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Effect of Thai traditional play protocol on working memory and inhibitory control in children with attention-deficit/hyperactivity disorder

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ABSTRACT

Background: Children with attention-deficit/hyperactivity disorder (ADHD) commonly have problems with executive functions (EFs), especially working memory and inhibitory control. There are a growing number of appropriate EF interventions for children with ADHD. Since all aspects of occupational functioning can be affected, occupational therapists have much to offer in providing interventions for school-aged children with ADHD to improve their executive function skills.

Objectives: The aim of this research was to examine the effects of Thai traditional play protocol on working memory and inhibitory control in children with ADHD.

Materials and methods: The study was conducted with a one group-pretest-posttest research design. Seven school-aged children with ADHD, aged between 8 and 9 years with T-scores ≥ 65 on the Behavioral Rating Inventory of Executive Function (BRIEF), Parent Form: Thai version, participated in this study. The Thai traditional play protocol was designed and developed by researchers. Twenty Thai traditional play activities that had cognitive challenges focusing on working memory and inhibitory control skills were selected and analyzed. Self-regulatory strategies, heavy work activities, and parent education were also implemented. Children with ADHD participated in a 24-session protocol, across 8 weeks with 3 sessions per week, lasting 60 minutes per session. An outcome measure was the Stroop Color and Word Test (SCWT): Children Edition. Data was analyzed using descriptive and non-parametric statistics.

Results: By using the Wilcoxon Signed-Rank Test, a comparison of SCWT scores between before and after receiving a protocol showed a statistical difference of $p<0.05$ in working memory, whereas no statistically significant difference was found in inhibitory control ($p>0.05$).

Conclusion: The findings demonstrated the positive effect of Thai traditional play protocol on working memory in children with ADHD. Occupational therapists can apply this protocol as a prototype for planning intervention focusing on working memory for school-aged children with ADHD.

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Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders found in children, with its main symptoms being attention deficit, hyperactivity, and impulsiveness that can potentially affect emotional, behavioral, educational, and social development.[1] Moreover, it has been found that ADHD often causes deprivation of group activities and separation from friends.[2] Therefore, ADHD may cause children to struggle with school, social, and home activities. Additionally, ADHD is associated with executive function deficits, especially impaired working memory and inhibitory control.[3-4] According to Diamond[5], executive functions are a higher brain function that can help control emotions and behaviors. Working memory, inhibitory control and cognitive flexibility are the basis of EFs that underpin goal-directed behaviors, and lead to the development of metacognitive ability.[3,5]

Working memory is the ability to process and remember information and it is necessary for a number of everyday functions as well as for academic performance.[6-7] Children with working memory problems may not be able to complete a task with multiple steps and are often reported as being easily distracted and forgetful, often missing details about instructions or forgetting instructions, and they lose their belongings easily.[3,5,8] Inhibitory control is the ability of a child to withhold and think before acting and being able to regulate emotions and behaviors in appropriate and/or effective ways, as well. Children with ADHD who have deficient inhibitory control often have difficulties in controlling themselves, so they are often reported as being unaware that they are bothering others.[9-10] These types of children have difficulty controlling emotions such as sadness, frustration, and regret are often prone to display outbursts due to these emotional triggers.[10]

Because of their poor executive functions, school-aged children with ADHD face more difficulties with daily activities than typically developed children of the same age.[10] Furthermore, EFs in childhood can predict adult health and well-being outcomes, such as physical health, substance dependency, wealth, and criminality independent of intelligence level and social class.[11] Furthermore, both working memory and inhibitory control skills are crucial for children with ADHD to effectively perform and participate in everyday tasks as well as academic performance. Thus, the appropriate assistances needed to allow these skills to emerge must be provided and it is necessary to ensure that children will have the opportunities to transfer and generalize these skills to their real-world contexts.[12] Research shows that there is efficacy of positive outcomes of specific interventions, such as computerized training, non-computerized games, aerobics, martial arts, yoga, mindfulness, and certain school curricula, that can help children with executive function deficits to gain better performance skills.[13-15] An occupational therapist is one member of a multidisciplinary team who can help children with ADHD improve certain skills, such as the ability to do daily occupations,[16] motor coordination,[17] self-regulation,[18] and executive function abilities.[19] For executive function interventions, an occupational therapist will help to identify the specific EF skills that a child has challenges with and can enhance the relevant skills required for executive functioning in the performance of daily life activities.

