KMAN PUBLISHING INSTITUTE
Journal Website

Article history:
Received 15 July 2025
Revised 19 October 2025
Accepted 24 October 2025
Initial Published 26 October 2025
Final Publication 10 December 2025

Journal of Adolescent and Youth Psychological Studies

Volume 6, Issue 12, pp 1-11

E-ISSN: 2981-2526

Comparison of the Effectiveness of Cognitive and Metacognitive Strategies Training and Mindfulness on Academic Self-Regulation Components in Female High School Students

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A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Hoodarsha, F., Sepahmansour, M., & Barzegar, M. (2025). Comparison of the Effectiveness of Cognitive and Metacognitive Strategies Training and Mindfulness on Academic Self-Regulation Components in Female High School Students. *Journal of Adolescent and Youth Psychological Studies, 6*(12), 1-11.
http://dx.doi.org/10.61838/kman.jayps.4610

A B S T R A C T

Objective: The objective of this study was to compare the effectiveness of cognitive and metacognitive strategy training and mindfulness training on the components of academic self-regulation—metacognition, cognition, and motivation—among female high school students.

Methods and Materials: This applied, semi-experimental study employed a pre-test, post-test, and follow-up design with a control group. The statistical population consisted of female high school students in District 13 of Tehran during the 2024–2025 academic year. Using cluster sampling, 45 students with low academic self-regulation, hope, and buoyancy scores were selected and randomly assigned to three groups: cognitive and metacognitive strategies training (n = 15), mindfulness training (n = 15), and control (n = 15). Interventions consisted of eight weekly one-hour sessions based on McCombs' cognitive-metacognitive training protocol and Kabat-Zinn's mindfulness training protocol. Data were collected using the validated Academic Self-Regulation Questionnaire (Bouffard et al., 1995; Ghasemi & Fooladchang, 2011) at pre-test, post-test, and three-month follow-up. Data were analyzed using mixed ANOVA and Bonferroni post-hoc tests in SPSS v.22.

Findings: Inferential results showed significant main effects of time and significant time-by-group interactions for all components of academic self-regulation ($p < .0005$). Cognitive and metacognitive strategy training produced the largest improvements in cognition and motivation, whereas mindfulness training was particularly effective in enhancing metacognitive awareness and demonstrated sustained improvements at follow-up. Bonferroni comparisons indicated that both intervention groups significantly outperformed the control group across all components, with cognitive and metacognitive strategies training showing stronger effects on motivation and cognition, while mindfulness training exhibited more durable effects on metacognition.

Conclusion: Both cognitive and metacognitive strategy training and mindfulness training effectively improved academic self-regulation in adolescents, though their strengths varied across components. The findings suggest that strategy-based training enhances motivation and cognitive regulation more strongly, while mindfulness training fosters sustainable metacognitive awareness. These results highlight the potential value of integrating both approaches in educational interventions to promote comprehensive academic self-regulation.

Keywords: *Academic self-regulation, cognitive strategies, metacognitive strategies, mindfulness, motivation, adolescents, educational intervention*

1. Introduction

Academic self-regulation has emerged as one of the most significant predictors of students' academic performance, psychological well-being, and long-term educational success. Self-regulation is broadly understood as the capacity to monitor, control, and direct one's cognitive, motivational, and behavioral processes toward achieving academic goals. Within this framework, cognitive and metacognitive strategies, along with mindfulness-based interventions, have gained increasing scholarly attention as mechanisms that enhance self-regulatory skills and improve learning outcomes. The importance of such mechanisms is particularly emphasized in adolescence, a critical developmental stage when students face complex academic, social, and emotional challenges. In recent years, researchers have demonstrated that fostering self-regulation not only boosts academic achievement but also serves as a protective factor against maladaptive behaviors such as procrastination, test anxiety, and disengagement from school. Consequently, interventions that enhance cognitive, metacognitive, and mindfulness skills have become central in educational psychology research and practice (Ghasemi et al., 2025).

Cognitive and metacognitive strategies represent a structured set of skills that allow learners to plan, monitor, and evaluate their thinking processes, while simultaneously applying concrete methods to improve academic outcomes. Cognitive strategies include rehearsal, elaboration, and organization, whereas metacognitive strategies involve planning, monitoring, and regulating cognitive activities. Studies have indicated that training in these domains can profoundly improve students' capacity for autonomous learning and problem-solving (Ashoori et al., 2014). For example, Ashoori and colleagues established a predictive model in which cognitive and metacognitive strategies, together with achievement goal orientation and spiritual intelligence, explained significant variance in academic success among high school students. Similarly, research on self-regulation has consistently shown that students who are better able to deploy cognitive and metacognitive strategies demonstrate higher levels of motivation, academic resilience, and long-term goal orientation (Osuli et al., 2016). This evidence highlights the central role of cognitive and metacognitive interventions in academic contexts.

