



# Effects of a Computer-Based Intervention on Sustained Attention, Divided Attention, and Impulsivity in Children with Attention Deficit Hyperactivity Disorder

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## Abstract

**Background:** Attention deficit hyperactivity disorder (ADHD) is a condition that causes poor academic performance. If left untreated, it can lead to different comorbidities such as depression, anxiety, and substance abuse.

**Objectives:** This study compared the effects of a computer-based intervention (Captain's Log MindPower Builder) combined with Ritalin to those of Ritalin alone on sustained attention, divided attention, and impulsivity in children with ADHD.

**Methods:** The statistical population included all boys and girls with ADHD aged 7 - 12 years who visited Baqiyatallah Hospital of Tehran in 2021 (N = 103). Purposive sampling was employed to select 30 eligible children as the research sample. They were then randomly assigned to an intervention group (Captain's Log MindPower Builder + Ritalin) and a waitlist control group (Ritalin alone). The computer-based intervention was performed in twelve 60-minute sessions. The data were collected by conducting the Integrated Visual and Auditory Continuous Performance Test. The analysis of covariance (ANCOVA) was then utilized to analyze the research data. SPSS software v26 was used for data analysis.

**Results:** The mean  $\pm$  SD of sustained attention, divided attention and impulsivity were  $78.26 \pm 6.90$ ,  $80.20 \pm 6.01$ , and  $73.70 \pm 8.91$  on the pretest in the intervention group; moreover, it was  $88.87 \pm 7.19$ ,  $90.94 \pm 5.45$ , and  $82.41 \pm 8.46$  on the pretest in the control group. According to the results, the computer-based intervention had significant effects on both sustained attention and divided attention; however, it failed to significantly improve impulsivity ( $P < 0.001$ ). Additionally, the intervention effects during the 45-day follow-up period only showed stability for sustained attention ( $P < 0.001$ ). In fact, its effects on divided attention and impulsivity control were not significant.

**Conclusions:** The computer-based intervention enhanced Ritalin's effects in some ways and improved sustained attention. Therefore, education centers for children with ADHD are recommended to adopt this method in order to improve attention in such children. Nevertheless, further studies are needed in this field to gain a better insight into the effectiveness of Captain's Log MindPower Builder.

**Keywords:** Attention Deficit Hyperactivity Disorder, Attention, Impulsive Behavior, Children

## 1. Background

Attention deficit hyperactivity disorder (ADHD) is a neurodegenerative developmental disorder characterized by intense motor activity, attention issues, and impulsivity that can cause serious damage and distress throughout life (1). This disorder is also associated with difficulties in cognitive flexibility, inhibition of motor responses, and deficiencies in executive functions (skills such as attention, planning, and decision-making needed to achieve goals) (2). To diagnose this disorder, the unmentioned symptoms must not be caused by children's

evolutionary-developmental levels but must affect their daily functioning (3, 4).

Attention deficit hyperactivity disorder affects seven out of every 100 Iranian children. This disorder affects 8.7% of children in Iran, compared with a global rate of 7.6% (5). Although the precise causes of this disorder have not yet been identified, a combination of environmental and genetic factors may play a key role in its development (6). The brain structures of children with ADHD differ from those of their peers. Ludyga and Ishihara (7) examined 4,576 children aged 9 - 11 years, of whom 602 had this disorder, and the rest were considered a control group.

They found that the amount of gray matter and the ratio of gray matter to white value in these children would predict that they might have a (low) cognitive control ability. People with a higher body mass index (BMI) showed much lower cognitive control than other children with this disorder and with an optimal level of body mass (8).

Children with this disorder perform poorly in school, receive low grades, and earn less as adults than their peers (9, 10). In addition, if left untreated, this disorder can set the stage for different comorbidities such as depression, anxiety, personality disorders, antisocial behavior, and substance abuse (11, 12). Attention deficit hyperactivity disorder can also be classified as a chronic and complex disorder with long-term consequences lasting until adulthood (13, 14). According to Sibley et al. (15), 63% of children with ADHD may still exhibit some symptoms of this disorder as adults and only 9% of them may recover even if they do not meet all the criteria for ADHD diagnosis.

