



Executive functions and emotion regulation relationship of suicidal ideation in children with ADHD

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Abstract

Aim: There is evidence that suicidal thoughts are increased in attention deficit/hyperactivity disorder (ADHD). The aim of this study is to investigate the relationship between executive function (EF) deficits and emotion regulation negativity/lability (ERNL) in children with ADHD who reported suicidal ideation.

Materials and Methods: This study was conducted in children aged 8-12 years with ADHD. Thirty-eight cases (ADHD + SI) with suicidal ideation and 41 cases without suicidal ideation (pure ADHD) were included in the study. Participants completed using the Children's depression inventory (CDI), the Screen for child anxiety-related emotional disorders (SCARED), the Behavior rating inventory of executive function (BRIEF) and the Emotion regulation checklist (ERC).

Results: A significant difference was found between the 3 groups in terms of EF deficits and ERNL, CDI and SCARED. BRIEF subcomponents; there was a significant difference between inhibit, emotion control, monitor and behavior regulation index.

Conclusion: Suicidal ideation is an important psychiatric health problem. Recognizing suicidal ideation in children; It can be effective in preventing suicidal behavior. Cognitive features such as EF deficits and ERNL may contribute negatively to suicidal ideation, especially in children with ADHD.



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Introduction

Attention Deficit/Hyperactivity Disorder (ADHD) is one of the psychiatric problems worldwide [1]. Inattention, hyperactivity and impulsivity are known as core symptoms in children with ADHD. However, there are significant impairments in emotional regulation (ER) and executive functions (EF) [2,3]. ADHD is a developmental disorder that should be carefully evaluated in a wide spectrum of EF [3]. Recently, researchers have begun to highlight emotion dysregulation along with EF deficits, which is an important feature of ADHD and contributes greatly to the functional impairment experienced by children with ADHD [2,4]. During the development of children, EF deficits undermines their capacity for behavioral and ER. The increased negative impact with this condition leads to difficulty controlling thoughts and actions and can make it difficult to cope positively in response to stress [5,6]. Difficulties in emotion regulation in children with ADHD; refers to difficulties in identifying-processing negative emotions [7]. Emotional dysregulation in general; It occurs

when a person fails to change an emotional state in order to display the adaptive behaviors necessary to achieve their goals [8]. Children with ADHD have the greatest impairment in ER negativity/lability (ERNL), one of the characteristics of emotion dysregulations [9]. There is strong evidence that children with ADHD have EF deficits and emotion dysregulations [10,11].

ADHD and suicidal ideation

Studies have shown a questionable association between ADHD and suicide in adolescent [12,13]. There are studies reporting that ADHD is the most common mental disorder in children under the age of 12 who died by committing suicide [13,14]. Suicidal behavior was associated with ADHD in a prospective longitudinal study conducted between the ages of 7-12 [15]. It has been reported that especially male gender and psychiatric comorbidities such as behavioral disorder and depression increase the risk of suicidal behavior in children and adolescents with ADHD [12].

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The present study

In the present study, we planned a research on the relationship between EF and ER in children with ADHD who had suicidal ideation.

Our hypothesis is that EF deficits and ERNL may be more prominent in children with ADHD who describe suicidal ideation, since more EF deficits and emotion dysregulation are known in children with ADHD compared to natural population because, enough relational associations have been described in the literature on this subject. It is important to emphasize that ADHD, which is most diagnosed in childhood, when suicidal ideation is strongly emphasized, coincides with these ages [7-12]. This study speculates that ERNL and EF deficits, two features of ADHD, may lead to suicidal ideation in children with ADHD.

Materials and Methods

This study has been previously prepared as a specialist thesis (*). The study was approved by the Inonu University Non-Interventional Clinical Research Ethics Committee (2016/213) and was completed in accordance with the Helsinki Declaration. Detailed information was given to all participants and their parents. Written consent was obtained.

Participants

The study was carried out in Inonu University, Department of Child and Adolescent Mental Health and Diseases. Children between the ages of 8-12 and previously diagnosed with ADHD were included in the study. According to the power analysis, when $\alpha = 0.05$ and $1-\beta$ (power) = 0.95, groups were formed based on the minimum required number of participants. And the non-probable method was used to determine the base sample.

While the study was being designed, in both ADHD groups and control group; stimulant and other non-stimulant medication, substance abuse disorder, neurological diseases, autism spectrum disorder and other neurodevelopmental diseases were excluded from the study. Those who were not under any psychiatric follow-up and treatment were included in the study. The control group was formed from those who did not have any health problems.

