



Case Study

## Effects of interactive metronome training on timing, attention, working memory, and processing speed in children with ADHD: a case study of two children

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**Abstract.** [Purpose] The purpose of this study was to present the effects of Interactive metronome (IM) on timing for children with Attention-Deficit Hyperactivity Disorder (ADHD). [Subjects and Methods] The subjects of the present study were 2 children diagnosed with ADHD. Pre- and post-intervention tests were completed by the researcher using Long Form Assessment (LFA) test of IM and K-WPPSI-IV. The subjects were provided with IM for 40 minutes at a time, 2 times per week, for a total of 8 weeks. [Results] The timing decreased after IM intervention. The subjects showed improvement in attention span after IM intervention. Working memory index as well as processing speed index were increased after intervention, as shown by the Korean-Wechsler Preschool and Primary Scale of Intelligence-IV (K-WPPSI-IV). [Conclusion] IM was effective in improving timing, attention, working memory and processing speed in children with ADHD.

**Key words:** Interactive metronome, ADHD, Cognitive function

*(This article was submitted Jul. 19, 2017, and was accepted Sep. 4, 2017)*

### INTRODUCTION

Attention-Deficit Hyperactivity Disorder (ADHD) is a disorder characterized by inattention and hyperactivity-impulsivity. In addition to the key symptoms, the disorder also presents problems related to attention and executive function. Children with ADHD tend to exhibit clinical deficits in working memory and processing speed<sup>1,2)</sup>. Of the ADHD subtypes, predominantly the inattentive type is associated with short attention span and inability to remain focused on task<sup>3)</sup>, which lead to a number of secondary problems such as low academic achievement, difficulty with interpersonal relationships, negative emotional development, low self-esteem, etc<sup>4)</sup>. Attention is dependent on executive function and timing, which are reported to be associated with the function of the frontal lobe<sup>5)</sup>. It is known that interventions designed to improve the brain's data-processing ability, through accurate timing and repetitive rhythm training can play a key role in reducing inattention, and that the single most effective measure of attention is timing<sup>3)</sup>.

Interactive metronome (IM), a tool founded on neuro-sensory and neuro-motor principles, can improve motor function and cognitive function simultaneously<sup>6)</sup>. In IM training, the individual synchronizes a range of hand and foot exercises to a precise computer-generated reference tone heard through headphones. Magnetic resonance imaging (MRI)-based studies have provided sufficient evidence to suggest that such a training activates all regions of the brain and increases the processing speed of neural networks<sup>6)</sup>.

Bartscherer & Dole<sup>7)</sup> conducted a study in which they examined the effects of a 7-week IM training on 9-year-old boys

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with attention and motor coordination deficits. The study found that the training program had a positive effect across a range of measures, including timing accuracy, balance, response speed, visual motor coordination, upper limb speed, and agility. In a study by Namgung and colleagues<sup>8)</sup>, two children diagnosed with ADHD were inducted into a 4-week IM program. Upon completion of the program, the children were reported to have improved timing, attention, bilateral coordination, and upper limb coordination. Shaffer and colleagues<sup>9)</sup> also studied the effect of IM training on children with ADHD. The researchers found that the training was effective for improving the children's attention, motor control, language processing, reading ability, as well as the ability to control aggressive impulses. However, the effect of IM training on the cognitive variables of children with ADHD has not been studied extensively. The purpose of the present study is to identify the effect of IM training on timing, attention, and cognitive function (working memory, processing speed) in ADHD children.

## SUBJECTS AND METHODS

Two children diagnosed with ADHD were included as the subjects for the current study. The researcher briefed the children and parents/legal guardians about the purpose of the study and potential risk factors. All participants provided written consent, in accordance with the ethical principles of the Declaration of Helsinki. Child 1 was a 4.5-year-old boy attending daycare, who had a K-WPPSI-IV composite score of 85. As for the child's behavioral characteristics, he had difficulties focusing on conversations, and he tended to say inappropriate things that did not fit the context of the situations at hand. Child 2 was a 6-year-and-3-month-old boy attending kindergarten, who had a K-WPPSI-IV composite score of 100. The child exhibited behavioral characteristics of inattention, and difficulties participating in kindergarten class activities.

