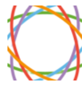
KMANPUB  Health Nexus Vol. 4 No. 2 (2026): 1-10

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Comparative Effectiveness of Eye Movement Desensitization and Reprocessing (EMDR) and Neurofeedback on Executive Functions in Female Senior High School Students with Internalizing and Externalizing Behavioral Disorders in Tehran

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ABSTRACT

Internalizing and externalizing behavioral disorders are common problems during adolescence and may adversely affect students' executive functions. The present study compared the effectiveness of Eye Movement Desensitization and Reprocessing (EMDR) and neurofeedback on executive functions in female upper secondary school students with internalizing and externalizing behavioral disorders in Tehran. This applied study used a quasi-experimental pretest-posttest design with a one-month follow-up and included two experimental groups and one control group. The study population comprised female upper secondary school students in Tehran during the 2024-2025 academic year. Forty-five students were selected through convenience sampling and randomly assigned to three groups: EMDR, neurofeedback, and control. Data were collected using the Child Behavior Checklist (CBCL) and the Behavior Rating Inventory of Executive Function (BRIEF). Data were analyzed using repeated-measures analysis of variance and post hoc tests in SPSS version 27. Both EMDR and neurofeedback significantly improved executive functions compared with the control group, and these improvements remained stable at follow-up. No statistically significant difference was observed between the two intervention groups in the post hoc comparisons, although both interventions outperformed the control group. These findings suggest that both EMDR and neurofeedback are effective interventions for enhancing executive abilities in students with behavioral disorders and may be considered in therapeutic and educational programs.

Keywords: *EMDR; neurofeedback; executive functions; internalizing disorders; externalizing disorders; adolescents*

1. Introduction

In recent years, developmental psychology and neuropsychology have paid increasing attention to the complex interplay among emotional, cognitive, and behavioral processes during adolescence. This developmental period is now viewed not simply as a transitional stage but as a critical phase in the formation of enduring patterns of psychological adaptation or maladaptation, particularly in relation to academic functioning (1). Within developmental models, adolescent behavioral problems are commonly conceptualized as

internalizing and externalizing problems. Internalizing problems refer to inwardly directed emotional symptoms, such as anxiety, depression, and social withdrawal, whereas externalizing problems involve outwardly directed behaviors such as aggression, defiance, and violation of social norms (2, 3). Research indicates that these two behavioral patterns are associated not only with emotional and social maladjustment but also with impairments in learning-related cognitive functions, including working memory, selective attention, and cognitive flexibility, thereby restricting students' ability to benefit from learning opportunities and academic progress (4-6).

One of the key domains for explaining adolescent behavioral problems is executive functioning. Executive functions are higher-order capacities involved in monitoring and controlling behavior, planning, organization, self-monitoring, and emotion regulation, and they play a decisive role in adolescents' academic and social success (7). Executive functions include components such as working memory, response inhibition, and cognitive flexibility, all of which are related to an individual's ability to prioritize information, shift strategies, sustain attention during learning activities, and monitor academic progress (1). Recent evidence suggests that students with internalizing and externalizing behavioral disorders experience substantial impairments in this domain, such that deficits in inhibitory control, working memory, and cognitive flexibility are associated with elevated internalizing and externalizing behaviors, difficulties in managing academic tasks, problems in emotion regulation, and lower performance on complex tasks (3, 8-10). In addition, contextual factors such as stress, grief, loneliness, sleep deprivation, and physical inactivity may undermine executive functioning, whereas positive emotional experiences, rich social interaction, and regular physical activity are associated with better concentration, working memory, self-control, and problem-solving ability in school settings (11, 12). Because the development of executive functions begins in childhood and continues through adolescence and early adulthood, deficits in these abilities may prevent students with behavioral disorders from fully utilizing their cognitive and academic potential, highlighting the importance of targeted educational-cognitive interventions (1, 13, 14).

Given the widespread deficits in executive functioning among students with internalizing and externalizing behavioral disorders and the direct consequences of these deficits for academic achievement and school adjustment, the need for targeted interventions is clear. In this context, Eye Movement Desensitization and Reprocessing (EMDR) and neurofeedback may represent promising approaches because each affects emotional processing, neural self-regulation, attention, and working memory through distinct mechanisms. However, these two interventions have rarely been compared within a single study, particularly in school-based settings and among adolescents with behavioral disorders.

