Metacognitive Awareness and Executive Function in Attention Deficit/Hyperactivity Disorder

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ABSTRACT

Background: A pilot study was performed to examine the relationship between metacognitive awareness and executive functions in children with attention deficit/hyperactivity disorder (ADHD).

Methods: Children who were diagnosed with ADHD and were treatment naïve were consecutively included in the study. The Wechsler Intelligence Scale for Children-Revised (WISC-R) and the Metacognitive Awareness Inventory for Children (Jr. MAI)-A and B forms were used. The participants' teachers and parents completed the Behavioral Rating Inventory of Executive Function (BRIEF) and Conners' Rating Scale (CRS) forms.

Results: This study included 45 children with ADHD (51.1% boys) with a mean age of 9.7±2.2 years. While the BRIEF-parent-initiate scores were positively correlated with the WISC-R-total scores (r=0.315, p=0.040), they were negatively correlated with the Jr.-MAI scores (r=-0.378, p=0.011). No correlation was found between the Conners' and Jr.-MAI scores. A positive correlation was found between the Conners'-parent and the BRIEF-parent-emotional control (r=0.324, p=0.030) and BRIEF-parent-initiate (r=0.422, p=0.004) scores. There were positive correlations between the Conners'-teacher and all BRIEF-teacher-sub-domains.

Conclusion: Metacognitive awareness and executive functions and intelligence level and executive functions were not correlated in children with ADHD.

INTRODUCTION

Attention deficit/hyperactivity disorder (ADHD) is one of the most frequently diagnosed neurodevelopmental disorders during childhood and adolescence, with a prevalence rate of 5% in children 4–17 years old (1). ADHD is characterized by symptoms of inattention, hyperactivity, and impulsivity at a frequency and intensity inappropriate for the individual's age and level of development. ADHD does not involve a simple deficit in attention; the symptoms have been associated with deficits in executive function (EF). Several authors have proposed that the symptoms of ADHD arise from a primary deficit in a specific EF domain such as response inhibition, working memory or a more general weakness in executive control (2-7).

Metacognition is defined as an individual's knowledge of his/her cognitive processes and the ability to regulate his/her own cognitive processes using this knowledge and express the operations he/she uses to be aware of, monitor, control, and regulate his/her cognitive processes (8, 9). The cognitive processes that are monitored and regulated include learning, problem solving, comprehension, reasoning, and memory (9, 10). Children with ADHD often have difficulties with inhibitory control and frequently fail to manage or control their behavioral responses (11), and in school, these children have difficulty maintaining on-task behaviors or following through when given instructions, producing work of poorer quality than they are capable of (12, 13). A neurobiological dysfunction involving regions of the prefrontal cortex associated with behavioral inhibition is combined with the executive dysfunctions in ADHD, especially regarding the multidimensional EF system controlling higher-order cognitive processes implemented by an executive prefrontal control

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network that interacts with the cortical and subcortical affective networks (14, 15). The conceptual link between behavioral inhibition, EF, and metacognition has led to the hypothesis that children with ADHD may experience difficulties in metacognition and, thus, that measures of EF, especially behavioral inhibition and metacognition, should be positively correlated. Because children with ADHD encounter numerous psychosocial and occupational challenges as they grow up, it is particularly important for intervention efforts to understand EF, metacognition, and how they relate to each other. Some authors have reported that metacognitive interventions for attention produce encouraging results with children with ADHD, although the research is still limited (16). There is continued interest in the research and clinical utility of EF measures, including both neuropsychological and behavioral ratings. The most frequently used rating scale for EF is the Behavior Rating Inventory of Executive Function (BRIEF) (17). Gioia et al. (17) used the standardized parent and teacher report forms of the BRIEF and reported that children with ADHD had significantly higher scores on virtually all of the scales than the comparison controls. Based on this knowledge, we aimed to examine the relationship between metacognitive awareness and executive functions in children with ADHD.

Our hypothesis is that children with ADHD will have lower scores on learning behaviors and have lower academic achievements. The second objective was to analyze the relationships among EF, metacognitive awareness, and symptoms of inattention and hyperactivity/impulsivity, and identify which aspects of EF and/or ADHD symptoms have greater relevance for metacognition in children with ADHD.

Our goal is that our study will aid in developing methods to help students with ADHD achieve academic success and lead to more effective intervention strategies.

