

The Utility of EEG in Attention Deficit Hyperactivity Disorder: A Replication Study

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Abstract

The routine use of stimulants in pediatrics has increased dramatically over the past 3 decades and the long-term consequences have yet to be fully studied. Since 1978 there have been 7 articles identifying electroencephalogram (EEG) abnormalities, particularly epileptiform discharges in children with attention deficit hyperactivity disorder (ADHD). Many have studied the prevalence of these discharges in this population with varying results. An article published in 2011 suggests that EEG technology should be considered prior to prescribing stimulants to children diagnosed with ADHD due to a high prevalence of epileptiform discharges. The 2011 study found a higher prevalence (26%) of epileptiform discharges when using 23-hour and sleep-deprived EEGs in comparison with other methods of activation (hyperventilation or photostimulation) and conventional EEG. We sought to replicate the 2011 results using conventional EEG with the added qEEG technologies of automatic spike detection and low-resolution electromagnetic tomography analysis (LORETA) brain mapping. Our results showed 32% prevalence of epileptiform discharges, which suggests that an EEG should be considered prior to prescribing stimulant medications.

Keywords

attention deficit hyperactivity disorder, electroencephalogram, epileptiform discharges, stimulants, anticonvulsants, qEEG, LORETA

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Introduction

The well-being of children diagnosed with ADHD is a priority for physicians, but negative side effects to common drug-based treatments occur frequently.¹ Even though the percentage of serious side-effects for stimulants is low, a Canadian study found that 9% of children prescribed stimulants for the first time developed psychotic symptoms.² Majority of children with ADHD are diagnosed using *DSM (Diagnostic and Statistical Manual of Mental Disorders)* criteria based solely on symptoms.^{3,4} Using stimulants to treat this population when diagnosed in this manner has increased dramatically over the past 3 decades⁴ and the long-term consequences have yet to be fully studied. It is well known that these side effects are insomnia and loss of appetite, but there may be more severe issues affecting medicated children. Stimulant medication, especially extended release, can increase the risk of seizures in these children when complicated by epilepsy or those with subclinical electrographic abnormalities whose seizures are not controlled by anticonvulsants medication.⁵ Less invasive interventions should be considered instead of prescribing medications capable of such harm, which is typically the first choice of many physicians.⁶

Electroencephalography has existed for more than 4 decades, yet this technology is underutilized in psychiatry, despite its promising potential for clinical application.^{7,8} In an

effort to evolve the diagnostic process and move toward a science-based classification, the National Institute of Mental Health (NIMH) has launched the Research Domain Criteria (RDoC), highlighting the importance of electrophysiological testing. By utilizing EEG, epileptiform activity can be identified and stimulant medication reconsidered. In a recent review, 7 articles have been published identifying EEG abnormalities, including epileptiform discharges (ED) in children with ADHD.⁹ The prevalence of ED in these studies ranged from 6% to 44%. In 2011, a published report⁵ suggests that EEG technology should be considered prior to prescribing stimulants due to a high prevalence of ED.

The 2011 study⁵ found that 1 in 4 children had ED significant enough to consider anticonvulsants in children with ADHD. This study shows the importance of using EEG prior to the treatment of children with ADHD. Surprisingly, none of the prior studies, including the 2011 study, were replicated. Replicated studies have more weight to inspire physicians to

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consider the use of EEG in children with ADHD. Researchers studying the prevalence of ED in nonepileptic children with ADHD using hyperventilation, photostimulation, and conventional EEGs (cEEG) have found results varying from 6% to 10%. The 2011 study⁵ suggests that sleep deprivation and 23-hour extended EEGs provide higher prevalence of ED. Out of the 8 ADHD studies reviewed in the 2011 study,⁵ the average yield of ED was 23%, ranging from 6% to 53%, whereas their data supported a yield of 26%.