Alongside cognitive and metacognitive training, mindfulness has been proposed as a complementary or alternative approach to enhancing self-regulation. Mindfulness involves paying deliberate, non-judgmental attention to present-moment experiences, and its application in education has been shown to reduce academic stress and promote adaptive self-regulation. For example, Ramli and colleagues found that mindfulness mediated the relationship between academic stress and self-regulation in Malaysian students, illustrating its potential as a psychological buffer in demanding educational environments (Ramli et al., 2018). Similarly, Tajoldini and colleagues showed that mindfulness-based stress reduction training improved both academic buoyancy and self-regulation in high school students, demonstrating the practical value of mindfulness interventions in adolescence (Tajoldini et al., 2018). These findings align with the growing body of evidence suggesting that mindfulness enhances students' awareness of their own cognitive and emotional processes, thereby improving metacognitive awareness and adaptive coping strategies.

At the intersection of these approaches lies an important research gap. While both cognitive/metacognitive training and mindfulness have been individually linked to improved academic self-regulation, fewer studies have directly compared their relative effectiveness in the same educational context. This comparison is crucial, as each approach may foster different aspects of self-regulation. For example, cognitive and metacognitive strategies may primarily strengthen planning, monitoring, and evaluation skills, whereas mindfulness may enhance emotional regulation and attention control. Enayati Shabkolai and colleagues demonstrated that an intervention based on acceptance and commitment therapy improved self-regulation and cognitive flexibility among students with specific learning disorders, highlighting the relevance of emotion-focused and mindfulness-based methods (Enayati Shabkolai et al., 2023). In contrast, Mohammadi Darvish Bighal and colleagues found that training in cognitive and metacognitive self-regulation strategies had substantial effects on motivational beliefs, academic self-efficacy, and test anxiety, pointing to the particular strength of strategy-based interventions (Mohammadi Darvish Bighal et al., 2020). Comparing these two paradigms can provide deeper insight into their unique contributions to academic self-regulation.

Beyond direct intervention studies, theoretical and empirical work has provided further justification for focusing on these constructs. Ihor and Ruslana emphasized the importance of metacognitive awareness as a predictor of academic self-regulation among university students, underscoring the generalizability of these processes across educational levels (Ihor & Ruslana, 2021). Ziegler and Opdenakker demonstrated that the development of academic

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

procrastination in secondary education was strongly linked to metacognitive self-regulation, self-efficacy, and effort regulation, reinforcing the idea that deficits in self-regulation can manifest as maladaptive academic behaviors (Ziegler & Opdenakker, 2018). Rafezi and colleagues reported that group-based metacognitive therapy significantly improved emotional self-regulation and ego strength among anxious students, showing the relevance of metacognitive approaches not only in academic but also in clinical and emotional contexts (Rafezi et al., 2021). These findings together suggest that self-regulation is a multi-dimensional construct that can be enhanced through both cognitive/metacognitive and mindfulness-based strategies.

Other Iranian studies have added valuable evidence to this field. Bargamadi and colleagues compared the effectiveness of working memory training and mindfulness on educational well-being, self-regulation, and academic motivation, finding that both approaches led to significant gains, though with differences in effect sizes (Bargamadi et al., 2019). Jafari and Bigdeli explored the relationship between cognitive and metacognitive self-regulation and academic procrastination, revealing that higher levels of self-regulation predicted lower procrastination and better adaptation to academic goals (Jafari & Bigdeli, 2023). Babaei-Monqari and colleagues modeled the relationship between motivational strategies, metacognitive self-regulation, and peer learning in high school students, confirming that self-regulation skills significantly mediated peer learning processes (Babaei-Monqari et al., 2022). These studies reinforce the importance of targeting both motivational and cognitive dimensions in interventions.