A major symptom of ADHD is difficulty in controlling impulsivity, which is acting without thinking and without considering the consequences (16). Other symptoms include deficits in divided attention, which is the inability to pay attention to two or more sources of information simultaneously, and deficits in sustained attention, which is the inability to focus attention for a long time (17). Due to their attentional disturbances and inability to consider their actions in light of the situation and the possible consequences, these symptoms can make children with ADHD unable to function normally (18). Compared with their normal peers, children who suffer from this disorder or exhibit some of its symptoms face challenges at school such as disinterest in learning, a propensity to skip school, victimization by peers, and high expectations from parents (16). These can negatively affect the academic performance of children with ADHD compared with their normal peers, lowering their performance in school and being linked to challenges with reading, writing, and math. This implies that children with ADHD should benefit from a different type of education than those without this disorder (19).

The first line of ADHD treatment is primarily the administration of methylphenidate or Ritalin, which can reduce symptoms within a year and a half if combined with psychotherapy (20). However, studies have reported side effects such as accelerated puberty, increased blood pressure, and heart rate, a halt or slowing of weight and height gain, loss of appetite, and trouble falling asleep, which make people reluctant to continue taking this medication (21-24). Additionally, the majority of patients who start taking medication for this disorder as children stop taking it during adolescence (25). The World Health Organization (WHO) refused to add Ritalin to the list of

necessary medications for the second time in a row due to doubts about its advantages (26). These cases highlight the significance of non-invasive treatments such as psychological interventions and cognitive rehabilitation (i.e., recovery of cognitive functions).

The computer-based intervention with Captain's Log MindPower Builder was initially introduced to treat children with neurodevelopmental injuries (27). It is one of the novel treatments for alleviating ADHD symptoms that specifically presents video games. Through interaction with a computer and the use of a mouse, this software can offer a variety of cognitive skills training in the three areas of training working memory, training problem-solving abilities, and training attention skills (28). Neuroplasticity or neural flexibility has been used as the mechanism for this treatment's effectiveness because it can help therapeutic effects to be transferred (29). According to Wiest et al. (27), this intervention can help ADHD sufferers improve their attention and working memory. Aivazy et al. (30) and Barzegar et al. (31) also demonstrated that this intervention could enhance working memory in ADHD children.

A few studies have compared the effects of a computer-based intervention (Captain's Log MindPower Builder) combined with Ritalin to those of Ritalin alone on sustained attention, divided attention, and impulsivity in children with ADHD. Considering the significant prevalence of ADHD in Iran, further studies must be conducted in this field to propose non-invasive treatments that adhere to the evidence-based paradigm of psychological treatments.

## 2. Objectives

Accordingly, this study aimed to investigate the effects of a computer-based intervention (Captain's Log MindPower Builder) on sustained attention, divided attention, and impulsivity in children with ADHD.

## 3. Methods

The statistical population of this quasi-experimental study included all children with ADHD aged 7 - 12 years who visited Baqiyatallah Hospital of Tehran in April, May, and June 2021 (N = 103). The inclusion criteria were suffering from ADHD (based on DSM-5), non-affliction with psychiatric disorders and acute or severe physical diseases, not attending any other psychological interventions, taking only Ritalin (no other psychiatric drugs), and parental consent. The exclusion criteria were unwillingness to continue the study and absence in two consecutive intervention

sessions. Based on the inclusion criteria, 30 eligible children with ADHD were selected as the sample and were then randomly assigned to the intervention group (Captain's Log MindPower Builder + Ritalin) and a waitlist control group (Ritalin alone) (Figure 1). In the present research, 15 children with ADHD were included in each group by use of G\*power (effect size = 1.60, test power = 0.90,  $\alpha = 0.05$ ). The computer-based intervention was performed in twelve 60-minute sessions, and the data were collected in three stages: Pretest, posttest, and 45-day follow-up. Participants in the control group also received the intervention at the end of the study. Table 1 presents an overview of the computer-based intervention (32). This study was approved by the ethics committee of the university with code IR.IAU.AHVAVZ.REC.1400.104. Before conducting the research, informed consent was obtained from the participants and their parents.

