Quantitative EEG in Children with Attention Deficit Hyperactivity Disorder

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ABSTRACT

Background: ADHD affects approximately 4-8% of children worldwide. EEG studies in children with ADHD search for data with respect to various aspects of brain function. Objective: To investigate if children with ADHD have a distinctive EEG pattern that reflects their alertness and behavior using quantitative EEG. Methods: Thirty children with ADHD and 33 control children were evaluated using digital EEG recordings. Power spectral analysis was carried out for the absolute and relative power of the frequency bands delta (1-3 Hz), theta (4-7 Hz), alpha (8-11 Hz), beta1 (12-15 Hz), beta2 (16-20 Hz). QEEG findings were correlated to the Conners’ Parent Rating Scale scores. Results: ADHD children showed more delta power and less alpha power mainly in frontal leads. Of the whole sample, children who scored >65 on the Conners’ DSM-IV Total had lower beta1 power in frontal, central and temporal leads. Regression analysis of the relative power across frequency bands at the midline leads showed that relative theta power at Cz positively predicted the score. At Cz as well, children scoring >65 on the DSM-IV Inattentive subscale had increased theta relative power and theta/beta ratio and children scoring >65 on the DSM-IV Hyperactive-Impulsive subscale had decreased beta1 relative power. The increased theta/beta ratio at Cz predicted both the scores of the inattention and hyperactivity/impulsivity scales of the DSM-IV. Conclusion: There is increased low frequency activity and decreased high frequency activity in children with ADHD. The increased theta/beta ratio at Cz may aid as an indicator in the diagnosis of ADHD. [Egypt J Neurol Psychiat Neurosurg. 2010; 47(3): 399-406] Key Words: ADHD, QEEG, theta / beta ratio, Conners’ Parent Rating Scale.

INTRODUCTION

Behavioral symptoms of inattention, impulsivity, and hyperactivity serve as a foundation for the diagnosis of attention-deficit/ hyperactivity disorder (ADHD). Various states of alertness, behavioral inhibition, and information processing have been associated with the electrical currents (alternating and direct) produced by the brain¹. Variation in alertness and behavioral control reflects the activity of specific thalamocortical generator mechanisms and the arousal of the prefrontal cortex which are noted on surface EEG recordings².³

Power spectral analysis [PSA] has been increasingly investigated and suggested to be used in the diagnosis of ADHD in young children. It is the computerized analysis of the “power” (i.e., wave amplitude squared) produced by brain waves¹. Parents and caregivers of children with ADHD are reluctant to initiate and maintain treatment without a more comprehensive evaluation process than the clinical interview¹. As has been frequently expressed by parents of patients with ADHD, if ADHD is a medical condition best treated by medication, then why hasn’t a medical test been developed to diagnose this condition? particularly when the most common course of treatment is initiation of medication for a time period extending throughout childhood, adolescence, and adulthood¹.

The aim of the work is to investigate, using PSA, if children with ADHD have a distinctive EEG pattern that reflects their alertness and behavior and whether this EEG pattern is associated with the symptoms they present with.

SUBJECTS AND METHOD

Thirty children (20 males, 10 females) diagnosed as having ADHD were recruited consecutively from the psychiatric outpatient clinic of Kasr Al-Aini pediatric hospital. Patients fulfilled the DSM-IV-TR diagnostic criteria of ADHD³. A control group of thirty three children (19 males, 14 females) matched for age and sex were recruited for comparison. They had no previous psychiatric or neurological disorder. All patients and control had an IQ >70, no chronic medical illness or sensory deficit. Assent from the child and written consent from the caregiver was obtained before the start of the research. The following was applied to both patients and control:
The Arabic version of Conners’ Parent Rating Scale- Revised- Long version CPRS-R-L²:

A paper and pencil screening questionnaire designed to be completed by parents to assist in determining whether children between the ages of three and 17 years might suffer from ADHD. It consists of 80 questions answered along a four point scale: 0 (not at all), 1 (just a little), 2 (pretty much), or 3 (very much). The following subscales are provided after scoring the test:

