

Effect of Mindfulness Practices on Executive Functions of Elementary School Students

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Article info:

Received: 10 Aug. 2015

Accepted: 25 Nov. 2015

Keywords:

Cognition, Mindfulness,
Executive functions

ABSTRACT

Objective: The present study aimed to investigate effectiveness of mindfulness exercises on the executive functions of elementary school students.

Methods: To this end, 32 female students of second and third grade were selected by cluster sampling method with regard to inclusion criteria (having average IQ, being right-handed) and exclusion criteria (having physical and mental illness, or psychological and psychiatric interventions) and randomly assigned in experimental (mean±SD age; 97.12±3.48 mo) and control groups (mean±SD age; 96.18±3.33 mo). Then, the experimental group participated in 8 sessions of mindfulness exercise (each session, 1 h), but control group received no intervention. Before and after intervention, all participants took working memory test, continuous performance test, and Wisconsin card sorting test. Finally, the obtained data were analyzed by ANCOVA with SPSS 21 software.

Results: Our findings showed that mindfulness had significant effect on forward and backward memory as well as total score of memory ($P<0.01$). Also, findings showed that mindfulness improved perseveration dimension of cognitive flexibility ($P<0.05$). Finally, mindfulness could somewhat improve response time of attention ($P<0.01$).

Conclusion: These findings are consistent with previous research in which the effectiveness of mindfulness on executive functions was approved, though in some dimensions of our variables, the effects were not significant which might be due to the limited sessions of training.

1. Introduction

To be adaptive in this complex world, one must filter out irrelevant information and selectively focus on more important aspects of the environment. The importance of selective attention in the regulation of cognitive processes has already been approved. It facilitates the selection of the correct and appropriate responses by filtering out environmental information and guiding cognitive resources toward the processing of data related to current goal (Diamond & Lee, 2011).

The ability of learning interacts with the mechanisms of selective attention and is regulated by the environment feedback. Thus, selective attention determines what one must learn and pay attention to (Wilson & Niv, 2011). In addition, development and academic success of children necessarily depend on their working memory, attention, and cognitive flexibility (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Baldo & Shimamura, 1997; Chi, Kim, Han, Lee, Park, & Lee, 2012; Van Der Elst, Hurks, Wassenberg, Mejis, & Jolles, 2011) which are known as executive functions. Executive functions play important role in physical and mental health, success in school and life, as well

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as cognitive and psychosocial development (Collins & Koechlin, 2012). Thus, helping children to improve their executive functions is important because the executive functions in early childhood predict their success, mental and physical health, and quality of life (Crescioni, Ehrlinger, Alquist, Conlon & Baumeister, 2011; Miller, Barnes, & Beaver, 2011; Riggs, Spruijt-Metz, Sakuma, Chou, & Pentz, 2010) in their whole life.

Therefore, attention and cognitive flexibility are correlated to mindfulness because in the conceptualization of mindfulness, attention or orienting toward current experiences is implied (Moore & Malinowsky, 2009). Cognitive flexibility is the ability of using cognitive processing strategies to deal with unexpected and new situations which is naturally related to attention processes. We inhibit irrelevant information and focus on directing attention toward goals through cognitive flexibility. Therefore, we deal with attention and inhibition of incorrect responses in the practice of mindfulness because these capabilities are the characteristics of cognitive flexibility. Mindfulness practices are derived from meditation, which is related to paying attention to moment experiences without any description, interpretation, or judgment.

Regarding conceptualization of mindfulness practices, it has been suggested that these practices improve self-regulation of attention (Bishop, 2004). Children in elementary school have difficulties more than the older children on how to learn the lessons and how to hold their concentration while learning new things. Therefore, they should learn to direct their attention toward new content that teacher give them while ignore distracting elements.

Various studies have been conducted on the effectiveness of mindfulness on executive functions in general (Flook et al., 2010; Diamond & Lee, 2011; Teper & Inzlicht, 2013), the attention in particular (Napoli, Krech, & Holley, 2005; Jha, Krompinger, & Baime, 2007; Tamm, Epstein, Peugh, Nakonezny, & Hughes, 2013), memory (Jha, Stanelly, Kiyonaga, Wong, & Gelfand, 2010), and psychological flexibility (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010), but no research has been done so far on the effectiveness of mindfulness on different dimensions of executive functions, particularly among elementary students in Iran. Thus, this study aimed to evaluate the effectiveness of mindfulness training on executive functions of female students of second and third grade.