Furthermore, cultural and contextual factors must be considered when applying such interventions in Iranian schools. Sayedi and colleagues highlighted the link between attachment styles, self-regulation, and academic achievement, suggesting that self-regulatory skills are influenced not only by cognitive or emotional training but also by interpersonal and cultural dynamics (Sayedi et al., 2017). Hoseini-Motlaq and colleagues showed that integrated self-knowledge, incorporating self-compassion and mindfulness, predicted emotional-cognitive self-regulation among students, thereby providing a culturally grounded model of self-regulation (Hoseini-Motlaq et al., 2012). A similar line of research by Hosseini Motlagh and colleagues emphasized that self-compassion and mindfulness play mediating roles in the relationship between self-knowledge and emotional regulation in university students (Hosseini Motlagh et al., 2022). These insights suggest that interventions addressing self-regulation in Iran must take into account not only cognitive processes but also socio-emotional and cultural dimensions.

In addition to these perspectives, recent contributions have examined self-regulation through clinical, motivational, and behavioral lenses. Babakhanlou presented a structural model of emotional eating in individuals with obesity, identifying self-regulation and emotional processing as mediating factors, which extends the concept of self-regulation into health and lifestyle behaviors (Babakhanlou, 2023). Puthusserry and Delariarte developed and implemented a mindfulness-based intervention for premenstrual dysphoric symptoms, demonstrating improvements in quality of life and psychological well-being among adolescents, further supporting the broader applicability of mindfulness in youth populations (Puthusserry & Delariarte, 2023). These findings suggest that both self-regulation strategies and mindfulness interventions are effective across multiple domains, including education, health, and clinical psychology.

Within the Iranian educational context, the importance of designing interventions that integrate cognitive, metacognitive, and mindfulness-based approaches is particularly pronounced. Osuli and colleagues investigated the relationships between metacognitive beliefs, academic self-regulation, and parent–child conflicts, pointing to the complex interplay of individual and relational factors in self-regulation outcomes (Osuli et al., 2016). Asdolahzadeh and colleagues modeled structural equations linking metacognition and self-efficacy with tendencies toward cyberspace use in gifted students, mediated by self-regulation, demonstrating how these processes extend into modern challenges such as digital engagement (Asdolahzadeh et al., 2021). These studies collectively highlight the multifaceted role of self-regulation in academic and social functioning.

Taken together, the literature underscores that both cognitive/metacognitive strategy training and mindfulness-based interventions have empirical support as effective methods for enhancing academic self-regulation. However, the question of which approach yields stronger and more sustainable outcomes in adolescent learners remains underexplored. Previous studies suggest that cognitive and metacognitive strategies may be particularly effective for enhancing academic motivation, achievement, and goal orientation, while mindfulness may be more effective for reducing stress, enhancing emotional regulation, and improving present-moment awareness (Ghasemi et al.,

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

2025; Rafezi et al., 2021; Ramli et al., 2018). Given the unique challenges faced by Iranian high school students—including high academic pressures, the influence of digital media, and socio-cultural expectations—a comparative analysis of these two intervention approaches is both timely and necessary.

The present study seeks to fill this gap by comparing the effectiveness of cognitive and metacognitive strategy training and mindfulness training on the components of academic self-regulation—metacognition, cognition, and motivation—among female high school students in Tehran.

2. Methods and Materials

2.1. Study Design and Participants

This study employed an applied, semi-experimental design with pre-test, post-test, and follow-up phases, along with a control group. The statistical population consisted of all female high school students in District 13 of Tehran during the 2024–2025 academic year, totaling approximately 2,000 students. Using a cluster sampling approach, three classes were selected from girls' high schools in the district. From these classes, students who obtained lower scores in the Academic Self-Regulation Questionnaire, the Academic Hope Questionnaire, and the Academic Buoyancy Questionnaire were identified. A total of 47 students met the criteria and were randomly assigned into three groups: a cognitive and metacognitive strategies training group (n = 15), a mindfulness training group (n = 15), and a control group (n = 15).

The sample size was determined using G*Power software, considering an effect size of 0.25, an alpha level of 0.05, and a statistical power of 0.80, which indicated that a minimum of 15 participants per group was required. To account for potential dropouts, the final sample included 45 participants evenly distributed among the three groups. Over the course of the intervention, several students withdrew, but the final sample size was retained at 45.

Inclusion criteria consisted of being a female high school student in the second cycle, willingness to participate in the study, absence of serious medical conditions, absence of major psychiatric disorders, and no substance dependence. Exclusion criteria included failure to respond to all questionnaire items. Following ethical approval from the university and authorization from the Ministry of Education in District 13, eligible students were invited to participate voluntarily. Informed written consent was obtained from all participants.