A. Oppositional, B. Cognitive problems/ Inattention, C. Hyperactivity, D. Anxious- Shy, E. Perfectionism, F. Social problems, G. Psychosomatic, H. Conners’ ADHD Index, I. Conners’ Global Index Restless/ Impulsive, J. Conners’ Global Index Emotional lability, K. Conners’ Global Index Total, L. DSM-IV Inattentive, M. DSM-IV Hyperactive- Impulsive, N. DSM-IV Total. A (T score) of more than 65 of the Conners’ rating scale indicates that the patient has a significant pathology. The Conners’ rating scale allows for a spectral assessment of symptoms severity rather than the absent/present diagnostic criteria. Comparison of patients and controls was done, then the whole sample (patients and controls) were divided into children who scored > 65 group and who scored ≤65 group on different subscales and compared.

Quantitative EEG:

Digital EEG was recorded using Schwarzer BrainLaB 4 GmbH. The exam was carried while the child recumbent in dorsal position in semi-luminated room. The electrodes were placed according to the international 10-20 system with electrode impedance below 10 Kohm, and ear lobe electrodes served as reference. Recording was carried for about 15 minutes with 3 minutes hyperventilation.

Epochs selected for QEEG while awake and resting (free from eye movements artifacts), the absolute and relative powers of 19 electrodes (Fp1, Fp2, F7, F8, F3, F4, C3,C4, T3, T4, T5, T6, P3, P4, O1, O2, Fz, Cz and Pz) were studies in the following frequency bands: delta (1-3Hz), theta (4-7 Hz), alpha (8-11 Hz), beta1(12-15) and beta 2 (16-20 Hz). Relative power is represented by the percentage of the amplitude in a given frequency band compared with the total amplitude across all frequency bands. Relative delta power, for example, is equal to (absolute delta power/absolute delta power + absolute theta power + absolute alpha power + absolute beta power) * 100. The theta/ beta power ratio was calculated as follows: [relative theta/ (relative beta1+relative beta2].

Statistical Analysis:

Data collected was analyzed using the SPSS version 16. To compare results between groups, chi square test for categorical data and t-test for continuous data was used. Stepwise Regression analysis was used to predict the value of a dependent variable using a set of predictor variables. P value was considered significant at <0.05.

RESULTS

Mean age (SD) of patients group was 9.3 (1.9) years [range 6-13 years] and of the control group 10.2 (2.3) years [range 6-15 years] with no significant difference between the two groups in age or sex (p>0.05).

Patients differed significantly from controls in all the Conners’ Subscales except the Anxious-Shy, Social problems, Psychosomatic and the Emotional lability Index (p>0.05). Patients scored higher than controls in the Oppositional (p=0.049), Cognitive problems /Inattention (p=0.004), Hyperactivity (p=0.035), Conners’ ADHD Index (p=0.045), Conners’ Global Index Restless/ Impulsive (p=0.000), Conners’ Global Index Total (p=0.006), DSM-IV Inattentive (p=0.001), DSM-IV Hyperactive- Impulsive (p=0.003), and DSM-IV Total (p=0.003) subscales. Control group on the other hand had more Perfectionism (p=0.017) than the ADHD children group. Comparing patients to control regarding QEEG, patients showed decrease in the absolute and relative power of alpha and increase in the relative power of delta in the frontal leads and decrease in the relative alpha power at T4 compared to controls (Table 1).

According to the DSM-IV total score obtained on the Conners’ scale, the whole sample was divided into two groups: those above 65 and those < 65. Comparing the two groups regarding QEEG, children with Conners’ DSM-IV Total > 65 showed a decrease in the absolute and relative power of beta1 in the frontal, central and temporal leads compared to children with DSM-IV Total ≤ 65 (Table 2).

