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Original Article PSYCHIATRY

Electroencephalogram abnormalities in children have rotated error on block design performance: An university hospital child and adolescent psychiatry clinic sample

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ABSTRACT

OBJECTIVE: Neuropsychiatric assessment is essential part of child and adolescent psychiatry clinic practice, also provides important information about central nervous system dysfunctions. In studies conducted to date, it has been known that both the high frequency of psychiatric comorbidity in epileptic patients and that epilepsy comorbidity is quite common in neurodevelopmental disorders. In fact, considering the high comorbidity of epileptic abnormalities and psychiatric disorders, it has been very important to determine predictors for epileptic abnormalities in a clinical sample of child and adolescent psychiatry. In this retrospective study, we aim to determine possible predictive factors for epileptic abnormalities in a clinical sample of child and adolescent psychiatry according to Weschler Intelligence Scale for Children (WISC-R) results.

METHODS: We identified patients who had two or more rotation errors in the block design subtest of WISC-R by retrospectively scanning the system records of 2609 cases who were applied WISC-R with different prediagnoses at Gazi University Child and Adolescent Psychiatry Outpatient Clinic between January 2013 and December 2020 (n=71). After the first step identification, we selected the ones who had a previous electroencephalography (EEG) recording available for our own re-review (n=60).

RESULTS: We found 15% EEG abnormalities and ADHD is the most common diagnosis in both normal and abnormal EEG groups. Due to correlation analysis, there was a positive-mild correlation between presence of EEG abnormality and WISC-R performance (r=0.56) in intellectual disability (ID) group and a positive-strong correlation between presence of EEG abnormality and WISC-R performance-verbal scores (r=0.74) in ID group.

CONCLUSION: This study has shown that many different abnormal EEG patterns can be found in patients who have rotation errors in the block design test of WISC-R, suggesting diagnoses of ID, and having notable performance-verbal subtests scores difference and rotation errors in the block design subtest of WISC-R should be predicitive factors for epileptic abnormalities.

Keywords: Block design; EEG; intelligence tests; neurodevelopmental disorders; neuropsychiatric assessment; rotation error.

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Neuropsychiatric assessment is an evaluation that measures the brain-behavior relationship through various tests, which is widely used in the field of neurology and psychiatry. While neuropsychological evaluations target individuals who experienced brain damage at wars in the past [1], nowadays, populations for which neuropsychological assessments have been useful include all neuropsychiatric conditions [2]. The problem of normal and abnormal functioning of the central nervous system includes not only the evaluation of the consequences of trauma and diseases on the central nervous system but also the impact of psychiatric conditions, in which central nervous system involvement is presumed but not well defined. In neuropsychological assessment, special assessment procedures have been used to measure deficiencies in cognitive functions, personality, and sensory-motor functions [3]. The assessment of the cognitive domain has been typically carried out by a battery approach that includes tests of various cognitive skill areas such as memory, attention, processing speed, reasoning, judgment and problem solving, visiospatial, and language functions with multiple tests per skill area [4]. With the assessment, a patient's cognitive strengths and weaknesses are determined qualitatively (observing the approach to tasks and behavior) and quantitative (standardized and scaled measures) [5]. In the field of neurology, neuropsychological tests are used in the diagnosis and follow-up processes of many pathologies, especially epileptic disorders. Moreover, neuropsychological tests in child and adolescent psychiatry practice; while it has an important place in the differential diagnosis of psychiatric diseases, it also provides important information about central nervous system dysfunctions. Furthermore, in studies conducted to date, it has been known that both the high frequency of psychiatric comorbidity in epileptic patients and that epilepsy comorbidity is quite common in neurodevelopmental disorders.

The most common neuropsychological assessment tool in child and adolescent psychiatry clinical practice is intelligence tests. The most widely used intelligence test in our country for this purpose has been the Wechsler Intelligence Scale for Children-Revised form (WISC-R) which was developed by David Wechsler for children aged 6–16 [6]. By the WISC-R test, performance score, verbal score and general intelligence score have been obtained. Verbal subtests of the WISC-R are as follows: general knowledge, similarities, arithmetic, judgment, vocabulary, and number sequence. Performance subtests are picture completion, picture editing, block design, combining parts, password, and labyrinth [7]. The block design subtest, one of the performance subtests, is a complex task that is found in many neuropsychological evaluations and requires visual-spatial ability, and it also requires processing speed and fine motor control. This subtest, which examines the patient's copying of abstract designs using colored blocks (red and white), has long been regarded as the most important indicator of intelligence [8, 9], neuropsychological functioning and one of the most sensitive test to central nervous system dysfunction [10]. Although there were many studies about WISC-R profiles of epileptic patients in the literature, there is no enough evidence about the predictor effects of the block design test, which was known to be the most sensitive to central nervous system dysfunctions, on the electroencephalography (EEG) abnormalities [11, 12]. In fact, considering the high comorbidity of epileptic abnormalities and psychiatric disorders, it has been very important to determine predictors for epileptic abnormalities in a clinical sample of child and adolescent psychiatry.

