Electroencephalographic alterations in children with attention deficit hyperactivity disorder: A single-center observational study.

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Abstract

Introduction: Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder that affects daily functioning. The potential of video electroencephalogram (V-EEG) and rhythm map analysis for the early diagnosis of ADHD, particularly in at-risk children, has been investigated. The objective of the present study was to evaluate electroencephalographic alterations in children with ADHD.

Methods: A retrospective analysis was performed at the Center for Neuropsychological Evaluation and Advanced Neurotherapy (CENNA) in Quito-Ecuador from January to March 2022; the demographic characteristics, V-EEG use, and rhythm map findings were documented.

Results: The sample included 73 patients aged 3 to 16 years, 21.92% of whom were women and 78.08% of whom were men. The average age was nine years. All patients underwent V-EEG as part of their evaluation, revealing slow waves (delta range) in 30% (n=22) of patients. The bilateral temporal region was the most affected in 63.64% (n=14) of the patients with slow waves, followed by the frontal areas in 18.18% (n=4), occipital regions in 9.09% (n=2), frontotemporal regions in 4 55% (n=1) and parietal regions in 4.55% (n=1).

Conclusions: V-EEG, which reveals slow waves in bilateral temporal regions, may be a valuable tool for diagnosing ADHD. These results indicate the need for further research to confirm these findings and establish the validity and clinical utility of V-EEG in ADHD patients.

Keywords:

MeSH: Attention deficit disorder with hyperactivity; Electroencephalography; Learning disabilities; Epilepsy; Language disorders; Child.

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Introduction

Attention deficit hyperactivity disorder (ADHD) is a developmental disorder that affects children and adolescents and is characterized by the presence of persistent symptoms of inattention, hyperactivity, and impulsivity that interfere with the functioning and development of the individual. According to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), the diagnosis of ADHD requires the presence of several characteristic symptoms in two or more settings (for example, at home, at school, or work). The minimum duration was six months [1]. This disorder leads to difficulties in the affected individuals' academic performance, social interaction, and emotional well-being. Early and accurate diagnosis of ADHD is crucial for facilitating appropriate interventions and improving patients' quality of life.

Although ADHD has been the subject of extensive research and studies in recent decades, its diagnosis has been challenging because ADHD symptoms can overlap with other disorders or be difficult to diagnose, making accurate identification of the disorder difficult. First, ADHD symptoms may overlap with other disorders or conditions, which can complicate the precise identification of the disorder. For example, overlapping features between ADHD and anxiety disorders can lead to challenges in both the diagnosis and treatment of patients with ADHD [2]. Furthermore, some ADHD symptoms are shared by comorbid psychiatric conditions, which could result in an artifact of overlapping symptoms being diagnosed with ADHD [3]. In children aged four to six years, diagnosis is particularly challenging, as ADHD diagnosis may overlap with age-appropriate behaviors, requiring a combination of direct clinical observation and parent interviews for proper diagnosis [4].

Second, existing diagnostic methods, which often rely on clinical assessment and information provided by parents and teachers, can be subjective and biased. Diagnostic guidelines recommend using a variety of methods to evaluate and diagnose ADHD. However, subjective measures always incorporate risks such as informant bias or significant differences between ratings obtained from various sources. Furthermore, it has been shown that grades and tests appear to assess somewhat different constructs, highlighting the need for objective measures for a more accurate diagnosis of ADHD [5].

In this context, the present study aimed to investigate the usefulness of video-electroencephalogram (V-EEG) data as a potential biomarker for the diagnosis of ADHD in children and adolescents. Background Research has suggested that patterns of brain electrical activity may differ between individuals with ADHD and those without this disorder. Initial studies suggested a robust connection between ADHD diagnosis and resting EEG markers of reduced attention, hypoarousal, or immaturity, such as increased theta wave activity and an increased theta/beta ratio (TBR). However, more recent studies failed to replicate a consistent increase in the TBR in individuals with ADHD [6].

