Original Article

Executive Function Training for Children with Attention Deficit Hyperactivity Disorder

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Abstract

Background: Accumulating evidence indicates that attention deficit hyperactivity disorder (ADHD) is associated with core deficits in executive function (EF) which predicts poorer academic and occupational functioning. This makes early intervention targeting EF impairments important to prevent long-term negative outcomes. Cognitive training is a potential ADHD treatment target. The present study aimed to explore the efficacy, feasibility, and acceptability of a cognitive training program (targeting child's multiple EF components and involving parent support in daily life), as a nonpharmacological intervention for children with ADHD.
Methods: Forty-four school-age children with ADHD and their parents participated in 12 sessions of EF training (last for 12 weeks) and 88 health controls (HC) were also recruited. Training effects were explored using both neuropsychological tests (Stroop color-word test, Rey-Osterrieth complex figure test, trail making test, tower of Hanoi, and false-belief task) and reports of daily life (ADHD rating scale-IV, Conners' parent rating scale, and behavior rating inventory of executive function [BRIEF]) by analysis of paired sample *t*-test and Wilcoxon signed-rank test. The differences on EF performances between children with ADHD after training and HC were explored using multivariate analysis.
Results: The results (before vs. after EF training) showed that after intervention, the children with ADHD presented better performances of EF both in neuropsychological tests (word interference of Stroop: 36.1 ± 14.6 vs. 27.1 ± 11.1, $t = 4.731$, $P < 0.001$; shift time of TMT: 194.9 ± 115.4 vs. 124.8 ± 72.4, $Z = -4.639$, $P < 0.001$; false-belief task: $\chi^2 = 6.932$, $P = 0.008$) and reports of daily life (global executive composite of BRIEF: 148.9 ± 17.5 vs. 127.8 ± 17.5, $t = 6.433$, $P < 0.001$). The performances on EF tasks for children with ADHD after EF training could match with the level of HC children. The ADHD symptoms (ADHD rating scale total score: 32.4 ± 8.9 vs. 22.9 ± 8.2, $t = 6.331$, $P < 0.001$) and behavioral problems of the children as reported by parents also reduced significantly after the intervention. Participants reported that the EF training program was feasible to administer and acceptable.
Conclusions: The EF training program was feasible and acceptable to children with ADHD and parents. Although replication with a larger sample and an active control group are needed, EF training program with multiple EF focus and parent involving in real-life activities could be a potentially promising intervention associated with significant EF (near transfer) and ADHD symptoms improvement (far transfer).

Key words: Attention Deficit Hyperactivity Disorder; Cognitive Behavior Therapy; Executive Function

Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common mental and behavior disorders in childhood with recent estimates from studies indicating that at least 3.0–7.8% of the general population meet the criteria for the disorder.[1] Accumulating evidence indicates that ADHD is associated with core deficits in executive function (EF).[2-5]

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The concept of EF is generally agreed to be a product of the coordinated operation of various processes undertaken to accomplish a particular goal in a flexible manner, including components such as inhibition, working memory (WM), planning, flexibility, and verbal fluency (VF) as cold EF, and theory of mind (ToM) as hot EF.[5-7]

Studies indicate that childhood EF predicts academic and occupational functioning. A cohort study following 1000 children from birth to the age of 32 years demonstrated that childhood EF predicted physical health, substance dependence, personal finances, and criminality independent of intelligence and social class.[8] Therefore, it is important to target EF impairments early in life to prevent long-term difficulties.[9,10]

Front-line ADHD treatment is normally medication which can help reduce the symptoms and improve EF. However, lack of compliance, reservations about medication use from some parents, and failure to target academic and social functions mean medication alone may be insufficient.[11-14] Functional improvement requires both improvement in core symptoms and the opportunity to develop and apply new skills and reduce impairment.[15] Cognitive training is a potential ADHD treatment which was reported to have significant effects on ADHD symptoms with raters most proximal to treatment delivery, although these effects reduced substantially when assessors were probably blind to treatment allocation.[16,17] However, all the studies in previous review did not provide additional support to parents to coach their child's acquisition of EF skills in real-life activities.[17] Only recently had researchers started to explore the impact of parenting variables on the development of EF in children and understand the positive role that parental interaction and support can play on the typical development of EF.[18,19]

The purpose of this study was to explore whether combining traditional EF training for children with ADHD with behavioral intervention for parents could improve the EF and ADHD symptoms in children with ADHD.

Methods

Participants

The study included 44 Chinese children diagnosed with ADHD (ADHD group) through the Clinical Diagnostic Interviewing Scales.[20,21] Participants in ADHD group were recruited from the outpatient clinics at Xinhua Hospital and the Peking University Sixth Hospital in China from February 2006 to December 2012, including 23 combined type, 18 inattentive type, and three hyperactive-impulsive type. Twenty-three children presented with comorbidities (15 oppositional defiant disorder; one conductive disorder; four tics; one special phobia; and two anxiety). ADHD with severe comorbidities such as major depression, mania, and bipolar disorder were excluded. Five participants were taking medications (three children on methylphenidate and two children on atomoxetine) who were asked to maintain a stable medication status during the intervention and evaluation period.

The 88 children as health control (HC) were recruited from two primary schools. They were matched with the ADHD group by age (within 6 months) and intelligence quotient (IQ) (within 15-scaled score points). The matching process aimed to decrease error variance and prevent matching variables from becoming competing causal factors for any effect.[22] The children in HC group were administered the same interview and EF tasks battery as ADHD group, with purpose to investigate whether the ADHD group could reach the normal EF level after treatment.

Children with major sensory-motor difficulties (e.g., paralysis, deafness, and blindness), a history of brain damage, epilepsy, or an estimated full-scale IQ of <80 (using Wechsler Intelligence Scale for Chinese Children-Revised) were excluded for both groups.

The study was approved by the Ethics Committee of the Xinhua Hospital, and informed consent and assent were obtained from all parents and children.

Measurements

Rating scales

ADHD rating scale-IV: Parent rated ADHD symptom including intention, hyperactivity, and impulsivity about their children.[23]

Conners' parent rating scale: Six factor were measured: conduct, learning, psychosomatic, impulsive-hyperactive, anxiety problems, and a hyperactivity index.[24]

Behavior rating inventory of executive function (BRIEF): The instrument included eight factors measuring parental reports of EF: initiate, WM, plan/organize, organization of materials, monitor (formed metacognition index [MI]), inhibit, shift, and emotional control (formed behavioral regulation index [BRI]).[25]

Parent report and satisfaction survey: This questionnaire was designed to gather information from the parent about child's behaviors at home and academic performance at school, as well as the parent's opinions about the intervention.

