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A Comparison of the Effectiveness of Acute Aerobic Exercise, Mindfulness Practices, Combined Mindfulness, and Exercise Training on Executive Functions in Fourth-Grade Female Students

Fereshteh Mohammadi[1], Mohammad Javadipour[2*], Ali Nouri[3]

1. Department of Curriculum Development & Instruction Methods, Faculty of psychology and Educational Science, Tehran University, Tehran, Iran. Email: fereshtemohamadi36@gmail.com

2. Corresponding Author, Department of Curriculum Development & Instruction Methods, Faculty of psychology and Educational Science, Tehran University, Tehran, Iran. Email: javadipour@ut.ac.ir

3. Department of Educational Science, Faculty of Humanities, Malayer University, Malayer, Iran. Email: a.nouri@malayeru.ac.ir

Extended Abstract

Aim

One of the most influential models of executive functions is the Unity and Diversity model, which conceptualizes executive functions as three independent yet related components: inhibition, shifting, and updating (Miyake et al., 2000). Exercise is one variable that has been shown to affect executive functions (Zhang et al., 2023); however, the literature does not consistently report the same outcomes regarding its effectiveness (Müller et al., 2021). Similarly, mindfulness is another factor that can improve executive function performance in children (Flook et al., 2010). Yet, the findings regarding the effectiveness of mindfulness interventions on executive functions are also inconsistent (Flook et al., 2015).

Few studies have directly compared the impact of exercise and mindfulness on executive functions (Müller et al., 2021). Moreover, the effectiveness of combining both exercise and mindfulness has been explored less frequently, and the findings remain inconsistent (Torre et al., 2023; Lenze et al., 2022).

Given the mixed results regarding the effectiveness of exercise and mindfulness interventions, and the fact that most studies have either assessed these interventions in isolation or only compared them with a control group, there is a lack of research comparing the two directly or evaluating the combined effect of exercise and mindfulness. Therefore, the aim of this study was to compare the effectiveness of aerobic exercise, mindfulness practices, and their combination on the executive functions of fourth-grade female students.

Methodology

This study employed an experimental, pretest–posttest design with a control group. The statistical population consisted of all fourth-grade female students in Amol city during the 2020–2021 academic year. From this population, 90 students were selected through convenience sampling and divided into four groups: aerobic exercise training, mindfulness practices, combined mindfulness and aerobic exercise training, and a control group. The aerobic exercise group, mindfulness group, and combined intervention group each included 23 students, while the control group consisted of 21 students.

A total of 18 training sessions, each lasting 30 minutes (Adams, 2015), were conducted for the experimental groups, with sessions held every two days. A pretest was administered before the intervention period, and a posttest followed its completion. The data were analyzed using analysis of covariance (ANCOVA) with SPSS software, version 22.

Data collection was done using the Free Research Executive Function Evaluation (FRFE) test (Zanini et al., 2021), which is based on the Unity and Diversity model of executive functions. Multivariate analysis of covariance (MANCOVA) was used to analyze the data.

Findings

The results showed a significant difference in inhibition among students participating in all three programs: aerobic exercise training (Eta = 0.18), mindfulness (Eta = 0.26), and the combined mindfulness and exercise training (Eta = 0.76), compared to the control group ($p < 0.05$). Additionally, there was a significant difference in shifting performance in the group participating in the combined mindfulness and exercise training program (Eta = 0.56). Students in the combined mindfulness and exercise training group outperformed those in the other groups.

The results of Benferroni's post hoc test for intergroup comparisons among the aerobic exercise, mindfulness, combined interventions, and control groups are as follows:

The variables	Indexes	the combination with control	mindfulness with control	Mindfulness with combination	Aerobic with control	Aerobic with combination	Aerobic with mindfulness
Inhibition tasks. Stroop Color-Naming task	mean difference	0.39	0.13	-0.25	0.15	-0.24	0.02
	Significance level	0.001	0.018	0.001	0.007	0.001	0.99
Happy Sad Stroop	mean difference	0.31	0.14	-0.17	0.01	-0.30	-0.13
	Significance level	0.001	0.001	0.001	0.99	0.001	0.001
Shifting tasks. Color Shape task	mean difference	0.04	0.05	0.02	0.05	0.01	-0.003
	Significance level	0.99	0.99	0.99	0.99	0.99	0.99
Category Switch task	mean difference	0.50	0.03	-0.47	0.07	-0.43	0.04
	Significance level	0.001	0.99	0.001	0.99	0.001	0.99
Spatial 2-Back task	mean difference	0.03	-0.01	-0.04	0.02	-0.01	0.03
	Significance level	0.99	0.99	0.99	0.99	0.99	0.99
Updating tasks. Number Memory	mean difference	-0.001	0.001	0.001	0.01	0.01	0.01
	Significance level	0.99	0.99	0.99	0.99	0.99	0.99

For shifting tasks, such as the Color-Shape Task, the mean differences between groups were minimal, and no significant differences were observed ($p > 0.99$ across comparisons).

For updating tasks, such as the Number Memory Task, no significant differences were observed across the groups ($p > 0.99$).

Conclusion

The results demonstrated significant differences in inhibition among participants in all three experimental groups—those in aerobic exercise training, mindfulness practices, and the combined mindfulness and aerobic exercise training—compared to the control group. Additionally, a significant improvement in shifting was observed in the combined intervention group compared to the control group. Overall, the combined mindfulness and aerobic exercise training group outperformed the other two groups in both inhibition and shifting tasks.

The findings suggest that mindfulness practices enhance inhibition by promoting non-automatic responding, enabling individuals to react more flexibly to situations rather than relying on habitual,

automatic responses (Wenk-Sormaz, 2005; Kang et al., 2013). Similarly, aerobic exercise training enhances inhibition by potentially priming the central nervous system through increased blood flow to the prefrontal and subcortical areas responsible for regulating inhibitory control (Levin et al., 2021). Notably, the combined mindfulness and aerobic exercise group showed the most significant improvements in both inhibition and shifting, outperforming the other groups.

Keywords: Combined Mindfulness and Exercise Training, Executive Functions, Exercise, Mindfulness, Quasi-experiment with a Pre-test and Post-test Design with a Control Group.

Ethical Considerations

This study adhered to all ethical standards, including obtaining informed consent from participants and their parents, ensuring the confidentiality of personal information, and promoting voluntary participation. Ethical principles were fully observed throughout the research process.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to the findings or reporting of this study.

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