**Table 1.** An Overview of the Computer-Based Intervention

Sessions	Objectives	Description
1	Pretest, greeting, and software introduction	Pretest, greeting and rapport, and introducing the Mysterious Message game
2	Increasing sustained attention and divided attention and reducing impulsivity	Playing mouse hunter
3		Playing brick breaker
4		Playing driving on the road
5		Playing target practice
6		Playing treasure hunter
7		Playing hide-and-seek
8		Playing explosion
9		Playing firefighter
10		Playing fiery dragons
11		Playing top speed racing
12	Posttest	Posttest, playing puzzles

### 3.1. Measurement Tool

Integrated Visual and Auditory (IVA)-2 Continuous Performance Test: This neuropsychological test was developed to assess impulsivity, visual attention, and auditory attention in people aged 6 - 66 years. This 20-minute test includes 500 stimuli connected to the participant's response or lack thereof (inhibition). This tool has a high sensitivity (92%) and a high predictive power (90%) for diagnosing ADHD, according to Moreno-Garcia et al. (33). The Iranian version of this test has also been reported to have a high sensitivity (92%) and high predictive power (89%). Cronbach's alpha coefficients were determined as 0.89 for this tool.

### 3.2. Statistical Analyses

Descriptive statistics including mean and standard deviation were used for data analysis. Moreover, in this study, the analysis of covariance (ANCOVA) was performed in SPSS 26 to measure the effects of the proposed intervention on the research variables. The significance level of the research was considered to be  $\alpha = 0.05$ .

## 4. Results

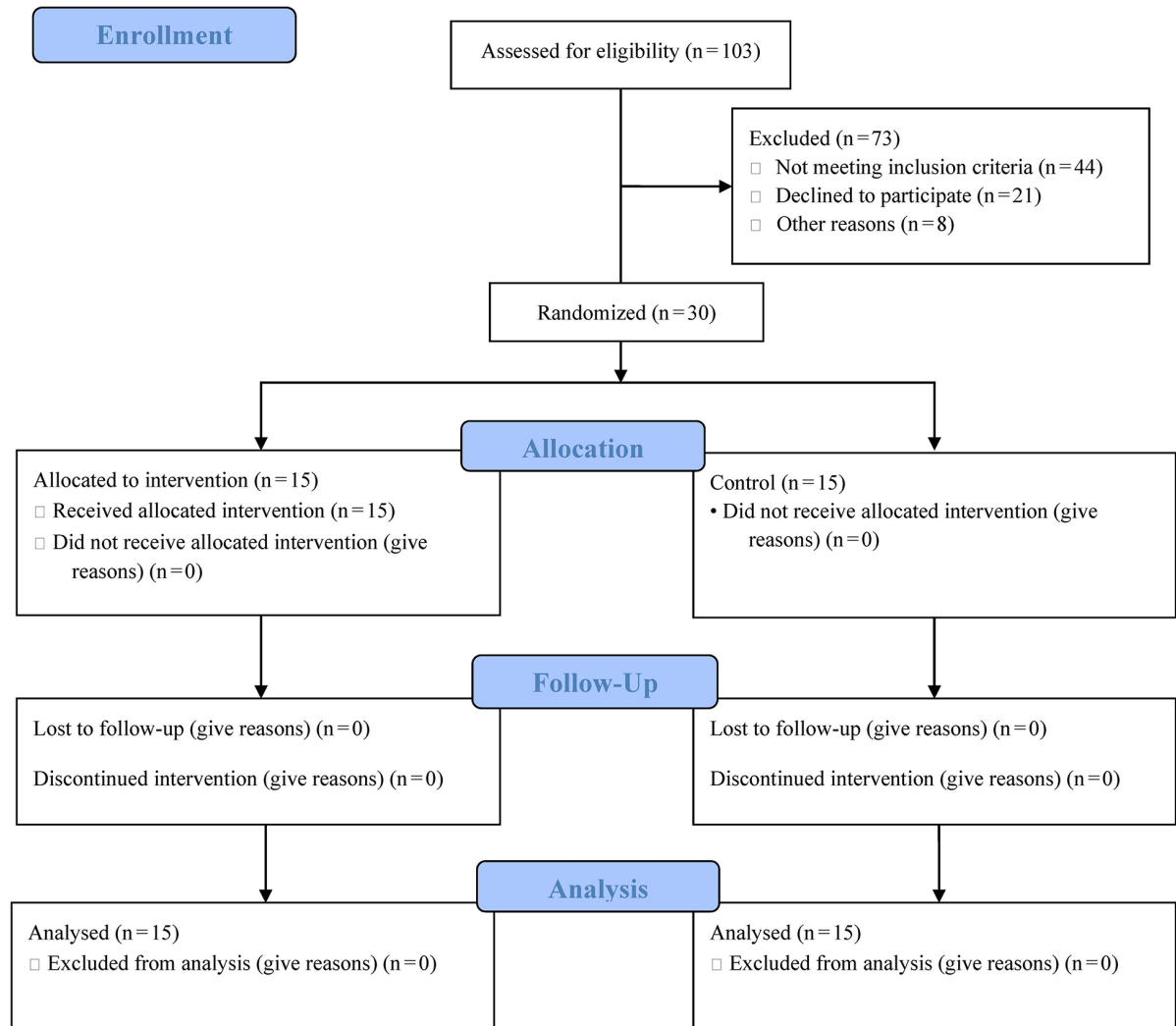
In terms of gender, the intervention group included 5 girls and 10 boys, whereas the waitlist control group consisted of 8 girls and 7 boys. The mean age of participants was  $8.93 \pm 1.79$  in the intervention group, whereas it was  $9.13 \pm 1.76$  in the waitlist control group. The intervention and control groups were homogeneous in terms of demographic variables. Table 2 reports the pretest, posttest, and follow-up descriptive information of the participants.

