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QUANTITATIVE EEG COMPARATIVE ANALYSIS BETWEEN AUTISM SPECTRUM DISORDER (ASD) AND ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD)

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ABSTRACT

Background: Autism is a mental developmental disorder, manifested in the early childhood. Attention deficit hyperactivity disorder is another psychiatric condition of the neurodevelopmental type. Both disorders affect information processing in the nervous system, altering the mechanisms which control how neurons and their synapses are connected and organized.

Purpose: To examine if quantitative EEG assessment is sensitive and simple enough to differentiate autism from attention deficit hyperactivity disorder and neurologically typical children.

Material and methods: Quantitative EEG is a type of electrophysiological assessment that uses computerized mathematical analysis to convert the raw waveform data into different frequency ranges. Each frequency range is averaged across a sample of data and quantified into mean amplitude (voltage in microvolts mV). We performed quantitative EEG analysis and compared 4 cohorts of children (aged from 3 to 7 years): with autism (high [n=27] and low [n=52] functioning), with attention deficit hyperactivity disorder [n=34], and with typical behaviour [n75].

Results: Our preliminary results show that there are significant qEEG differences between the groups of patients and the control cohort. The changes affect the potential levels of delta-, theta-, alpha-, and beta- frequency spectrums.

Conclusion: The present study shows some significant quantitative EEG findings in autistic patients. This is a step forward in our efforts, aimed at defining specific neurophysiologic changes, in order to develop and refine strategies for early diagnosis of autism spectrum disorders, differentiation from other development conditions in childhood, detection of specific biomarkers and early initiation of treatment.

Keywords: Autistic spectrum disorder, Attention deficit hyperactivity disorder, Quantitative electroencephalography,

BACKGROUND:

Autistic spectrum disorder (ASD) is a neurodevelopmental disorder that is clinically characterized by impaired social interaction, language retardation, behavioural stereotypes, and cognitive deficits. Attention deficit hyperactivity disorder (ADHD) is another mental disorder of the neurodevelopmental type. It is characterized by problems with attention, excessive activity, or impaired behaviour control which is not appropriate for the person's age. In children, problems with attention may result in poor school performance.

Despite being the most commonly studied and diagnosed mental disorder in children and adolescents, the cause is unknown in the majority of cases. Both diagnoses are primarily based on detailed clinical interview and behavioural observation, and there are no suitable laboratory tests available. Although behavioural observation remains the major diagnostic tool, it may be confounded by inter-rater bias. Some efforts have been made to develop neurobiological measures, which may become more objective and sensitive diagnostic tools for ASD and ADHD.

Given that there is an increasing trend in the prevalence rate of ASD worldwide [1] and that early intervention is critical to remediate the symptoms [2], it is important to develop a biological screening test that is relatively easy and applicable even in young children.

Quantitative EEG (qEEG) is a type of electrophysiological assessment that applies computerized mathematical analysis to convert the raw waveform data into different frequency ranges. Each frequency range is averaged across a sample of data and quantified into mean amplitude (voltage in microvolts mV).The absolute power in each frequency band is calculated.

Our hypothesis is that a one-minute noise-free EEG recording would yield reliable and valid data, provided that the technique can be applied in children with special needs, who may not be able to sit still for a long time or comply easily. The aim of the present study is to examine if qEEG assessment is sensitive and simple enough to differentiate children with ASD from ADHD and neurologically typical ("neurotypical") children.

Given that the qEEG technique has the advantages of being less expensive, easier to perform, and noninvasive compared with some other neuroimaging techniques (e.g., positron emission tomography and computed tomography), it has been advocated as a potential clinical assessment for neurological and psychiatric disorders (Hughes & John, 1999).

MATERIAL AND METHODS:

Participants

A total of 156 children participated in the present study. The normal control (NC) subjects were recruited from local primary schools. Parents were invited to complete and return the consent form to the research team if they agreed to have their children participate in the project. Children who had a history of neurological problems or abnormal developmental milestones were excluded from the study, resulting in a control group of 75 children. ASD patients were 79, including 52 low functioning and 27 high functioning autistic children. ADHD patients were 34. Mean age was 4.82 years, age range was 3-7 years, gender ratio (male/female) was 59/16 for the control group, 50/12 for low functioning ASD, 21/6 for high functioning ASD, and 27/7 for ADHD subjects. Children with ASD and these with ADHD were either recruited from the Association of the Resource centres in Bulgaria, or from the subject database of the Clinic for Children psychiatry at the Medical university of Varna. Children with ASD and ADHD had previously been diagnosed by specialists at the University clinics in the country.

EEG Recording

Each child was tested individually in a sound- and light-attenuated room. Before the EEG assessment, the child and/or the parent were given a brief verbal explanation of the procedure along with a written description. Informed consent was obtained from the parents of all subjects. The experimental procedure was preapproved by the Clinical Research Ethics Committee of The Varna Medical University. After the parents had indicated that they understood the procedure, an electrode cap with 8 electrodes, based on the International "10-20" System (Jasper, 1958) referenced to linked ears, was positioned on the head of the child. To keep the children engaged and awake, they were asked to focus on a computer screen, which displayed some swimming fish of different colours or a car. We recorded few minutes of continuous EEG signals in eyes-open condition.