It has been suggested that participating in physical activities such as aerobic exercise and yoga; organized sports activities such as soccer; and traditional marital arts such as Tae Kwon Do with repeated practice and constantly challenging executive functions are crucial for EFs.[14-15,20] It is quite clear that the significant effects of using physical activities, organized sport activities, and martial arts with cognitive challenges on EFs are substantiated. Once these challenges are embraced, the children's attention span, working memory, perseverance, flexibility, creativity, emotional, and behavioral control are improved.[13,21-22] This emerging data is promising for school-aged children with ADHD, as these activities require children to practice by the rules, regulate their own emotions and behaviors, adapt and display flexibility toward peers' behaviors and actions, and must monitor their own performance. However, not all of them are feasible or appropriate for some children with ADHD. Furthermore, EFs can be fostered or hindered by many factors, such as a child's stress levels, family structure, and educational opportunities.[23]

As Thai traditional play activities involve body movement and cognitive training, they can be used to practice both cognitive and physical skills. Thai traditional play refers to traditional games for children and adults that are played for enjoyment, including games with or without rules, and games with songs and without songs.[24] Furthermore, Thai traditional play has been manifested as a group game that requires players to interact in groups and to develop social skills. While playing, children are allowed to learn to control themselves both emotionally and behaviorally.[25] Recent evidence has shown that inhibitory control based on Thai traditional game training program in elementary school students was effective in enhancing inhibitory control among elementary school students.[26] These findings suggest that Thai traditional play could be beneficial to enhance EFs in school-aged children. Therefore, Thai traditional play activities that employed working memory and inhibitory control were selected, analyzed, and applied in the present study.

Educating parents and teachers about the symptoms of ADHD, understanding of the deficits, and learning how to deal with disruptive behaviors is also a key in helping children with ADHD.[27] Previous studies of executive function training for children with ADHD revealed the significant outcomes of parental involvement in interventions on the improvement of working memory, inhibitory control, and planning and organizing skills in children.[28-29]

Children with ADHD frequently fail in proper self-regulation. Therefore, teachers and parents often reported that children are inattentive, hyperactive, and impulsive. Learning new skills that require working memory and inhibitory control skills became problematic because children with ADHD cannot control themselves enough to focus at length on the task at hand.[30] Students with ADHD are often described by teachers as getting easily distracted by peers, being fidgety, or calling out answers and commenting without permission.[31]

Children with ADHD have diminished self-awareness and have less self-monitoring skills than children without ADHD.[32] Since the self-regulatory shortfalls in children with ADHD can impact occupational functioning, it is important to help them possess optimal levels of arousal as well as demonstrate well-organized behaviors, when engaging in daily tasks. Self-regulatory strategies and sensory-based activities, such as heavy work activities[33] are commonly used in helping children with ADHD to be calm and focused.[34] Occupational therapists use self-regulatory strategies by starting to teach a child to identify his or her own arousal level and then guiding the child to choose appropriate sensory strategies to adjust arousal level to meet environmental demands.[35] Heavy work activity refers to a type of sensory-based activity that typically involves pushing, pulling, squeezing, carrying, and lifting heavy objects or items.[35] The research found that heavy work activities can help children to regulate their sensory needs and to adapt their arousal to an optimal level. For instance, they can learn to stay still and sit in a chair for longer durations[36-37] and display improved selective attention.[34]