Neuropsychological measures

In this study, the neuropsychological assessments were selected to cover the comprehensive domains of EF components. The Chinese versions of these tests have been found to discriminate well between ADHD and age-/IQ- matched HC.[26]

The Stroop color and word test was used to capture the inhibition component of EF.[27] The test consisted of four parts as word naming (Part 1), color naming (Part 2), color interference (Part 3), and word interference (Part 4). The time taken to complete Part 3 was subtracted from that for Part 1 to indicate color interference, and the time taken to complete Part 4 was subtracted from that for Part 2 to indicate word interference.

The Rey-Osterrieth complex figure test (RCFT) was used to evaluate visuospatial construction ability and visual WM.[28] This test estimates participants' short- and long-term memory performances. Two measure derived scores are created for both structural and detailed memory. The immediate scores were subtracted from the delayed scores to generate "forgotten" scores that indicated the information that was lost during the 20 min interval.

The trail making test (TMT) has two parts. Part 1 provided a baseline indication of visual search speed and visuomotor functioning, while Part 2 estimated flexibility.[29,30] The time for Part 1 was subtracted from the time for Part 2 to indicate the shift time.

The tower of Hanoi (ToH) was used to assess planning.[31,32] Latency from the examiner's signal to the children's initiation of the first move (initiation time), the total time to reach a solution (accomplish time), number of moves (accomplish steps), and the number of rule violations (error steps) were recorded.

The VF test required the participants to name as many animals as possible in 2 min. The examiners recorded all correct words and counted whether they were named in the first or second minute. Repetitions and words that were not identifiable as animal names (error responses) were also recorded.[33]

The false-belief task is used to assess the children's hot EF by determining their understanding of a protagonist's false belief.[34] The children were presented with a scenario, in which the protagonist was unaware that his processions had been moved to a new location.

Design and procedure

Parents were provided with information about the study in outpatient clinic, including medication and the EF training program. Fifty participants were willing to engage in the intervention. The participants on medication received their drug titration (2–6 weeks) before completing baseline evaluation. They were asked to maintain a stable medication status during the evaluation and intervention period. Participants attended one 90-minute sessions (60-minute for children, 30-minute for parents except the first and the last session which was for parents only) per week for 12 weeks. After the final session, participants and their parents completed post intervention evaluations. Four participants withdrew during the study due to difficulties with compliance or time conflicts. Two participant's data were excluded as their parents opted for neurofeedback treatment at the same time. Four children's parents could not attend the final session leads to missing the post intervention scales evaluations. Therefore, 44 participants' neuropsychological data and 40 participants' scales data were included in the final analysis.

Assessments were administered and scored by examiners who were blind to the diagnostic and treatment status of participants due to known differences in outcome for blinded and unblinded measures.[17,35]

Intervention

The aim of the training program was to help the child develop the skills and strategies needed to cope with the difficulties and impairments associated with ADHD. The intervention had the following features:

1. Targeting multiple EF components related to ADHD including inhibition, WM, planning and organization, shifting, ToM,[26] time management,[36] and emotional regulation,[37] because EF training transfer is narrow, the training protocol targeted a broad range of neuropsychological deficits[17]
2. Intervene both with the child and the child's environment. In addition to targeting intervention at the child by teaching them executive skills, motivating them to practice and use the skills, the training program also intervened via the child's environment by changing the task nature and ways support and cues were provided. Combining these two strategies, the executive skills ADHD children lacked were taught externally, promoted to practice, and used to the point where the child could apply the skill independently, in a way that became habitual and automatic[38]
3. Involving Parent. The parents were provided with psychoeducation about ADHD, information about behavioral management skills (behavioral contract, response cost, etc.), and other skills necessary for living with and raising children with ADHD (eye contact, giving short direction, capturing good moment, etc.). Parental intervention can improve both the child's behavior and parental function[39]
4. Implementing in daily life by assigning homework to make sure the child exercised and used the EF skills, as well as to coach the parent on how to support and promote the child's EF in real-life activities.

Statistical analysis

Statistical analysis was performed using SPSS version 19.0 (IBM, SPSS Software, Armonk, NewYork, USA). Differences were deemed significant when $P < 0.05$, in line with advice from Perneger[40] control for multiple measures was not applied.

First, differences in EF tests were explored between baseline and training completion, as well as the child's everyday life EF and behaviors reported by the parent. Parametric variables were analyzed using *t*-tests. Nonparametric variables were analyzed using nonparametric Wilcoxon signed-rank tests. All statistical tests were two-tailed. Second, we explored differences on EF performances between children with ADHD after training and HC using multivariate analysis of covariance controlling for age and IQ.

Results

Outcomes included parent ratings of ADHD symptoms, other behavioral problems, and EF performance both in the laboratory and in real life.

Table 1 lists the results (before vs. after EF training) for parental ratings. Parents rated their children as having fewer ADHD symptoms on the ADHD rating scale-IV inattentive, hyperactive-impulsive, and total score (32.4 ± 8.9 vs.

Table 1: Mean score of each scale before and after executive function training for parental ratings (n = 40)

Subscale	ADHD-before training	ADHD-after training	Statistical value	P
ADHD Rating Scale-IV (symptom item)				
Inattentive	7.4 ± 1.6	4.5 ± 2.3	7.182*	<0.001
Hyperactive-impulsive	4.7 ± 2.6	2.6 ± 2.3	5.442*	<0.001
Total item	12.1 ± 3.7	7.1 ± 4.1	6.960*	<0.001
ADHD rating scale-IV (symptom score)				
Inattentive	18.6 ± 3.8	13.7 ± 3.9	6.381*	<0.001
Hyperactive-impulsive	13.5 ± 6.2	9.2 ± 5.5	4.990*	<0.001
Total score	32.4 ± 8.9	22.9 ± 8.2	6.331*	<0.001
Conners' parent rating scale				
Conduct problem	8.7 ± 5.0	5.7 ± 4.2	5.394*	<0.001
Learning problem	7.4 ± 1.9	5.7 ± 2.1	4.603*	<0.001
Psychosomatic	1.4 ± 1.7	0.8 ± 1.1	−2.022†	0.043
Impulsive-hyperactive	5.7 ± 3.2	3.6 ± 2.4	5.102*	<0.001
Anxiety	2.5 ± 1.9	1.4 ± 1.5	−4.112†	<0.001
Hyperactivity index	14.1 ± 5.2	9.4 ± 4.8	6.860*	<0.001
BRIEF‡				
Inhibition	19.1 ± 4.8	15.8 ± 4.1	4.669*	<0.001
Shift	12.6 ± 2.8	11.7 ± 2.3	1.992*	0.054
Emotional control	17.2 ± 5.0	14.6 ± 3.5	3.815*	0.001
Initiate	15.1 ± 2.8	12.8 ± 2.2	4.920*	<0.001
Working memory	22.7 ± 2.9	20.0 ± 2.8	4.262*	<0.001
Plan	28.0 ± 3.2	24.1 ± 4.0	5.409*	<0.001
Organize	13.8 ± 2.8	11.6 ± 2.7	4.611*	<0.001
Monitor	20.3 ± 2.5	17.4 ± 3.4	6.097*	<0.001
Behavior regulation index	48.4 ± 9.6	42.0 ± 7.7	4.153*	<0.001
Metacognition index	100.0 ± 10.1	85.8 ± 11.6	6.365*	<0.001
Global executive composite	148.9 ± 17.5	127.8 ± 17.5	6.433*	<0.001