The eta square rates for Pillai's trace and Wilks' lambda were equal to 0.53 and 0.65, respectively, in the multivariate tests that examined the general hypothesis in the posttest stage while controlling the pretest scores. Additionally, the eta square rates of Pillai's trace and Wilks' lambda were equal to 0.17 and 0.18, respectively, in these tests during the follow-up period with the control of pretest and posttest scores. Table 3 reports the results of the posttest ANCOVA with the control of the pretest scores as well as the results of the follow-up ANCOVA with the control of pretest and posttest scores.

The posttest and the follow-up effects of the intervention were examined through the adjusted mean values. According to Table 4, the posttest effects of the intervention on sustained attention and divided attention were significant ( $P = 0.001$ ); however, its effect on impulsivity control was not significant. However, the follow-up effect of the intervention was significant only on sustained attention ( $P = 0.030$ ), which means that the intervention effect on sustained attention remained stable for up to 45 days. The effects of Ritalin on the posttest impulsivity as well as the follow-up divided attention and impulsivity were nearly the same in the waitlist control group and the intervention group.

## 5. Discussion

This study compared the effects of a computer-based intervention (Captain's Log MindPower Builder) combined with Ritalin to those of Ritalin alone on sustained attention, divided attention, and impulsivity in children with ADHD. The research results indicated that sustained



**Figure 1.** CONSORT diagram of the participants through each stage

attention and divided attention improved significantly in the intervention group in comparison with the control group. Only sustained attention retained significant treatment effects during the follow-up period. In other words, using Ritalin in combination with the intervention based on Captain's Log MindPower Builder kept improvements in sustained attention going for at least 45 days. However, there were no significant differences between the waitlist control group and the intervention group in terms of the follow-up effects of treatments. This finding indicates that the intervention based on Captain's Log MindPower Builder only had temporary effects. In other words, the divided attention improved while receiving the computer-based

intervention; however, the effects of the treatment did not last after the intervention was stopped. The study results regarding attention improvement were consistent with the findings reported by Hosseini and Bahramipour Isfahani (34). However, the intervention based on Captain's Log MindPower Builder cannot apparently be used as a stand-alone therapy to treat the primary symptoms of ADHD.

According to the results, the computer-based intervention failed to improve divided attention for a longer duration but succeeded in improving symptoms of impulsivity and increasing impulsive control. The prevalence of online gaming among children with ADHD and the correlation between the number of hours spent

**Table 2.** Mean and Standard Deviation of Studied Variables in Intervention and Control Groups

Variables and Groups	Mean $\pm$ SD		
	Pretest	Posttest	Follow-up
<b>Sustained attention</b>			
Intervention	78.26 $\pm$ 6.90	88.87 $\pm$ 7.19	91.85 $\pm$ 5.36
Control	76.92 $\pm$ 8.32	80.25 $\pm$ 8.70	80.88 $\pm$ 8.12
<b>Divided attention</b>			
Intervention	80.20 $\pm$ 6.01	90.94 $\pm$ 5.45	92.05 $\pm$ 4.85
Control	75.02 $\pm$ 9.84	80.31 $\pm$ 8.24	80.63 $\pm$ 8.52
<b>Impulsivity</b>			
Intervention	73.70 $\pm$ 8.91	82.41 $\pm$ 8.46	85.03 $\pm$ 9.22
Control	66.09 $\pm$ 13.00	73.86 $\pm$ 8.84	84.14 $\pm$ 9.06

