Cognitive profiles of children with attention deficit hyperactivity disorder: Differences between those with and without comorbid psychiatric diagnoses

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SUMMARY

Objective: The Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV) is widely used to measure cognitive abilities of children with attention-deficit/hyperactivity disorder (ADHD). In this study, we aimed to investigate whether the cognitive profiles of children with ADHD and comorbid psychiatric disorders differ from those of children with a diagnosis of ADHD only. Specifically, the study aimed to examine whether the processing speed index (PSI) scores differed between the two groups..

Method: The participants were 245 children aged between 6 and 17 years old, who had been diagnosed with ADHD and completed the WISC-IV test. The participants were divided into two groups, one with a psychiatric comorbidity (n=52) and one without (n=193). The two groups were compared regarding age, sex, WISC-IV full scale IQ, and subtest scores which were retrospectively collected from medical records.

Results: The results showed that the mean age of the comorbidity group (11.56 + 3.25) was higher than the group without comorbidities (10.08 + 2,78, p=0.004). Furthermore, the group with comorbidities had lower PSI scores (81.69 + 21.518) compared to the group without comorbidities (89.88 + 19.105, p=0.008).

Discussion: The results support the hypothesis that the cognitive profiles of children with ADHD and comorbid psychiatric disorders differ from those of children with ADHD only. These findings provide important insights for the assessment and diagnosis of ADHD, as well as the role of cognitive assessments in identifying potential comorbidities in children with ADHD.

Key Words: Attention deficit, processing speed, academic achievement, ADHD, anxiety, depression

INTRODUCTION

Attention Deficit and Hyperactive Disorder (ADHD) is a highly prevalent neurodevelopmental disorder that is typically characterized by varying yet persistent patterns of impaired attention, motor hyperactivity and impulsivity. The global prevalence of ADHD among children and adolescents is estimated to be around 5-7% (1, 2) and according to a recent systematic review and meta-analysis by Ayano and colleagues (3), those prevalence statistics range from 2.2% to 17.8%. The prevalence of ADHD among primary school children in Turkey was found 19.6 % in a nationwide population-based study (4). In addition to the challenges with sustained attention and increased motor activity, prior research has also demonstrated that children with ADHD perform poorly in other areas of cognitive functioning such as executive functions, working memory, processing speed, psychomotor speed, motor coordination and intelligence (5-7). Consequently, this behavioral disorder interferes with the individual's ability to concentrate on daily requirements and routines, learn, interact with ot-

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hers, and overall makes it difficult to function in daily life (8, 9).

It is common for children with ADHD to also experience other psychiatric conditions (2). Previous studies indicated that more than 2/3 of patients with ADHD have a comorbid psychiatric disorder (10, 11). The most common ADHD comorbidities include Oppositional Defiant Disorder (ODD; 25–75%) and Conduct Disorder (CD; 33%) during childhood, and tic disorders (55%), anxiety disorders (25-33%) and major depressive disorder (MDD; 6–30%) in mid-school years and adolescence (11-13). These comorbid conditions can increase the level of impairment experienced, make treatment more challenging and thus further strain the functioning of those children (12, 14). In the literature, comorbid conditions are linked with poorer outcomes in a child's academic performance (e.g., grade retention) and social-emotional well-being (e.g., delinquency, social competence, parent-child communication) (14, 15).

To date, there is no single test, tool, or technique specific for the diagnosis of ADHD. The diagnosis of ADHD is made based on a combination of assessments including a clinical interview, observations in the clinical setting as well as observations obtained from parents and teachers via standardized rating scales and neuropsychological testing (16, 17). As ADHD is associated with deficits across multiple cognitive domains (18), intelligence tests which assess a child's overall cognitive abilities are employed in the assessment of ADHD complementing other behavioral assessments (5). Wechsler Intelligence Scales for Children (WISC), Stanford-Binet Intelligence Scale, Leiter International Performance Scale and Kaufmann Assessment Battery for Children are some of the most used tests of intelligence and cognitive abilities (19). Those tests provide a comprehensive measure of verbal and nonverbal abilities, problem-solving skills, and memory. Thus, they reveal the weaknesses and strengths of children with ADHD and can contribute to the implementation of intervention and education programs targeted to the specific needs of those children (20, 21).