Analysis of the relative power and theta/beta ratio was done in relation to symptoms of inattentition and hyperactivity at Cz. Children with Conners’ - DSM-IV Inattentive > 65 showed significant increase in theta relative power (t=2.28, p=0.026) and increase in the theta/beta ratio (t=2.05, p=0.044) compared to children with DSM-IV Inattention ≤ 65 (Table 3). Children with Conners’ - DSM-IV Hyperactive- Impulsive > 65 showed significant decrease in beta1 relative power (t=-2.18, p=0.033) compared to children with DSM-IV Hyperactive- Impulsive ≤ 65 (Table 4).
Regression analysis of the three DSM-IV scales as dependent factors was done. Factors entering the equation were the relative band frequencies (relative delta, theta, alpha, and beta) and the theta/beta ratio in the midline leads Fz, Cz and Pz. The increase in the theta/beta ratio predicted both the scores of the inattention and hyperactivity/impulsivity scales of the DSM-IV (p=0.014, and 0.016 respectively), while the increase in the relative theta power predicted the total scale score (p=0.007) (Table 5).

A sample of QEEG changes in children with ADHD are shown in Figures (1) and (2).

Table 1. The difference in absolute and relative power between children with ADHD (n=30) and controls (n=33).

<table>
<thead>
<tr>
<th>Electrode</th>
<th>FREQUENCY BANDS</th>
<th>(Absolute power)</th>
<th>[Relative power]</th>
<th>Delta</th>
<th>Theta</th>
<th>Alpha</th>
<th>Beta 1</th>
<th>Beta 2</th>
<th>Theta/beta ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fp1</td>
<td>[p=0.033]*</td>
<td>NS</td>
<td>(p=0.017)**</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F7</td>
<td>[p=0.017]*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F8</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>[p=0.048]**</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T4</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>[p=0.015]**</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

NS non-significant (p>0.05), ADHD attention-deficit/hyperactivity disorder
* Significant at p<0.05 (Greater in the ADHD Group)  ** Smaller in the ADHD Group

Table 2. The difference in absolute and relative power between children with ADHD with the Conners’ DSM-IV Total > 65 Group (n=36) and with Conners’ DSM-IV Total≤ 65 (n=24).

<table>
<thead>
<tr>
<th>Electrode</th>
<th>FREQUENCY BANDS</th>
<th>(Absolute power)</th>
<th>[Relative power]</th>
<th>Delta</th>
<th>Theta</th>
<th>Alpha</th>
<th>Beta 1</th>
<th>Beta 2</th>
<th>Theta/beta ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fz</td>
<td>NS</td>
<td>NS</td>
<td>[p=0.030]*</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cz</td>
<td>NS</td>
<td>NS</td>
<td>[p=0.008]*</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>T3</td>
<td>NS</td>
<td>NS</td>
<td>[p=0.033]*</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T4</td>
<td>NS</td>
<td>NS</td>
<td>[p=0.034]*</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>T5</td>
<td>NS</td>
<td>NS</td>
<td>[p=0.044]**</td>
<td>NS</td>
<td></td>
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</tbody>
</table>

NS non-significant (p>0.05), ADHD attention-deficit/hyperactivity disorder
* Significant at p<0.05 (Smaller in the DSM-IV Total > 65 Group)  ** Greater in the DSM-IV Total > 65 Group

Table 3. Analysis of Relative Power and Theta/Beta Power Ratio at Cz In Relation to Inattention in children with ADHD

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Relative Power % [µV^2]</th>
<th>Mean (Standard Deviation) at Cz</th>
<th>Delta</th>
<th>Theta</th>
<th>Alpha</th>
<th>Beta 1</th>
<th>Beta 2</th>
<th>Theta/beta ratio</th>
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<tbody>
<tr>
<td>Conners’ DSM-IV</td>
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<td></td>
</tr>
<tr>
<td>Inattentive &gt; 65</td>
<td>28</td>
<td>44.5 (13.5)</td>
<td>28.8</td>
<td>17.0</td>
<td>3.0</td>
<td>1.6</td>
<td>7.3</td>
<td></td>
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<tr>
<td>Conners’ DSM-IV</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Inattentive ≤ 65</td>
<td>32</td>
<td>45.3 (17.8)</td>
<td>22.7</td>
<td>13.6</td>
<td>4.7</td>
<td>1.9</td>
<td>5.2</td>
<td></td>
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</tbody>
</table>