EMDR is a structured protocol that guides individuals in reprocessing emotionally challenging experiences and thereby helps reorganize cognitive and emotional resources (15). In the present study, EMDR is considered not merely as a clinical treatment but as an educational-cognitive intervention aimed at improving attention, working memory, and response inhibition, thereby enhancing executive functions in students with internalizing and externalizing behavioral patterns (16, 17). Research involving children and adolescents suggests that EMDR can reduce emotional burden, facilitate information processing, improve selective attention, and decrease cognitive difficulties associated with anxiety and stress (18, 19). Accordingly, EMDR appears capable of improving executive functioning and academic performance in adolescents with behavioral disorders by reducing chronic emotional strain and releasing cognitive resources.

The second intervention examined in the present study is neurofeedback, an educational-cognitive program designed to strengthen students' mental capacities and executive performance (20). By providing individuals with real-time neural feedback, this intervention enables them to identify and regulate patterns of brain activity associated with attention, working memory, and cognitive flexibility (21). Neurofeedback was selected on the basis of evidence demonstrating its effectiveness in improving cognitive control, response inhibition, and emotional functioning, and it may therefore serve as an appropriate option for school-based interventions (20, 22, 23).

Taken together, the available evidence indicates that internalizing and externalizing behavioral disorders in

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adolescents are accompanied by impairments in cognitive and executive functioning and may adversely affect academic performance, emotional regulation, and social interactions (8, 10). EMDR and neurofeedback offer distinct mechanisms for enhancing cognitive abilities and executive functioning, and preliminary evidence suggests that each exerts specific effects on reducing emotional burden and improving attention, working memory, and inhibitory control (17, 24). Nevertheless, the direct comparison of these two approaches in female upper secondary school students with behavioral disorders has not yet been systematically examined. Therefore, the present study was designed to compare the effects of EMDR and neurofeedback on executive functioning in female students with internalizing and externalizing behavioral disorders in Tehran and to determine whether the effectiveness of the two interventions differs significantly.

2. Methods and Materials

2.1. Study design

This applied study used a quasi-experimental pretest-posttest design with a one-month follow-up and included two experimental groups and one control group. The intervention arms consisted of EMDR and neurofeedback, while the control group was placed on a waiting list and received no intervention during the study period.

2.2. Participants and setting

The target population comprised female upper secondary school students in Tehran, Iran, during the 2024-2025 academic year who showed symptoms of internalizing and externalizing behavioral disorders. Sample size was estimated using Cohen's table, assuming an effect size of 0.50, an alpha level of 0.05, and a statistical power of 99%. Based on this calculation, 45 students were recruited through convenience sampling and subsequently assigned randomly to three equal groups: EMDR (n = 15), neurofeedback (n = 15), and control (n = 15).

After ethical approval had been obtained from the Science and Research Branch of Islamic Azad University and the necessary permissions had been secured from District 1 of the Tehran Department of Education, three centers providing services to students with learning-related difficulties were randomly selected. In collaboration with center staff and after review of clinical records, 89 eligible female students were initially identified (33 from the first center, 27 from the second, and 29 from the third). All eligible students completed the screening phase. Based on the predetermined cutoff point of one standard deviation below the mean, 45 students were selected and randomly assigned to the three study groups.

The inclusion criteria were: being a female upper secondary school student, willingness to participate, provision of informed consent, parental consent for participation, adequate physical and psychological health, absence of acute physical or psychiatric illness, no simultaneous participation in similar studies, and no medication use during the intervention period. The exclusion criteria were absence from more than two sessions and unwillingness to continue participation.

2.3. Measures

Internalizing and externalizing behavioral disorders were assessed using the parent-report version of the Child Behavior Checklist (CBCL) developed by Achenbach (2). This questionnaire consists of 113 items and evaluates emotional-behavioral problems and social and academic competencies in children and adolescents aged 6 to 18 years. In the present study, the internal consistency of the CBCL was acceptable, with a Cronbach's alpha of 0.84.