The intervention groups participated in eight one-hour weekly sessions. For the cognitive and metacognitive strategies group, the training program was based on McCombs' (1988) framework, focusing on structured techniques for regulating thought processes and learning strategies. For the mindfulness group, the program followed Kabat-Zinn and colleagues' (2003) standardized mindfulness-based training protocol. Both interventions were delivered face-to-face in group format within the schools. The control group did not receive any psychological or educational intervention during the study. Pre-test measures were collected before the interventions began, post-tests were administered after the eight sessions concluded, and a follow-up assessment was conducted three months later.

2.2. Measures

The main instrument for this research was the Academic Self-Regulation Questionnaire, originally developed by Bouffard and colleagues in 1995. The original questionnaire consisted of 19 items, but for this study, the Persian version validated by Ghasemi and Fooladchang (2011) was employed, which contains 17 items. These items are divided into three dimensions: metacognition (8 items), cognition (4 items), and motivation (5 items). The responses are rated on a five-point Likert scale ranging from "strongly agree" to "strongly disagree." Bouffard and colleagues reported Cronbach's alpha coefficients of 0.72 for metacognition, 0.78 for cognition, and 0.68 for motivation, along with construct validity demonstrated through inter-factor correlations ranging from 0.40 to 0.42. In the Persian validation study, the reliability coefficients were reported as 0.73 for metacognition, 0.73 for cognition, and 0.75 for motivation. Factor analysis confirmed the three-factor structure with a Kaiser-Meyer-Olkin (KMO) index of 0.80 and a significant Bartlett's test of sphericity. In the present study, Cronbach's alpha coefficients for metacognition, cognition, and motivation were 0.79, 0.77, and 0.78, respectively, confirming high internal consistency.

2.3. Interventions

The cognitive and metacognitive strategies training protocol was designed as an eight-session group program, each session lasting one hour and conducted weekly. The program began with an introduction to the objectives of the training, definitions of learning strategies, and the process of information processing involving short-term, intermediate,

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

and long-term memory. Subsequent sessions introduced the categorization of cognitive and metacognitive strategies, with an emphasis on rehearsal, elaboration, and organization as cognitive strategies, alongside planning, regulation, monitoring, and control as metacognitive strategies. Students were guided in the use of elaboration techniques for both simple and complex materials, as well as the study method "PQ4R" to support active engagement with texts. Exercises were incorporated to practice organizing content, with explicit instruction on how organization enhances conceptual learning. In later sessions, metacognitive dimensions such as planning, monitoring, and regulation were taught in an integrated manner, highlighting their simultaneous application for effective self-regulated learning. The final session emphasized reflective questioning, identification of ineffective strategies, and replacement with more appropriate ones, along with guidelines on the dos and don'ts of study planning. To reinforce motivation, the program incorporated the Premack principle as a behavioral strategy, and students were encouraged to evaluate their progress and apply the strategies flexibly in academic contexts.

The mindfulness training protocol was also conducted over eight weekly sessions, each lasting one hour, and aimed to cultivate present-moment awareness and emotional regulation. The first session introduced participants to the concept of mindfulness through orientation, body-scan exercises, meditation, mindful movements, and a three-minute breathing practice. In the second week, participants were asked to observe and record pleasant daily experiences using a structured log, while in the third week the same practice was extended to unpleasant events. The fourth session focused on recognizing emotions as combinations of events and interpretations, designed to enhance emotional awareness. In the fifth session, participants learned to disrupt habitual emotional reactions, such as aversion, muscle tension, and negative thought spirals, through mindfulness-based practices. The sixth session emphasized the bidirectional relationship between thoughts and emotions, encouraging participants to use mindfulness skills to break reactive chains and adopt broader perspectives. The seventh session challenged the assumption that thoughts are facts, teaching participants to view them as mental events and to disengage from negative cognitions. The final session consolidated all skills by focusing on sustained attention to present experiences, avoiding mindless repetition and habitual responses, and cultivating persistence in mindful awareness. Each session concluded with reflective discussions, question answering, and encouragement for daily practice, ensuring that participants integrated mindfulness techniques into their everyday academic and personal lives.

2.4. Data Analysis

Data were analyzed using SPSS version 27. Descriptive statistics, including frequency and percentage, were calculated to summarize demographic characteristics of the participants. To examine the effectiveness of the interventions over time, repeated-measures analysis of variance (ANOVA) was conducted, with group as the between-subjects factor (psychodynamic therapy, cognitive behavioral therapy, and control) and time as the within-subjects factor (pretest, posttest, follow-up). Where significant effects were found, Bonferroni-adjusted post-hoc tests were applied to compare group means across time points. Statistical significance was set at $p < .05$ for all tests. Prior to conducting the analyses, assumptions of repeated-measures ANOVA, including normality, homogeneity of variances, sphericity, and absence of outliers, were checked and confirmed.