Data were presented with mean ± SD. *t value; †Z value; ‡Two BRIEF scales were eliminated because the validity issue including negativity and inconsistency. SD: Standard deviation; ADHD: Attention deficit hyperactivity disorder; BRIEF: Behavior rating inventory of executive function.

22.9 ± 8.2, t = 6.331, P < 0.001) after treatment. Significant improvements were found for the Conner's parent rating scale on all factors and BRIEF except shift (MI: 100.0 ± 10.1 vs. 85.8 ± 11.6, t = 6.365, P < 0.001; BRI: 48.4 ± 9.6 vs. 42.0 ± 7.7, t = 4.153, P < 0.001; Global executive composite: 148.9 ± 17.5 vs. 127.8 ± 17.5, t = 6.433, P < 0.001).

Changes in children's performance in EF tests are presented in Table 2. For the Stroop test, the time used for all the parts was significantly shorter after treatment. Errors in the word inhibition subtest (2.2 ± 2.3 vs. 1.3 ± 1.3, Z = −2.079, P = 0.038) and word interference (36.1 ± 14.6 s vs. 27.1 ± 11.1 s, t = 4.731, P < 0.001) reduced significantly. In RCFT, both the scores on structure (immediate: 1.9 ± 2.0 vs. 3.3 ± 2.1, Z = −4.512, P < 0.001; delay: 1.9 ± 2.0 vs. 3.2 ± 2.1, Z = −3.498, P < 0.001) and detail (immediate: 6.5 ± 5.8 vs. 12.1 ± 7.4, t = −7.590, P < 0.001; delay: 6.4 ± 5.7 vs. 11.7 ± 7.1, t = −6.340, P < 0.001) were significantly increased. In contrast, the forgotten scores did not present significant change. In TMT, the time spent in all the parts (shift time: 194.9 ± 115.4 s vs. 124.8 ± 72.4 s, Z = −4.639, P < 0.001), and the errors made in Part 2 (1.8 ± 2.1 vs. 0.7 ± 1.1, Z = −3.264, P = 0.001) were significantly reduced. In ToH, the participants needed less time and fewer steps to finish the task, making fewer violations during the task (2.2 ± 2.5 vs. 0.5 ± 0.8, Z = −4.780, P < 0.001). In VF test, correct responses in the first minute and overall total (17.8 ± 4.9 vs. 19.8 ± 5.2, t = −3.325, P = 0.002) were significantly increased. More participants gave the right answer in the false-belief task (χ^2 = 6.932, P = 0.008) after the treatment compared with the baseline.

The results of the consumer investigation and satisfaction rating scale are listed in Table 3. Parental reports of children's problem behaviors at home reduced significantly, while expected behaviors increased significantly. With regard to parent's disappointment with the child's behaviors (χ^2 = 24.337, P < 0.001) and studies (χ^2 = 10.323, P = 0.001) reduced significantly, parenting communication (χ^2 = 14.596, P < 0.001), motivation (χ^2 = 20.570, P < 0.001), implementing rewards (χ^2 = 39.822, P < 0.001), and punishment (χ^2 = 24.965, P < 0.001) strategies improved significantly. The children showed significant academic improvement including enhanced scores on examinations (77.5 ± 14.0 vs. 80.0 ± 12.3, t = −2.584, P = 0.014) and an increased academic rank (29.2 ± 20.2 vs. 37.2 ± 22.6, t = −3.553, P = 0.001) within the class. About 77.5% parents could usually or always carry out the strategies presented during the training program, while 95% of parents reported usually or always feel satisfaction with the intervention and would like to recommend the training program to other parents with ADHD children.

Table 2: Children's performance of each EF tests before and after EF training (n = 44)