Based on a review of previous studies, we proposed to develop and use Thai traditional play protocol (targeting physical activities, cognitive challenges focusing on working memory and inhibitory control training, self-regulation strategies, heavy work activity and parent education) as an intervention to improve working memory and inhibitory control for Thai school-aged children with ADHD. Thus, the objective of this study was to examine the effectiveness of Thai traditional play protocol on working memory and inhibitory control in school-aged children with ADHD. In this sense, it was hoped that examining its effect on children with ADHD may lead to an evidence-based intervention that helps broaden the treatment options for this population

Materials and methods

Study design

This study was a single group, pretest-posttest research design with an aim to examine the effectiveness of Thai traditional play protocol on working memory and inhibitory control in school-aged children with ADHD.

Participants

Seven children with ADHD who were studying during the 2020 academic year at Ban Rim Tai School, Mae Rim District, Chiangmai Province, Thailand, were selected using purposive sampling. Their caregivers were also asked to participate in this study. The inclusion criteria for children were as follows: 1) being able to communicate with fluent Thai, 2) being diagnosed with ADHD by a pediatrician and/or a child and adolescent psychiatrist, 3) having no other developmental problems such as intellectual disability, autistic spectrum disorder, or cerebral palsy, 4) having T-scores of ≥ 65 on the Behavioral Rating Inventory of Executive Function (BRIEF), Parent Form: Thai version that presented EFs deficit, and 5) having obtained informed signed by their parents before participating in the study. All caregivers were required to meet the following inclusion criteria: 1) being able to communicate with fluent Thai, 2) haven taken care of children for more than 6 months, and 3) providing informed signed consent before participating in the study. Ethical approval for the study was obtained from the Ethical Review Committee for Research in Humans, Faculty of Associated Medical Sciences, Chiang Mai University (Ref. no AMSEC-62FB-003).

Measurements

Two instruments were used in data collection, including the Behavioral Rating Inventory of Executive Function (BRIEF), Parent Form: Thai version and the Stroop Color and Word Test (SCWT): Children Edition.

The BRIEF is a rating scale for parents and teachers of school-aged children (aged between 5-18 years) to assess everyday behaviors associated with executive functions in the home and school settings. There are two forms, including the Parent Form and Teacher Form. Each form contains a total of 86 questions, and it takes about 10-15 minutes to complete. The BRIEF has sound psychometric properties, with high test–retest reliability (r=0.82 for parents and r=0.88 for teachers), and internal consistency score of 0.80-0.98.[38] This tool has proven to be sensitive to EF impairment in ADHD, oppositional defiant disorder (ODD) and autism spectrum disorders.[38-40] In this study, the Behavioral Rating Inventory of Executive Function (BRIEF), Parent Form: Thai version was used to screen whether a child had executive function problems. A cutoff T-score of ≥65 was used as the threshold for impairment in executive functioning.[38]

The SCWT: Children Edition was developed and designed by Golden *et al*.[41] to assess flexibility, inhibitory control, and working memory for children aged 5-14 years. The assessment tool includes 3 subtests: Word Test (W), Color Test (C), and Color-Word Test (CW). During testing, the participants are asked to read the names of colors printed in black ink for testing their abilities in Word Test (W), name different colored patches for evaluating their abilities in Color Test (C) and read the names of colors printed in various colors for the Color-Word Test (CW). Each word was printed inconsistently in colored ink, for instance, the word "red" was printed in green ink. When testing, the evaluator observes how quickly and accurately the subject responded, and how many words and colors the children could read in 5 minutes. The CW score shows ability in flexibility and working memory. An increased CW score shows higher working memory and flexibility performance, and the interference score shows the ability of inhibitory control. A decreased interference score shows higher inhibitory control performance. Psychometric property of the SCWT has shown excellent test- retest reliability (r=0.86 for Word Test, r=0.82 for Color Test, and r=0.83 for Color-Word Test).[41]