3. Findings and Results

The demographic profile of the participants indicated that the study included a total of 45 female high school students, evenly distributed across the three groups of cognitive and metacognitive strategies training, mindfulness training, and control. In the cognitive and metacognitive strategies group, 26.67% of the students were 16 years old, 33.33% were 17 years old, and 40% were 18 years old. In the mindfulness training group, 33.33% were 16 years old, 40% were 17 years old, and 26.67% were 18 years old. In the control group, 40% of the students were 16 years old, 26.67% were 17 years old, and 33.33% were 18 years old. Overall, the participants represented a balanced age distribution across the three groups, with students aged 16, 17, and 18 years contributing 33.33%, 33.33%, and 33.33% of the sample respectively, ensuring comparability between the intervention and control groups.

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

Table 1

Descriptive Statistics of Academic Self-Regulation Components (Metacognition, Cognition, Motivation) Across Groups and Time Points (N = 45)

Component	Group	Pre-test M (SD)	Post-test M (SD)	Follow-up M (SD)
Metacognition	Cognitive & Metacognitive Strategies	17.33 (2.50)	28.47 (1.30)	22.93 (2.02)
	Mindfulness Training	16.87 (1.73)	20.93 (2.02)	31.20 (2.73)
	Control	17.87 (2.07)	18.27 (2.22)	19.27 (2.19)
Cognition	Cognitive & Metacognitive Strategies	7.80 (1.47)	16.67 (0.90)	16.13 (0.74)
	Mindfulness Training	9.20 (1.27)	13.73 (0.70)	18.53 (0.83)
	Control	7.40 (1.76)	8.40 (1.76)	9.07 (1.98)
Motivation	Cognitive & Metacognitive Strategies	9.40 (1.88)	20.33 (1.23)	16.13 (0.74)
	Mindfulness Training	10.13 (1.73)	15.53 (0.99)	18.53 (0.83)
	Control	9.13 (2.13)	9.80 (2.01)	9.10 (1.99)

The descriptive results demonstrate clear differences across the three groups in the components of academic self-regulation at different time points. In the cognitive and metacognitive strategies group, substantial improvements were observed from pre-test to post-test in metacognition (M = 17.33, SD = 2.50 to M = 28.47, SD = 1.30), cognition (M = 7.80, SD = 1.47 to M = 16.67, SD = 0.90), and motivation (M = 9.40, SD = 1.88 to M = 20.33, SD = 1.23). These gains were largely maintained during follow-up, although a slight decline was observed in motivation and cognition scores. Similarly, the mindfulness group showed increases in metacognition from M = 16.87 (SD = 1.73) at pre-test to M = 20.93 (SD = 2.02) at post-test, and then a substantial improvement at follow-up (M = 31.20, SD = 2.73). Cognition and motivation scores also improved significantly over time in this group. In contrast, the control group exhibited minimal change across all components, with only slight increases in metacognition (M = 17.87, SD = 2.07 to M = 19.27, SD = 2.19), cognition (M = 7.40, SD = 1.76 to M = 9.07, SD = 1.98), and motivation (M = 9.13, SD = 2.13 to M = 9.10, SD = 1.99). These descriptive patterns suggest that both cognitive and metacognitive strategies training and mindfulness interventions had marked effects on improving academic self-regulation, while no meaningful progress occurred in the control group.

Before conducting the main statistical analyses, the underlying assumptions of the tests were carefully examined to ensure the validity of the results. The normality of the data distributions was assessed using the Shapiro–Wilk test, and the findings indicated that the distributions of the dependent variables did not significantly deviate from normality. The assumption of homogeneity of variances across the groups was evaluated using Levene's test, which showed no significant violations, confirming that the variances were equal. Additionally, the assumption of sphericity, relevant for repeated measures analyses, was checked with Mauchly's test and, where necessary, Greenhouse–Geisser corrections were applied. Taken together, these results demonstrated that the statistical assumptions were adequately met, allowing the use of parametric methods such as mixed-design ANOVA and ANCOVA with confidence.