METHODS

PATIENTS

All children who visited the Department of Child and Adolescent Psychiatry in our hospital over a six-month period and were diagnosed with ADHD were consecutively included in the study. Children were diagnosed as having ADHD according to a structured clinical interview based on the criteria defined by the Diagnostic and Statistical Manual of Mental Disorders-5th edition (DSM-5) (18). The children with ADHD were included in the study on condition that they were treatment naïve. The exclusion criteria were the presence of a chronic medical illness, any sensory-motor disability, neurological disorder, diagnosis of autistic spectrum disorder, and other developmental disorders. The entire initial number of children admitted to our hospital during these six months was about 300. However, 55 children with ADHD had severe comorbidities such as major depression, mania, and bipolar disorder and were excluded; 60 children with ADHD were taking medications previously (31 children on methylphenidate and 29 children on atomoxetine) and were excluded. Ninety-five of the children with ADHD did not agree to participate in the study and 45 children with ADHD had chronic medical illnesses. Children with any sensory-motor disability or neurological disorder were excluded. Finally, 45 children who were eligible to enter the study were selected.

PROCEDURE

A clinician administered the Wechsler Intelligence Scale for Children-Revised (WISC-R) and the Metacognitive Awareness Inventory for Children (Jr. MAI)-A and B forms. The participants' teachers and parents completed the Behavioral Rating Inventory of Executive Function (BRIEF) and the Conners' Rating Scale (CRS) forms. The parents' forms were completed by both the mother and father. The teacher form was completed by the teacher of each participant's class.

ASSESSMENTS

The Metacognitive Awareness Inventory for Children (Jr. MAI) was developed by Sperling et al. (19) for children and based on the MAI developed by Schraw and Dennison (20) for adults. The MAI consists of 52 items; for the Jr. MAI, 12 items from Form A and 18 items from Form B were selected, and the statements taken from the selected items were simplified because they were considered to be difficult for children to understand. The Jr. MAI is a Likert-type scale consisting of two forms, for different age groups (Form A is for 3rd to 5th grade students and Form B is for 6th to 9th grade students), that measures the level of metacognitive skills without depending on a specific area and in accordance with the development of metacognitive skills. The items on Form A are answered on a 3-point Likert-type scale (never, sometimes, and always), and those on Form B are answered on a 5-point Likert-type scale (never, seldom, sometimes, often, and always). A high total score indicates high metacognitive skills (19). The validity and reliability study for the Turkish version of the Jr. MAI was performed by Karakelle and Saraç (21).

The Wechsler Intelligence Scale for Children-Revised is one of the most widely used tests for measuring the

intelligence of children and adolescents. It consists of 12 subtests; six of the subtests are included in the verbal scale, and six subtests make up the performance scale (22). It was adapted into Turkish by Savaşır and Şahin (23).

The Behavioral Rating Inventory of Executive Function is a behavioral rating measure that was specifically designed to assess everyday executive skills in children and adolescents in natural, everyday environments, including the home and school (17). The BRIEF was developed by Gioia et al. (17) to examine the associations between performance-based measures of executive function and ratings of executive function processes by parents and teachers. It consists of two forms: the Parent Form and Teacher Form. Both forms contain 86 questions, including eight sub-domains. The Behavioral Regulation Index (BRI) is composed of the Inhibit, Shift, and Emotional Control sub-domains, and the Metacognition Index (MI) is composed of the Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor sub-domains. The BRI and MI are also combined to obtain Global Executive Composite (GEC) scores (17). High scores indicate high levels of executive impairment. Reliability and validity studies of the BRIEF in a Turkish normative sample were conducted by Batan et al. (24).

Conners' Parent Rating Scale-Revised (CPRS-R) and Conners' Teacher Rating Scale-Revised (CTRS-R) are used to collect information from parents or teachers about childhood behavioral problems. CPRS-R is composed of seven sub-scales: Cognitive problems, Oppositional, Hyperactivity-Impulsivity, Anxious-Shy, Perfectionism, Social Problems, and Psychosomatic (25). CTRS-R includes 6 sub-scales: Oppositional, Cognitive Problems/Inattention, Hyperactivity, Anxious-Shy, Perfectionism, and Social Problems (26). Conners' scales are available in both long and short versions. Validity and reliability studies for the Turkish versions of these scales have been performed previously (27, 28).

STATISTICAL ANALYSIS

Data were analyzed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, U.S.A.). The Shapiro-Wilks test was used to test for normality. Descriptive statistics are expressed as the mean, standard deviation, maximum, and minimum for the numerical variables. Pearson's correlation analysis was used to evaluate the relationship between quantitative data showing a normal distribution. The level of statistical significance was predetermined to be $p<0.05$.

Regression analyses of the BRIEF-parent-emotional control and initiate scores on the Conners' parent scores and the BRIEF-teacher inhibit, shift, emotional control, initiate, working memory, plan/organize, organization of materials, monitor, behavioral regulation index, metacognition index, and global executive composite scores on the Conners' teacher scores were performed using backward regression analysis.