The WISC is the most widely used intelligence test for measuring specific aspects of cognitive functioning in children with ADHD (22, 23). The most recent edition, the Wechsler Intelligence Scale for Children– Fifth Edition (WISC-V) is one of the most widely used intelligence tests for children which has been well-validated and reliable (19, 24). Yet in the Turkish context, WISC - IV is the most widely employed edition as its adaptation and standardization in Turkey were completed in 2011 by the Turkish Psychological Association (25). The WISC-IV is appropriate for children aged 6 years 0 months and 16 years 11 months and consists of a series of subtests that measure a four-factor model of intelligence, including verbal comprehension, perceptual reasoning, working memory, and processing speed.

Although the WISC-IV is not specifically designed to diagnose ADHD, it provides information on a child's cognitive abilities that can be used in conjunction with other assessment tools (e.g., behavioral) and techniques in the diagnosis and treatment of the disorder. Among those various cognitive skills that WISC-IV measures, particularly working memory, and processing speed, intersect with a variety of neurocognitive disorders, especially deficits associated with ADHD (5, 6, 26). The working memory index of the WISC-IV measures the ability to retain and manipulate orally presented information over a short period of time. Relatedly, a low score on this index may suggest difficulties with attention and memory, which are common symptoms of ADHD (27-29). The processing speed index of WISC-IV measures the ability to process and understand visual information quickly as well as visual motor coordination. Individuals with ADHD often have problems with processing speed, which is the ability to quickly and accurately complete cognitive tasks (29-31). Earlier studies demonstrated that low processing speed was a predictor of behavioral and emotional impairment in children with ADHD and is associated with increased internalizing problems (32, 33).

In this regard, we hypothesized that the cognitive profiles of children with ADHD and a comorbid diagnosis would be different from the cognitive profiles of children with ADHD without comorbidity. And in light of the prior studies, we expected the former to have lower performances on the processing speed index (PSI) compared to the latter.

METHODS

Participants consisted of 245 children, between the ages of 6 to 17 years old, who were treated in a university hospital child psychiatry outpatient unit with a diagnosis of ADHD. The participants were retrospectively included in the study. All of the participants received a diagnostic interview by a child and adolescent psychiatrist and completed a WISC-IV test administered by a certified clinical psychologist..

Procedure

The data for this study was collected retrospectively from participants' medical chart files. The researchers extracted the age, sex, psychiatric and medical comorbidity presence, WISC-IV full scale IQ, verbal comprehension, perceptual reasoning, working memory, and processing speed index scores and subtest standard scores. The inclusion criteria for the study were to have a diagnosis of ADHD, a WISC-IV result and being between the ages of 6 to 18 years old. We excluded patients with missing details regarding comorbidities, and we also excluded patients with chronic medical comorbidities such as type 1 diabetes mellitus (n=11) or epilepsy (n=8), with a comorbidity of autism spectrum disorder (n=8) and specific learning disability (n=24). We did not have an exclusion criterion based on FSIQ and included participants from all IQ levels. The participants were divided in two groups according to the presence or absence of a psychiatric comorbidity. Participants who have been diagnosed with ADHD but do not have any additional comorbidities comprised ADHD Only group (n=193), and participants who have been diagnosed with ADHD as well as one or more additional psychiatric comorbidities comprised ADHD Plus Comorbidity group (n=52).

Materials

Diagnostic interview: All the participants were evaluated by a child psychiatrist using comprehensive clinical diagnostic interview based on DSM-5 criteria at their first admission to the psychiatry outpatient clinic and their psychiatric diagnoses were reported in their medical records. Age, sex, and presence of an intellectual disability were collected from medical records.

The WISC-IV: The WISC-IV is an assessment tool used to measure cognitive ability in children and adolescents (24). It is a standardized test that is typically administered by a psychologist or other trained and certified professional. The WISC-IV consists of a series of subtests that measure various cognitive skills, including verbal comprehension, perceptual reasoning, working memory, and processing speed. The test is designed to be age-appropriate and culturally fair, and it is widely used in clinical, educational, and research settings to assess cognitive ability and identify strengths and weaknesses in children's cognitive skills. The WISC-IV tests were applied by two clinical psychologists in our department.