Table 2

Mixed ANOVA Results for Academic Self-Regulation Components Using the Greenhouse–Geisser Correction

Dependent Variable	Source	SS	df	MS	F	p	η^2
Metacognition	Time	1218.904	2	609.452	331.276	.0005	.888
	Time × Group	701.941	4	175.485	95.416	.0005	.820
Cognition	Time	1009.126	2	504.563	686.060	.0005	.942
	Time × Group	370.430	4	92.607	125.919	.0005	.857
Motivation	Time	866.237	2	433.119	216.789	.0005	.838
	Time × Group	497.274	4	124.319	62.235	.0005	.748

The results of the mixed-design ANOVA with the Greenhouse–Geisser correction revealed significant effects of time and significant time-by-group interactions across all three components of academic self-regulation. For

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

metacognition, there was a strong main effect of time, $F(2, 609.452) = 331.276$, $p < .0005$, $\eta^2 = .888$, indicating significant improvements across measurement points. The interaction between time and group was also significant, $F(4, 175.485) = 95.416$, $p < .0005$, $\eta^2 = .820$, showing that the rate of improvement differed across the intervention and control groups. Similarly, for cognition, there was a significant main effect of time, $F(2, 504.563) = 686.060$, $p < .0005$, $\eta^2 = .942$, with a significant time-by-group interaction, $F(4, 92.607) = 125.919$, $p < .0005$, $\eta^2 = .857$. Motivation also demonstrated a significant time effect, $F(2, 433.119) = 216.789$, $p < .0005$, $\eta^2 = .838$, and a significant time-by-group interaction, $F(4, 124.319) = 62.235$, $p < .0005$, $\eta^2 = .748$. Collectively, these results suggest that both intervention groups showed marked gains in metacognition, cognition, and motivation compared to the control group, and that these effects persisted over time with large effect sizes.

Table 3

Bonferroni Post-Hoc Comparisons of Academic Self-Regulation Components Across Groups

Dependent Variable	Group	Comparison Group	Mean Difference	Std. Error	p
Metacognition	Cognitive & Metacognitive Strategies	Mindfulness Training	5.422*	0.660	.0005
	Cognitive & Metacognitive Strategies	Control	7.200*	0.660	.0005
	Mindfulness Training	Cognitive & Metacognitive	-5.422*	0.660	.005
	Mindfulness Training	Control	2.711*	0.660	.030
Cognition	Cognitive & Metacognitive Strategies	Mindfulness Training	1.310*	0.423	.009
	Cognitive & Metacognitive Strategies	Control	4.040*	0.423	.0005
	Mindfulness Training	Cognitive & Metacognitive	-1.310*	0.423	.009
	Mindfulness Training	Control	2.711*	0.423	.0005
Motivation	Cognitive & Metacognitive Strategies	Mindfulness Training	2.156*	0.400	.0005
	Cognitive & Metacognitive Strategies	Control	6.758*	0.400	.0005
	Mindfulness Training	Cognitive & Metacognitive	-2.158*	0.400	.0005
	Mindfulness Training	Control	4.600*	0.400	.0005

*p<0.05

The results of the Bonferroni post-hoc comparisons indicated significant differences across all three components of academic self-regulation between the experimental and control groups. For metacognition, students in the cognitive and metacognitive strategies group scored significantly higher than those in both the mindfulness and control groups, while the mindfulness group also outperformed the control group, though to a lesser extent. In the cognition component, significant mean differences were found across all groups, with the cognitive and metacognitive strategies group achieving the greatest improvements, followed by the mindfulness group, both outperforming the control group. For motivation, both intervention groups demonstrated significant gains over the control group, with the cognitive and metacognitive strategies group showing the largest increase. Importantly, the differences between the two intervention groups themselves were also statistically significant, suggesting that while both approaches were effective, the cognitive and metacognitive strategies training was more impactful overall in enhancing self-regulatory skills compared to mindfulness training.

4. Discussion and Conclusion

The present study aimed to compare the effectiveness of cognitive and metacognitive strategies training and mindfulness training on the components of academic self-regulation, namely metacognition, cognition, and motivation, among female high school students. The results demonstrated significant improvements across all components for the intervention groups compared to the control group. Specifically, cognitive and metacognitive training yielded stronger effects on the cognitive and motivational dimensions, whereas mindfulness training was particularly effective in enhancing metacognitive awareness and sustaining gains at follow-up. These findings not only confirm the importance of self-regulation interventions in adolescence but also highlight the nuanced ways in which different approaches exert their influence.