Executive functioning was measured using the parent form of the Behavior Rating Inventory of Executive Function (BRIEF) developed by Gioia et al (25). This instrument contains 86 items and assesses the behavioral manifestations of executive functioning in children and adolescents aged 5 to 18 years. It comprises two broad dimensions, Behavioral Regulation and Metacognition, and evaluates eight components: inhibition, shifting, emotional control, initiation, working memory, planning, organization of materials, and monitoring. In the present study, the BRIEF demonstrated good reliability, with a Cronbach's alpha of 0.84.

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2.4. Intervention procedures

2.4.1. EMDR program

The EMDR intervention was based on the protocol developed by Shapiro (26) and was delivered as a structured educational-therapeutic program. The EMDR group received eight 60-minute sessions administered twice per week. The sessions focused on history taking, target identification, cognitive preparation, bilateral eye movement-based desensitization, emotional processing, strengthening adaptive responses, body scan, and re-evaluation.

Table 1

EMDR educational protocol

Session	Session goal	Session content	Homework
1	History taking and preparation	Assessment of psychological history, identification of distressing experiences, and training in emotional self-awareness	Daily emotional self-awareness practice and recording thoughts and feelings related to distressing experiences
2	Identification of treatment target	Identification of the target memory or distressing experience, along with associated images, thoughts, and emotions	Practice focusing on distressing memories and recording accompanying emotions and their intensity
3	Cognitive framing	Identification of positive and negative aspects of the target memory, review of automatic thoughts and negative beliefs	Practicing replacement of negative thoughts with positive alternatives and recording them daily
4	Desensitization - Phase I	Use of bilateral eye movements to process memories, initiation of emotional processing, and reduction of distress	Deep breathing and relaxation exercises, with attention focused on memories whose distress has decreased
5	Desensitization - Phase II	Continued memory processing using bilateral stimulation and strengthening emotional flexibility	Recording changes in emotional intensity and thoughts related to the memory
6	Installation	Reinforcement of positive responses, creation of a sense of safety, and practice of emotional self-regulation skills	Relaxation exercises and review of positive thoughts
7	Body scan and physiological response review	Identification and processing of residual bodily tension and training in body awareness	Physical relaxation and physiological self-regulation exercises
8	Re-evaluation and review	Review of progress, evaluation of emotional and cognitive changes, and consolidation of outcomes	Concentration exercises, progress notes, and reflection on responses

2.4.2. Neurofeedback program

The neurofeedback intervention was based on the protocol attributed to Lubar and implemented as an educational-neurorehabilitative package for children and adolescents with attention and executive function problems. In the current study, participants in the neurofeedback group received 12 sessions, each lasting 60 minutes, delivered twice per week. The intervention employed a beta/theta training protocol and aimed to improve attention, working memory, cognitive flexibility, self-monitoring, self-regulation, decision-making, and processing speed through computerized brainwave-based feedback tasks (20, 22, 23).

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Table 2

Neurofeedback educational protocol

Session	Session goal	Session content	Homework
1	Baseline assessment and familiarization with the neurofeedback device	Electrode placement, initial instruction, and baseline brainwave recording	Short concentration practice (5-10 minutes focusing on breathing or a fixed image)
2	Beta/theta control training and familiarization with visual feedback	Computerized games controlled by brainwave activity with simple visual feedback	Ten-minute concentration practice and recording the experience in a notebook
3	Increasing concentration and attention	Simple games designed to increase the beta/theta ratio	Continued daily 10-minute concentration practice and note-taking on learning experiences
4	Improving working memory	Tasks involving working memory elements, such as retaining and organizing short-term information	Short-term memory practice at home using cards or simple tables
5	Strengthening cognitive flexibility	Multi-step games with changing rules	Reviewing and recording strategies used during the tasks
6	Enhancing self-monitoring and self-regulation	Reward-control and stop-response exercises during games; learning impulse control	Concentration practice and pausing whenever distraction occurs
7	Integrating concentration and working memory	Complex tasks involving multiple simultaneous goals	Daily concentration and memory practice for 15 minutes
8	Strengthening decision-making and problem-solving	Tasks with multiple options and immediate feedback	Problem-solving practice with simple everyday examples
9	Consolidating learning and memory skills	Repetition of previous sessions with increased difficulty	Self-monitoring and concentration practice for 15 minutes
10	Improving information-processing speed	Speed-based tasks with beta/theta feedback	Practice with fast-paced cognitive games at home
11	Consolidating flexibility and executive functions	Combined training of attention, memory, and decision-making in complex tasks	Combined practice for 20 minutes
12	Final evaluation and summary	Assessment of progress, comparison with baseline brainwave patterns, and feedback to the student	Optional practice for maintaining acquired skills