Highlight key points

- Electroencephalogram abnormalities have been quite common in neurodevelopmental disorders.
- Abnormal EEG patterns can be found in patients who have rotation errors in the block design test of WISC-R.
- Diagnoses of ID, existing notable performance-verbal subtests scores difference, and showing rotation errors in the block design subtest of WISC-R should be predictive factors for epileptic abnormalities.

In this retrospective study, we aim to determine possible predictive factors for epileptic abnormalities in a clinical sample of child and adolescent psychiatry under the guidance of neuropsychiatric evaluation results. We aim to indicate the frequency of EEG abnormalities in children who have two or more rotation errors in the block design test, to examine the relationship between age, gender, psychiatric diagnosis, and WISC-R subtest scores in children with or without EEG abnormality in the block design test and to determine the localization of the abnormalities in cases with EEG abnormality.

MATERIALS AND METHODS

We identified patients who had two or more rotation errors in the block design subtest of WISC-R by ret-

rospectively scanning the system records of 2609 cases who were applied WISC-R with different prediagnoses at Gazi University Child and Adolescent Psychiatry Outpatient Clinic between January 2013 and December 2020. We included cases with two or more rotation errors in our study, because, at standard practice, two or more rotation errors in the WISC-R cube design subtest are noted by the implementer according to test instructions [8]. After the first step identification, we selected the ones who had a previous EEG recording available for our own re-review. After the retrospective evaluation, age, gender, psychiatric diagnosis, and EEG evaluations were obtained from the system records of the cases with rotation errors. The cases whose EEG results could not be obtained from the system records and the WISC-R verbal subtest score could not be calculated were excluded from the analysis. All EEG's were minimum 20 min in duration. The EEG's were re-reviewed by a certified pediatric epileptologist. The awake background rhythm, slow wave abnormalities, and epileptiform activity (sharp wave, spike, spike-and-slow-wave, and multiple spike-and-slow-wave complex) were noted. Epileptiform activity was assessed and classified according to localization as: frontal, temporal, central, parietal, and occipital. Gazi University Clinical Research Ethics Committee approval was obtained for the study (170221/126).

Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences for Windows (SPSS) 20.0 version (SPSS for Windows, version 20.0. Armonk, NY: IBM Corporation; 2012). Demographic information was analyzed through descriptive statistics. Chi-square test was used for categorical variables. Kolmogorov–Smirnov test was used to test for normality. Descriptive analyses of WISC-R scores in normal-abnormal EEG groups were presented using means and standard deviations, separately in each groups. Since the scores were normally distributed, the ındependent sample t-test was used the compare the differences of WISC-R scores in groups. Pearson correlation analysis was used to determine associations between presence of EEG abnormality and WISC-R scores between groups. Sample t-test was used to compare the WISC-R scores between normal and abnormal EEG groups. A 5% type-I error level was used to infer statistical significance.

Table 1. Descriptive statistics and frequencies of neurodevelopmental diseases, EEG abnormality localizations

	Normal EEG group (n=51)	Abnormal EEG group (n=9)
Age*	9.22±2.98	6.89±0.92
Gender (%)		
Boy	64.7	55.6
Girl	35.3	44.4
Neurodevelopmental disease diagnosis		
None	7 (13.7)	1 (11.1)
ADHD	27 (52.9)	3 (33.3)
Dyslexia	6 (11.8)	2 (22.2)
Intellectual disability	11 (21.6)	3 (33.3)
Localization of EEG abnormalities		
None	51 (100)	–
Posterior	–	2 (22.2)
Temporal	–	1 (11.1)
Frontosantral	–	2 (22.2)
Jeneralize	–	1 (11.1)
Centrotemporal		2 (22.2)
Asymmetry	–	1 (11.1)

*: There is a significant difference instead of age among groups (p=0.02); EEG: Electroencephalography.