The significant effect of cognitive and metacognitive strategy training on the cognition and motivation components of self-regulation supports the notion that structured strategy-based training enables students to become more active participants in their own learning processes. The results are in line with findings by Mohammadi Darvish Bighal and colleagues, who showed that cognitive and metacognitive strategy training improved

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

motivational beliefs, academic motivation, self-efficacy, and reduced test anxiety in high school students (Mohammadi Darvish Bighal et al., 2020). Similarly, Ashoori and colleagues demonstrated that cognitive and metacognitive strategies predicted academic achievement when combined with achievement goal orientation and spiritual intelligence (Ashoori et al., 2014). In the current study, the improvement of motivational regulation among participants in the cognitive and metacognitive group further validates these earlier findings and confirms the essential role of strategy-based interventions in fostering self-determined learning.

At the same time, mindfulness training showed a marked influence on metacognitive self-regulation, confirming the growing evidence that mindfulness enhances awareness of internal cognitive and emotional states. This outcome aligns with the results of Tajoldini and colleagues, who reported that mindfulness-based stress reduction significantly improved academic buoyancy and self-regulation in high school students (Tajoldini et al., 2018). Similarly, Ramli and colleagues found that mindfulness served as a mediator between academic stress and self-regulation among Malaysian students, illustrating its protective role in stressful academic environments (Ramli et al., 2018). In our study, the mindfulness group demonstrated substantial gains in metacognitive awareness, particularly during the follow-up phase, suggesting that mindfulness interventions may foster sustainable internalized skills that endure beyond the immediate intervention period.

The comparative analysis further revealed that the cognitive and metacognitive strategies group achieved superior results in motivation and cognition compared to the mindfulness group. This result indicates that while mindfulness strengthens awareness and emotional regulation, explicit strategy training is more effective in enhancing academic task management and motivation. This observation is consistent with findings from Jafari and Bigdeli, who reported that higher levels of cognitive and metacognitive regulation were associated with reduced procrastination and better goal adaptation (Jafari & Bigdeli, 2023). Likewise, Babaei-Monqari and colleagues found that motivational strategies and metacognitive self-regulation significantly predicted peer learning, highlighting the pivotal role of cognitive strategy training in social and academic engagement (Babaei-Monqari et al., 2022). These results together suggest that strategy-based interventions may provide a stronger motivational framework for sustained academic engagement than mindfulness alone.

Nevertheless, the sustained improvement in the mindfulness group at follow-up deserves emphasis. The results indicate that the effects of mindfulness training on metacognition continued to grow after the formal intervention period. This finding echoes research by Ghasemi and colleagues, who demonstrated that cognitive therapy programs based on mindfulness improved emotional self-regulation and social comparison among students with internet addiction (Ghasemi et al., 2025). The durability of mindfulness training may be explained by its emphasis on cultivating habits of attention and emotional awareness that persist as students continue to apply the techniques in daily life. In contrast, cognitive and metacognitive strategy training may require ongoing reinforcement to sustain its effects, as suggested by the slight decline observed in motivational scores at follow-up.

The present results also contribute to broader theoretical perspectives. Ihor and Ruslana emphasized that metacognitive awareness is a foundational predictor of self-regulation among university students, which supports the effectiveness of both interventions in our study (Ihor & Ruslana, 2021). Ziegler and Opdenakker further highlighted the role of metacognitive self-regulation in preventing academic procrastination and strengthening effort regulation (Ziegler & Opdenakker, 2018). In line with these perspectives, our findings confirm that strengthening metacognitive capacities—whether through direct strategy training or mindfulness—provides a robust pathway to improved self-regulatory functioning. Moreover, the evidence that both interventions enhanced self-regulation aligns with earlier research by Rafezi and colleagues, who demonstrated the efficacy of metacognitive therapy in improving emotional regulation and ego strength among anxious students (Rafezi et al., 2021). Thus, the current results extend prior findings by showing that mindfulness-based and strategy-based approaches converge on improving academic self-regulation through different but complementary mechanisms.

From a clinical and motivational perspective, our findings resonate with research by Enayati Shabkolai and colleagues, who demonstrated that acceptance and commitment therapy enhanced academic self-regulation and cognitive flexibility in students with learning disorders (Enayati Shabkolai et al., 2023). Although the theoretical underpinnings differ, the common thread lies in enhancing students' capacity to regulate cognition and emotions under challenging conditions. Furthermore, Babakhanlou proposed a model linking emotional processing and self-regulation with

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

emotional eating, suggesting that self-regulation is a core process underlying both educational and clinical outcomes (Babakhanlou, 2023). Our results confirm that interventions targeting self-regulation have broad applicability beyond academic contexts.