2.5. *Procedure and statistical analysis*

After screening and random allocation, both intervention groups began their respective programs. The EMDR group received eight sessions, and the neurofeedback group received 12 sessions, with both interventions conducted twice weekly. The control group did not receive any intervention during the study period and remained on a waiting list. All participants were assessed at three time points: before the intervention (pretest), immediately after completion of the intervention (posttest), and one month later (follow-up). Data were analyzed using SPSS version 27. Descriptive statistics were calculated for all study variables, and repeated-measures analysis of variance (ANOVA) was performed to examine the effects of time, group, and the interaction between time and group. Post hoc comparisons were conducted where appropriate. The significance level was set at alpha = 0.05.

3. Findings and Results

A total of 45 female students participated in the study. Regarding grade distribution, 23 students (51.1%) were in Grade 11, 12 students (26.7%) were in Grade 10, and 10 students (22.2%) were in Grade 12.

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Table 3

Descriptive statistics of executive function scores across groups and time

Group	Time point	Mean	SD
EMDR	Pretest	93.60	7.73
EMDR	Posttest	134.67	14.79
EMDR	Follow-up	124.60	13.66
Neurofeedback	Pretest	95.00	14.57
Neurofeedback	Posttest	137.87	27.06
Neurofeedback	Follow-up	127.40	22.86
Control	Pretest	92.07	9.42
Control	Posttest	87.60	3.37
Control	Follow-up	86.00	0.14

Both intervention groups exhibited a substantial increase in executive function scores from pretest to posttest, whereas the control group showed no meaningful improvement. Although there was a slight decrease from posttest to follow-up in both intervention groups, scores remained considerably higher than baseline, suggesting sustained intervention effects.

All assumptions for repeated-measures ANOVA were satisfied. Skewness and kurtosis values were within acceptable limits (±2), the Kolmogorov-Smirnov test was non-significant for all variables, and Levene's test supported homogeneity of variances. Box's M test and Mauchly's test were also non-significant, indicating that the assumptions of equality of covariance matrices and sphericity were met.

Table 4. Multivariate tests for group × time interaction

Test	Value	F	df (hypothesis)	df (error)	p	Partial η²
Pillai's Trace	0.769	13.132	4	84	.001	0.385
Wilks' Lambda	0.231	22.195	4	82	.001	0.520
Hotelling's Trace	3.338	33.375	4	80	.001	0.625
Roy's Largest Root	3.337	70.087	2	42	.001	0.769