RESULTS

A total of 45 children with ADHD with a mean age of 9.7±2.2 (range: 7-14) years were included in the study; 23 (51.1%) were boys, and 22 (48.9%) were girls. The mean age of the mothers was 33.8±4.1 years, and the mean age of the fathers was 37.6±4.8 years; 13.3% of the mothers and 15.6% of the fathers had a university degree or higher. The scores of the scales used for the children, parents, and teachers are summarized in Table 1.

Correlation analysis of the WISC-R-total score with the BRIEF-parent scale and BRIEF-teacher scale scores showed that there was a significant positive correlation between WISC-R total and BRIEF-parent-initiate ($r=0.315$, $p<0.040$), whereas no significant correlation was found with the other sub-domains of the BRIEF scale (Table 2). Regression analysis was not performed because only the BRIEF-parent-initiate score was associated with WISC-R scores.

The correlation analysis of the Jr. MAI with the BRIEF and Conners' scales showed a significant negative correlation between the Jr. MAI scores and BRIEF-parent-initiate scores ($r=-0.378$, $p<0.011$); however, no significant correlation was found with the other BRIEF sub-domains. Moreover, no significant correlation was found between the Conners' scores and Jr. MAI scores (Table 3).

The correlation analysis between the BRIEF and Conners' scales completed by the parents revealed a significant positive correlation between the Conners' scores and BRIEF-emotional control ($r=0.324$, $p<0.030$) and BRIEF-initiate ($r=0.422$, $p<0.004$) scores (Table 4).

The correlation analysis between the Conners' teacher and BRIEF-teacher-scales revealed a significant positive correlation between the Conners' teacher and all BRIEF-teacher-sub-domains (Table 5).

When we evaluated the effect of the BRIEF-parent-emotional control and initiate scores on the Conners' parent scores using regression analysis, the model was found to be significant ($p<0.05$), and the R-square value was 0.213. The effect of the initiate scores on the model was found to be statistically significant ($p: 0.021$; $p<0.05$). A one-unit increase in the initiate scores increased the Conners' family scores by 0.75 units (Table 6).

Table 1. *Scores of all scales used in the study*

	n	Mean±SD	Minimum-Maximum
WISC-R Verbal	44	88.2±14.08	64-114
WISC-R Performance	44	102.41±11.6	75-122
WISC-R Total	43	94.84±10.97	75-117
Jr. MAI[a]	45	37.96±17.26	20-83
Conners'-Parent	45	45.78±20.29	17-104
Conners'-Teacher	45	29.49±18.09	6-75
BRIEF-Parent	45		
Inhibit		78.56±10.22	57-98
Shift		79.4±11.27	56-95
Emotional Control		64.04±10.15	43-83
Initiate		61.78±9.49	46-84
Working Memory		69.33±9.45	45-90
Plan/Organize		74.04±9.64	51-89
Organization of Materials		61.38±8.32	45-72
Monitor		60.67±9.47	43-88
Behavioral Regulation Index (BRI)		76.96±9.64	55-99
Metacognition Index (MI)		69.49±9.33	49-89
Global Executive Composite (GEC)		73.13±8.73	51-88
BRIEF-Teacher	45		
Inhibit		76.96±15.18	49-124
Shift		78.78±19.86	46-127
Emotional Control		66.09±14.86	43-96
Initiate		66.56±15.38	39-97
Working Memory		72.53±18.47	40-113
Plan/Organize		80.27±13.51	52-107
Organization of Materials		61.29±13.44	42-99
Monitor		71.69±14.87	43-112
Behavioral Regulation Index (BRI)		76.51±16.09	47-121
Metacognition Index (MI)		74.84±15.85	44-113
Global Executive Composite (GEC)		76.64±15.62	47-121

[a]Form A was used in 29 children and Form B was used in 16 children
BRIEF, Behavioral Rating Inventory of Executive Function; Jr. MAI, Metacognitive Awareness Inventory for Children; SD, Standard deviation; WISC-R, Wechsler Intelligence Scale for Children-Revised

When we evaluated the effect of the BRIEF-teacher inhibit, shift, emotional control, initiate, working memory, plan/organize, organization of materials, monitor, behavioral regulation index, metacognition index, and global executive composite scores, which are associated with the Conners' teacher scores, using backward regression analysis, the model was found to be significant ($p<0.05$), and the R-square value was 0.422. The effect of the emotional control scores on the model was found to be statistically significant ($p<0.000$; $p<0.05$). A one-unit increase in the emotional control scores increased the Conners' teacher scores by 0.79 units.