Evaluation and Measurements

Schedule for affective disorders and Schizophrenia for school-age children, present and lifetime version (K-SADS-PL)

This semi-structured interview schedule; evaluates current and past episodes of psychopathology [16]. Suicidal ideation was determined using the questions in the screening part of the diagnostic interview: "1" = absent in the suicidal thoughts item, "2" = occasionally, "3" = frequent. This interview schedule; it is valid and reliable for Turkish children and adolescents [17].

Behavior rating inventory of executive function (BRIEF)

BRIEF [18] evaluates EFs in children aged 5-18 years through parental observation. The sum of the inhibiting,

shift and emotion control sub-EF parameters creates Behavioral regulation index (BRI). Initiate, working memory, monitor, plan/organize and organization of materials sub-EF parameters also create Meta cognition index (MCI). The sum of each index; Exports the global executive composite. It consists of 8 EF sub-parameters in total the higher the scores, the more dysfunctional. BRIEF; It was developed for a wide range of children, such as ADHD, learning disabilities, autism. The validity and high internal consistency ($\alpha = 0.8-0.98$) and test-retest reliability of the BRIEF for the parent forms were 0.82 [18]. Turkish validity and reliability Batan et al. [19] was conducted as a thesis study. BRIEF is considered to have high ecological value.

Emotion regulation checklist (ERC)

The ERC [20] evaluates the feeling of negativity/lability and emotional regulation in children and is a 24-item parent assessment scale. In this study, two sub-factors of negativity/lability and emotion regulation were used to assess regulation difficulties. Analyzes made by Shields and Cicchetti [20] showed that the scale has a 2-factor structure. The sub-factor, called "negativity/lability", includes items related to frequent mood swings, anger behavior, level of emotional intensity, and inability to judge positive emotion expressions well enough. This feature is now called ER negativity/lability (ERNL) in the literature. The other sub-factor was named as "emotional regulation" because it reflects the applicable emotional regulation such as understanding emotions well, empathy skills and composure in the face of events. Turkish adaptation of the ERC for the age group 6-13, Kapçı et al. [21] made by.

Children's depression inventory (CDI)

The CDI consists of 27 items covering the main symptoms of depression and is filled in by the participant [22]. Each item of the scale has three response options. It is scored as 0, 1, or 2 based on symptom severity. The validity and reliability of the CDI for Turkish children was completed for ages 6-17 [23].

Screen for child anxiety-related emotional disorders (SCARED)

SCARED [24] is a 41-item self-report measure of the broad spectrum of anxiety symptoms appropriate to the five anxiety subtypes in the DSM-IV. It is administered to children aged 7 to 12 years, and each item is scored from 0 to 2, with high scores clinically indicating the presence of anxiety. The validity and reliability of SCARED has been adapted to Turkish children. It showed that the total Cronbach α score of the scale was 0.88. Turkish translation and adaptation of SCARED was made by Karaceylan [25].

Study design

In the children and their parental interview, a child and adolescent psychiatrist completed socio-demographic data form administered by the clinician K-SADS-PL (25). K-SADS-PL was applied in interaction with the child with the help of the researcher. Participating parents of the

children were asked to fill out the ERC and BRIEF. Participating children were explained in detail and asked to complete the CDI and SCARED. Suicidal ideation was determined using a combination of parental statement and child's statement regarding KSADS-PL. Parents stated that they had heard of suicide from their children before during the K-SADS-PL interview. Why did we use this method; It is similar to the methods used in some previous studies to detect the concept of suicide in children with ADHD [26,27]. According to both child and parent statements; It was considered positive in the presence of suicidal ideation in the last 6 months.

Thus, 38 ADHD children were accompanied by suicidal ideation (ADHD+SI group). There were no suicidal thoughts in 41 ADHD children (ADHD group). 33 healthy children (Control group) without any illness were included in the study.

Statistical analysis

Data were summarized as mean \pm standard deviation, median (min-max) and number (percentage). Chi-square analysis was applied for categorical / binary variables in independent groups. Whether numerical variables showed normal distribution feature in independent groups was tested with Shapiro-Wilks tests. The Mann-Whitney U test was used to compare numerical variables that did not show normal distribution between the two groups, and independent samples t-test was used to compare if they did. When comparing more than two groups, Kruskal-Wallis test was used if it did not show normal distribution. If it showed normal distribution, one-way analysis of variance was used. After one-way analysis of variance, multiple comparisons were made using Tukey HSD or Tamhane's T2 tests, depending on whether the assumption of homogeneity was provided or not.