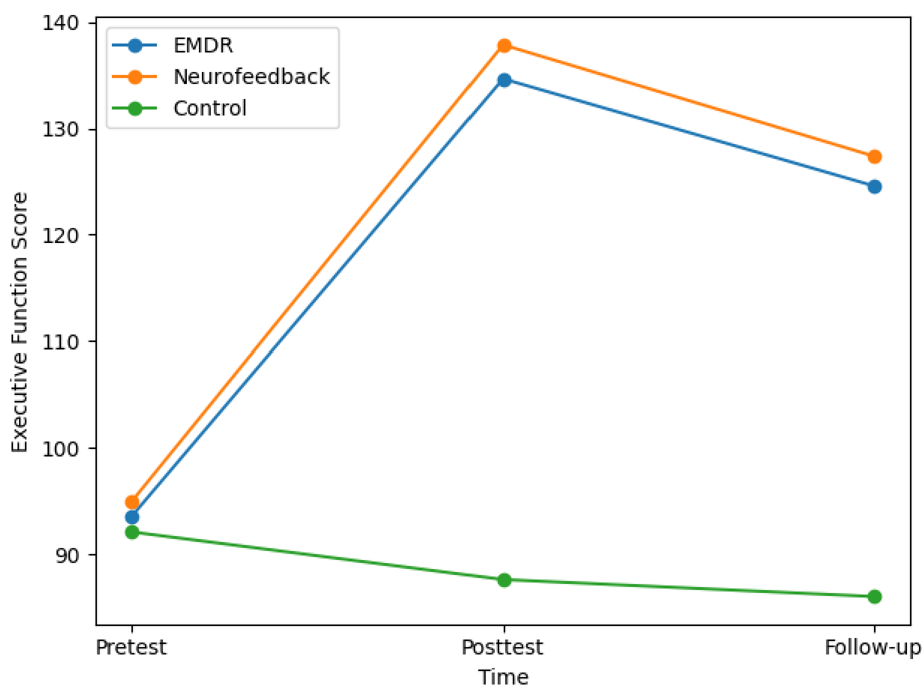
The repeated-measures multivariate analysis revealed a statistically significant group × time interaction for executive functioning. Based on Wilks' Lambda, approximately 52% of the variance in executive functioning was explained by the interaction of group and time, reflecting a strong intervention effect.

Follow-up univariate analyses showed that all components of executive functioning were significantly affected by the interventions: inhibition ($F = 14.962$, $p < .001$, $\eta^2 = 0.468$), shifting ($F = 15.991$, $p < .001$, $\eta^2 = 0.485$), emotional control ($F = 24.893$, $p < .001$, $\eta^2 = 0.594$), planning ($F = 46.460$, $p < .001$, $\eta^2 = 0.732$), organization ($F = 32.909$, $p < .001$, $\eta^2 = 0.659$), monitoring ($F = 30.824$, $p < .001$, $\eta^2 = 0.645$), working memory ($F = 32.515$, $p < .001$, $\eta^2 = 0.657$), and initiation ($F = 62.884$, $p < .001$, $\eta^2 = 0.787$).

Bonferroni-adjusted comparisons showed that both EMDR and neurofeedback significantly outperformed the control group across all executive function components (all $p < .001$), whereas no statistically significant differences were observed between the EMDR and neurofeedback groups at the subscale level. Pairwise comparisons across time showed significant improvement from pretest to posttest ($t = -7.028$, $p < .001$) and from pretest to follow-up ($t = -5.816$, $p < .001$), whereas the posttest-follow-up difference was not significant, indicating maintenance of treatment gains.

Figure 1

Changes in executive function scores across time.



4. Discussion

The present study compared the effectiveness of EMDR and neurofeedback on executive functions among female adolescents with internalizing and externalizing behavioral disorders. The findings demonstrated that both interventions significantly improved executive functioning and that these improvements were maintained at follow-up. Overall, the results provide strong support for both approaches as educational-cognitive interventions targeting executive processes in adolescents.

Regarding EMDR, the findings indicated significant improvement in working memory, inhibitory control, cognitive flexibility, attention, planning, and decision-making. These results are consistent with previous studies reporting beneficial effects of EMDR on cognitive and emotional functioning (27, 28). Executive functions are higher-order cognitive processes responsible for regulating behavior, emotion, and cognition in complex situations, and they are closely associated with the functioning of the prefrontal cortex and its interaction with limbic structures such as the hippocampus and amygdala. Traumatic experiences and chronic stress may disrupt these neural networks, leading to impairments in executive functioning.

From a neuropsychological perspective, EMDR may improve executive functioning by facilitating the reprocessing of distressing memories and reducing emotional overload. According to Shapiro's Adaptive Information Processing model (26), unresolved emotional experiences consume cognitive resources and interfere with adaptive functioning. By reducing the emotional intensity of such memories, EMDR may free cognitive capacity, particularly in working memory, thereby enhancing the ability to process information, regulate emotions, and make decisions. This interpretation is consistent with the central role of working memory in problem-solving, emotional regulation, and decision-making (29). EMDR may also improve cognitive flexibility, enabling adolescents to adapt their thinking and behavior to changing environmental demands (1, 30). Improvements in inhibitory control further suggest that EMDR can enhance regulation of impulsive responses and aggressive behaviors. In addition, improvements in attention and concentration may reflect reductions in anxiety and emotional distress. Similar gains

in planning, monitoring, and decision-making suggest that EMDR contributes to better integration of cognitive and emotional processes, allowing adolescents to engage in more adaptive and goal-directed behavior (31).