2. Methods

This research design was an experimental research with pretest-posttest with a control group. Statistical popula-

tion comprised from elementary schools students of Shahriyar City. Research sample in the first stage, Etrat girls elementary school was randomly selected from 3 elementary schools in the secondary stage of the north area of Shahriyar.

Then, 4 classes (2 classes in grade two and 2 classes in grade 3) were selected. Finally, 32 female students were selected from these classes by considering the research exclusion and inclusion criteria. Afterwards, the participants were randomly assigned in the experimental ($n=16$, mean age 97.12 ± 3.48 mo, with an average IQ of 111.0 ± 1.43) and control groups (mean age 96.18 ± 3.33 mo, with an average IQ of 111.18 ± 1.52). To avoid research bias, all students (140 students) in the school received consent forms. The students were the same in terms of demographic characteristics (all of them were female, 8-10 years old, with similar academic achievements, or extremely poor or skillful based on IQ registered in their private documents). Inclusion criteria were having IQ of 100-115 and being right-handed. Exclusion criteria were diagnosis of psychological disorders or physical illnesses, as well as receiving psychiatric or psychological interventions.

Wechsler Intelligence Scale for Children: Wechsler intelligence scales were developed by David Wechsler, a clinical psychologist at Bellevue Hospital. This scale was designed to measure intellectual performance by children. Wechsler Intelligence Scale for Children (WISC-IV) contains 10 main subtests and 5 additional subtests. They comprised 4 indexes (the verbal comprehension index, perceptual reasoning index, working memory index, and the processing speed index) and one full scale IQ (FSIQ) which ranges from 40 to 160 points (Wechsler, 1981).

We used working memory index, which includes digit span and letter-number sequencing. It assesses children's ability to memorize new information, hold it in short-term memory, concentrate, and manipulate that information to produce some results or perform reasoning processes. The test is run individually. The scale of letter-number included 10 items and each item is composed of 3 trials. In this subscale, the examiner reads a random set of numbers and letters to the participant who must arrange numbers in the ascending order and letters in alphabetical order. Digit span subscale has 2 parts: direct span (forward) and backward span. Each of them includes 10 items and each item is composed of 2 trials. Total score of both subscales is 20. The Cronbach α coefficients are 0.01 and 0.76 for the subscales including digit span (forward & backward) and digit-letter sequence,

respectively (Sarmad, Bazargan, & Hejazi, 2004; cited in Ramezani, 2009).

Wisconsin Card Sorting Test: It is a neuropsychological test of “set-shifting”, i.e. the ability to display flexibility in the face of changing schedules of reinforcement. Wisconsin card sorting test (WCST) was written by David A. Grant and Esta A. Berg in 1948. A number of stimulus cards are presented to the participant who is told to match the cards, but not how to match. However, he or she is told whether a particular match is right or wrong. The test takes approximately 12–20 minutes and generates a number of psychometric scores, including numbers, percentages, and percentiles of achieved categories, trials, errors, and preservative errors. WCST allows the clinician speculate to the following frontal lobe functions: strategic planning, organized searching, utilizing environmental feedback to shift cognitive sets, directing behavior toward achieving a goal, and modulating impulsive responding. The test can be administered to people from 6.5 to 89 years old. Preservative error is helpful to determine problems regarding the formation of concepts, learning from correction, and cognitive flexibility (Raofi, 2003). The validity of the evaluators was satisfactory and excellent and reported over 83% and its reliability was reported as 91% by test-retest method. Wisconsin card sorting test measures cognitive flexibility (Satim, 1977).

Continuous Performance Task: Continuous performance test (CPT) measures sustained attention, impulse control or impulsivity, and alertness. In this test, participant must concentrate his or her attention on a relatively simple set of audio or visual target stimuli and push a button to show his or her response. Visual stimuli are presented for a short time on the computer screen and the participant must respond to the stimulus target by pressing one of the keyboard buttons. In this test, a total of 150 stimuli (picture or number) are provided, of them, 30 (20%) are considered as the target stimuli and the remaining 80% are considered as non-target ones. Duration of test, including practice stage in which the participant was helped to understand main stage takes 200 seconds. According to the results of Hadianfard, Najarian, Shekarshekan, and Mehrabizadeh Honarmand (2000), reliability of the Persian version of CPT is between 0.52 and 0.93 in different parts of the test and criterion validity showed significant difference between the two groups by comparing normal participants and patients with attention deficit hyperactivity disorder, which indicates the acceptable validity of the test.