Table 2. *Correlation analysis of the Wechsler Intelligence Scale for Children-Revised total with the Behavioral Rating Inventory of Executive Function -parent and -teacher scales*

	WISC-R total	
	r	p
BRIEF-Parent scale subdomains		
Inhibit	-0.021	0.895
Shift	0.238	0.124
Emotional Control	0.231	0.137
Initiate	0.315	0.040
Working Memory	0.033	0.836
Plan/Organize	0.139	0.374
Organization of Materials	0.087	0.580
Monitor	0.222	0.153
Behavioral Regulation Index (BRI)	0.158	0.312
Metacognition Index (MI)	0.224	0.148
Global Executive Composite (GEC)	0.074	0.639
BRIEF-Teacher scale subdomains		
Inhibit	0.042	0.787
Shift	-0.073	0.643
Emotional Control	-0.033	0.831
Initiate	-0.157	0.316
Working Memory	-0.054	0.731
Plan/Organize	-0.215	0.166
Organization of Materials	0.026	0.870
Monitor	-0.067	0.668
Behavioral Regulation Index (BRI)	-0.006	0.972
Metacognition Index (MI)	-0.031	0.845
Global Executive Composite (GEC)	-0.061	0.700

BRIEF, Behavioral Rating Inventory of Executive Function; WISC-R, Wechsler Intelligence Scale for Children-Revised

DISCUSSION

Children with ADHD have been reported to have lower academic success compared to their peers. Although the reason for this remains unclear, it is thought that the learning process is negatively affected by the disease symptoms and impaired executive functions (29). Attention control and cognitive abilities are among the factors that influence the learning processes (30, 31). Students who use metacognitive strategies have been reported to be more successful (32). In various studies performed on school-age children, metacognitive education programs have been shown to enhance academic performance (33, 34). It has been reported that metacognitive training improves academic performance such as in mathematical reasoning or reading comprehension and that it is particularly important for intervention efforts to understand

Table 3. *Correlation analysis of the Metacognitive Awareness Inventory for Children with the Behavioral Rating Inventory of Executive Function and Conners' scales*

	Jr. MAI	
	r	p
BRIEF-Parent scale subdomains		
Inhibit	0.06	0.693
Shift	-0.25	0.098
Emotional Control	-0.009	0.956
Initiate	-0.378	0.011
Working Memory	-0.111	0.466
Plan/Organize	-0.273	0.070
Organization of Materials	-0.023	0.882
Monitor	-0.097	0.528
Behavioral Regulation Index (BRI)	-0.068	0.659
Metacognition Index (MI)	-0.211	0.165
Global Executive Composite (GEC)	0.025	0.872
BRIEF-Teacher scale subdomains		
Inhibit	0.093	0.541
Shift	0.165	0.278
Emotional Control	0.141	0.357
Initiate	0.08	0.601
Working Memory	0.165	0.278
Plan/Organize	0.144	0.344
Organization of Materials	0.06	0.694
Monitor	0.147	0.336
Behavioral Regulation Index (BRI)	0.139	0.364
Metacognition Index (MI)	0.055	0.720
Global Executive Composite (GEC)	0.180	0.236
Conners'-Parent	-0.190	0.212
Conners'-Teacher	-0.117	0.443

BRIEF, Behavioral Rating Inventory of Executive Function; Jr. MAI, Metacognitive Awareness Inventory for Children

EF, metacognition, and how they relate with each other (35). Tamm and Nakonezny (36) carried out a study on children with ADHD and reported that executive function training with a metacognitive focus was a potentially promising intervention and that executive functions were improved in the children who were trained, but they emphasized that studies with larger sample sizes that include active control groups are required to clarify the subject. Basile et al. (37) investigated social information processing from a metacognitive perspective. In their study, the ADHD group was more confident in identifying angry and sad faces than the normally developing children, but the ADHD group exhibited lower resolution, indicating that the normally developing group was significantly better at discriminating correct from

Table 4. *Correlation analysis between the Conners'-Parent and Behavioral Rating Inventory of Executive Function-parent scales*

	Conners'-Parent	
	r	p
BRIEF-Parent scale subdomains		
Inhibit	0.255	0.091
Shift	0.205	0.176
Emotional Control	0.324	0.030
Initiate	0.422	0.004
Working Memory	0.098	0.521
Plan/Organize	0.200	0.187
Organization of Materials	0.280	0.063
Monitor	0.263	0.081
Behavioral Regulation Index (BRI)	0.407	0.006
Metacognition Index (MI)	0.114	0.455
Global Executive Composite (GEC)	0.184	0.227

