

Changes in Visual Attention and Reading Fluency of the Children with ADHD through the Interactive Metronome Training

Sung-Min Son^{1*}

¹Professor, Department of Occupational Therapy, Jeonju Kijeon College 267 Jeonjucheonseo-ro, Wansan-gu, Jeonju-si, Jeollabuk-do, 54989, Republic of Korea

Corresponding author*: Sung-Min Son, E-mail: ertreat@naver.com

ABSTRACT

Purpose of this study is aimed to analyze the changes in visual attention and reading fluency of the children with Attention Deficit Hyperactivity Disorder (ADHD) through the Interactive Metronome (IM) training. Study subjects were 16 children with ADHD and they consisted of 8 male (Age ranges: 11.28±2.56) and 8 female (Age ranges: 11.25±2.31). They participated in the IM training for 8 weeks. The assessment of visual attention was used by Trail Making Test and the assessment of reading fluency was used by Basic Academic Skills Assessment: Reading. As the performance time was reduced, the results of visual attention showed the improvement through the application of the training. In the case of the results of the analysis about the reading fluency, the scores increased and the reading fluency was improved through the application of the training. Based on the results in this study, IM training acts for them positively to improve the visual attention and reading fluency. Thus, to improve the visual attention and reading fluency of the children with ADHD, IM training should be considered for them.

Keywords

ADHD, Children, Interactive metronome, Reading fluency, Visual attention

1. Introduction

Generally, ADHD is defined as a chronic neuro-developmental disorder including the cognitive problem of attention deficit and behavioral problems such as hyperactivity and impulse control problems [1]. Moreover, it is considered as a mental illness with maladjustment to social environment, low self-esteem, and depression. The major symptoms of ADHD occurred in childhood frequently [2].

Based on the American Psychiatric Association, the incidence of ADHD in school age is reported to be at 3-10%, and this is being increased continuously. In Korea, the incidence of ADHD in school age is reported to be up to 12.25% by the various studies [1]. In addition, about 70% of the children with ADHD continue to have symptoms until adolescence, so they have difficulties in normal school life and forming and maintaining the relationships significantly. More than 50-60% of them persist until adulthood, causing significant problems in social, academic function and work [3].

Among the various problems suffering from learning process in their school age, visual attention deficit directly prevents the perception and processing the visual information from the environment [4]. Especially, it causes a significant problem in selecting, classifying, and interpreting the information among the various information, and causes a significant delay in the development of linguistic and basic learning functions, such as reading and writing [5]. In learning process, these effects directly on the performance of the learning tasks [6].

Especially, the children with ADHD have most difficulties in reading [7]. As they have difficulties in paying attention to the reading materials, the children with ADHD frequently miss

the line or paragraph in a reading task [6]. Accordingly, they miss the words and important details, and are interfered with the understanding of reading materials. As the results, they easily forget what they read and often have to read again frequently [7]. Therefore, to reduce the difficulties in reading process and to improve the reading ability of them, the appropriate intervention should be applied in the reading process [5].

The non-pharmacological interventions for the children with ADHD are applied variously, such as the cognitive behavioral therapy, social skills training, the education for the caregiver and teacher in charge, art therapy, and environment modification [8]. Among these, the IM training attracts the attention as an intervention to improve effectively the motor and cognitive function of the children with ADHD [9]. IM training is a training to strengthen the neurological functions related to timing inside the body through the simultaneous action between the external and internal rhythm of the body, based on the timing theory [10].

The feedback of the timing errors during IM training induces the rapid interaction between the motor and sensory nerve [11]. At this time, the cranial neural network related to timing is activated with the increase of nerve vibration speed. This promotes the improvement of the cognitive and motor function effectively through the improvement of attention level by the output in the form of working memory [10]. Thus, the increase of the timing by IM training effectively acts to organize the cognitive process, such as the motor planning and sequencing and attention [12].

Previously, based on the effects of the training, a number of studies applying IM training for the children with various disabilities were reported, such as intellectual disability [13], autism spectrum disorder [14], language and reading disorder [15], cerebral palsy [16]. The most studies reported that IM training positively acts to increase the attention level and improve the cognitive functions by inducing the activation of the nervous system. In addition, through the performance of timing movements with participants; hands and feet, the motor function and postural control ability are effectively improved.