EF tests	ADHD-before training	ADHD-after training	Statistical value	P
Stroop				
Part 1 time (s)	23.4 ± 5.4	21.5 ± 6.5	2.199*	0.033
Part 2 time (s)	30.7 ± 9.1	27.5 ± 6.4	3.506*	0.001
Part 3 time (s)	31.8 ± 12.7	27.1 ± 9.0	3.515*	0.001
Part 4 time (s)	66.8 ± 18.1	54.6 ± 15.4	6.481*	<0.001
Part 1 error	0.3 ± 0.6	0.1 ± 0.3	−1.941†	0.052
Part 2 error	0.3 ± 0.7	0.2 ± 0.4	−0.966†	0.334
Part 3 error	0.7 ± 1.4	0.4 ± 0.7	−1.214†	0.225
Part 4 error	2.2 ± 2.3	1.3 ± 1.3	−2.079†	0.038
Color interference (s)	8.4 ± 9.4	5.6 ± 5.6	−1.835†	0.066
Word interference (s)	36.1 ± 14.6	27.1 ± 11.1	4.731*	<0.001
RCFT				
Structure immediate	1.9 ± 2.0	3.3 ± 2.1	−4.512†	<0.001
Structure delay	1.9 ± 2.0	3.2 ± 2.1	−3.498†	<0.001
Structure forgotten	0 ± 0.9	0.7 ± 0.7	−0.394†	0.693
Detail immediate	6.5 ± 5.8	12.1 ± 7.4	−7.590*	<0.001
Detail delay	6.4 ± 5.7	11.7 ± 7.1	−6.340*	<0.001
Detail forgotten	0.1 ± 2.5	0.4 ± 1.8	−0.182†	0.856
Trail making test				
Part 1 time (s)	77.4 ± 30.8	62.4 ± 24.1	4.457*	<0.001
Part 2 time (s)	272.3 ± 123.3	187.2 ± 81.1	5.551*	<0.001
Shift time (s)	194.9 ± 115.4	124.8 ± 72.4	−4.639†	<0.001
Part 1 error	0.2 ± 0.5	0.1 ± 0.3	−1.000†	0.317
Part 2 error	1.8 ± 2.1	0.7 ± 1.1	−3.264†	0.001
Tower of Hanoi				
Complete/fail	32/12	39/5	2.625‡	0.105
Initiation time (s)	0.5 ± 1.2	0.5 ± 3.0	−1.614†	0.107
Accomplish time (s)§	254.8 ± 173.9	131.5 ± 86.1	4.063*	<0.001
Accomplish steps§	42.5 ± 28.2	32.3 ± 16.7	2.296*	0.029
Error steps	2.2 ± 2.5	0.5 ± 0.8	−4.780†	<0.001
Verbal fluency test				
Correct first 1 min	12.6 ± 4.0	13.9 ± 4.0	−2.652*	0.011
Correct last 1 min	5.2 ± 2.7	5.8 ± 2.9	−1.572*	0.123
Total correct	17.8 ± 4.9	19.8 ± 5.2	−3.325*	0.002
Repeat responses	0.7 ± 0.9	0.6 ± 1.0	−1.086†	0.278
Error responses	0.1 ± 0.3	0.1 ± 0.3	0†	1.000
False-belief task (C/W)	26/18	38/6	6.932‡	0.008

Data were presented with mean ± SD and n. *t value; †Z value; ‡χ^2 value; §32 children who completed tower of Hanoi successfully both before and after training. ADHD: Attention deficit hyperactivity disorder; EF: Executive function; SD: Standard deviation; RCFT: Rey-Osterrieth complex figure test; C/W: Correct answer/wrong answer.

The intervention sample postintervention was compared with HC on aspects of the EF. Table 4 indicates that there were no significant differences between these two groups on age (8.4 ± 0.9 years vs. 8.4 ± 0.8 years, t = −0.126, P = 0.900) and IQ (106.3 ± 12.1 vs. 106.4 ± 11.6, t = −0.063, P = 0.950). The performances are listed in Table 5. There were no significant differences on Stroop (word interference: 27.1 ± 11.1 s vs. 28.1 ± 11.9 s, F = 0.814, P = 0.369, η^2P = 0.006), TMT (shift time: 124.8 ± 72.4 s vs. 118.6 ± 73.5 s, F = 0.023, P = 0.879, η^2P < 0.001) and false-belief task (χ^2 = 0.007, P = 0.932). While the children with ADHD after training performed better in RCFT, ToH, and VF, compared with NC. However, most of the ES of these differences was very small (between 0 and 0.047), except for the detail scores in RCFT and accomplish time in ToH (between 0.090 and 0.157).

Discussion

Efficacy

The goal of this study was to evaluate a nonpharmacological intervention for children with ADHD in routine clinical practice to address difficulties associated with EF impairment, given the link between EF impairment and educational and social difficulties.[41]

Children's performance improved significantly on all of the EF tests. The participants demonstrated improvement not only in basic processing speed (Part 1 and 2 of Stroop, Part 1 of TMT) but also on the higher level of the cognitive function such as interference inhibition (Part 3 and 4 of Stroop),[42,43] and efficient shifting (Part 2 of TMT).[44] The improvements in RCFT indicated that the WM skills on both grasping the

Table 3: Results of the consumer investigation and satisfaction rating scale for the training program (n = 40)

Questions	Before training	After training	Statistical value	P
Children's behavior at home ([none + sometimes]/[usually + always]), n				
Impulsivity	19/21	33/7	9.286*	0.002
Difficult waiting	14/26	37/3	26.180*	<0.001
Efficient homework completion	38/2	16/24	25.128*	<0.001
Distraction during homework	1/39	16/24	14.641*	<0.001
Poor organization	9/31	27/13	14.596*	<0.001
Following parental requests	26/14	8/32	14.783*	<0.001
Parents' perspective ([none + sometimes]/[usually + always]), n				
Disappointed at child's behaviors	10/30	33/7	24.337*	<0.001
Disappointed at child's studies	8/32	23/17	10.323*	0.001
Communicated with the child in a good way	31/9	13/27	14.596*	<0.001
Reward the child with a system	37/3	8/32	39.822*	<0.001
Punish the child with a system	35/5	12/28	24.965*	<0.001
Can motivate the child	37/3	17/23	20.570*	<0.001
Children's study performance, mean ± SD				
Mean score during the latest examination	77.5 ± 14.0	80.0 ± 12.3	−2.584†	0.014
Rank (1-child's place/total number of the class)	29.2 ± 20.2	37.2 ± 22.6	−3.553†	0.001

*χ^2 value; †t value. ADHD: Attention deficit hyperactivity disorder; SD: Standard deviation.

Table 4: Mean score of demographic variables for children with ADHD and health controls

Demographic variables	Children with ADHD (n = 44)	Health controls (n = 88)	t	P
Age (years)	8.4 ± 0.9	8.4 ± 0.8	−0.126	0.900
VIQ	110.1 ± 14.2	107.8 ± 14.9	0.726	0.470
PIQ	100.3 ± 12.0	103.3 ± 10.9	−1.198	0.234
IQ	106.3 ± 12.1	106.4 ± 11.6	−0.063	0.950

Data were presented as mean ± SD. VIQ: Verbal intelligence quotient; PIQ: Performance intelligence quotient; IQ: Total intelligence quotient; SD: Standard deviation; ADHD: Attention deficit hyperactivity disorder.

structural concepts[45] and the detailed segments[46] of the complex stimuli were better after the EF training program. After treatment, the children generated and executed their own plans more efficiently when engaged in ToH. Meanwhile, the rule violations reduced significantly, indicating that children had better self-control to comply with rules.[47,48]

Taken together, the results showed that EF training improved all components of cold EF as demonstrated by the significant improvements on performance during the neuropsychological tests. This was in line with former studies because the EF capacity and its associated levels of brain activity are not static but may be altered by task-repetition or training.[49] In fact, cognitive remediation therapy might improve cognitive function by increasing activation of the frontal lobe[50] which is crucial for EF. However, most of the past interventions, especially computerized programs, focus on training single domain of EF like WM or inhibition,[51-54] finding treatment effects on outcome measures of trained EF but not untrained EF.[55,56] Due to the fact that EF training transfer is narrow,[17] training of multiple EFs might be a potentially more effective strategy to improve overall EF.[55] In this study, the training program was aimed at multiple EF components to obtain overall improvement.