After coordination with the Ministry of Education, and selection of the participants, written informed consents

were obtained from both parents and participants. Participants could leave the intervention program whenever they wanted. Before doing the intervention program, each participant took 3 research tools individually. A trained person with specialized competence in the field of mindfulness held the intervention for 8 sessions as weekly 2-hour sessions. The program was age appropriate and in the framework of exercises and games to promote self-awareness through 5 main senses. After the intervention sessions, tools were taken again by each participant and collected data were analyzed by 1-way analysis of covariance (ANCOVA) using SPSS software version 21.

This protocol was designed based on Kaiser Greenland (2010) and Burdick (2014) protocol. Firstly, the intervention was set just 2 sessions per week for 4 weeks. Each session began with breathing exercises, continued with a dialogue, and ended with an assignment at home. Table 1 shows the content of the intervention sessions.

3. Results

After data collection, they were analyzed using SPSS and the results were presented in both descriptive and analytical statistics. The descriptive statistics for all variables in 3 groups are shown in the analytical section, and assumptions were analyzed by using 1-way analysis of covariance (ANCOVA). Table 2 shows descriptive statistics of variables in the pretest and posttest. We used covariance analyzing for assessing the effectiveness of mindfulness on the different aspects of executive functions.

Before analyzing data, normality (by Wilks-Shapiro test), homogeneity of slope of regression, and equality of error variance (by Levene's test) were tested for each dimension of working memory. With regard to meeting the assumptions, ANCOVA was used for assessing the effectiveness of mindfulness on the different aspects of memory (Table 3).

According to Table 3, by removing the effects of memory pretest results, a significant difference is seen between the experimental and control groups regarding the posttest results ($P=0.001$, $F=18.78$). According to Eta size effect, mindfulness improved forward memory, backward memory, and digit-letter memory about 39%, 48%, and 28%, respectively. These findings suggest that mindfulness practices improve different aspects of working memory capacity.

To evaluate the effectiveness of mindfulness on cognitive flexibility, ANCOVA was used which its results are shown in Table 4. However, we should first analyze the assumptions of normality (by Wilks-Shapiro test), homo-

Table 1. Summary of mindful awareness practices protocol.

Session	Session content
One	Breathing practices (20 min), positive imagination (8 min), talking about imagination (15 min), and drawing complex forms and shapes with closed eyes (15min).
Two	Breathing practices (10 min), mindful seeing, awareness of objects, and remembering the objects.
Three	Breathing practices (10 min), mindful listening, listening to the sounds in the room, dancing until the music stops, playing with auditory words.
Four	Breathing practices (10 min), mindful smell, imagine that smell, name that smell, mindful tasting, taste tester, mindful flavors matching game, mindful eating.
Five	Mindful touching, ice cube game, textures game, guess the objects game.
Six	Mindful eating raisin practice.
Seven	Mindfulness of thoughts, lazy river, blank white board, get in between thoughts, changing the channel, meditation for concentration.
Eight	Mindfulness of compassion, loving kindness for self and others, acts of kindness.

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genicity of slope of regression, and equality of error variance (by Levene's test) for each dimension of cognitive flexibility. According to Table 3, by removing the effects of pretest of preservation ($P=0.001$, $F=7.31$) a significant difference is seen between the experimental and control groups with regard to posttest results ($P=0.04$, $F=4.41$).

According to Eta size effect, mindfulness explains about 13% of preservation. This means that mindfulness practices decreased preservation and thus have relatively significant effects. By eliminating the effects of pretest number of errors of WCST ($P=0.14$, $F=2.22$), there will be no significant difference between the experimental and control

Table 2. Descriptive statistics of aspects of memory, cognitive flexibility, and attention.

Variable	Group	Pre-test		Post-test		
		Mean	SD	Mean	SD	
Memory	Forward	Experimental	10.31	1.88	12.87	1.92
		Control	9.75	2.38	9.75	2.74
	Backward	Experimental	8.50	1.89	11.68	3.32
		Control	8.56	1.89	8.75	2.26
	Digit-letter	Experimental	15.50	3.65	18.87	3.05
		Control	14.75	3.67	15.12	3.51
Cognitive flexibility	Preservation	Experimental	23.31	12.57	16.31	9.65
		Control	17.43	7.87	20.56	9.16
	Error	Experimental	25.81	14.12	20.87	14.60
		Control	16.68	10.46	14.31	9.42
Attention	Commission	Experimental	14.25	26.93	4.81	9.67
		Control	2.93	4.99	3.25	3.35
	Omission	Experimental	3.93	4.22	1.93	2.11
		Control	1.43	2.25	1.12	1.14
	Correct	Experimental	133.06	26.97	143.25	11.12
		Control	146.25	3.51	145.25	4.09
	Time	Experimental	620.87	84.61	666.75	81.10
		Control	619.25	73.39	558.87	88.20

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Table 3. Analysis of covariance of effectiveness of mindfulness on memory.