RESULTS

There were 2609 children who were applied WISC-R with different prediagnoses at Gazi University Child and Adolescent Psychiatry Outpatient Clinic between January 2013 and December 2020 and of these 71 children had two or more rotation errors in the block design subtest of WISC-R, 60 children underwent an EEG recording. In the study group, 30 (50%) children had ADHD, eight (13.3%) had dyslexia, 14 (23.3%) had intellectual disability (ID), and eight had no diagnosed neurodevelopmental or other psychiatric disorder. The most frequently diagnosed neurodevelopmental disorder in normal EEG group is ADHD (52.9%), also in abnormal EEG group, the most frequently diagnosed neurodevelopmental disorders are ADHD and intellectuel disabilities (33.3% and 33.3%, respectively). None of these patients had a diagnosis of epilepsy. Nine of these children (five boys and four girls, mean Age: 6.8 ± 0.9) presented an epileptiform activity, showing a prevalence of 15%.

Table 2. Comparison of weschler intelligence scale for children (WISC-R) scores between normal and abnormal electroencephalography (EEG) groups in attention deficit hyperactivity disorder (ADHD), dyslexia, and intellectual disability

	Normal EEG	Abnormal EEG	Statistics
ADHD (n=30)			
Total	93.6±16.3	98.6±4.1	F=4.8, t=-0.5, p=0.60
Performance	93.5±18.0	95.0±3.6	F=3.2, t=-0.1, p=0.89
Verbal	95.1±15.4	102.0±7.5	F=1.6, t=-0.7, p=0.46
Performance-verbal	-1.5±15.3	-7.0±9.5	F=0.7, t=-0.5, p=0.55
Dyslexia (n=8)			
Total	88.1±11.8	103.0±43.8	F=21.7, t=-0.8, p=0.41
Performance	94.8±14.4	109.8±26.8	F=1.6, t=-1.0, p=0.35
Verbal	83.6±13.4	96.0±50.9	F=146.7, t=-0.6, p=0.55
Performance-verbal	11.1±17.2	13.0±24.0	F=0.3, t=-0.1, p=0.90
Intellectual disability (n=14)			
Total	57.9±12.4	68.3±8.5	F=2.2, t=-1.3, p=0.20
Performance	57.0±12.9	77.0±12.1	F=**0.1**, t=-**2.3**, p=**0.03**
Verbal	62.6±12.9	63.3±4.6	F=7.1, t=-0.9, p=0.92
Performance-verbal	-3.8±6.2	13.6±10.5	F=**1.0**, t=-**3.6**, p=**0.004**

EEG: Electroencephalography.

Table 3. Correlations between presence of electroencephalography (EEG) abnormality and weschler ıntelligence scale for children (WISC-R) Scores

	ADHD	Dyslexia	Intellectual disability
Presence of EEG abnormality/total	0.09	0.33	0.37
Presence of EEG abnormality/performance	0.02	0.38	**0.56**
Presence of EEG abnormality/verbal	0.14	0.24	0.02
Presence of EEG abnormality/performance-verbal	-0.11	0.04	**0.74**

EEG: Electroencephalography.

Localization of EEG abnormalities was posterior (n=2), temporal (n=1), frontosantral (n=2), jeneralize (n=1), sentrotemporal (n=2), and asymmetry (n=1) (Table 1).

Comparison of WISC-R Scores Between Normal and Abnormal EEG Groups in ADHD, Dyslexia, and ID Children

When we compared the WISC-R scores of children with normal and abnormal EEG's, we found that there was not a significant difference in ADHD and dyslexia groups (p>0.05). However, in ID group, children with abnormal EEG had significantly higher "Performance" and "Performance-Verbal difference" than others (Table 2).

Presence of EEG Abnormality Related with WISC-R Scores in Diagnosis Groups

Due to correlation analysis, there was a positive-mild correlation between presence of EEG abnormality and WISC-R performance (r=0.56) in ID and a positive-strong correlation between presence of EEG abnormality and WISC-R performance-verbal scores (r=0.74) in ID group (Table 3).

