: Progressive Muscle Relaxation (PMR) was taught. After a brief review of the previous session, participants learned PMR techniques, including tensing and relaxing various muscle groups. The relaxation exercises were performed for 14 muscle groups with closed eyes: forearms (5 minutes), arms (5 minutes), calves and lower legs (10 minutes), thighs (5 minutes), abdomen and chest (10 minutes), shoulders and neck (10 minutes), lips and jaws (10 minutes), and forehead and eyes (10 minutes). To prevent sleep, participants opened their eyes for 2 minutes after each exercise.

JAYPS Adolescent and Youth Psychological Studies E-ISSN: 2981-2526

Session Three: This session reviewed the previous session and repeated PMR for 6 muscle groups with closed eyes: hands and arms (10 minutes), legs and thighs (10 minutes), abdomen and chest (10 minutes), neck and shoulders (10 minutes), jaws and lips (10 minutes), and forehead and eyes (10 minutes). As in the previous session, participants opened their eyes for 2 minutes between exercises. Homework was assigned, requiring participants to practice PMR for 20 minutes, and a simple guide was provided.

Session Four: Breath awareness was introduced. After reviewing the previous session, participants were trained in mindful breathing. Techniques included normal and deeper breathing, observing the flow of air and chest movements, and mentally repeating calming phrases. The session consisted of sitting comfortably (10 minutes), practicing deeper breathing (15 minutes), observing breath movements (15 minutes), and repeating calming words (15 minutes). Breaks of 2 to 3 minutes were given between steps to prevent sleepiness. Homework was to practice deep breathing before bed.

Session Five: The Body Scan technique was taught in this session. Participants practiced observing chest and abdomen movements (15 minutes), focusing on different body parts to increase awareness (20 minutes), listening to surrounding sounds and their own breath (15 minutes), and exploring smell and taste by mindfully eating a sweet (10 minutes). Breaks of up to 5 minutes were provided between exercises. Homework was to practice mindful eating at least once.

Session Six: Mindfulness of Thoughts was the focus. Participants first practiced concentrating on a mental point or symbol without thinking about anything else (15 minutes). Then, a negative thought was introduced, and participants were guided to non-judgmentally observe it (30 minutes). A positive thought was subsequently introduced, and participants practiced observing it non-judgmentally (30 minutes). Breaks of 5 to 10 minutes were given as needed.

Session Seven: This session involved a comprehensive review of techniques from sessions 4, 5, and 6. Participants practiced normal and deeper breathing (8 minutes), observing breath movements (10 minutes), repeating calming words (10 minutes), performing the Body Scan (8 minutes), and focusing on body awareness and sounds (8-10 minutes each). Breaks of 2 to 5 minutes were given. Homework included practicing deep breathing for 20 minutes before sleep and mindful eating.

Session Eight: The final session reviewed all techniques, emphasized the importance of integrating mindfulness into daily life, and administered the post-test (30 minutes). Participants were encouraged to use mindfulness techniques to promote well-being and improve their health.

2.4. Data Analysis

Inferential statistics were used to analyze the data. To perform parametric statistical tests, the interval scale of measurement for the variables and the condition of homogeneity of variances were required. Additionally, to use repeated measures analysis of variance, it was necessary to check Mauchly's test of sphericity. Before conducting repeated measures analysis of variance, the assumptions of the test were assessed, and Mauchly's test was used to examine the homogeneity of the variance-covariance matrices of the research variables.

3. Findings and Results

The descriptive statistics for the variables, cognitive flexibility and working memory, across all stages (pre-test, post-test, and follow-up) for both the mindfulness training and control groups are presented in Table 1.

Table 1

Mean (M) and Standard Deviation (SD) of Cognitive Flexibility and Working Memory

Variable	Group	Pre-test M (SD)	Post-test M (SD)	Follow-up M (SD)
Cognitive Flexibility	Control	60.70 (2.95)	60.85 (2.97)	60.50 (2.92)
	Mindfulness Training	60.85 (2.98)	67.30 (3.26)	65.90 (3.12)
Working Memory	Control	48.25 (2.15)	48.75 (2.13)	48.15 (2.10)
	Mindfulness Training	48.35 (2.19)	62.60 (3.02)	60.40 (2.90)

Table 1 indicates that in the mindfulness training group, the mean scores for both cognitive flexibility and working memory increased from pre-test to post-test and were maintained at follow-up. In contrast, the control group's scores remained relatively stable across all stages.

JAYPS
Adolescent and Youth Psychological Studies
E-ISSN: 2981-2526

The results of the univariate analysis of covariance (ANCOVA) for cognitive flexibility and working memory are combined in Table 2.

Table 2

Results of Univariate ANCOVA for Cognitive Flexibility and Working Memory

Variable	Effect	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	F	Significance Level (P)	Effect Size (Eta)
Cognitive Flexibility	Group (Post-test)	135.53	1	135.53	59.57	.001	.53
	Group (Follow-up)	124.32	1	124.32	50.48	.001	.49
Working Memory	Group (Post-test)	163.23	1	163.23	75.14	.001	.62
	Group (Follow-up)	155.15	1	155.15	70.20	.001	.58

Table 2 shows that the F values for ANCOVA were significant for both cognitive flexibility and working memory in both the post-test and follow-up phases ($P < .001$). The effect sizes indicate a strong effect of the mindfulness training on both variables.