In addition to improvements on cold EF, the children also showed progress on hot EF, which was important because poor ToM might also represent a prognostic marker or predictor of worse functional outcome and greater clinical need.[57] The treatment for children with ADHD, both medication and nonmedication methods, rarely reports an impact on ToM. In fact, emotional regulation and social understanding skills aiming for improving ToM element might address children's stress in their lives, giving children a sense of belonging and social acceptance, which would probably improve EF and school outcomes.[58]

The performances on EF tasks for children with ADHD after EF training were matched with the level of HC children. However, medication including both methylphenidate and atomoxetine could improve the performances on some EF subtests but still could not achieve the normal level in Stroop test and TMT.[11] Therefore, EF training program is an important and useful candidate for children with ADHD to reduce the EF developmental gap by teaching children appropriate coping skills and strategies.

The EF improvements not only showed in the laboratory tests but also showed in the child's everyday life captured by BRIEF. These indicated that a wide variety of EF skills were improved in child's real daily life, which were very important since the everyday EF problems were predictors of comorbid psychopathology.[54,59]

In addition to EF improvements on neuropsychological tests and daily life, the child's ADHD symptoms and behaviors also showed significant improvements. This was in line with a study using meta-cognitive therapy, which targeted EF impairments and developed self-management

Table 5: Performance of each EF tests between children with ADHD after EF training with HC

EF tests	ADHD-after training (n = 44)	Health controls (n = 88)	F or χ^2	P	η^2P
Stroop					
Part 1 time (s)	21.5 ± 6.5	21.1 ± 6.0	0	0.996	0.000
Part 2 time (s)	27.5 ± 6.4	26.4 ± 5.9	0.420	0.518	0.003
Part 3 time (s)	27.1 ± 9.0	26.9 ± 8.3	0.043	0.837	0.000
Part 4 time (s)	54. ± 615.4	54.5 ± 15.0	0.215	0.643	0.002
Part 1 error	0.1 ± 0.3	0.1 ± 0.4	0.478	0.490	0.004
Part 2 error	0.2 ± 0.4	0.2 ± 0.4	0.004	0.948	0.000
Part 3 error	0.4 ± 0.7	0.3 ± 0.6	0.664	0.417	0.005
Part 4 error	1.3 ± 1.3	0.9 ± 1.3	2.464	0.119	0.019
Color interference (s)	5.6 ± 5.6	5.9 ± 6.2	0.080	0.778	0.001
Word interference (s)	27.1 ± 11.1	28.1 ± 11.9	0.814	0.369	0.006
RCFT					
Structure immediate	3.3 ± 2.1	2.6 ± 2.0	6.261	0.014	0.047
Structure delay	3.2 ± 2.1	2.7 ± 1.9	3.981	0.048	0.030
Structure forgotten	0.7 ± 0.7	−1.2 ± 0.9	1.836	0.178	0.014
Detail immediate	12.1 ± 7.4	8.9 ± 5.5	13.724	<0.001	0.097
Detail delay	11.7 ± 7.1	8.7 ± 5.4	12.715	0.001	0.090
Detail forgotten	0.4 ± 1.8	0.2 ± 1.9	0.368	0.545	0.003
Trail making test					
Part 1 time (s)	62.4 ± 24.1	63.9 ± 23.2	0.451	0.503	0.004
Part 2 time (s)	187.2 ± 81.1	182.5 ± 82.4	0.003	0.954	0.000
Shift time (s)	124.8 ± 72.4	118.6 ± 73.5	0.023	0.879	0.000
Part 1 error	0.1 ± 0.3	0.1 ± 0.4	0.001	0.977	0.000
Part 2 error	0.7 ± 1.1	0.8 ± 1.0	0.530	0.468	0.004
Tower of Hanoi					
Complete/fail	39/5	61/27	4.955*	0.026	
Initiation time (s)	0.5 ± 3.0	4.0 ± 20.5	1.357	0.246	0.010
Accomplish time (s)	143.2 ± 98.9	252.7 ± 168.7	17.843	<0.001	0.157
Accomplish steps	33.1 ± 16.4	32.1 ± 15.7	0.030	0.862	0.000
Error steps	0.5 ± 0.8	0.9 ± 1.2	4.686	0.032	0.035
Verbal fluency test					
Correct first 1 min	13.9 ± 4.0	13.1 ± 3.6	3.700	0.055	0.028
Correct last 1 min	5.8 ± 2.9	5.4 ± 2.7	1.800	0.186	0.014
Total correct	19.8 ± 5.2	18.4 ± 4.9	5.100	0.026	0.038
Repeat responses*	0.6 ± 1.0	0.5 ± 0.7	0.200	0.675	0.001
Error responses*	0.1 ± 0.3	0 ± 0.2	0.500	0.536	0.003
False-belief task (C/W)	38/6	74/14	0.007*	0.932	

*χ^2 value. Data were presented as mean ± SD or as n. ADHD: Attention deficit hyperactivity disorder; EF: Executive function; SD: Standard deviation; RCFT: Rey-Osterrieth complex figure test; C/W: Correct answer/wrong answer.

skills showed marked improvement with respect to adult's ADHD symptoms.[60] However, some previous studies, focusing on training WM or inhibition, could not lead to the generalized improvement of ADHD symptoms or behaviors.[53,56,61] Therefore, the cognitive training program should tailored to meet child's real-world situations or settings.[61] In this study, the intervention was intertwined with relevant real-life EF activities (e.g., completing chores in daily life), which might the reason brought more ecologically valid effect.[62] The parent involvement might also contribute these improvements because parenting interventions were beneficial for ADHD symptom reduction and neuropsychological function.[63] Some other intervene studies required parent to learn, and administer activities targeting child's EF also showed an impact on ADHD symptoms and other disruptive behaviors.[64,65] Actually, the intervention with the parent implement in the home setting dramatically intensifies the dose of intervention, and moreover, the intervention is integrated into the daily activities.[64]

Good academic performance is an important issue for Chinese parents not only because it is thought to be an important stepping stone to success, but also because is reflects well on parents and family in Chinese culture.[66,67] Therefore, it was very meaningful and important to help the children with ADHD improve their school outcomes. After treatment, children got better scores in later examinations, and also increased their rank in the class. In academics, EF coordinated the temporal and spatial processes of mathematics and filters irrelevant information during calculation and reading.[68-70] Therefore, the benefits of EF training program especially targeting on inhibition, WM, and planning could be extended to child's learning skills and various aspects of schooling.[53,71,72]

Feasibility

The results from this study suggested that the EF training program was feasible to administer and could be successfully administered. Attendance was acceptable; every participant attends at least 10 sessions (>80% attendance rate). The dropout rate was 8%, which was particularly impressive given the fact that families were asked to attend this program weekly for 12 weeks. Most dropouts occurred during the first two classes, which means both parent and the child need at least one session to determine whether the treatment suited their needs.