The findings also showed that neurofeedback significantly improved executive functions, including working memory, response inhibition, cognitive flexibility, and attention. These results are consistent with earlier studies highlighting the effectiveness of neurofeedback in enhancing executive functioning and cognitive performance (20, 24, 32-34). The effectiveness of neurofeedback can be explained through several complementary mechanisms. First, according to self-regulation theory, the brain can modify its own activity through real-time feedback, leading to improved neural efficiency and balance. Second, operant conditioning principles suggest that reinforcing desirable brainwave patterns promotes their stabilization over time (35). Third, neurophysiological evidence indicates that neurofeedback enhances the coordination of neural networks involved in attention and executive control, particularly within the prefrontal cortex (36). In the domain of working memory, neurofeedback may improve the ability to maintain and manipulate information, likely through enhanced prefrontal-hippocampal connectivity (4). Improved working memory, in turn, contributes to better emotional regulation and impulse control. Similarly, enhanced response inhibition is consistent with evidence that executive control depends on prefrontal and fronto-subcortical circuitry (37).

In terms of cognitive flexibility, neurofeedback may promote adaptive thinking by strengthening fronto-parietal networks, enabling adolescents to adjust their responses to changing conditions. Improvements in attention may be explained by regulation of brainwave activity, particularly the reduction of theta activity and enhancement of beta activity (38). These changes reduce cognitive distraction and improve sustained and selective attention. From a behavioral perspective, strengthening executive functions through neurofeedback can contribute to reductions in anxiety, depression, aggression, and impulsivity (2).

A key point that emerged from the present analysis is that, although both interventions were clearly superior to the control condition, the post hoc comparisons did not show a statistically significant difference between EMDR and neurofeedback at the subscale level. Therefore, the findings support the effectiveness of both interventions rather than the superiority of one over the other. This interpretation aligns most closely with the statistical results reported in the present study and should be emphasized in the final conclusion.

Despite these positive findings, several limitations should be acknowledged. The sample included only female students, limiting generalizability to male adolescents or other age groups. In addition, environmental and psychological variables such as family conditions, sleep quality, nutrition, stress, and social support were not fully controlled and may have influenced the outcomes. The follow-up period was relatively short, and long-term effects remain unclear.

Future research should include more diverse samples, control contextual variables more rigorously, and employ longer follow-up periods to assess the durability of intervention effects. From a practical perspective, EMDR and neurofeedback may both be incorporated into school counseling and mental health services. Furthermore, integrating cognitive training, such as problem-solving, planning, and working memory exercises, with emotional regulation strategies, such as mindfulness and impulse-control training, may strengthen intervention outcomes. Involving parents and teachers in follow-up programs may also help sustain improvements and prevent relapse.

5. Conclusion

In conclusion, both EMDR and neurofeedback appear to be effective interventions for improving executive functioning in adolescents with behavioral disorders. By enhancing cognitive control and emotional regulation, these approaches may contribute to better academic performance, social adaptation, and psychological well-being.

Authors' Contributions

Seyedeh Golzar Razavi contributed to conceptualization, data collection, analysis, and drafting of the manuscript. Ali Zadehmohammadi contributed to study supervision, methodological guidance, and critical revision of the manuscript. Mohammadreza Bigdeli contributed to methodology, interpretation of findings, and manuscript

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review. Hossien Bigdeli contributed to advisory support and manuscript review. All authors approved the final version of the manuscript.

Declaration

AI-assisted tools were used only for language refinement, formatting support, and reference renumbering during manuscript preparation. All scientific content, interpretation of results, and final editorial decisions were reviewed and approved by the authors.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol was approved by the Ethics Committee of the Science and Research Branch of Islamic Azad University. Permission was also obtained from District 1 of the Tehran Department of Education. Written informed consent was obtained from all participants and their parents or legal guardians before data collection. Participation was voluntary, and confidentiality and anonymity were maintained throughout the study.

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