In the case of the children with ADHD, a number studies applying the IM training were reported variously [2, 11, 17-19]. Park and Kim's study [2] reported that IM training positively acts to improve postural control and hand writing ability of the subjects through the IM training. Gu et al.'s study [11] reported that IM training effects on the reduction of behavioral symptoms and improvement of timing, hand coordination, and motor function of the subjects. Since most of the studies only studied a small number of subjects, they reported that the studies have limited in demonstrating and presenting the effectiveness of IM training. Thus, based on these, this study aimed to analyze the changes of visual attention and reading fluency of the children with ADHD through the interactive metronome training and then provide the basic information about that.

2. Methods

2.1 Study subjects and period

Subjects were 16 children with ADHD using in an E. Children Developmental center in K city. The criteria of subjects' selection were as follows: Only an individual who 1) was diagnosed as a ADHD based on the DSM-V and ADHD Rating Scale (ARS) [20], 2) has no neurological and

orthopedical problems in physical structures and functions interfered with performing the IM training, 3) has no problems in visual and auditory system, 4) is not taking any antipsychotic medication effecting directly on the performing the training.

ARS is an ADHD screening assessment by the checklist for parents consisted of 18 items according to the DSM-V diagnosis criteria for ADHD. ARS measures each item by a 4 points scale and if the results show at least 12 points, it is determined to be ADHD [20].

Prior to the training of subjects in this study, to confirm the cognitive level required for the performance of the training, the assessment used by the Mini Mental State Examination Korean ver. (MMSE-K) was performed. The items of MMSE-K consisted of the questions about orientation, memory registration and recall, attention and calculation, language function, and understanding judgement [21]. As the results of that, all results of the subjects showed at 20 points more which indicates the level in order to understand the instructions and then perform these and express the simple opinion. Based on these, all the subjects were participated in this study.

Related in the consent process of the participation in this study, the purpose and methods of this study were explained for the subjects sufficiently by using the visual materials. Accordingly, after understanding these, subjects were allowed to participate in this study voluntarily. The consent of the participation in this study was offered by writing. Additionally, considering the subjects were the children with ADHD, consent from their parents was offered by writing.

Study period was for 8 weeks from May 1 to July 31 in 2019.

2.2 Study procedures

Based on the study purpose, to analyze the changes of visual attention and reading fluency through the IM training for them, the analysis within a group was performed according to the pre-post experimental study and single group study design applied in this study. The training and assessment were performed individually in the occupational therapy room by an occupational therapist who is a researcher in this study. Prior to these, the environment was set in comfortable and stable condition and then the explanation about the training and assessment sufficiently was offered for the subjects by using visual materials. In the training and assessment process, a speech therapist was cooperated.

2.3 Interactive metronome training

Interactive metronome (IM) training is a training tool to improve brain ability for the information processes, attention and executive functions by increasing the capacity and speed of the integrated nervous system to perform the rhythm training accurately and repeatedly [22]. The training is consisted of total 13 tasks divided into hand, foot and hand-foot coordination tasks. These tasks are performed by touching or tapping the trigger with user's hand or foot according to the sound of a constant interval from the headset [11]. The results of training are recorded as task average points by measuring the accuracy of trigger tapping as millisecond. Task average points was recorded from 0 to 500 ms and the lower points indicates the higher accuracy of action [2].

Previously in the most study applying the interactive metronome training for their subjects, to facility the brain based on the principles of neuroplasticity, the training should be conducted at least 3 times a week and it consists of at least 4 weeks and 12-15 sessions [2, 23]. Thus, based on the process, in this study, the training was conducted 3 times a week for 8 weeks and it consisted of total 24 sessions.

2.4 Visual attention assessment

To measure visual attention, Trail Making Test (TMT) was used. TMT assessment is consisted of the Part A and B. Part A is performed that each number is connected in ascending order. Part B is performed that each number and letter are connected in ascending order. The results are recorded by total time. The total time is set from the start to the end time of the assessment and it is measured by seconds. The shorter the total performance time indicates the higher level of visual attention. Additionally, errors occurred during the assessment is pointed out to be modified voluntarily. However, if errors could not be modified voluntarily or the total time exceeds 5 minutes, the assessment is to be stopped. [24].