The Bonferroni post-hoc test results for comparing the adjusted means of cognitive flexibility and working memory between the mindfulness training and control groups are presented in Table 3.

Table 3

Bonferroni Post-hoc Test Results for Adjusted Means

Variable	Groups Compared	Adjusted Means	Mean Difference	Standard Deviation	Significance Level (P)
Cognitive Flexibility	Experimental - Control (Post-test)	67.30 - 60.85	-6.45	0.27	.001
	Control - Experimental (Post-test)	60.85 - 67.30	6.45	0.27	.001
	Experimental - Control (Follow-up)	65.90 - 60.50	5.40	0.23	.001
	Control - Experimental (Follow-up)	60.50 - 65.90	-5.40	0.23	.001
Working Memory	Experimental - Control (Post-test)	62.60 - 48.75	13.85	0.56	.001
	Control - Experimental (Post-test)	48.75 - 62.60	-13.85	0.56	.001
	Experimental - Control (Follow-up)	60.40 - 48.15	12.25	0.49	.001
	Control - Experimental (Follow-up)	48.15 - 60.40	-12.25	0.49	.001

Table 3 demonstrates that there were significant differences between the experimental and control groups in both cognitive flexibility and working memory for both the post-test and follow-up phases ($P < .001$). The mindfulness training group showed significantly higher adjusted means compared to the control group in both variables.

4. Discussion and Conclusion

The aim of the present study was to examine the effectiveness of mindfulness skills training on cognitive flexibility and working memory. The results indicated that in both the post-test and follow-up phases, the experimental group demonstrated greater cognitive flexibility compared to the control group. Therefore, mindfulness skills training has a significant impact on the cognitive flexibility of ninth-grade students in Jajarm. The findings of this hypothesis are well-supported by empirical evidence. Additionally, in both the post-test and follow-up phases, the experimental group showed higher levels of working memory compared to the control group. The results of the present study are sufficiently supported by empirical evidence and align with the previous findings (Ahmadi et al., 2019; Bitar et al., 2023; Emam Verdi & Taher, 2020; Gu et al., 2018; Saghebi et al., 2020), all of which provide evidence for the effectiveness of mindfulness. Many of these studies highlight the impact of mindfulness on psychological flexibility. Furthermore, the results are consistent with the prior findings (Kazemi et al., 2019; Nemati et al., 2019), which also provide evidence for the effectiveness of mindfulness and its impact on reducing mental wandering, distress, and consequently improving working memory.

JAYPS Adolescent and Youth Psychological Studies
E-ISSN: 2981-2526

To explain the results, it can be stated that mindfulness skills training leads to changes in breathing patterns, cultivation of attention and mental awareness, strengthening of the heart muscle, improved blood circulation, muscle relaxation, and the release of the mind from stress and negative emotions during practice (Bitar et al., 2023). As a result, this leads to improved adaptive behavior in response to environmental conditions. Williams suggests that mindfulness can increase cognitive flexibility, thereby enabling creative approaches to different issues. From another perspective, Kabat-Zinn asserts that maintaining present-moment awareness prevents the activation of automatic thought patterns and reduces cognitive biases and judgment errors, leading to a decrease in anxiety and depression and directing mental capacity toward ongoing tasks. By allocating attention resources to actions, working memory capacity increases, helping to prevent distractions and control attention, which in turn enhances problem-solving abilities (Kazemi et al., 2019). Consequently, students' performance during testing (i.e., the moments when an individual takes action after reaching a mental solution) improves. The increase in the number of correct solutions is logically related to a decrease in errors, and faster performance improves overall time efficiency. Mindfulness exercises, by generating alpha waves below the relaxation threshold, promote higher levels of alertness, reduce errors, and enhance working memory.

In conclusion, it can be asserted that mindfulness skills training is effective in improving cognitive flexibility and working memory among ninth-grade students. Mindfulness skills training can lay the foundation for enhancing cognitive flexibility and working memory in students.

5. Limitations & Suggestions

One of the main limitations of this study is the use of a quasi-experimental design, which may limit the ability to establish causal relationships. The sample size was relatively small and limited to ninth-grade students in Jajarm, which reduces the generalizability of the findings to other age groups or regions. Additionally, the reliance on self-reported measures for cognitive flexibility and working memory could introduce bias, as participants may not always accurately reflect their abilities. The study also did not control for other factors, such as individual differences in baseline stress levels or previous mindfulness experience, which could have influenced the outcomes. Using objective measures, such as neuroimaging or cognitive performance tasks, could provide more reliable assessments of cognitive flexibility and working memory. Longitudinal studies would also be beneficial to explore the long-term effects of mindfulness training. Moreover, mindfulness skills training can be incorporated into school curricula to help students enhance their cognitive flexibility and working memory, which are essential for academic success and overall well-being. Teachers and school counselors could be trained to deliver mindfulness-based interventions, fostering a supportive environment for students to manage stress and improve focus.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

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

Transparency of Data

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

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Authors' Contributions

All authors equally contributed to this article.

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