Sleep-deprived and 23-hour EEGs, as used in the 2011 study, required a great amount of time and effort compared with cEEG, especially for the more severely impaired hypersensitive psychiatric children and their parents. Conventional EEG collects data in a resting state, 10 minutes eyes closed and 10 minutes eyes open. In addition to the inconvenience, sleep deprivation EEGs for this population increase risk of inducing a seizure. Our hypothesis is that if using cEEG the results will be equal to the results of sleep deprivation EEG. Electroencephalogram should provide sufficient evidence for prescribing appropriate medication during initial treatment when ED is identified.¹⁰

Methods

Data Set

The Tarnow Center for Self-Management EEG/qEEG archival database was used for this study. The Swatzyna database contains demographic information, diagnosis, neurobiomarkers, and the number of medications prescribed for 257 ADHD clinical cases. The Sigma Xi: Rice University/Texas Medical Center Chapter Institutional Review Board granted a waiver for the analysis of the archival data contained in Swatzyna database. The Tarnow Center practices all HIPAA (Health Insurance Portability and Accountability Act) regulations. Of the 366 children in the database, 257 were diagnosed with ADHD.

Electroencephalography Data Collection Equipment

Prior to the EEG, patients were asked not to take stimulants the day of testing. Each patient's EEG was recorded using the Deymed TruScan 32 equipment, with impedance maintained below 10 kohm. The patients were seated in a slightly reclining chair in a silent and low light environment. An "Electrocap" was used to collect the data according to the international 10-20 system with linked ears (Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, and O2). A minimum of 20 minutes total data was recorded in both eyes open (10 minutes) and eyes closed (10 minutes) resting conditions (order of these could vary among subjects).

The EEG background activity and location was analyzed by LORETA.^{11,12} Voxel-based, normalized broad-band (delta, theta, alpha, and beta) and very narrow-band (VNB, 1Hz bandwidth, from 1 to 25 Hz) LORETA activity (=current source density, A/m²) were computed for each person.

All data were manually artifacted, processed, and analyzed by the same team, using both the Human Brain Indices and the

NeuroGuide databases as appropriate for the age of the client. Each of the raw EEG were read by the same board certified electroencephalographer. Automatic spike detection software was employed as a component of the qEEG data analysis. The qEEG was compared with 2 normative databases and analyzed by the same qEEG evaluator for each case.

Design

The design was structured to replicate the one published in 2011⁵ with a few alterations. The study conducted in 2011 included 624 children diagnosed with ADHD, ranging from 5 to 18 years, who were tested using sleep deprivation and 23-hour extended EEG testing (written communication). The children diagnosed with a seizure disorder and taking anticonvulsants drugs were excluded from the study; all children were medication free at the time of testing.

Our sample of 257 children includes only 82 (32%) who were medication free. Our study parallels theirs in age distribution, gender distribution (majority male), and screening techniques. Those children diagnosed with a seizure disorder or taking anticonvulsants medication were excluded. Unlike the method applied in the original study,⁵ we used only cEEG and qEEG automatic spike detection software.

Results

In comparison, the 2011 study⁵ identified 26% of their population with ADHD as having ED, whereas we identified ED in 32% of our sample. When excluding ADHD cases with comorbid diagnoses, 26% had ED, matching results found in 2011.⁵

Discussion

The use of sleep deprivation and extended 23-hour EEGs is considered by the industry to be more accurate in identifying spikes than the cEEG method. Using only cEEG, we unexpectedly found a higher percentage of patients with ED; 32% compared with 26%.⁵ A number of factors could explain this higher percentage. One reason is that our study may have identified more cases of ED because 68% of our patients were on medication at the time of the study, suggesting we may have a more pathologic sample. Additionally, it is our experience that the use of qEEG, LORETA mapping, and an automatic spike detection software helps to support the findings of the electroencephalographer.

Conclusion

Many medications, including stimulants and antipsychotics, lower seizure threshold and may account for some of the adverse side effects. Stimulant medication is the most widely used and accepted treatment of ADHD in children. However, our finding is that 32% of children have ED. We concur with the 2011 study⁵ that anticonvulsants should be considered prior to the application of stimulants for this population. This study also suggests that cEEG is at least equal to other EEG methods

and has less financial impact and/or inconvenience for the family. It is our experience that the automatic spike detection system allows for us to identify a higher percentage of ED compared with EEGs alone. With the inclusion of LORETA mapping, researchers can identify the specific parts of the brain associated with their symptoms and select an anticonvulsant that can be used more successfully. Our study concluded that one-third of our pediatric ADHD population have epileptiform activity compared with the one-fourth found in the study conducted in 2011.⁵ Overall, this replication study provides further evidence for the routine use of EEG with children and adolescents who have been diagnosed with ADHD. This may be even more critical for those who experience unacceptable side-effects with the first stimulant medication.

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Declaration of Conflicting Interests

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