The results of test-retest reliability of this assessment showed at .79 in Part A and .89 in Part B. The correlation between part A and B was 0.75 and the correlation of each test showed the high at .83 in Part A and .90 in Part B [25].

2.5 Reading fluency assessment

To measure reading fluency, Basic Academic Skills Assessment: Reading (BASA-R) was used. BASA-R is an effective assessments assessment by measuring the reading fluency of the disabled children effectively, based on the principle of Curriculum Based Measurement (CBM). This assessment is consisted of 20 reading items included 1109 letters in each item and this is designed to present reading items differently to minimize learning effects [25].

This assessment is performed by presenting a reading item to a subject and reading accurately for a minute through the instructions. Accordingly, this assesses how many letters have been read correctly and quickly during a minute [26]. In the process of assessment, an evaluator draws diagonal lines on the wrong letters on the assessment form for the evaluator. The results of assessment are calculated by subtracting the number of wrong letters such as missing, added, and mispronouncing letters from the total number of letters read accurately. However, if the subjects read wrong letters by correcting them, the letters are not graded with a wrong score. The equivalent test reliability was .96 [27]. Based on the manual of this assessment, in this study, the scores for each results were recorded as the raw scores and then analyzed.

2.6 Statistical analysis

The collected data were coded and then analyzed using SPSS version 23.0. Descriptive statistics were used to analyze the general characteristics of the subjects. To analyze the visual attention and reading fluency, Wilcoxon's signed ranked test was used. Additionally, effect sizes for Wilcoxon's signed ranked test can be calculated as the following: Absolute value of Z divided by the square root of the sample size. The significant level was set to 0.05.

3. Results

3.1 General characteristics of study subjects

The results of the general characteristics of study subjects showed as follows (Table 1). Study subjects were 16 children with ADHD. In the age of the subjects, their average age was 11.28 years in male and 11.25 in female. In the sex of them, male and female were 8 people respectively. As the results of ADHD rating scale (ARS), male showed 18.86 points and female showed 19.00 points. Based on the results, all the subjects were screened for ADHD.

Table 1.General characteristics of study subjects (n=16)

Age(years)		Sex(n, %)		ARS(points)	
Male	11.28±2.56	Male	8(50)	Male	18.86±2.04
Female	11.25±2.31	Female	8(50)	Female	19.00±1.85

3.2 The results of visual attention

The results of visual attention were showed as follows (Table 2). The results of visual attention showed the decrease at 23.60 average seconds from 184.80 points before the interactive metronome training to 161.20 points after the training. Additionally, the results showed the statistically significant difference at the 99 % significant level. The results of effect sizes showed the 11.88%. Thus, according to the interactive metronome training, the improvement of visual attention of the children with ADHD showed.

3.3 The results of reading fluency

The results of reading fluency were showed as follows (Table 2). The results of reading fluency showed the increase at 14.73 average points from 170.40 points before the interactive metronome training to 185.13 points after the training. Additionally, the results showed the statistically significant difference at the 99 % significant level. The results of effect sizes showed the 11.77%. Thus, according to the interactive metronome training, the improvement of reading fluency of the children with ADHD showed.

Table 2Results of visual attention and reading fluency

Variables	Pre (Mean±S.D)	Post (Mean±S.D)	Z	P	Effect size (%)
Visual attention(sec)	184.80±22.27	161.20±25.58	-3.041	.002**	11.88
Reading fluency (points)	170.40±29.81	185.13±40.72	-3.014	.003**	11.77

**p<0.01

4. Discussion

IM training is used in the rehabilitation process for the disabled children to organize the cognitive processes effectively by facilitating the brain function through rhythmic timing-based movements [9]. Especially, through these actions of IM training, the valid effects for the children with ADHD on the cognitive function and learning skills were reported in the most previous studies

[28]. Various previous studies [10][19] reported to contribute to visual motor control and visual attention changes by the IM training and they focused that these changes actually can have a positive effect in the process of performing learning including the writing and reading and various activities. Accordingly, these previous studies are judged to suggest that IM training may resolve visual motor control and velocity deficiencies.