**Table 3.** The Results of the Analysis of Covariance Test in the Post-test and Follow-up Scores of the Studied Variables

Phases and Variables	SS	df	MS	F	P
<b>Posttest</b>					
Sustained attention	2675.52	2	1328.76	44.82	0.001
Divided attention	2855.45	2	1427.72	54.82	0.001
Impulsivity	4972.05	2	2486.03	61.80	0.001
<b>Follow-up</b>					
Sustained attention	55.19	2	27.59	6.44	0.001
Divided attention	5.58	2	2.79	0.95	0.397
Impulsivity	30.98	2	15.49	2.79	0.071

**Table 4.** The Results of Paired Comparison of the Studied Variables Across Time Series

Phases and Variables	Groups	Mean Difference	SE	P
<b>Posttest</b>				
Sustained attention	Control - intervention	-7.66	2.08	0.001
Divided attention	Control - intervention	-8.60	1.95	0.001
Impulsivity	Control - intervention	-5.92	2.42	0.057
<b>Follow-up</b>				
Sustained attention	Control - intervention	-2.94	1.11	0.030
Divided attention	Control - intervention	-1.24	0.92	0.553
Impulsivity	Control - intervention	-1.40	1.26	0.823

playing video games and symptom severity explain this issue (34, 35). The games in Captain's Log MindPower Builder might not be as visually appealing as video games with extremely impressive graphics, which could make them less likely to draw players in and inspire them to be productive. Studies have shown that the effects of video games vary depending on the player's motivation, which lends support to this explanation (36).

The results showed that the computer-based

intervention combined with Ritalin improved sustained attention for 45 days. This finding can be explained by the nature of sustained attention, which serves as the foundation for other types of attention. If this type of attention improves, other types of attention, e.g., divided attention, may improve as well. It can be inferred that a longer treatment period with a higher dose (more sessions over a longer period) might be necessary to achieve more long-lasting effects of this treatment on divided attention

for a longer period (45 days after treatment) in order for the treatment to be effective on other symptoms of this disorder. According to Friesen and Markowsky (37), adding serotonin reuptake inhibitors to stimulant medications used in the treatment of ADHD can significantly reduce symptoms. Hence, further studies in this area are still required to determine whether the computer-based intervention using Captain's Log MindPower Builder in combination with various drug therapies is an effective form of treatment for ADHD (36).

Similar to any other research project, this study faced some limitations. For example, since the statistical population included girls and boys with ADHD in Tehran, caution should be taken while generalizing findings to children with ADHD in other regions with different cultural and economic conditions. Although this study evaluated the effects of treatments through the IVA-2 test, which can prevent memory bias and social desirability bias, future studies are recommended to adopt a self-report tool to analyze changes from the perspective of parents and teachers of children. Since the intervention group continued taking Ritalin similar to the waitlist control group, it is impossible to completely separate the observed effects from those of Ritalin. Although statistical significance was not observed, the families may observe the clinical efficacy of the intervention, which can help families decide whether to use this computer-based intervention as an evidence-based intervention.

### 5.1. Conclusions

The research findings generally suggested that the computer-based intervention using Captain's Log MindPower Builder could be used in combination with drug therapy or other cognitive rehabilitation techniques because its therapeutic effects persisted for 45 days only in improving sustained attention. However, its effects on divided attention persisted until the end of the intervention. It also exhibited no significant effects on impulsivity. The fact that this study used a sample of children with a confirmed diagnosis of ADHD and did not just rely on those who exhibited some symptoms of this disorder was one of its strengths. Another advantage of this study is the implementation of the intervention while being overseen by a supervisor contributed to providing the intervention under standard conditions. Future studies are recommended to assess how well this computer-based intervention works in combination with other medications, as using this intervention with medications other than Ritalin will probably yield better results.

### Footnotes

**Authors' Contribution:** FM and SB developed the study concept and design. SB acquired the data. HJ analyzed and interpreted the data, and wrote the first draft of the manuscript. All authors contributed to the intellectual content, manuscript editing and read and approved the final manuscript. SB and HJ provided administrative support.

**Conflict of Interests:** There are no conflicts of interest regarding the publication of the current research.

**Ethical Approval:** The Ethics Review Board of Islamic Azad University, Ahvaz Branch, approved the present study (code: [IR.IAU.AHVAZ.REC.1400.104](https://doi.org/10.1007/7854.2022.329)).

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**Informed Consent:** Informed consent was obtained from the participants and their parents.

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