The WISC-IV consists of a total of 14 subtests, which are grouped into four index scores: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. The specific subtests that make up each index score are defined in Table 1. The specific subtests included in the WISC-IV may vary slightly depending on the age and ability level of the child being tested. In our study we did not include the substitute subtest scores due to the low number of applications.

Analyses

The software IBM-SPSS Statistics, Version 26 was used for statistical analyses. Descriptive data were reported as percentages and numbers %(n) or as mean and standard deviation M(SD) according to the nature of the data. The Kolmogorov-Smirnoff test was used to test the normality of the data distribution. The continuous variables were compared between groups by independent samples t-test, the effect size of the significant results was defined by Cohen's d. The categorical variables sex, intellectual disability and the status of receiving treatment for ADHD were compared between groups using the chi-square test. We conducted a binary logistic regression test to identify the variables predicting

Table 1. Definition of subtests of each index score in WISC-IV test.

Subtest name	Definition
Verbal comprehension index	
Similarities	Measures verbal reasoning skills by asking the child to identify how two words are alike.
Vocabulary	Measures verbal knowledge by asking the child to define words
Comprehension	Measures social understanding by asking the child to answer questions about social situations and common-sense concepts
Perceptual Reasoning Index	
Block Design	Measures visual-spatial processing by asking the child to reproduce designs using colored blocks
Matrix Reasoning	Measures visual-spatial processing and abstract reasoning by asking the child to identify the missing element in a series of patterns
Picture Concepts	Measures abstract reasoning by asking the child to identify relationships among different objects or ideas
Working Memory Index	
Digit Span	Measures auditory attention and working memory by asking the child to repeat increasingly long sequences of numbers
Letter-Number Sequencing	Measures auditory attention and working memory by asking the child to repeat a series of numbers and letters in the correct order.
Processing Speed Index	
Coding	Measures visual-motor coordination and processing speed by asking the child to match symbols to numbers as quickly as possible, using a key that displays numbers, each paired with a different symbol.
Symbol Search	Measures processing speed by asking the child to find target symbols as quickly as possible among a group of distractors

the ADHD Plus Comorbidity group membership. The probability level of < 0.05 was considered as statistically significant.

Ethics

The study was reviewed and approved by the local Committee on Human Research, protocol number: 2023.040.IRB1.011.

RESULTS

Our sample consisted of 245 children with ADHD. The proportion of children with a known comorbid psychiatric diagnosis in addition to ADHD was 21.2 % (n = 52). The mean age of our sample was 10.39 + 2,94 (ranging between 6.00 and 16.75 years). The female to male ratio 1:1.90 in our sample (n = 84 female, n = 161 male). The comorbid psychiatric disorders were anxiety (10.2 %, n = 25), obsessive compulsive disorder (3.3%, n = 8), depression (2.0%, n = 5), tic disorders (1.6 %, n = 4), oppositional defiant disorder (0.8%, n = 2) and conduct disorder (0.8%, n = 2).

The comparison of ADHD Only and ADHD Plus Comorbidity groups regarding demographic variables, the presence of receiving treatment for ADHD and types of medications used are presented on Table 2. The mean age of the participants in the ADHD Only group was significantly lower than the mean age of the participants in the ADHD Plus Comorbidity group (p = 0.004). The sex distribution and the presence of receiving treatment for ADHD were comparable between groups (p > 0.05). The usage of non-stimulant ADHD medications (p=0.024), selective serotonin reuptake inhibitors (p<0.001) and atypical antipsychotics (p<0.001) were significantly higher in ADHD Plus Comorbidity group while methylphenidate usage was higher in ADHD Only group (p=0.018). We compared WISC-IV full scale IQ, sub-domain, and subtest scores between groups (Table 3). The full-scale IQ, verbal comprehension, perceptual reasoning and working memory index scores were comparable between the two groups (p > 0.05). The ADHD Only group performed better than the ADHD Plus Comorbidity group on processing speed index (p = 0.008, Cohen's d effect size = 0.417, 95 % CI = 0.108 - 0.725). The subtest scores were comparable between groups (p > 0.05) with the exception of coding subtests. The ADHD Only group had significantly higher scores than the ADHD Plus Comorbidity group on the coding subtest (p < 0.001, Cohen's d effect size = 0.545, 95 % CI = 0.235 - 0.855). We also conducted the analyses