Over the last decade, researchers have used EEG signals to identify several localized changes in children with ADHD, and it has recently been suggested that EEG signals can be used to diagnose autism spectrum disorder (ASD) and even to measure its severity. These findings led to the hypothesis that V-EEG could provide objective and quantifiable information to aid in diagnosing ADHD [7]. Despite this promise, the methodological limitations of using EEG as a diagnostic tool from a clinical perspective have also been discussed, pointing to a relative need for diagnostic studies [8].

The nature of this problem lies in the need to improve the accuracy of ADHD diagnosis and reduce the subjectivity associated with current assessment methods. ADHD can significantly impact the lives of affected individuals, their families, and their educational environments. Early and accurate diagnosis allows timely and appropriate intervention, which could improve patient prognosis and quality of life.

This research is potentially helpful in improving the accuracy of ADHD diagnosis and providing clinicians with objective, evidence-based tools. If the usefulness of V-EEG as a biomarker for ADHD is confirmed, diagnostic errors could be reduced, allowing for more individualized and effective treatment. Additionally, this research could lay the groundwork for future studies exploring the relationship between brain activity patterns and ADHD.

The objective of this research was to describe the electroencephalographic alterations in children and adolescents diagnosed with ADHD.

Materials and methods

Type of study

The study was observational and descriptive. The source was retrospective.

Scenery

The study was conducted at the Center for Neuropsychological Evaluation and Advanced Neurotherapy (CENNA) in Quito, Ecuador. CENNA is a private center specializing in diagnosing and treating neuropsychological and neurodevelopmental disorders. The study period was from January 1, 2022, to March 31, 2022.

Participants

Patients aged 5 to 18 years with a diagnosis of ADHD who underwent V-EEG were included. Participants were excluded due to a lack of complete or duplicate information or failure to perform V-EEG.

Variables

The variables analyzed in this study included demographic characteristics (such as age and sex). These findings were found in the rhythm maps obtained from the V-EEG. Special attention was given to slow waves (delta range) and their distribution in different brain regions.

Data sources/measurements

The source was indirect; an electronic form was used to fill out data from the institutional medical history of the patients who entered the hospitalization period. A review of the neuropsychology unit registry was carried out. The information was confidential; no personal data were included in identifying the study subjects.

Procedure

The process of selecting and confirming the eligibility of the participants was carried out, during which the medical and neuropsychological records of the patients treated at CENNA were reviewed from January 1 to March 31, 2022. The patients were hospitalized starting in the afternoon to prepare for the study. In a room dedicated to video recording, video-encephalography, polytomography, potentials, and P300, Neuroespectrum 65 equipment from the Neurosoft brand was installed.

Control of sources of bias

To avoid interviewer, information, and memory biases, the leading researcher always maintained the data with a guide and records approved in the research protocol. Observation and selection bias were avoided by applying participant selection criteria. Two researchers independently analyzed each record in duplicate, and the variables were registered in the database once their agreement was verified.

Universe and Sample

The universe comprised all the patients registered in the institution. The sample size was nonprobabilistic and discretionary since all incident cases in the study period were included.

Quantitative variables

Inferential statistics were used. Categorical results are expressed as frequencies and percentages.

Statistical analysis

Categorical variables are presented as proportions with 95% confidence intervals (CIs). The SPSS 25.0 statistical package was used for the analysis (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.).

Results

Study participants

A total of 125 individuals who met the criteria to be considered potential participants in the study were identified (Figure 1). The distribution of participants in each stage of the study is shown below:

- Initial number of identified individuals: 125 (100%).
- Number of individuals excluded due to lack of complete or duplicate information: 2 (1.6%)
- Number of individuals excluded due to failure to perform the V-EEG: 50 (40%)
- Final number of individuals eligible for analysis: 73 (58.4%).

Patient characteristics

The demographic composition of the sample eligible for analysis revealed that 21.92% (n=16) were women and 78.08% (n=57) were men, with an average age of 9 years.