Other Iranian studies support this integrative perspective. Bargamadi and colleagues compared working memory and mindfulness training and found that both improved academic self-regulation, although with different magnitudes of effect (Bargamadi et al., 2019). The present study's findings mirror these results, showing that both intervention types enhanced self-regulation components, but cognitive and metacognitive strategies produced larger immediate effects, while mindfulness demonstrated stronger sustainability. Likewise, Osuli and colleagues emphasized that self-regulation is influenced not only by metacognitive beliefs but also by the quality of parent–student relationships (Osuli et al., 2016). This contextual insight indicates that while interventions such as the ones implemented in this study are powerful, broader social and relational dynamics also shape self-regulatory outcomes.

The findings also extend work by Hoseini-Motlaq and colleagues, who argued that self-compassion, mindfulness, and emotional regulation constitute a combined model of integrated self-knowledge (Hoseini-Motlaq et al., 2012). The updated model presented by Hosseini Motlagh and colleagues emphasized the mediating role of mindfulness in predicting emotional cognitive regulation (Hosseini Motlagh et al., 2022). Our results reinforce these models by showing that mindfulness interventions effectively enhance self-regulation through heightened awareness and self-compassion processes. In contrast, cognitive and metacognitive training exerted a stronger influence on motivation, consistent with traditional learning theories that emphasize structured practice and feedback (Ashoori et al., 2014). These dual findings suggest that combining mindfulness and strategy training could yield even stronger outcomes, a possibility that merits future investigation.

The results also carry implications for addressing modern educational challenges such as digital engagement and academic procrastination. Asdolahzadeh and colleagues modeled relationships among metacognition, self-efficacy, and cyberspace tendencies, finding that self-regulation mediated the association (Asdolahzadeh et al., 2021). Similarly, Sayedi and colleagues emphasized that attachment styles and self-regulation jointly predicted academic achievement, underscoring the influence of personal and relational factors (Sayedi et al., 2017). These perspectives support our findings by situating self-regulation within broader psychosocial and technological contexts. The improvement observed in self-regulatory components among students in our study suggests that targeted interventions may help buffer against external risks such as excessive digital use, low academic motivation, and maladaptive coping strategies.

Overall, the current study adds to the growing body of evidence demonstrating that interventions targeting self-regulation are effective and necessary in adolescent educational settings. Both mindfulness and cognitive/metacognitive strategies yielded significant improvements in self-regulatory processes, though their strengths differed by domain. These findings underscore the importance of tailoring interventions to the specific needs of students, whether by emphasizing motivational and strategic components or focusing on awareness and emotional regulation.

5. Limitations & Suggestions

Despite the valuable contributions of this research, several limitations should be acknowledged. First, the study was conducted exclusively with female high school students in Tehran, which limits the generalizability of the findings to other age groups, male students, or students from different cultural or geographical contexts. Second, the relatively small sample size, while adequate for the statistical analyses employed, restricts the ability to draw broader conclusions. Third, the study relied primarily on self-report questionnaires, which may be subject to social desirability bias or inaccurate self-assessment. Finally, the follow-up period was limited to three months, which may not fully capture the long-term sustainability of the intervention effects.

Future research should expand the sample to include more diverse student populations across gender, educational levels, and cultural backgrounds. Larger-scale randomized controlled trials would help to validate and extend the present findings. Additionally, future studies could employ mixed-methods designs incorporating qualitative interviews or observational data to provide richer insights into the mechanisms through which these interventions exert their effects. Researchers should also explore hybrid models that combine mindfulness and strategy-based approaches, as the complementary strengths identified in this study suggest the potential for synergistic effects. Longer-term follow-ups would be valuable in assessing whether the benefits of these

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

interventions persist over time and in identifying strategies to sustain gains.

In terms of practice, the results of this study have clear implications for educational policy and school-based interventions. Educators and school psychologists should consider incorporating both cognitive/metacognitive strategy training and mindfulness practices into the curriculum, tailoring the approach to the needs of different students. Cognitive and metacognitive training may be particularly useful in addressing motivational and strategic deficits, while mindfulness training can help students develop emotional resilience and sustained awareness. By integrating such programs within schools, educational systems can foster more holistic student development, equipping adolescents not only with academic skills but also with the emotional and cognitive tools necessary for lifelong learning.

Acknowledgments

We would like to express our appreciation and gratitude to all those who cooperated in carrying out this study.

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.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

Authors' Contributions

All authors equally contributed to this article.

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E-ISSN: 2981-2526