Table 2. Comparison of mean age and sex distribution between ADHD Only and ADHD Plus Comorbidity groups

	ADHD Only (n = 193)	ADHD Plus Comorbidity (n = 52)	p
Age (M ± SD)	10.08 ± 2,78	11.56 ± 3.25	0.004*
Sex (female ratio)	35.2 % (n =68)	30.8 % (n = 16)	0.623
Presence of receiving treatment for ADHD	67.4 % (n=130)	59.6 % (n=31)	0.297*
Medication usage			
Stimulant ADHD medication	64.2 % (n=124)	46.2 % (n=24)	0.018*
Non-stimulant ADHD medication	3.6 % (n=7)	11.5 % (n=6)	0.024*
Selective serotonin reuptake inhibitors	3.6 % (n=7)	34.6 % (n=18)	<0.001*
Atypical antipsychotics	10.9 % (n=21)	34.6 % (n=18)	<0.001*

Note. * indicates p value is < 0.05.

(i) excluding the participants with a FSIQ lower than 70 and (ii) excluding the participants with a FSIQ lower than 55, and the results showed no difference from initial significant results.

A logistic regression was performed to ascertain the effects of age, sex, full scale IQ and WISC-IV index scores on the likelihood that participants have a psychiatric comorbidity in addition to their ADHD diagnosis. The logistic regression model was statistically significant, $\chi^2(13) = 33.304$, $p = 0.002$. The model explained 24.2 % (Nagelkerke R2) of the variance in psychiatric comorbidity in ADHD patients and correctly classified 82.3 % of cases. Increased age (p=0.004, OR=1.18, 95 % CI=1.054-1.317) and decreased processing speed index score (p=0.016, OR=0.96, 95 % CI=0.928-0.992) were associated with an increased likelihood of having a psychiatric comorbidity in addition to ADHD. We have conducted a second logistic regression to investigate the additional effects of medications used by the participants. The predictive effect of decreased processing speed index score on psychiatric comorbidity in ADHD patients persisted (p = 0.026) while also the use of SSRIs

Table 3. The comparison of WISC-4 full scale IQ, index and subtest scores between groups

	ADHD Only group (n = 193) *M* ± SD	ADHD Plus Comorbidity group (n = 52) *M* ± SD	p
Full scale IQ	86.06 ± 20.932	80.54 ± 24.075	0.103
Verbal Comprehension Index	88.11 ± 18.297	83.04 ± 20.583	0.086
Similarities	7.84 ± 3.542	7.86 ± 3.704	0.970
Vocabulary	7.65 ± 3.791	7.10 ± 4.098	0.357
Comprehension	8.61 ± 3.101	7.96 ± 4.014	0.211
Perceptual Reasoning Index	91.84 ± 19.016	87.13 ± 22.823	0.131
Block design	8.60 ± 3.613	8.15 ± 4.132	0.443
Picture concepts	8.07 ± 3.276	7.42 ± 3.952	0.227
Matrix reasoning	9.57 ± 3.485	8.90 ± 4.160	0.242
Working Memory Index	86.32 ± 18.004	85.12 ± 19.705	0.676
Digit span	7.78 ± 3.137	7.53 ± 3.818	0.626
Letter-number sequencing	8.13 ± 3.623	7.70 ± 3.533	0.472
Processing Speed Index	89.88 ± 19.105	81.69 ± 21.518	0.008*
Coding	8.74 ± 3.563	6.77 ± 3.761	<0.001*
Symbol search	7.95 ± 3.713	7.33 ± 4.129	0.299

Note. * indicates p < 0.001

and atypical antipsychotics had significant associations ($p < 0.001$ and $p = 0.001$, respectively).