Acceptability

Consumer investigation and satisfaction rating scale revealed that 72.5% parents could usually or always understand the strategies and implement them in their daily life. About 95% of parents were usually or always satisfied with the EF training program and would like to recommend this treatment to other parents who had children with ADHD. After attending the EF training program, the parents felt less disappointed and helpless about the child's behaviors and school work, they knew how to better communicate with their child, how to reward and punish the child in an appropriate way, how to motivate their child.

Limitations

A few limitations of this study should be noted. Although data were collected for 44 children with ADHD and 88 HC, the sample size was still small. The absence of a waiting group does not allow us to rule out the natural change as a result of the development of children.

This was an open trial, although the person who evaluated the EF was blind to the participant's situation, parental reports may still have been subjective. A recent meta-analysis has demonstrated that the significant treatment effects for ADHD identified using the most proximal respondents were usually lost when probably blinded assessments and informants were used, and it has not been possible to explore this issue in this data set.[35]

Therefore, a randomized controlled trial with a larger sample of children with ADHD, which includes a waiting list group that does not receive intervention, data from teachers who are not aware of the child's treatment state will be a necessary next step to explore the efficacy of this EF training program.

Overall, the results of this open trial suggested that EF training program was a feasible intervention to administer in a population of school-aged children with ADHD. Preliminary analyses suggested that the intervention was effective in improving cool EF including inhibition, WM, shifting, planning, VF and hot EF, as well as reducing ADHD symptoms, and improving aspects of daily life.

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Conflicts of interest

There are no conflicts of interest.

References

1. Biederman J. Attention-deficit/hyperactivity disorder: A selective overview. Biol Psychiatry 2005;57:1215-20. doi: 10.1016/j.biopsych.2004.10.020.
2. Pennington BF, Ozonoff S. Executive functions and developmental psychopathology. J Child Psychol Psychiatry 1996;37:51-87. doi: 10.1111/j.1469-7610.1996.tb01380.x.
3. Barkley RA. Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. Psychol Bull 1997;121:65-94. doi: 10.1037/0033-2909.121.1.65.
4. Nigg JT. The ADHD response-inhibition deficit as measured by the stop task: Replication with DSM-IV combined type, extension, and qualification. J Abnorm Child Psychol 1999;27:393-402. doi: 10.1023/A:1021980002473.
5. Sergeant JA, Geurts H, Oosterlaan J. How specific is a deficit of executive functioning for attention-deficit/hyperactivity disorder? Behav Brain Res 2002;130:3-28. doi: 10.1016/s0166-4328(01)00430-2.
6. Funahashi S. Neuronal mechanisms of executive control by the prefrontal cortex. Neurosci Res 2001;39:147-65. doi: 10.1016/s0168-0102(00)00224-8.
7. Chan RC, Shum D, Toulopoulou T, Chen EY. Assessment of executive functions: Review of instruments and identification of critical issues. Arch Clin Neuropsychol 2008;23:201-16. doi: 10.1016/j.acn.2007.08.010.
8. Moffitt TE, Arseneault L, Belsky D, Dickson N, Hancox RJ, Harrington H, *et al.* A gradient of childhood self-control predicts health, wealth, and public safety. Proc Natl Acad Sci U S A 2011;108:2693-8. doi: 10.1073/pnas.1010076108.
9. Miller M, Nevado-Montenegro AJ, Hinshaw SP. Childhood executive function continues to predict outcomes in young adult females with and without childhood-diagnosed ADHD. J Abnorm Child Psychol 2012;40:657-68. doi: 10.1007/s10802-011-9599-y.
10. Biederman J, Petty CR, Fried R, Doyle AE, Spencer T, Seidman LJ, *et al.* Stability of executive function deficits into young adult years: A prospective longitudinal follow-up study of grown up males with ADHD. Acta Psychiatr Scand 2007;116:129-36. doi: 10.1111/j.1600-0447.2007.01008.x.
11. Yang L, Cao Q, Shuai L, Li H, Chan RC, Wang Y. Comparative study of OROS-MPH and atomoxetine on executive function improvement in ADHD: A randomized controlled trial. Int J Neuropsychopharmacol 2012;15:15-26. doi: 10.1017/s1461145711001490.
12. Swanson J. Compliance with stimulants for attention-deficit/hyperactivity disorder: Issues and approaches for improvement. CNS Drugs 2003;17:117-31. doi: 10.2165/00023210-200317020-00004.
13. Berger I, Dor T, Nevo Y, Goldzweig G. Attitudes toward attention-deficit hyperactivity disorder (ADHD) treatment: Parents' and children's perspectives. J Child Neurol 2008;23:1036-42. doi: 10.1177/0883073808317726.
14. Molina BS, Hinshaw SP, Swanson JM, Arnold LE, Vitiello B, Jensen PS, *et al.* The MTA at 8 years: Prospective follow-up of children treated for combined-type ADHD in a multisite study. J Am Acad Child Adolesc Psychiatry 2009;48:484-500. doi: 10.1097/chi.0b013e31819c23d0.
15. Weiss M, Safren SA, Solanto MV, Hechtman L, Rostain AL, Ramsay JR, *et al.* Research forum on psychological treatment of adults with ADHD. J Atten Disord 2008;11:642-51. doi: 10.1177/1087054708315063.
16. Rapport MD, Orban SA, Kofler MJ, Friedman LM. Do programs designed to train working memory, other executive functions, and attention benefit children with ADHD? A meta-analytic review of cognitive, academic, and behavioral outcomes. Clin Psychol Rev 2013;33:1237-52. doi: 10.1016/j.cpr.2013.08.005.