Video-Electroencephalogram (V-EEG)

Analysis of rhythm maps derived from V-EEG recordings revealed the presence of slow waves (delta range) in 30% (n=22) of participants evaluated with this technique. When these findings were analyzed by brain region, it was observed that the bilateral temporal region was the most affected in 63.64% (n=14) of the patients. Other affected brain regions included the frontal cortex (18.18%; n=4), occipital cortex (9.09%; n=2), frontotemporal cortex (4.55%; n=1), and parietal cortex (4.55%; n=1%).

Figure 1 . Participant flowchart.

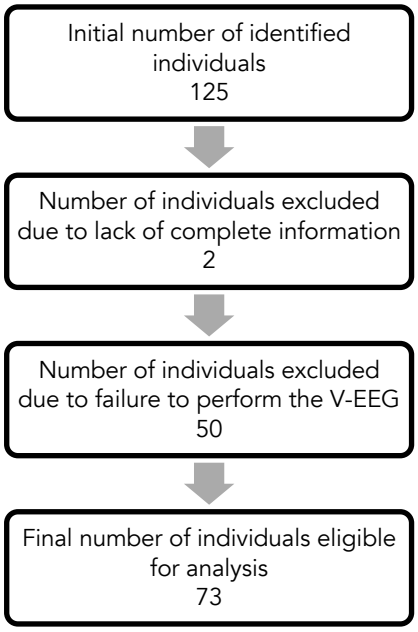

Table 1 . Frequency and confidence interval of EEG waves.

Wave type	Frequency	95% CI
Delta waves	22 (30%)	19.5% - 40.5%
Temporary R.	14 (63.64%)	43.5% - 83.7%
Front R.	4 (18.18%)	2.1% - 34.3%
Occipital R.	2 (9.09%)	-2.9% - 21.1%
Fronto-temporal R.	1 (4.55%)	-4.2% - 13.3%
Parietal R.	1 (4.55%)	-4.2% - 13.3%

CI: confidence interval. R: region.

Discussion

The present investigation explored the findings of alterations in the Video-Electroencephalogram (V-EEG) in children with attention deficit hyperactivity disorder (ADHD).

The demographic composition of the present study revealed a greater frequency of NAFLD in men. According to data from the National Institute of Mental Health (NIMH), the prevalence of ADHD is considerably greater in boys, with a ratio as high as 10 to 1 in clinical populations compared to girls [9]. Additionally, the Centers for Disease Control and Prevention (CDC)

reports that boys are more likely to be diagnosed with ADHD than girls between the ages of 12 and 17 [10]. This prevalence pattern was also evidenced in a study that reported a prevalence of ADHD according to the DSM-IV criteria of 9.2%, with a prevalence ratio between boys and girls of 2.28:1 [11].

The average age of the participants in the present study was nine years, which is especially relevant since it coincides with a critical phase of cognitive and behavioral development in childhood. This stage is essential in the context of ADHD since it is a period during which the symptoms of the disorder are usually more evident and diagnosable. At this age, children are in the middle of primary school and face academic and social challenges that can accentuate or make the symptoms of ADHD more evident. In this development phase, interventions can be particularly effective as patterns of behavior and learning that will persist over time are established. Identifying and treating ADHD at this age can have a significant impact on a child's educational and social trajectory, as well as their overall well-being.

In this study, a notable prevalence of slow waves (delta range) was observed in the V-EEG recordings of the participants, especially in the bilateral temporal region. This pattern of brain electrical activity suggests the possibility of neurophysiological abnormalities associated with ADHD. The literature supports the presence of abnormalities in slow-wave activity in children with ADHD. Several studies have reported increased activity in the theta frequency band, especially in frontocentral regions, in children with ADHD compared to controls without ADHD [12]. Likewise, decreased EEG rhythms in the frontocentral areas have been associated with abnormal brain function in children with behavioral problems, such as hyperactivity and impulsivity, which are core features of ADHD [8].

In the literature, EEG and V-EEG have been explored as potential tools for diagnosing neurodevelopmental disorders. For example, it has been suggested that EEG signals can be used to diagnose autism spectrum disorder (ASD) and measure its severity as well as to identify localized changes in brain electrical activity in children with ADHD [7, 8]. However, the literature also points to a relative need for diagnostic studies and methodological limitations in using EEG as a diagnostic tool [8].