DISCUSSION

In our retrospective study, we investigated the differences in WISC-IV FSIQ index and subtest scores between children with and without additional psychiatric comorbidity to their ADHD diagnoses. We found that the full-scale IQ, verbal comprehension, perceptual reasoning, and working memory index scores were similar between the two groups. However, participants with comorbid psychiatric diagnoses had significantly lower scores in the processing speed index than those without psychiatric diagnoses in addition to ADHD. The subtest scores were similar across the groups, except for the coding subtest of the processing speed index. The mean coding subtest score was significantly lower in the ADHD Plus Comorbidity group compared to the ADHD Only group. We also found an age difference between the two groups; the age of the ADHD Plus Comorbidity group was significantly higher compared to the ADHD Only group.

The male ratio (1.9:1) and psychiatric comorbidity rate (21.2 %) were lower than in other clinical studies (34-36). This may be related to the exclusion of participants with ASD, learning disabilities, and medical comorbidities. Additionally, our sample was followed up by a multidisciplinary team, and the majority of the patients were treated with medication. These factors are known to decrease psychiatric comorbidity rates among individuals with ADHD (37). We found that the mean age was higher in the ADHD Plus Comorbidity group. This finding, which indicates an increased age in the ADHD Plus Comorbidity group compared to the ADHD Only group, is in accordance with the literature. Older age significantly predicted psychiatric comorbidity in children with ADHD. In this regard, longitudinal and cross-sectional studies have shown that the frequency of both internalizing and externalizing disorders increased with age in children with ADHD (36, 38, 39). The increased prevalence of mood and anxiety disorders in adolescence may be one of the explanations for these findings (40). Furthermore, the cognitive load and the daily life expectations, which require the utilization of executive functions, increase from childhood to adolescence, resulting in increased impairment in adolescents with ADHD compared to children with ADHD (41, 42). This increased functional impairment in adolescence may also be related to the age and comorbidity relationship in ADHD. The female ratios were similar in ADHD Plus Comorbidity and ADHD Only groups, 35.2% and 30.8%, respectively. Population-based studies usually identify the occurrence of comorbidity more in boys than girls (43). However, in clinical studies, the ratios are similar in gender groups (35, 36). Our participants were recruited from a tertiary university hospital, which consisted of a clinical sample, and our finding is in correlation with those existing studies (35, 36).

The groups were significantly different regarding their medications. The methylphenidate usage was higher in the ADHD Only group, compared to the ADHD Plus Comorbidity group. On the other hand, the atomoxetine usage was higher in the ADHD Plus Comorbidity group. The most common comorbid diagnosis was anxiety disorders, and this finding is in correlation with other studies reporting that atomoxetine may reduce anxiety symptoms in ADHD better than methylphenidate (44, 45). The treatment with SSRIs and atypical antipsychotics were higher in ADHD Plus Comorbidity group; it is expected as these medications are indicated for the comorbid diagnosis anxiety disorders, obsessive compulsive disorder, and behavioral disorders (46-49).

Our results showed that the FSIQ, VCI, PRI, and WMI scores were comparable between groups. Children with a psychiatric comorbid condition in addition to ADHD had significantly lower scores in the PSI compared to children with ADHD without comorbid psychiatric conditions. Additionally, lower PSI predicted the presence of a psychiatric comorbidity in children with ADHD. PSI of WISC-IV provides an efficient estimation of how a child can perform basic or automatic tasks or tasks that require active acquisition of novel information (50). Performance on PSI requires speed and accuracy of visual identification, visual or auditory discrimination, decision-making and decision implementation (50). Lower scores in PSI are considered as a sign for clinical conditions, however a further clinical investigation is required to understand the nature of the clinical problem. In the literature, it is consistent that PSI is the lowest or one of the lowest indexes that children with neurodevelopmental disorders score (22, 24, 51, 52). The ability to maintain attention and focus on a task can impact processing speed. Children with ADHD, who struggle with sustained attention may be expected to have slower processing speed. Anxious and depressed children may perform lower on PSI due to lack of confidence and uncertainty in decision-making (50). Anxiety and depression have also been linked to slower processing speed in children. Children with anxiety may have difficulty filtering out irrelevant information, which can slow down their processing speed. Similarly, children with depression may experience cognitive slowing, where they have difficulty processing information and making quick decisions. Slower processing speed is not necessarily a direct result of these psychiatric conditions, but rather may be a symptom of the underlying neural dysfunction associated with these conditions. In clinical studies, lower PSI scores are not correlated with anxiety disorders or depression diagnoses (5). Nevertheless, genetic factors can contribute to processing speed in children such that they may influence the development of related neural pathways (53, 54). Investigating shared neural mechanisms and genetics that may explain this relationship between psychiatric comorbidity and processing speed may be a meaningful contribution to the neurocognitive field.