Results

This study was completed with a total of 112 children aged 8-12 years. Although there was male gender predominance, no significant difference was found between groups. There was no significant difference between the groups in terms of age, gender and other socio-demographic characteristics. The mean age was 9.98 ± 1.54 for ADHD + SI and 9.68 ± 1.24 for ADHD. These findings are shown in Table 1 and 2.

In comparison of BRIEF, SCARED and CDI scale scores between the patient groups (ADHD + SI and ADHD) and the control group, a strong significant difference was found in all factors ($p < 0.001^b$). The results in the comparison of all 3 groups are as follows: Among the BRIEF subscales; inhibit ($p < 0.001^{a,b}$), emotion control ($p < 0.001^{a,b}$), monitor ($p < 0.001^{a,b}$), behavior regulation index ($p < 0.001^{a,b}$), and global executive composite ($p < 0.001^{a,b}$), are significant for ADHD + SI. There was a significant difference between the groups in the ERNL ($p < 0.001^{a,b}$). There was a significant difference between the groups in terms of SCARED ($p < 0.001^{a,b}$) and CDI ($p < 0.001^{a,b}$) scales. These findings are shown in Table 3.

On the other hand, no significant difference was found in the metacognition index and emotion regulation scale in the comparison between the 3 groups.

Table 1. Participants characteristics.

	n	%
Gender		
Female	15	13.4
Male	97	86.6
Residential area		
Rural area	6	5.4
Urban area	106	94.6
Family structure		
Nuclear	95	84.8
Extended	11	9.8
Dispersed	6	5.4
Family income		
Low	25	22.3
Moderate	71	63.4
High	16	14.3
ADHD severity		
Mild	7	9.1
Moderate	57	74.0
Severe	13	16.9
	Mean \pm SD	Min-Max
Age	9.9 ± 1.32	8-12

ADHD, Attention Deficit/Hyperactivity Disorder.

Discussion

This study is among the few studies that consider EF deficits and ERNL in the relationship between ADHD and suicidal ideation. This study was similar to previous studies [27,28] on suicidal ideation in youth with ADHD that cannot be fully explained by comorbidities. We conducted a remarkable study on EF deficits and ERNL in children with ADHD who expressed suicidal ideation because EF deficits lie at the root of the main problems of children with ADHD. According to our study, we found EF deficits and emotion dysregulation findings in children with ADHD who expressed suicidal ideation. We found significant EF deficits in children with pure ADHD compared to healthy children. In fact, all EF deficits were significantly higher. However, global executive composite were found to be significant in children with ADHD describing suicidal ideation. It is more striking that there are deficiencies in the components of the BRI. In our test, in which we measured ERNL was found to be significantly impaired.

Suicide is reported to be the fourth leading cause of death among children [29]. There are studies on suicidal ideation in children and adolescents with ADHD [12]. According to a meta-analysis of 6 prospective studies on suicide [12]; If ADHD is accompanied by behavioral disorders and depression, the severity of the disease may increase and the tendency to suicidal behavior may increase. It seems that many factors have been reported to be associated with suicidal ideation in children and adolescents with ADHD. These are low socioeconomic status, male gender, child-

Table 2. Comparison of socio-demographic characteristics among ADHD groups.

Socio-demographic characteristics	ADHD+SI	ADHD	X ²	p*
	n (%)	n (%)		
Gender				
Female	5 (13.2)	5 (12.2)	0.017	1.000
Male	33 (86.8)	36 (87.8)		
Residential area				
Rural area	1 (2.6)	2 (4.9)	2.943	0.360
Urban area	37 (97.4)	39 (95.1)		
Family structure				
Nuclear	31 (81.6)	36 (87.8)	3.598	0.351
Extended	6 (15.8)	2 (4.9)		
Dispersed	1 (2.6)	3 (7.3)		
Family income				
Low	9 (23.7)	8 (19.5)	0.527	0.758
Moderate	23 (60.5)	28 (68.3)		
High	6 (15.8)	5 (12.2)		
	Mean ± SD	Min-Max	Z	p**
Age	9.98±1.54	9.68±1.24	-0.769	0.445

ADHD+SI, Attention Deficit/Hyperactivity Disorder + Suicidal Ideation; ADHD, Attention Deficit/Hyperactivity Disorder.

*P value from chi square analysis. **P value from independent sample t-test.