Data Analysis

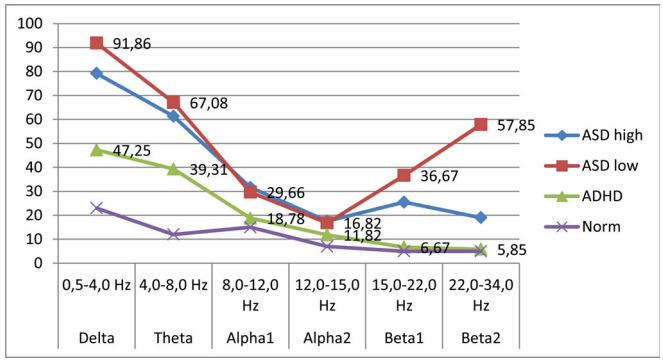
According to the criteria suggested to produce a reliable measure [4], only data that had at least one minute of artefact-free EEG data were selected. Frequency bands were classified into delta (0.5 – 4.0 Hz), theta (4.0 – 8.0 Hz), low alpha (8.0 –12.0 Hz), high alpha (12.0 – 15.0 Hz), low beta (15.0 – 22.0 Hz), and high beta (22.0 – 34.0 Hz). Data from 8 electrode sites – F3, F4, T3, T4, C3, C4, P3, P4 were selected for further analysis. The absolute power (the amount of energy in mV) was calculated for each frequency band at each electrode site.

RESULTS:

Absolute Power of Normal Children and Children with ASD and ADHD

The absolute power of each frequency band for the NC, ADHD and ASD groups were averaged. The topographic maps demonstrating the absolute powers of delta, theta, alpha1, alpha2, low beta1, and high beta2 between the groups are presented in Fig.1.

Fig. 1. Absolute power of the frequency bands for the assessed groups



Significant multivariate group differences were found for the absolute power. Our results revealed that ASD and ADHD groups demonstrated higher absolute delta and theta, lower alpha and higher beta1 and beta2 than the NC group.

In the ASD low function group, qEEG presented extremely increased electrical potentials across all leads – very high levels in the lower frequencies (delta and theta) and high beta frequencies. The abnormally low activity in the average alpha spectrum is remarkable.

The ASD high function group showed lower average qEEG frequency amplitudes than children with low function autism. Low-frequency delta and theta bands were identic for both groups. Asperger's children presented with lower beta activity, compared to classical autists.

The total amplitude of all frequencies in children with ADHD was lower in comparison with the values in ASD. Children with ADHD had increased potentials of low-frequency delta and theta. ADHD showed average values of alpha and high-frequency beta close to the NC group.

Neurotypical control group had the lowest electrical power activity and a balanced distribution of the frequency bands.

DISCUSSION:

The findings of the present study revealed that children with ASD demonstrated significantly higher delta, theta and beta and lower alpha levels compared with ADHD children and normal counterparts. The level of intelligence of ASD children reflect in the beta1 and beta2 activity, where the low functioning autists have higher electrical power, comparing with high functioning ASD. In contrast to the EEG profile of ASD, children with ADHD demonstrated abnormal delta–theta activity, but their beta activity was comparable with the NC. This dissociation might be suggestive of unique EEG characteristics of the neuro-

pathological profiles associated with different neurodevelopmental disorders. Children with ADHD have been consistently found to present with frontal dysfunction, but neuropathology among children with ASD was relatively more extensive, resulting in a more extended functional deficiency.

On the other hand, alpha rhythm has been associated with various cognitive processing such as memory [5] and arousal states. Because the present study examined the EEG pattern in resting state, it is unclear whether the relatively lower alpha is related to the overall cognitive arousal level of ASD children or it reflects some specific cognitive dysfunction.

Although the present findings are encouraging, more studies are needed to test the reliability and validity of the results before the technique can be applied clinically. Specifically, further studies should compare the profile of a larger sample of subjects with various developmental problems, including Asperger syndrome, specific learning disorders, epilepsy, and developmental language delay. Although the present results remain consistent after controlling for general intelligence in the ASD groups, further studies will be needed to compare children with a similar level of general intelligence to examine the specificity of this method to ASD.

CONCLUSIONS:

1. Functional EEG analysis is an objective and non-invasive method.
2. QEEG is applicable in a wider range of age groups.
3. The method is easy and convenient to use.
4. The results are encouraging for the development of a new instrumental method for screening and differential diagnosis of conditions such as ASD and ADHD.
5. Our investigation is still in progress and we need to perform further data analysis in order to achieve better representativeness of the results.

BENEFITS:

1. QEEG is useful to study the physiology of the brain and has a higher relative tolerance for involuntary movement, more easily applicable in clinical and outpatient settings.
2. The method allows data to be archived for repeated measurements.
3. QEEG is widely available and cheaper to perform than computed tomography, magnetic resonance imaging, and positron emission tomography.
4. The study doesn't require active participation from the patient's part.
5. QEEG study offers promising opportunities as an approach for monitoring and tracking the outcomes of the treatment.

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