The medications used by the groups may have different cognitive effects. The increased use of atypical antipsychotics, SSRIs and atomoxetine in the ADHD Plus Comorbidity group might have affected the cognitive results of the participants. SSRIs have demonstrated various cognitive effects on the literature, from decreasing cognitive performance at the early phase of the treatment (55) to decreased cognitive slowing in later phases (56). For atypical antipsychotics, either neutral or beneficial effects were reported in children with ADHD (57, 58). Both methylphenidate and atomoxetine have shown enhancing effects on cognitive performance (59). The test results might have been affected by these factors in our study, however, our results remain significant after controlling for medication type.

From another perspective, low processing speed in children with ADHD may be contributing to emergence of psychiatric comorbidities. Processing speed is closely linked to academic performance, particularly in tasks that require speed and accuracy, such as timed tests, reading comprehension, and math calculations. Children with slow processing speed may struggle to keep up with the pace of classroom instruction, leading to academic difficulties (5, 30). Slow processing speed can also impact social interactions, as children may have difficulty following conversations, processing social cues, and responding in a timely manner. Children with slow processing speed may become frustrated with their difficulties and develop low self-esteem and feelings of inadequacy. The frustration and difficulties associated with slow processing speed may consequently increase the risk of anxiety, depression, or behavioral disorders in children with ADHD. Longitudinal studies rather than studies with cross-sectional designs may aid to understand the relationship between low processing speed and psychiatric comorbidity developmentally.

There are several strategies that can be used to improve processing speed performance in children with ADHD. The medical treatment of ADHD with stimulant and nonstimulant medications improve processing speed in children (60, 61). Recent studies on clinician-delivered cognitive training programs and combining them with emerging interventions such as transcranial electrical stimulation present promising results on improving processing speed (62, 63). Regular physical exercise has been shown to improve cognitive function, including processing speed (64). Encouraging children to engage in physical activities may be helpful in improving processing speed. Application of classroom accommodations by the school managements for children with ADHD like providing a quiet, structured environment with limited distractions to help them focus on the task at hand help improve to ease the consequences of low processing speed.

By incorporating play into therapeutic interventions, clinicians can create a more engaging and interactive environment for children, which can lead to better cognitive outcomes in the treatment of ADHD and related conditions. A recent systematic review of studies suggests that play therapy has a high effect size for the treatment of ADHD and other related symptomatology (65). The use of play therapy can also help improve children's processing skills by enhancing their verbal, tactile, and visual engagement through the selection of various toys and designing play scenarios.

Our study has limitations mainly due to its retrospective design. There are other potential contributors for the psychiatric comorbidity in children with ADHD, such as age of onset and severity of ADHD symptoms and ADHD presentation type (34, 66). However, we were not able to analyze the effect of those in our study. The comorbidities were very heterogeneous and there may be differences in their mechanisms related to processing speed. All the participants were instructed not to take their medications on the day of the test until the test is completed, however we were not able to control that objectively and participants may be using long-acting medications with a wash-out period longer than 24 hours.

It is important for researchers and practitioners to have a comprehensive understanding of the characteristics associated with children with ADHD and other comorbid psychiatric diagnosis. This could lead to the development of more effective treatments which improve those children's intellectual, cognitive, and learning abilities as well as overall functioning and quality of life. The study findings highlight the importance of considering emotional processes in addition to cognitive assessments. The development of individualized interventions which are targeted to the enhancement of reduced PSI should be prioritized to alleviate comorbidity severities. It is important to address slow processing speed in children in order to minimize the functional consequences and support their overall well-being. Strategies such as those mentioned earlier, including cognitive training, physical exercise, play therapy and working memory training, may be helpful in improving processing speed and reducing the negative impact of slow processing speed on a child's life. Finally, in light of the current study findings, further research with longitudinal designs may also investigate whether children with lower PSI may be more likely to develop comorbidities.

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