Variable	Reference	SS	df	Mean	F	P-value	R ²
Forward memory	Pre-test	80.59	1	80.59	26.51	0.001	0.48
	Group	57.09	1	57.09	18.78	0.001	0.39
Digit & letter	Pre-test	98.76	1	98.76	12.63	0.001	0.30
	Group	90.31	1	90.31	11.55	0.002	0.28
Backward memory	Pre-test	61.91	1	61.91	9.94	0.004	0.25
	Group	71.25	1	71.25	11.44	0.001	0.48

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Variable	Reference	SS	df	MS	F	P-value	ETA.S
Preservation	Pre-test	535.40	1	535.40	7.31	0.001	0.20
	Group	323.14	1	323.14	4.41	0.04	0.13
Total error	Pre-test	322.74	1	322.74	2.22	0.14	0.07
	Group	120.75	1	120.75	0.83	0.37	0.03

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groups regarding posttest. According to Eta size effect, mindfulness did not change number of errors of WCST.

Lastly, to evaluate the effectiveness of mindfulness on attention, ANCOVA was used. However, before analyzing data, normality (by Wilks-Shapiro test), homogeneity of slope of regression, and equality of the error variance (by Levene's test) were tested for each dimension of attention. Results of ANCOVA for each dimension of attention are presented in Table 5.

According to Table 5, by removing the effects of pretest results of commission (F=1.52, P=0.23), no significant difference is seen between the experimental and

control groups regarding the post-test results (P=0.05, F=0.81). According to Eta size effect, mindfulness did not reduce commission errors. Regarding omission error, by removing the effects of pretest results of omission (P=0.01, F=7.24), no significant difference is seen between the experimental and control groups regarding the post-test results (P=0.67, F=0.18).

According to Table 5, by removing the effects of pretest results of correct responses (P=0.14, F=2.26), no significant difference is seen between the experimental and control groups regarding the posttest results (P=0.79, F=0.07). Also by removing the effects of pretest results of response time (P=0.96, F=0.002), a significant differ-

Table 5. Analysis of covariance for the effects of mindfulness on attention.

Variable	Reference	SS	df	MS	F	P	ETA.S
Commission	Pre-test	78.33	1	78.33	1.52	0.23	0.05
	Group	2.81	1	2.81	0.05	0.81	0.002
Omission	Pre-test	17.33	1	17.33	7.24	0.01	0.20
	Group	0.44	1	0.44	0.18	0.67	0.006
Correct response	Pre-test	152.34	1	152.34	2.26	0.14	0.07
	Group	4.89	1	4.89	0.07	0.79	0.002
Time of response	Pre-test	17.44	1	17.44	0.002	0.96	0.001
	Group	93058.67	1	93058.67	12.53	0.001	0.30

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ence is seen between the experimental and control groups regarding the posttest results ($P=0.001$, $F=12.53$). According to Eta size effect of 3 above-mentioned variables, mindfulness has no effects on attention but mindfulness changes time of response about 30%. In other words, mindfulness practices has no significant effects on different dimension of attention but only reduces response time.

4. Discussion

This study examined the effectiveness of mindfulness training on executive functions of second and third grade female elementary school students. The results showed that mindfulness practices have significant effects on working memory and some indicators of cognitive flexibility, but has no significant effects on aspects of attention. Most previous studies examined only one aspect of executive functions and reported the effectiveness of mindfulness practices. For example, some studies examined the effects of mindfulness practices on improving executive functions and behavioral inhibition (Raes, Bruyneel, Loeyens, Moerkerke, & De Raedt, 2015; Flook et al., 2010; Napooly et al., 2005), on working memory (Chamber, Lo, & Allen, 2008; Jha, Stanely, Kiyonaga, Wong, & Gelfand, 2010; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010), attention (Jha, Stanely, Kiyonaga, Wong & Gelfand, 2010), or cognitive flexibility (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010).