Intervention

The Thai traditional play protocol on working memory and inhibitory control in children with ADHD was developed by the researchers. The protocol was comprised of two main parts: (1) indirect intervention, in which caregivers of children with ADHD participated in a one-hour session of parent education with the aim to enhance caregivers' knowledge and understanding of the executive functions of school-aged children, especially in

working memory and inhibitory control. Caregivers were also required to acquire and gain knowledge about the symptoms of ADHD, its impacts, and behavioral management strategies; and (2) direct intervention, in which two occupational therapy graduate students, including the first author led twenty-four sessions, 60 minutes per session, three sessions a week for 8 consecutive weeks for children with ADHD (2 adults, 7 students). Duration and frequency of intervention were designed based on the outcomes of previous studies of Thai traditional play activity and heavy work activity[29,42] and in conjunction with the recommendations of Diamond *et al*. [13] in which the appropriate frequency in improving executive function must be more than two times per week for group therapy.

Direct intervention included three parts: self-regulatory strategies, heavy work activities, and Thai Traditional play activities.

In this study, self-regulatory strategies were developed by applying sensory integration knowledge[33] and were implemented before children began to engage in Thai traditional play activities. At first, children were asked to look at the self-regulation visual tool which contained a set of 3 pictures, including a sloth that appeared slow and inactive, a man appearing calm and productive, and a running tiger that was fast and hyper-energetic. Each picture represented a different state of arousal and feeling. Children chose one picture at the beginning of the session and stuck it on the board next to their names. After they finished playing Thai traditional play activities, they chose a picture again to indicate their arousal levels as well as feelings. Each child was asked to explain how he felt in relation to a picture he chose, and then was provided feedback regarding his performance during play.

Heavy work activities such as animal walks, jumping on a trampoline, weightlifting with a ball, and deep pressure activity were used in each intervention session to calm and organize children's behaviors.[34, 43] As a good sensory strategy that can provide proprioceptive input to calm and organize the brain,[36] children with ADHD in this study became involved with heavy work activities throughout the session,[34,44] especially prior to Thai traditional play activities. It was hoped that these activities could lead to organized behaviors and optimal learning.

Thai traditional play activities were chosen and analyzed by using the principle of executive function training as suggested by Diamond,[18] with the purpose to promote working memory and inhibitory control. Since there were many children activities that were categorized as Thai traditional games, key selection criteria were set. The researchers chose activities that presented actions and movements, had poems, lyrics, and songs that required children to memorize and act, be playful, had rules to follow and respond, allowed to play in a group/ team, and required repeated practice for skill acquisition. Furthermore, they must be age-appropriate, safe, and fun. For example, when children played "Ngoo Kin Hang or Tail-Eating Snake", they would play in a group. Two players were signified as a mother snake and a father snake. The rest of children acted as baby snakes. The aim of this game was for a mother snake to protect her baby snakes from being outwitted by a father snake. Baby snakes lined up behind a mother snake and tried to walk or run as quickly as possible to avoid being seized by a father snake. Children were expected to memorize lyrics, planned their actions according to their roles. In order to help children to understand the rules as well as how to play games, they had a chance to try out in advance of real games. Being able to memorize lyrics, sing, and perform movements accurately and appropriately demonstrated the ability of working memory, meanwhile inhibitory control abilities were observed in being able to follow the rules and to control their attention and behaviors, such as not running away from a mother snake and other baby snakes, staying in the playing area, waiting until a whistle signal was sounded.

After receiving feedback and recommendations from the thesis advisor (the second author), the content validity was examined. In this process, the Thai traditional play activities were examined by three experts including, one occupational therapy lecturer with more than 5 years of teaching experience in pediatric occupational therapy, one occupational therapist with professional experience in using sensory integration, and one university lecturer with research experience in using Thai traditional play to enhance executive function in school-aged children. Consequently, 20 activities were selected with the average index of item-objective congruence (IOC) at 0.91 which indicates a very good content validity.[45]

Data collection schedule

For the indirect intervention, the first author provided a one-hour session of parent education to caregivers. Apart from knowledge and understanding of the executive functions of school-aged children and ADHD symptoms and its impact, the Thai traditional play protocol was also introduced and explained in terms of how this protocol was implemented and its expected benefits. This was conducted one week before the pre-test at Ban Rim Tai School, Chiangmai Province.