DISCUSSION

In this study, our aim was to examine EEG profiles of children have rotation error on block design performance at WISC-R. Half of the children with rotation error were diagnosed with ADHD and we found 15% EEG abnor-

malities in children have rotation error, so ADHD is the most common diagnosis in both normal and abnormal EEG groups. ADHD is a neuropsychiatric disorder characterized by attention deficit, hyperactivity, and impulsivity symptoms that begin in childhood [13]. The majority of studies on EEG abnormalities accompanying psychiatric diseases in childhood were conducted in children with ADHD (46%), and when these studies were reviewed, it was suggested that quantitative EEG may be a biomarker in the diagnosis of ADHD. [13, 14]. Moreover, it has been known that ADHD has been the most common neuropsychiatric comorbidity associated with pediatric epilepsy, affecting about a third of children diagnosed with epilepsy [13]. Although it has been known that both epilepsy and EEG abnormalities are common in children with ADHD, the predictors of this relationship are still unclear. Studies have reported that more frequent EEG abnormalities were observed in the group with prominent attention deficit, treatment resistant, and severe symptoms, but the predictive factors about neuropsychological test performance have not been defined yet [15]. In this study, the frequency of EEG abnormalities in the ADHD group (10%) was most common than the normal population (1–3%) [13, 16]. However, studies with ADHD group, it has been shown that 30.1% epileptiform activity, mainly focal (usually occipital or temporal) [17]. In our study group, when the localization of EEG abnormalities in ADHD group was examined, abnormal activity was detected in the frontocentral region in two of the three cases and in the posterior region in one. Although the cases in this study were not clinically diagnosed with epilepsy, these findings are consistent with the literature, the most common epileptic disorders accompanying with ADHD are frontal lobe epilepsies [13, 15]. In this study, no significant difference was found between the WISC-R scores of normal and abnormal EEG Groups in ADHD. This result may be due to the negative effect of executive function problems observed in ADHD on neuropsychiatric tests [15, 18].

One of the important findings of this study is that EEG abnormalities located in centrotemporal and temporal region were determined in one quarter of the children who have rotation error on block design performance with dyslexia (reading disability) which is the most common learning disability in childhood. In accordance with our results, in a clinical study by Arhan et al. [19] which evaluated, interictal epileptiform discharges have been found 25% focal epileptic discharges in children with specific learning disability (SLD). Furthermore, this finding is consistent with the remark of "SLD as a problem of maldevelopment of temporal lobes during the fetal period" by Geschwing many years ago [20]. Nowadays, it has been known that children with temporal lob epilepsy have reduced reading accuracy [21].

ID is one of the most common secondary disabilities in people with epilepsy, and the prevalence of epilepsy increases with the severity of the ID. About 50% of those with profound disability and between 10% and 20% of those with mild disability have suffered from seizures at some time in life [22, 23]. In our study, EEG abnormalities were determined in 21% of the children who have rotation error on block design performance with ID. Our study group had mild ID, because profound group could not complete many of the subtests of the WISC-R. Thereby, our finding is consistent with literature. We also found positive-strong correlation between presence of EEG abnormality and WISC-R performance-verbal scores in ID group. It has been known that intelligence tests are commonly used assessment tools for determining epilepsy-related cognitive impairments, or the relationship between scores and epilepsy variables, but there is no evidence showing the sensitivity of those tools on epileptic abnormalities. In a study, the WISC-fourth edition (WISC-IV) has been shown the to be sensitive for epilepsy-related cognitive problems in clinically referred children with high seizure burden, particularly problems relating to expressive verbal, working memory, and processing speed difficulties. Compared to healthy children, children with epilepsy have a very high rate of cognitive difficulties as assessed by the WISC-IV [24]. Although this study has important implications for possible EEG abnormalities at child and adolescent psychiatric patient group, also it has some limitations. First, this is a retrospective study from patient folder and other than EEG records, there are no information about concurrent neurological examination. Second, the cases in this study were not clinically diagnosed with epilepsy and do not use antiepileptic drug, but we did not evaluate psychiatric drugs as a variable.

Conclusion

This study has shown that a wide spectrum of EEG abnormalities can be found in patients who have rotation errors in the block design test of WISC-R. Furthermore, our findings have been assserted that having ID diagnoses, existing notable differences performance-verbal subtests scores and showing 2 or more rotation errors in the block design subtest of WISC-R, should be predictable risk factors for epileptic abnormalities in a clinical sample of child and adolescent psychiatry.

Ethics Committee Approval: The Gazi University Non-Interventional Clinical Research Ethics Committee granted approval for this study (date: 17.02.2021, number: 17022021/126).