17. Cortese S, Ferrin M, Brandeis D, Buitelaar J, Daley D, Dittmann RW, *et al.* Cognitive training for attention-deficit/hyperactivity disorder: Meta-analysis of clinical and neuropsychological outcomes from randomized controlled trials. J Am Acad Child Adolesc Psychiatry 2015;54:164-74. doi: 10.1016/j.jaac.2014.12.010.
18. Fay-Stammbach T, Hawes DJ, Meredith P. Parenting influences on executive function in early childhood: A review. Child Dev Perspect 2014;4:258-64. doi: 10.1111/cdep.12095.
19. Hughes CH, Ensor RA. How do families help or hinder the emergence of early executive function? New Dir Child Adolesc Dev 2009;2009:35-50. doi: 10.1002/cd.234.
20. Barkley RA. Attention Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment. New York: The Guildford Press; 1998.
21. Yang L, Wang YF, Qian QJ, Gu BM. Primary exploration of the clinical subtypes of attention deficit hyperactivity disorder in Chinese children. Chin J Psychiatry 2004;4:204-7. doi: 10.3760/j:issn:1006-7884.2001.04.004.
22. Kirk RE. Experimental Design: Procedures for the Behavioral Science. 3rd ed. California: Books/Cole; 1995.
23. DuPaul GJ, Power TJ, Anastopoulos AD, Reid R. ADHD Rating Scale-IV: Checklists, Norms, and Clinical Interpretations. New York: Guilford Press; 1998.
24. Goyette CH, Conners CK, Ulrich RF. Normative data on revised conners parent and teacher rating scales. J Abnorm Child Psychol 1978;6:221-36. doi: 10.1007/bf00919127.
25. Gioia GA, Isquith PK, Guy SC, Kenworthy L. Behavior rating inventory of executive function. Child Neuropsychol 2000;6:235-8. doi: 10.1007/springerreference_184532.
26. Shuai L, Chan RC, Wang Y. Executive function profile of Chinese boys with attention-deficit hyperactivity disorder: Different subtypes and comorbidity. Arch Clin Neuropsychol 2011;26:120-32. doi: 10.1093/arclin/acq101.
27. Stroop JR. Studies of interference in serial verbal reactions. J Exp Psychol 1935;18:643-62. doi: 10.1037/h0054651.
28. Lezak MD. Neuropsychological Assessment. 3rd ed. New York: Oxford University Press; 1995.
29. Reitan RM, Wolfson D. The Halstead-Reitan Neuropsychological Test Battery. Tucson: Neuropsychology Press; 1985.
30. Anderson V. Assessing executive functions in children: Biological, psychological, and developmental considerationst. Pediatr Rehabil 2001;4:119-36. doi: 10.1080/13638490110091347.
31. Simon HA. The functional equivalence of problem solving skills. Cogn Psychol 1975;7:268-88. doi: 10.1016/0010-0285(75)90012-2.
32. Kopecky H, Chang HT, Klorman R, Thatcher JE, Borgstedt AD. Performance and private speech of children with attention-deficit/hyperactivity disorder while taking the tower of Hanoi test: Effects of depth of search, diagnostic subtype, and methylphenidate. J Abnorm Child Psychol 2005;33:625-38. doi: 10.1007/s10802-005-6742-7.
33. Tucha O, Mecklinger L, Laufkötter R, Kaunzinger I, Paul GM, Klein HE, *et al.* Clustering and switching on verbal and figural fluency functions in adults with attention deficit hyperactivity disorder. Cogn Neuropsychiatry 2005;10:231-48. doi: 10.1080/13546800444000047.
34. Perner J, Lang B. Development of theory of mind and executive control. Trends Cogn Sci 1999;3:337-344. doi: 10.1016/s1364-6613(99)01362-5.
35. Sonuga-Barke EJ, Brandeis D, Cortese S, Daley D, Ferrin M, Holtmann M, *et al.* Nonpharmacological interventions for ADHD: Systematic review and meta-analyses of randomized controlled trials of dietary and psychological treatments. Am J Psychiatry 2013;170:275-89. doi: 10.1176/appi.ajp.2012.12070991.
36. Yang B, Chan RC, Zou X, Jing J, Mai J, Li J. Time perception deficit in children with ADHD. Brain Res 2007;1170:90-6. doi: 10.1521/adhd.9.5.7.19060.
37. Kats-Gold I, Besser A, Priel B. The role of simple emotion recognition skills among school aged boys at risk of ADHD. J Abnorm Child Psychol 2007;35:363-78. doi: 10.1007/s10802-006-9096-x.
38. Dawson P, Guare R. Executive Skills in Children and Adolescents: A Practical Guide to Assessment and Intervention. New York: Guildford Press; 2004.
39. Gerdes AC, Haack LM, Schneider BW. Parental functioning in families of children with ADHD: Evidence for behavioral parent training and importance of clinically meaningful change. J Atten Disord 2012;16:147-56. doi: 10.1177/1087054710381482.
40. Perneger TV. What's wrong with Bonferroni adjustments. BMJ 1998;316:1236-8. doi: 10.1136/bmj.316.7139.1236.
41. Gathercole SE, Pickering SJ, Knight C, Stegmann Z. Working memory skills and educational attainment: Evidence from national curriculum assessments at 7 and 14 years of age. Appl Cogn Psychol 2004;1:1-16. doi: 10.1002/acp.934.
42. Doyle AE, Biederman J, Seidman LJ, Reske-Nielsen JJ, Faraone SV. Neuropsychological functioning in relatives of girls with and without ADHD. Psychol Med 2005;35:1121-32. doi: 10.1017/s0033291705004496.
43. Homack S, Riccio CA. A meta-analysis of the sensitivity and specificity of the Stroop color and word test with children. Arch Clin Neuropsychol 2004;19:725-43. doi: 10.1016/j.acn.2003.09.003.
44. Murphy P. Cognitive functioning in adults with attention-deficit/hyperactivity disorder. J Atten Disord 2002;5:203-9. doi: 10.1177/108705470100500402.
45. Shin MS, Kim YH, Cho SC, Kim BN. Neuropsychologic characteristics of children with attention-deficit hyperactivity disorder (ADHD), learning disorder, and tic disorder on the Rey-Osterreith complex figure. J Child Neurol 2003;18:835-44. doi: 10.1177/088307380301801203.
46. Sami N, Carte ET, Hinshaw SP, Zupan BA. Performance of girls with ADHD and comparison girls on the Rey-Osterrieth complex figure: Evidence for executive processing deficits. Child Neuropsychol 2003;9:237-54. doi: 10.1076/chin.9.4.237.23514.
47. Oosterlaan J, Scheres A, Sergeant JA. Which executive functioning deficits are associated with AD/HD, ODD/CD and comorbid AD/HD+ODD/CD? J Abnorm Child Psychol 2005;33:69-85. doi: 10.1007/s10802-005-0935-y.
48. Sarkis SM, Sarkis EH, Marshall D, Archer J. Self-regulation and inhibition in comorbid ADHD children: An evaluation of executive functions. J Atten Disord 2005;8:96-108. doi: 10.1177/1087054705277265.
49. Klingberg T. Training and plasticity of working memory. Trends Cogn Sci 2010;14:317-24. doi: 10.1016/j.tics.2010.05.002.
50. Wei YY, Wang JJ, Yan C, Li ZQ, Pan X, Cui Y, *et al.* Correlation between brain activation changes and cognitive improvement following cognitive remediation therapy in schizophrenia: An activation likelihood estimation meta-analysis. Chin Med J 2016;129:578-85. doi: 10.4103/0366-6999.176983.
51. Beck SJ, Hanson CA, Puffenberger SS, Benninger KL, Benninger WB. A controlled trial of working memory training for children and adolescents with ADHD. J Clin Child Adolesc Psychol 2010;39:825-36. doi: 10.1080/15374416.2010.517162.
52. Klingberg T, Fernell E, Olesen PJ, Johnson M, Gustafsson P, Dahlström K, *et al.* Computerized training of working memory in children with ADHD – A randomized, controlled trial. J Am Acad Child Adolesc Psychiatry 2005;44:177-86. doi: 10.1097/00004583-200502000-00010.
53. Re AM, Capodieci A, Cornoldi C. Effect of training focused on executive functions (attention, inhibition, and working memory) in preschoolers exhibiting ADHD symptoms. Front Psychol 2015;6:1-9. doi: 10.3389/fpsyg.2015.01161.
54. Tamm L, Hughes C, Ames L, Pickering J, Silver CH, Stavinoha P, *et al.* Attention training for school-aged children with ADHD: Results of an open trial. J Atten Disord 2010;14:86-94. doi: 10.1177/1087054709347446.
55. Dovis S, Van der Oord S, Wiers RW, Prins PJ. Improving executive functioning in children with ADHD: Training multiple executive functions within the context of a computer game. A randomized double-blind placebo controlled trial. PLoS One 2015;4:1-30. doi: 10.1371/journal.pone.0121651.
56. Donk MV, Hiemstra-Beernink A, Tjeenk-Kalff A, Leij AV, Lindauer R. Cognitive training for children with ADHD: A randomized controlled trial of cogmed working memory training and 'paying attention in class'. Front Psychol 2015;6:1-13. doi: 10.3389/fpsyg.2015.01081.
57. Murphy D. Theory of mind functioning in mentally disordered offenders detained in high security psychiatric care: Its relationship to clinical outcome, need and risk. Crim Behav Ment Health 2007;17:300-11. doi: 10.1002/cbm.664.