The study employed a "before and after" design in order to test the effect of IM training on the subjects' attention, executive function, working memory, and processing speed. Timing and attention were measured using IM training's Long Form Assessment (LFA) results. For measurement of working memory and processing speed, K-WIPPSI-IV was used. A total of two measurements were performed for each variable, one before and one after the intervention. For the process of intervention, the standard 15-session IM protocol was selected, which consisted of a 40-minute session taking place twice a week. The intervention was provided by the first author, in child private center. During each session, the subjects put on a headphone which delivered a computer-generated reference tone. A trigger detected any contact or motion generated by the subject while performing the tasks, and transmitted the data to a computer system. Therefore, the subject is expected to synchronize a range of hand and foot exercises to a precise computer-generated reference tone heard through headphones. With every movement, the subject is immediately provided with an audio feedback, indicating how well a participant is performing. In the present study, the IM pro 9.0 software (manufactured by Interactive Metronome) was used, which offered a total of 13 tasks in each session. Timing and attention were measured with LFA-IM. As a measurement of timing, the parameter "task average" was used, and the accuracy of each tap on the trigger was measured in milliseconds (ms) and the millisecond average was recorded. A decreasing millisecond average was interpreted as improvement in timing. As a measurement of attention, Super Right On (SRO%) was used, which refers to the percentage of hits within 15 ms. The subjects were provided with audiovisual feedback as an indicator of the quality of their performance. An increasing SRO% was interpreted as improving attention. K-WPPSI-IV is an intelligence test which provides developmentally responsive subtest and composite scores that represent intellectual functioning of a child. In the present study, working memory index and processing speed index obtained from the K-WPPSI-IV test were used as measurements of working memory and processing speed.

## RESULTS

Table 1 displays the millisecond averages before and after the intervention, which suggest changes in timing. In Table 2, SRO% measurements before and after the intervention are displayed, which suggest changes in attention. Table 3 displays the working memory index and processing speed index obtained from the K-WIPPSI-IV test, before and after the intervention.

## DISCUSSION

The present study aimed to test the effect of IM training on the timing, attention, working memory, and processing speed of children diagnosed with ADHD. Attention and timing were measured with LFA-IM, while working memory and processing speed were measured with K-WIPPSI-IV. Child 1 showed improvement in attention, timing, and processing speed, but no significant change was observed in terms of working memory. As for Child 2, improvement was observed across all measures, including attention, timing, working memory, and processing speed.

A number of previous studies have already reported the effect of IM training on the timing, attention, and balance of children with ADHD. A study by Jung & Kim, which examined the effect of IM training on bilateral coordination, balance, and upper limb function in paretic children, reported improvement in bilateral coordination and balance<sup>10)</sup>. A case study by Namgung and colleagues also reported improved visual attention division and sustained attention in children with ADHD, following an IM intervention<sup>8)</sup>. The results obtained in the current study regarding increased attention span and improved motor skills (such as timing) following an IM intervention support the findings of previous studies. To inquire whether the improvements observed in the study had a real effect in the children's everyday life, parents/legal caregivers were consulted.

**Table 1.** Pre-test and post-test millisecond averages

Case	Pre-test	Post-test
1	244 m/s	134 m/s
2	238 m/s	97 m/s

**Table 2.** Pre-test and post-test SRO%

Case	Pre-test	Post-test
1	3.5%	13.7%
2	4.0%	27.6%

**Table 3.** Pre-test and post-test K-WPPSI-IV working memory index and processing speed index

Case	Category	Working memory index		Processing speed index	
		Pre-test	Post-test	Pre-test	Post-test
1	Percentile rank	94	97	20	55
	Descriptive category	Superior	Superior	Below average	Average
2	Percentile rank	68	96	34	83
	Descriptive category	Average	Superior	Average	Above average

It turned out that the children indeed exhibited less distractedness following the intervention. Reports from teachers also verified that the children's attention span and participation in class had improved following the intervention.

The other finding of the present study pertains to improvement in cognitive functions following the IM intervention, as measured by working memory and processing speed. The finding is substantiated by a previous study which reported that IM interventions had a positive effect on the overall brain function, contributing to improved neural network processing<sup>6</sup>. A study by Jessica & Donald reported the effect of IM training on language skills training in teenagers with language learning deficits<sup>11</sup>, while Bak & Yoo reported of its efficacy in improving short-term memory<sup>12</sup>. As for studies concerning IM training's effect on the cognitive function of individuals diagnosed with ADHD, one study reported reduced impulsivity and improved attention following IM intervention<sup>13, 14</sup>. On the other hand, the current study employed the working memory index and processing speed index obtained from K-WIPPSI-IV based on the fact that they are reported to be the most salient measures for screening children for ADHD<sup>3, 15</sup>, and the results indicated that the IM intervention contributed to both improved working memory and processing speed. The contribution of the present study lies in the evidence it provides in support of the effectiveness of IM training in improving the cognitive function of children diagnosed with ADHD.

This study suggests that IM can be used as an intervention for improvement of physical and cognitive function of children with developmental disabilities such as ADHD and may be applied in the field of physical/occupational therapy. Generalizing the results of the present study calls for caution, however, as the study is a case report involving only two subjects. On this note, a follow-up study with a larger sample size would be beneficial, as well as a comparative study examining the therapeutic effects of IM training and other treatments for ADHD.

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