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REFERENCES

1. Goldstein K. The Organism. New York: Zone Books; 1995.
2. Milberg WP, Hebben N, Kaplan E. The Boston process approach to neuropsychological assessment. In: Grant I, Adams KM, editors. Neuropsychological Assessment of Neuropsychiatric and Neuromedical Disorders. 3rd ed. New York: Oxford University Press; 2009. p.42–65.
3. Parsons TD. Clinical Neuropsychology and Technology: What's New and How We Can Use It. 1st ed. New York: Springer; 2016.
4. Tracy JI, McGrory AC, Josiassen RC, Monaco CA. A comparison of reading and demographic-based estimates of premorbid intelligence in schizophrenia. Schizophr Res 1996;22:103–9. [CrossRef]
5. Krinick R. Factors related to compliance with recommendations after a neuropsychological assessment (dissertation). New Jersey: Fairleigh Dickinson University; 2015.
6. Kaufman AS, Flanagan DP, Alfonso VC, Mascolo JT. Test review: Wechsler intelligence scale for children, Fourth Edition (WISC-IV). J Psychoeduc Assess 2006;24:278–95. [CrossRef]
7. Ceylan G, Baykal S, Karabekiroğlu K, Tekin A. Relationship between WISC-R subtests and psychiatric symptom groups in attention and learning disorders. [Article in Turkish]. Cukurova Medical Journal 2018;43:785–91. [CrossRef]
8. Wechsler D. Manual for the Wechsler Adult Intelligence Scale. New York: The Psychological Corporation; 1955.
9. Kohs SC. Intelligence Measurement: A Psychological and Statistical Study Based Upon The Block-Design Tests. New York: The Macmillan Company; 1923. [CrossRef]
10. Lezak MD, Howieson DB, Loring DW. Neuropsychological Assessment. 4th ed. New York: Oxford University Press; 2004.
11. Yagci S. Neuropsychological assessment guide in epilepsy surgery. [Article in Turkish]. Epilepsi 2012;18 Suppl 1:33–8.
12. Holtz JL. Applied Clinical Neuropsychology: An Introduction. 1st ed. New York: Springer Publishing Company; 2010.
13. Vidaurre J, Twanow JDE. Attention deficit hyperactivity disorder and associated cognitive dysfunction in pediatric epilepsy. Semin Pediatr Neurol 2017;24:282–91. [CrossRef]
14. McVoy M, Lytle S, Fulchiero E, Aebi ME, Adeleye O, Sajatovic M. A systematic review of quantitative EEG as a possible biomarker in child psychiatric disorders. Psychiatry Res 2019;279:331–44. [CrossRef]
15. Williams AE, Giust JM, Kronenberger WG, Dunn DW. Epilepsy and attention-deficit hyperactivity disorder: links, risks, and challenges. Neuropsychiatr Dis Treat 2016;12:287–96. [CrossRef]
16. Russ SA, Larson K, Halfon N. A national profile of childhood epilepsy and seizure disorder. Pediatrics 2012;129:256–64. [CrossRef]
17. Hughes JR, DeLeo AJ, Melyn MA. The electroencephalogram in attention deficit-hyperactivity disorder: emphasis on epileptiform discharges. Epilepsy Behav 2000;1:271–7. [CrossRef]
18. Agnew-Blais JC, Polanczyk GV, Danese A, Wertz J, Moffitt TE, Arseneault L. Are changes in ADHD course reflected in differences in IQ and executive functioning from childhood to young adulthood? Psychol Med 2020;50:2799–808. [CrossRef]
19. Arhan E, Güney E, Bulan A, Karalök S, Teber S, Güven A, et al. The electroencephalogram in learning disability: special emphasis on interictal epileptiform discharges. GMJ 2017;28:171–3. [CrossRef]
20. Geschwind N. Specializations of the human brain. Sci Am 1979;241:180–99. [CrossRef]
21. Lah S, Castles A, Smith ML. Reading in children with temporal lobe epilepsy: a systematic review. Epilepsy Behav 2017;68:84–94. [CrossRef]
22. Deb S. Epilepsy in people with mental retardation. In: Jacobson JW, Mulick JA, Rojahn J, editors. Handbook of Intellectual and Developmental Disabilities. Boston, MA: Springer; 2007. p. 81–96. [CrossRef]
23. Lei Wang, Cluitmans PJ, Arends JB, Yan Wu, Sazonov AV. Epileptic seizure detection on patients with mental retardation based on EEG features: a pilot study. Annu Int Conf IEEE Eng Med Biol Soc 2015;2015:578–81. [CrossRef]
24. Sherman EM, Brooks BL, Fay-McClymont TB, MacAllister WS. Detecting epilepsy-related cognitive problems in clinically referred children with epilepsy: is the WISC-IV a useful tool? Epilepsia 2012;53:1060–6. [CrossRef]