After the completion of parent education, caregivers were asked to fill out the BRIEF. Data obtained from the BRIEF was interpreted by an occupational therapy graduate student who was formally trained in the proper administration of this battery. This graduate student did not get involved in providing the intervention protocol. Seven children who had T-scores of ≥65 on the BRIEF indicating having executive function deficits were chosen to receive the direct intervention from two occupational therapy graduate students, including the first author. These two graduate students worked together to understand the protocol, plan the intervention sessions, administrate the direct intervention to children with ADHD, record children's performance and behaviors, and review progress. They provided the protocol to seven children with ADHD at Ban Rim Tai School for a period of 8 weeks, three times per week, one hour each time.

Pre- and post-test data was collected within a 1-day timeframe immediately before and immediately after the study by a clinical psychologist who was trained in the proper administration of the SCWT. The Color-Word (CW) score and the Interference score were recorded and then interpreted. In order to certify the accuracy of reporting

and scoring, both researchers checked and reviewed all data obtained from every step of the data collection process.

Statistical analysis

Demographic characteristics of children with ADHD were calculated using descriptive statistics. The comparisons of the SCWT scores at pre- and post-intervention were analyzed using the Wilcoxon Signed Ranks Test. The level of statistical significance was set at 0.05. All statistical analyses were conducted using SPSS statistical package.

Results

All children completed the study successfully and they were eligible for data analysis. As shown in Table 1, all of them were boys and most of them studied in Grade 2.

Table 1 Demographic data of children with ADHD (n=7).

Demographic data	Variables	Numbers (%)
Gender	Boy	7 (100)
	Girl	0 (0)
Age (years)	8-9	7 (100)
Class level	Grade 1	1 (14.30)
	Grade 2	5 (71.40)
	Grade 3	1 (14.30)

Since the Color-Word Test scores reflected the ability of working memory and the Interference Test scores represented the ability of inhibitory control, the results also showed that participants' working memory and inhibitory control scores increased after receiving the protocol, as shown in Table 2.

Table 2 Median, quartile deviation (Q.D.), minimum and maximum scores of working memory and inhibitory control, before and after receiving the intervention protocol (n=7).

Variables	Pre-test				Post-test			
	Median	Q.D	Min	Max	Median	Q.D	Min	Max
Working memory (Color Word Test)	21	3	17	21	25	3.5	22	31
Inhibitory control (Interference Test)	-14	5	-24	-5	-18	4	-26	-1

As displayed in Table 3, it was found that children's level of performance in working memory after receiving the protocol had changed. There was an increased number of children in the average (A) in the post-test category. It was also impressive that there was one child identified in the high average (HA) level in the post-test category that was not labeled as such before intervention.

Table 3 Comparison of performance level in working memory and inhibitory control, before and after receiving the intervention protocol (n=7).

Variables	Level of performance							
	Pre-test Numbers (percentage)				Post-test Numbers (percentage)			
	HA	A	BA	SI	HA	A	BA	SI
Working memory (Color Word Test)	0 (0)	2 (28.57)	4 (57.14)	1 (14.28)	1 (14.28)	5 (71.42)	1 (14.28)	0 (0)
Inhibitory control (Interference Test)	1 (14.28)	6 (85.71)	0 (0)	0 (0)	1 (14.28)	6 (85.71)	0 (0)	0 (0)

Note: HA: high average, A: average, BA: below average, SI: severely impaired

The results showed that scores of working memory at post-intervention were significantly higher than those at pre-test ($p<0.05$) and no statistically significant difference was found in inhibitory control ($p>0.05$), as shown in Table 4.

Table 4 Comparison of working memory and inhibitory control in children with ADHD, before and after receiving the intervention protocol (n=7).