Regarding the role of mindfulness on improving working memory, the researchers have suggested that attention has a considerable impact on working memory. Awh, Anllo-Vento, & Hillyard (2000) suggested that selective attention in working memory acts as a rehearsal mechanism. So regard, mindfulness practices involves the attention skills, therefore it seems cause improving working memory that in turn improve the selected or divided attention of students. This improvment in the memory and holding information in mind is due to increasing awareness of the present moment by mindfulness practices (Bertranda & Camos, 2015).

There are contradicting results with regard to the role of attention in working memory, because we did not find any supporting evidence for increasing attention by mindfulness practices. Possible explanation for this inconsistency may be due to various types of information processing such as visual and auditory ones that maintain attention; however, we only examined visual processing. Perhaps mindfulness practices improved other types of attention, such as divided attention and focused attention. In this regard, we observed its possible impact on the improvement of working memory in the first part

of results that requires divided attention and focused attention. Another explanation is the existence of various age-appropriate mindfulness practices. In this regard, we need to observe the effect of other types of practices on sustaining attention.

The findings of our study are consistent with the findings of Mrazek and Franklin, Phillips, Baird, Schooler (2013); van Vugt and Jha (2011); and Jha, Stanely, Kiyonaga, Wong, & Gelfand (2010). Practices of mindfulness in the present study like Mrazak intervention (2013) emphasizes on continuous efforts to keep the focus on one aspect of the experience, especially on breathing. When this ability directed toward focusing on the task at hand, it may prevent displacement of the important information of the current task despite distractions and perhaps the reason of increasing scores of students in memory task was the lack of distraction. A neurological explanation of this condition is reduction of default activity of neural network. This network consists of several brain areas that are more active at rest than during performing cognitive directed tasks. These networks have a positive correlation with distraction and by more activity of the network, more distraction occurs during goal-oriented task (McCloskey, 2015).

In other words, performing task in habituation state may increase distraction (McCloskey, 2015). And mindfulness practices reduce the activity of this network so that one does cognitive task in a non-habituation state by awareness of the present time (Beaver, Writght, & Delisi, 2011). Regarding the effectiveness of mindfulness practices on cognitive flexibility, our findings are somewhat consistent with previous studies (Parker, Kuper-smidt, Mathis, Scull, & Sims, 2014; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010).

Cognitive flexibility is the ability to change strategies, tasks, and sets to free mental states from non-related tasks and start new and appropriate tasks (Miyake et al., 2000; Huizinga, Dolan, & van der Molen, 2006). Neuropsychological and neurophysiological evidence increasingly showed that switch between tasks or sets is related to the frontal lobe, although other brain regions may be involved too. For example, event-related potential studies showed that switching between two tasks activates areas of the frontal, parietal, and occipital lobes (Miyake et al., 2000).

Wisconsin card sorting test is a tool that can evaluate the cognitive flexibility. In this test, the participants will be asked to categorize cards based on the specific rules (such as form) and will receive positive or negative feedback. When receiving negative feedback, he

or she should determine new rule for categorization of cards (such as color). Successful switch between rules requires the ability to inhibit mental states that were active before, while the preservation error appears when participant insist on previous rules despite failure (Alvarez & Emory, 2006).

Perseveration is the key symptom of frontal lobe dysfunction and is related to reduction of flexibility (Alvarez & Emory, 2006). With more activity in the frontal lobe, preservation errors of research sample reduce. Ultimately, regarding the effectiveness of mindfulness on attention, the findings of the study showed no significant change, which was not consistent with the previous findings (Napolooli et al., 2005; Jha, Krompinger, & Baime, 2007).

Based on Luria (1986) model of attention development, early school-age children need more intervention sessions on their prefrontal activities. In this study, there was no possibility for us to increase the number and duration of sessions, because students could not attend in intervention program more than 3 times a week and be away from school classroom. Also, it was not possible for families to take children in the intervention program outside of school hours. So, further research with more comprehensive tools and mindfulness protocols should be conducted before reaching definitive conclusions. Another study limitation was the parents' uncooperativeness because such intervention is so new and inventive that they were not aware of its effectiveness. Thus, we recommend that school psychologists hold meeting with parents to inform them about psychological interventions that may be effective for improving behaviors and decrease stress along with increasing executive skills without any danger or side effects. However, those psychologists must be aware of such interventions before talking about it with parents.

Based on this study, we suggest that the effectiveness of this intervention be evaluated with respect to age and grade of the students and using new versions of MAPs. Also, we suggest that working memory and cognitive flexibility (creative) be improved both in clinical and nonclinical populations to treat former group and increase skills of executive functions in the latter one.

Acknowledgements

We appreciate all participants in this study and those who helped us in conducting this research.

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