In addition, in this study, the level of visual attention and reading fluency of study subjects were changed positively after the participation in IM training and the effect size of these results was 11% or more for all variables. Accordingly, we judged that the IM training induces for the children with ADHD to the positive changes of the variables and the training may resolve reading deficiencies. Based on these, this study has clinical significance to report the positive changes through the participation in the IM training for the children with ADHD. Thus, IM training should be considered as a tool in the rehabilitation process for positive changes in their visual attention and reading fluency of the children with ADHD.

The results of visual attention of study subjects showed the increase after the training. IM training induce the participants to respond to the correct timing by performing the movement of tapping the trigger with hand and foot to match the metronome sound [9]. In this process, the auditory signals provided by IM stimulate the perceptual area in brain and then, the participants are able to pay more attention to the task [10]. These actions improves the familiarity of eye-hand coordination through the executive process of triggering the hand to foot operation, and more effectively organizes the cognitive process [19]. Accordingly, it is judged that a positive change in visual attention of participants showed through the participation in the IM training.

Leisman and Melillo's study [29] reported that the participation in IM training induce participants to focus their attention through the performance of timed activities. Bak and Yoo's study [12] also reported the IM training significantly contributes the participants to improve the visual attention level and especially in the case of short term memory and these actions effectively induces an improvement in the learning level. Yeon [30] reported that the IM training effects positively on the visual attention and visual perception ability for the children with intellectual disability.

These results were supported by the various previous studies. These studies commonly explained that timing tasks in IM training contribute to improve the accuracy of participants' performance, and that the level of visual attention is effectively improved in this process. In addition, the studies also explained that these are effective not only for the children with intellectual disability, but also, for the children with ADHD. Therefore, based on these actions and effects of IM training, it is necessary to consider the IM training as a tool to induce positive changes in visual attention of the children with ADHD.

Moreover, the results of reading fluency of study subjects showed the increase after the training. Reading fluently is an activity requires the execution by an interactive process of cognitive function, which includes visual attention and perception processes and motor control [2]. IM training contributes to promote the activation of cognitive and motor areas in the brain [31]. This process is defined in the process of exercise planning through sequential timing activities based on the inner sense of rhythm [32], improving timing and accuracy, and effectively organizing the

process of perception and thought judgment. Accordingly, it induces to improve the cognitive process in the central nervous system [33].

Based on these actions of IM training, IM training induce to change positively in the reading fluency of the participants. These were supported by various previous studies. Ritter et al. [15] also reported a significant improvement in reading speed and fluency in the children with language and reading disability after the participation in the IM training. Thus, the application of IM training in the process of reading intervention contributes to the improvement of the reading ability of the participants. Thaub et al. [31] reported that high school students' language fluency and reading comprehension improved significantly through IM training, and they explained that these results were the result of improving the language comprehension and processing speed by improving the level of visual attention and reading speed.

Seok [34] reported that the subjects' ability of information process and calculation improved most based on the participation of IM training. Accordingly, he explained that IM training is an improvement in the basic academic ability of the children with ADHD. Accordingly, it is judged that a positive change in reading fluency of participants showed through the participation in the IM training. Most studies commonly suggested that the participation in the IM training is valid in the rehabilitation process to improve the basic reading ability of the participants. Therefore, based on these actions and effects of IM training, it is necessary to consider the IM training as a tool in the reading intervention process to induce positive changes in reading fluency of the children with ADHD.

The study limitation of this study was as follows. Based on the results in this study, the effects of IM training on various basic learning abilities, such as reading and writing, should be verified to demonstrate the effects of the application of IM training on the level of basic learning for the children with ADHD. In this study, other factors related to ADHD symptom severity or developmental histories were not fully examined. Thus, it cannot necessarily understand if this approach may work best for particular children with certain ADHD presentations or other co-occurring factors. According to these, further studies should be carried out with sufficient reflection of the severity of ADHD symptom and other factors associated with the developmental history. Along with these, study subjects should be categorized according to the severity of ADHD symptoms and developmental characteristics so that the application of IM training can be understood to be effective in the children with ADHD.

5. Conclusions

This study aimed to analyze the changes in visual attention and reading fluency of the children with ADHD through the IM training. As the results, after the participation in the training, the results of visual attention and reading fluency showed the positive changes. Based on these, IM training should be considered as a tool to induce the changes positively in the visual attention and reading fluency of the children with ADHD. Thus, IM training should be considered for the children with ADHD in the rehabilitation process to improve the visual attention and reading fluency.

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