Variables	Mean Rank	Z	Asymp. Sig. (2-tailed)
Working Memory (Color Word Test)	4.0	-2.366	0.018*
Inhibitory Control (Interference Test)	3.0	-0.318	0.750

*$p<0.05$

Discussion

Working memory and inhibitory control in this study were measured by the Color-Word Test and Interference Test of the SCWT, respectively. Results showed that working memory of children with ADHD increased significantly from pre-intervnetion to post-intervention ($p<0.05$). However, scores in inhibitory control of these children between pre-intervnetion and post-intervention was not significantly different ($p>0.05$). Additionally, as displayed in Table 3, it was found that children's level of performance in working memory after receiving the protocol had changed. There were an increasing number of children in the average (A). It was also notable that there was one child identified in the high average (HA) level after receiving the protocol.

The results from this study indicated that the Thai traditional play protocol has potential as a promising intervention for school-aged children with ADHD who had difficulties in executive functioning on working memory. Thai traditional play activities were properly designed to target working memory for children with ADHD. As Baddeley pointed out, short-term memory normally disappears quickly, with the exception of when being repeatedly memorized.[46-47] This process that is a complex operation performed by the central executive is the core of working memory.[47-48] As explained earlier in terms of how the protocol was designed in the intervention section, children were allowed to practice poems, songs, and rhymes at least 3-4 times until they could sing along, and then they were taught to remember movements that were required for each activity. The fundamental gestures for each part of the songs were demonstrated by the researcher (the first author) and her assistant. Both songs and movements were considered as task-relevant information for children. Furthermore, the opportunities to perform repetition on practice were provided. Therefore, it was clear that both effects worked significantly on working memory abilities of children with ADHD in this study. For instance, after being taught the lyrics and gestures of the "Tap Tap Tap" game, children practiced their dances along with singing. Each child had to put his hands together and move them like a fish in water when their friends sang the lyrics "the little mermaid is floating". Children were provided the proper time to play again and again during the intervention hour under close attention of researchers. Children were challenged by playing the same game later on during a few sessions that included a full version of lyrics and more complex movements. Before more complex movements were demonstrated, they had the opportunities to recall and repeat the previous game songs and gestures once again. Subsequently, it was found that they could learn new movements and memorize additional lyrics quickly. In addition, recent research showed that structured game activities with music or poems were found to help children improve their working memory in children with ADHD.[49] Also, there is evidence that aerobic dancing with music can improve working memory and executive function.[50]

It has conclusively been shown that executive function can be developed by choosing the right activity to meet specific EF skills that a child has challenges with.[18] All intervention sessions were also implemented in a motivating and playful atmosphere as well as in a small group setting. Moreover, in order to promote EF skills, the appropriate frequency in improving executive function must be more than two times per week for group therapy.[13,18] Likewise, a study by Tamm *et al*.[51] which sought to study the effect of executive function training in young children with ADHD has confirmed that by giving a 60-minute session, 3-4 sessions per week, for 8 weeks, flexibility and working memory abilities were improved. Such appropriate duration and frequency of intervention was applied effectively in this study, as well.

It was evident that prior to the intervention, children with ADHD in this study were more likely to have high levels of arousal. Disorganized behaviors, such as hyperactivity, impulsivity, and being easily distracted were observed. They often rocked their bodies, stomped their feet, and jumped around which indicated they had problems in regulating themselves.[52-53] However, after self-regulatory strategies and heavy work activities were employed, children displayed more organized behaviors, such as calming down, sitting still for a longer period, staying focused on tasks, listening intently to instructions and rules, and being able to follow commands. Consequently, children could memorize lyrics and gestures much better. Adults' warnings and reminders were gradually decreased, as well. According to sensory integration theory, if children can adapt their level of arousal appropriately, they can control their behaviors better.[45,54] It has been suggested that heavy work activities can assist children to regulate their sensory needs and to adjust their level of arousal to optimal learning states. For instance, children can sit still on chair for longer durations of time[36-37] and have improved selective attention.[34] Meanwhile, Horowitz *et al*.[22] found that sensory-motor activity can help children to adapt their optimal arousal and promote selective attention, and children with good selective attention make progress in working memory.[5,34]