Table 3. Comparison of BRIEF, ERC, SCARED, CDI scale scores among all groups.

Scales	ADHD+SI	ADHD	Control	p
	(n=38)	(n=41)	(n=33)	
	Median (Min-Max)	Median (Min-Max)	Median (Min-Max)	
BRIEF				
Inhibit	34 ^{a,b} (23-43)	27 ^b (17-39)	17 (15-30)	<0.001***
Shift	23 ^b (16-29)	21 ^b (15-26)	16 (13-24)	<0.001
Emotion Control	24 ^{a,b} (12-29)	19 ^b (11-26)	16 (12-20)	<0.001***
Initiate	18 ^b (13-23)	16 ^b (9-21)	14 (10-16)	<0.001
Working Memory	26 ^b (18-32)	26 ^b (15-32)	16 (12-20)	<0.001
Plan/Organize	34 ^b (23-43)	34 ^b (21-40)	24 (17-25)	<0.001
Organization of Materials	18 ^b (10-24)	17 ^b (9-23)	13 (8-15)	<0.001
	Mean ± SD	Mean ± SD	Mean ± SD	F
Monitor	19.32±2.78 ^{a,b}	17.78±3.02 ^b	12.58±2.07	59.940
	Median (Min-Max)	Median (Min-Max)	Median (Min-Max)	
Behavior Regulation Index	78 ^{a,b} (58-101)	67 ^b (43-87)	51 (40-68)	<0.001***
Meta Cognition Index	112 ^b (89-143)	112 ^b (72-131)	78 (55-88)	<0.001
Global Executive Composite	165 ^{a,b} (135-210)	155 ^b (109-184)	110 (83-132)	<0.001***
ERC				
ERNL	18 ^{a,b} (5-40)	13 ^b (3-27)	6 (-4-17)	<0.001***
ER	14 ^b (5- 19)	13 ^b (5-19)	17 (9-20)	<0.001
SCARED	32 ^{a,b} (9-68)	22 ^b (5-66)	15 (5-21)	<0.001***
CDI	14 ^{a,b} (2-48)	9 ^b (0-20)	5 (0-12)	<0.001***

BRIEF, Behavioral Rating Inventory of Executive Function; ERNL, Emotion Regulation Negativity/Lability; ER, Emotion Regulation; SCARED, Screen for Child Anxiety and Related Emotional Disorders; CDI, Children Depression Inventory.

p^a: Significant compared to ADHD group. p^b: Significant compared to control group.

hood emotional and behavioral problems, psychiatric comorbidities, chronic stress, low social support [12,13,26]. Studies have shown EF deficits in suicidal and self-harming behavior in children with ADHD [30,31]. According to studies investigating the effect of EF deficits on suicidal behavior, the effect of EF on the development of suicidal ideation was predicted [32]. One study found that EF deficits were prominent in recent attempters with suicidal ideation. It is not yet clear which sub-components of EF deficits play an active role in the development of suicidal ideation. In a few studies on this subject, some of its subcomponents have been held responsible for suicidal ideation. For example, in one study, the inhibition subcomponent was found to be associated with suicidal behaviors [33].

There are few reports of the relationship between EF subcomponents and suicidal ideation. There are studies showing that suicidal ideation can develop in individuals with EF deficits [34]. Weaker executive function aids the overall deterioration in ADHD [35] and may also be a risk factor for suicidal ideation that should be taken seriously. We found more impaired EF deficits in the ADHD (ADHD+SI) group with suicidal ideation. Although there are studies similar to ours [36,37], some of them are inhibit, emotion control, monitor, behavior regulation index, and global executive composition. The results seem mixed and not directly comparable. In studies using BRIEF, it has been reported that the behavior regulation index is more impaired in individuals with combined type ADHD, and the metacognition index is more impaired in ADHD inattentive predominant type [38]. Accordingly, although subtypes were not differentiated in our study, we can say that our results are due to this reason, since all individuals with mixed ADHD were included.

Suicide attempt has been studied in many studies, but similar to our study, Bauer et al. [27] studied suicidal ideation. Very similar to our study, Bauer et al. [27] conducted it with children under 12 years of age with ADHD. They found EF deficits in these children, but their measurement method is BRIEF in ours and they are in the form of test batteries. Bauer et al. [27] used a larger sample in their study. The role of response inhibition in suicide ideations is heavily debated [39]. Studies have shown more deterioration in the inhibit EF-subcomponent in suicide attempts than in suicidal ideation [32]. Bauer et al. [27] reported that working memory mediates suicidal ideation in people with ADHD. Bauer et al. [27] said that: "Due to the prevalence of EF impairment in children with ADHD and their increased suicide risk, this population is a critical locus for clarifying these associations". Working memory is one of the subunits of impaired executive function in children with ADHD [39]. Bauer et al. [27] and Swanson et al. [33] working memory and inhibit found different results from ours in EF subcomponents.