BRIEF, Behavioral Rating Inventory of Executive Function

Table 5. *Correlation analysis between the Conners'-teacher and Behavioral Rating Inventory of Executive Function-teacher scales*

	Conners'-Teacher	
	r	p
BRIEF-Teacher scale subdomains		
Inhibit	0.432	0.003
Shift	0.452	0.002
Emotional Control	0.650	<0.001
Initiate	0.427	0.003
Working Memory	0.328	0.028
Plan/Organize	0.317	0.034
Organization of Materials	0.318	0.033
Monitor	0.502	0.000
Behavioral Regulation Index (BRI)	0.576	0.000
Metacognition Index (MI)	0.344	0.021
Global Executive Composite (GEC)	0.477	0.001

BRIEF, Behavioral Rating Inventory of Executive Function

Table 6. *Evaluation of the effect of Conners' parent and Conners' teacher scores and BRİEF parent and teacher scale subdomains by regression analysis*

	B	S.E.	Beta	t	p
Conners' Parent and BRIEF-Parent scale					
(Constant)	-26,009	21,794		-1,193	0,239
Emotional	0,396	0,293	0,198	1,352	0,184
İnitiate	0,751	0,313	0,351	2,397	0,021*
Conners' Teacher and BRIEF-Teacher scale					
(Constant)	-22,760	9,555		-2,382	0,022*
Emotional	0,791	0,141	0,650	5,602	0,000*

incorrect responses (37). Notably, metacognition has often been neglected in theoretical models of executive functions, and metacognition and executive functions are closely linked (38).

In addition to impaired executive functions, difficulties in metacognitive and behavioral regulation have also been reported in children with ADHD (39). Pezzica et al. (40) investigated the awareness of attention deficit both in children with ADHD and in their peers without ADHD. They concluded that children with and without ADHD have almost similar degrees of metacognitive awareness of attention and that children with ADHD are aware of what is required in the school context but are not able to meet the requirements. Therefore, in the present study, we explored the relationship between metacognitive awareness and executive functions in children with ADHD. For this purpose, we measured the level of metacognitive awareness of the children using the Jr. MAI and evaluated the executive functions of children using scales (BRIEF and Conners' scale) completed by the parents and teachers. Based on our findings, there was no significant correlation between the Jr. MAI scores and the scores of either the BRIEF (excluding parent-BRIEF-initiate) or the Conners' scale. Thus, no significant interaction was found between metacognitive awareness and executive functions in children with ADHD in the present study group.

Given that the level of intelligence likely affects the cognitive functions, the WISC-R test was also performed with the children. In a literature review, Jepsen et al. (41) evaluated the relationship between attention deficit and IQ scores in treatment-naïve children with ADHD and reported that the associations between IQ and attention deficits in ADHD are generally modest, with the mean influence on IQ probably amounting to 2 to 5 IQ points. In addition, they also stated that in clinical practice, low scores on a Wechsler IQ test for children and adolescents with ADHD may not only reflect intellectual deficits but also may be the result(s) of attention deficits during the administration of the IQ test. In the present study group, the total WISC-R score was 94.84±10.97 (range 75-117). The absence of children with an IQ score <70, which is considered as borderline intelligence, and the fact that the mean scores corresponded to average intelligence indicate that there was no problem in this regard in the present study group. No significant correlation was found between the total WISC-R score and the BRIEF scale sub-domains (excluding BRIEF-parent-initiate). Accordingly, no significant interaction was found between the level of intelligence and executive functions in children with ADHD in the present study group.

When the Conners' and BRIEF scales completed by the parents were considered, a significant correlation was found between two parent-BRIEF sub-domains (emotional control and initiate) and the Conners' scores. For the scales completed by the teachers, a positive correlation was found between the Conners' scale scores and all teacher-BRIEF scale sub-domains, suggesting that more consistent evaluations were performed by the teachers.

It has long been known that people with ADHD have difficulty with emotional dysregulation (ED), and the nature of the relationship between this difficulty and ADHD is an interesting area of research. Studies have shown that ED is frequently observed in ADHD, has an effect on functioning, and is important in the course of the disorder (42). One of the important limitations of our study is that ED was not assessed, especially in the families of children with ADHD.

In conclusion, the present study found no significant correlation between metacognitive awareness and executive functions or between the level of intelligence and executive functions in children with ADHD. Further studies on this topic that include larger sample groups and control groups would clarify the physiopathological mechanisms and provide beneficial information.

Ethical standards

The study was approved by the Ethics Committee of Haydarpaşa Numune Training and Research Hospital. Informed consent from the parents and assent from the patients were obtained.

Conflict of interest

The authors declare that they have no conflict of interest.

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