Furthermore, all intervention sessions were also

implemented in a motivating and playful atmosphere as well as in a small group setting. The design of the protocol was based on Diamond's and Kaufman's suggestions,[18,55] in which the intervention program that will successfully improve EFs are those that give children playfulness and a sense of belonging that helps them feel included.[18,55] Moreover, as this protocol was designed to provide children with ADHD a chance to play in a group, it was found that playing with peers in a group game format can help increase the opportunities for children in this study to learn to work together, listen to each other, and respect other people's opinions. It was congruent with a research study by Clark *et al*.[56] which found that playing with friends helped increased social skills and adaptive behaviors, which connects to executive function ability in working memory, inhibitory control, and flexibility.

In contrast to a recent study conducted by Somsri *et al*.,[26] our study found no difference in inhibitory control scores after children with ADHD completely participated in the intervention protocol. This may be due to how the Thai traditional play protocol was designed for children with ADHD in the current study. We aimed to target two executive function skills in children with ADHD, including working memory and inhibitory control. Therefore, children had to practice both skills in each activity. As a result, the findings demonstrated the positive effect of the Thai traditional play protocol on working memory in children with ADHD. However, these results could imply that improving inhibitory control in these children required more time and practice for these skills to be developed and generalized. It will be very interesting for future research to increase the number of Thai traditional play activities that provide inhibitory control skills in the Thai traditional play protocol. As is already known, inhibitory control helps children to change and choose how to behave and react. Without inhibitory control, children will respond or behave based on their old habits and/or stimuli in the environment or external temptations.[18] Children must be taught to learn and practice to have the ability to exercise inhibitory control and be able to apply and transfer these skills to be use on a daily basis.[55] Even though Thai traditional play activities were designed and analyzed to ensure that inhibitory control skills would emerge, we found that our protocol targeting inhibitory control skills was in need of revision in order to add more opportunities for children to use these skills at home as well as in classrooms. Moreover, the physical environment itself may be a barrier to treatment.[55] Regardless, the overall surroundings appeared to work perfectly for these interventions as the large-open space in the basement hall was sufficient for children to move, since most of Thai traditional play activities are often played outdoors or in open spaces. However, during intervention sessions, it was noticeable that children with ADHD were frequently distracted by noises and people walking by. Even though researchers had adjusted the environment by roping in the area and using shades to reduce other stimuli, it was evident that children with ADHD were still distracted by school announcements and noises from activities taking place around the area. An environment for inhibitory control training should be adapted or arranged by eliminating anything that disrupts or bothers the children.[55,57] For that reason, a good environment can help children to focus more on their activities, which leads to selective attention ability and appropriate response to stimuli.[5]

Limitations and Future Research

There are some limitations of this study. Since the present study was a one-group pre-test and post-test research design, there was no control group of children with ADHD to compare the outcome variables. The use of one geographic location and the small numbers of the participants also limits the generalizability of this study. An important future research goal must be to increase the collaboration process with homeroom teachers in the intervention protocol.

Conclusion

This study examined the effectiveness of the Thai traditional play protocol on working memory and inhibitory control in children with ADHD at Ban Rim Tai School, Mae Rim District, Chiangmai Province, Thailand. The results showed that working memory of children with ADHD increased significantly from pre-intervention to post-intervention ($p<0.05$). Scores in inhibitory control of these children between pre-intervention and post-intervention was not significantly different ($p>0.05$). On the basis of the current findings, the study results proved that the Thai traditional play protocol has potential as a promising intervention for school-aged children with ADHD who had difficulties in executive functioning on working memory.

Conflict of interest

The authors declare no competing interests in this research.

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