Similar to EF, emotional dysregulation has also been associated with suicidal ideation [40]. It is consistent with studies reporting the relationship between suicidal ideation and emotional dysregulation [27,41]. Emotion regulation problems in children with ADHD have been studied in different subcomponents. ERNL has been reported in children with ADHD in this context [2,9]. In our study, ERNL

was also found to be significant in the ADHD+SI group. "Youth with ADHD have the greatest impairment on emotion reactivity/lability" was stated in their review study. This is consistent with the literature. In our study, we made a comparison based on suicidal ideation in children. This finding seems to be consistent with previous studies that found strong associations between ADHD, EF deficits, and ERNL [10,11].

Studies show the role of depression as one of the factors affecting the development of suicidal ideation in children with ADHD [42]. They emphasized the indirect effectiveness of depression in the development of suicidal ideation. In our study, we also found the CDI score to be significant from the ADHD+SI group to the other groups. We did not test whether it has an indirect role in our study. However, considering that the CDI score indicates the current situation, it does not seem possible to deny its effect on the development of suicidal ideation. However, Van Eck et al. [42] it should be noted that their study was conducted with young adults. They stated that the indirect effect of the development of depression on suicidal ideation was mediated by the ER. In fact, studies often point to the mediating role of depression. However, we have sufficient evidence to think that the EF and ER structures that explain cognitive processes are mediated.

It has been reported that accompanying anxiety exacerbates EF deficits in children with ADHD [43]. In particular, they reported that they detected more deterioration in the inhibit subcomponent. In our study, we found significantly higher anxiety scores in the ADHD+SI group. These results indicate greater EF deficits in the ADHD group with suicidal ideation. However, we did not evaluate the suicidal idea independently from the anxiety effect. It is difficult to express the pure effect of anxiety here. In addition, we could not find a study examining the effect of anxiety on suicidal ideation in children with ADHD.

According to the comparison we made as 3 groups in our study, it was observed that all EF and ER parameters were found to be significantly impaired in the pure ADHD group compared to the control group. We found more impaired EF deficits and ERNL in the ADHD (ADHD+SI) group with suicidal ideation. When all this is compiled; According to the strong findings reporting the relationship between EF deficits and emotion dysregulation, we can point out the effect of suicidal ideation on the development of suicide in children under 12 years of age with ADHD.

Limitations

Despite these findings, this study has some limitations. The sample size of the study is relatively small. It would be better to do it with a larger sample. The excess male gender in our study limits the generalization of the results. In questioning children's suicidal thoughts, learning about suicidal ideation in the last 6 months, rather than "here and now" may not constitute sufficient evidence. We did not use a direct suicide assessment tool to detect suicidal ideation. This is relatively a limitation.

Testing of executive functions was based solely on parental assessment. However, it could be supported with a computer-based task. There are many scales about inability to

regulate emotions used in the literature. Of course emotion regulation questionnaires answered by ADHD children could be used. Nevertheless, we designed this study according to the parents' opinions, which are of great importance in diagnosing ADHD. This view can also offer a perspective. Ultimately, it is clear that the evaluation of cognitive, executive function and emotional regulation of children with ADHD is not standardized enough.

Conclusion

In conclusion, we emphasize that these conditions may be associated with suicidal ideation in the younger age group (8-12 years) in children with ADHD who are affected by EF deficits and ERNL cognitive processes. As a result, we draw attention to suicidal ideations in children with ADHD. Suicidal ideations are important in children of this age. Prevention and treatment may require interventions. It is different from the core symptoms of attention and hyperactivity/impulsivity in that these children have more suicidal thoughts than healthy controls. EF deficits and ERNL may contribute to the development of suicidal ideation. It is necessary to be aware of these cognitive deficits in children with ADHD. However, more evidence-based studies are needed on this subject.

Declarations

The author(s) declared no potential conflicts of interest regarding this article.

Ethics approval

This for study, ethical approval was obtained from the Inonu University Non-Interventional Clinical Research Ethics Committee with the code 2016/213.

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Conflict of interest

The author(s) declares no potential conflict of interest about this article.

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