58. Diamond A, Lee K. Interventions shown to aid executive function development in children 4 to 12 years old. Science 2011;333:959-64. doi: 10.1126/science.1204529.
59. Lawson RA, Papadakis AA, Higginson CI, Barnett JE, Wills MC, Strang JF, *et al.* Everyday executive function impairments predict comorbid psychopathology in autism spectrum and attention deficit hyperactivity disorders. Neuropsychology 2015;29:445-53. doi: 10.1037/neu0000145.
60. Solanto MV, Marks DJ, Mitchell KJ, Wasserstein J, Kofman MD. Development of a new psychosocial treatment for adult ADHD. J Atten Disord 2008;11:728-36. doi: 10.1177/1087054707305100.
61. Smith SD, Vitulano LA, Katsovich L, Li S, Moore C, Li F, *et al.* A randomized controlled trial of an integrated brain, body, and social intervention for children with ADHD. J Atten Disord 2016. pii: 1087054716647490. doi: 10.1177/1087054716647490.
62. Gathercole SE. Commentary: Working memory training and ADHD – Where does its potential lie? J Child Psychol Psychiatry 2014;55:256-7. doi: 10.1111/jcpp.12196.
63. Tarver J, Daley D, Sayal K. Beyond symptom control for attention-deficit hyperactivity disorder (ADHD): What can parents do to improve outcomes? Child Care Health Dev 2015;1:1-14. doi: 10.1111/cch.12159.
64. Tamm L, Nakonezny PA. Metacognitive executive function training for young children with ADHD: A proof-of-concept study. Atten Defic Hyperact Disord 2015;7:183-90. doi: 10.1007/s12402-014-0162-x.
65. Healey DM, Halperin JM. Enhancing neurobehavioral gains with the aid of games and exercise (ENGAGE): Initial open trial of a novel early intervention fostering the development of preschoolers' self-regulation. Child Neuropsychol 2015;21:465-80. doi: 10.1080/09297049.2014.906567.
66. Xiao LN, Liang SW, He XS. Relationship among youth academic stress, parental support and mental health. Contemporary Youth Research. 2014;5:29-34. Doi: 10.3969/j.issn.1006-1789.2014.05.005.
67. Stevenson HW, Lee SY. The Academic Achievement of Chinese Students. Hong Kong: Oxford University Press; 1996.
68. Huang F, Sun L, Qian Y, Liu L, Ma QG, Yang L, *et al.* Cognitive function of children and adolescents with attention deficit hyperactivity disorder and learning difficulties: A developmental perspective. Chin Med J 2016;129:1922-8. doi: 10.4103/0366-6999.187861.
69. Borella E, Carretti B, Pelegrina S. The specific role of inhibition in reading comprehension in good and poor comprehenders. J Learn Disabil 2010;43:541-52. doi: 10.1177/0022219410371676.
70. Bree KD, Beljan P. Neuro-cognitive intervention for working memory: Preliminary results and future directions. Appl Neuropsychol Child 2016;5:202-13. doi: 10.1080/21622965.2016.1167504.
71. Daley D, Birchwood J. ADHD and academic performance: Why does ADHD impact on academic performance and what can be done to support ADHD children in the classroom? Child Care Health Dev 2010;36:455-64. doi: 10.1111/j.1365-2214.2009.01046.x.
72. Blakey E, Carroll DJ. A short executive function training program improves preschoolers' working memory. Front Psychol 2015;6:1827. doi: 10.3389/fpsyg.2015.01827.