The identification of electrophysiological biomarkers using V-EEG could represent a significant advance in the stratification and early diagnosis of ADHD. The clinical utility of V-EEG, especially in combination with rhythm map analysis, could allow for more accurate and earlier assessments of patients with ADHD, thus facilitating early and personalized interventions. However, the clinical utility of V-EEG still requires additional validation, underscoring the need for future research to confirm and support these preliminary findings.

This study faced several limitations that must be considered when interpreting the results. The exclusion of many potential participants due to lack of complete information or nonperformance of V-EEG could have introduced bias into the findings. Furthermore, the final sample of 43 participants was relatively small, limiting the results' generalizability to a broader population.

Given the preliminary nature of these findings, it is crucial to conduct future research with more extensive and diversified samples to validate the utility of V-EEG in the diagnosis of ADHD. It would also be beneficial to explore further the relationship between slow waves in temporal regions and ADHD and investigate other neuroimaging modalities and electrophysiological techniques for a more complete understanding of the neurophysiological basis of ADHD.

These findings highlight a trend toward a more significant bilateral presence of slow waves (delta range) in temporal regions in patients evaluated with ADHD. The results suggest that V-EEG, in combination with rhythm map analysis, may reveal useful electrophysiological biomarkers for the early identification and diagnosis of ADHD, especially in the temporal regions of the brain. However, it is imperative to note that the clinical utility of V-EEG as a diagnostic tool for ADHD

requires additional validation and further research to confirm and support these preliminary findings.

The present research focused on exploring the usefulness of V-EEG and rhythm map analysis for the early identification and diagnosis of attention deficit hyperactivity disorder (ADHD) in a pediatric population. The findings revealed a notable prevalence of slow waves (delta range) in the participants' V-EEG recordings, especially in the bilateral temporal region. This pattern of brain electrical activity suggests the possibility of neurophysiological correlations with ADHD, which is in line with the literature supporting the presence of abnormalities in slow-wave activity in children with this disorder. The demographic composition of the sample, with a predominance of male participants and an average age of 12 years, provided a valuable window of observation at a critical stage of neurocognitive development.

Despite the promise that these findings may suggest, it is critical to recognize that the clinical utility of V-EEG as a diagnostic tool for ADHD requires additional validation and further research to confirm and support these preliminary findings. The literature indicates a relative lack of diagnostic studies and methodological limitations in using EEG and V-EEG to diagnose neurodevelopmental disorders. However, the concordance of our study findings with previous literature underscores the potential of these tools in improving the diagnosis and understanding of ADHD.

Conclusions

The present study provides preliminary evidence on the usefulness of electrophysiological biomarkers revealed through V-EEG for the early identification and diagnosis of ADHD in children. Future research that addresses methodological limitations and expands the understanding of the neurophysiological correlates of ADHD is needed to improve diagnostic and treatment strategies in the pediatric population.

Abbreviations

IDD: Intellectual development disorder.
ADHD: Attention Deficit Hyperactivity Disorder.
ASD: Autism spectrum disorder.

Supplementary information

No supplementary materials are declared.

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Not declared.

Author contributions

Álvaro Nicolay Astudillo Mariño: Conceptualization, data curation, formal analysis, acquisition of funds, research, writing - original draft.
Doménica Santamaría Obando: Methodology, project administration, resources, Software, supervision, validation, visualization, writing - review and editing.
All the authors read and approved the final version of the manuscript.

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Availability of data and materials

The data were collected from medical archives and are not publicly available due to patient confidentiality but are available through the corresponding author upon reasonable academic request.

Statements

Ethics committee approval and consent to participate

This study was approved by the Human Research Ethics Committee of the Faculty of Medicine, Universidad Internacional del Ecuador. The participants' guardians signed the consent to participate.

Publication consent

Patient-specific images, X-rays, and studies were not available for publication.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Author information

Not declared.

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