ADHD attention-deficit/hyperactivity disorder
*p=0.026  **p=0.044

Table 4. Analysis of Relative Power and Theta/Beta Power Ratio at Cz In Relation to Hyperactivity in children with ADHD

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Relative Power % [µV^2]</th>
<th>Mean (Standard Deviation) at Cz</th>
<th>Delta</th>
<th>Theta</th>
<th>Alpha</th>
<th>Beta 1</th>
<th>Beta 2</th>
<th>Theta/beta ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conners’ DSM-IV</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperactive- Impulsive &gt; 65</td>
<td>35</td>
<td>45.5</td>
<td>25.9</td>
<td>15.5</td>
<td>2.9</td>
<td>1.6</td>
<td>6.8</td>
<td></td>
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<tr>
<td>Conners’ DSM-IV</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperactive- Impulsive ≤ 65</td>
<td>25</td>
<td>44.1</td>
<td>25.1</td>
<td>14.7</td>
<td>5.3</td>
<td>2.0</td>
<td>5.2</td>
<td></td>
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</tr>
</tbody>
</table>

ADHD attention-deficit/hyperactivity disorder
*p= 0.033
Table 5. Prediction of The Conners’ DSM-IV Scales Using The Band Frequencies and Theta/Beta Relative Power In The Midline Leads (Fz,Cz,Pz) in children with ADHD.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Predictors</th>
<th>F</th>
<th>Sig (F)</th>
<th>Beta</th>
<th>T</th>
<th>Sig (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Total</td>
<td>Cz relative theta</td>
<td>7.8</td>
<td>0.007*</td>
<td>.345</td>
<td>2.7</td>
<td>0.007*</td>
</tr>
<tr>
<td>DSM-IV Inattentive</td>
<td>Cz theta/ beta ratio</td>
<td>6.3</td>
<td>0.014*</td>
<td>.315</td>
<td>2.5</td>
<td>0.014*</td>
</tr>
<tr>
<td>DSM-IV Hyperactive/ impulsive</td>
<td>Cz theta/ beta ratio</td>
<td>6.1</td>
<td>0.016*</td>
<td>.309</td>
<td>2.4</td>
<td>0.016*</td>
</tr>
</tbody>
</table>

* Significant at p<0.05

Figure 1. QEEG showing increased frontal delta and theta power and decreased alpha and beta power in a child with ADHD.
DISCUSSION

Based on the understanding of the relationship between the frequency and amplitude of brain electrical discharges and states of mental awareness, neurophysiologists have examined whether individuals diagnosed with ADHD manifest any type of abnormality in brain regions associated with alerting, sustained concentration, behavioral inhibition, and working memory. The most commonly reported finding in electrophysiological studies of children with ADHD is increased low frequency activity (predominantly theta) compared with age-matched normal controls. Mann et al reported increased theta in prefrontal, midline regions and decreased posterior beta in a sample of 25 boys diagnosed with ADHD without hyperactivity when EEG recordings were obtained during academic challenges. Using the ratio of theta to beta to account for maturational and intra subject variability, Lubar and colleagues hypothesized that evidence of cortical slowing (a higher ratio of slow wave activity relative to fast EEG activity- i.e.: theta/ beta ratio) would be noted in individuals with ADHD. Their findings...
obtained during multiple tasks supported this hypothesis with Cz and Fz appearing the most promising for consideration.

Generally, fast wave activity (alpha and beta) is reduced in children and adolescents with ADHD. Matsuura et al. in a World Health Organization (WHO) study of several western pacific countries, reported that children with ADHD had more delta and fast theta activity and fewer alpha waves than age matched controls and a group of children with deviant behaviors. This is in accordance with our findings (Table 1) of the reduced alpha and increased delta activity in children with ADHD especially in the frontal leads.

We proposed that tolerance of ADHD symptoms in the community can result in significant pathology without the parents seeking psychiatric help. In the sixty children who completed the Conners’ rating scale, twenty one patients and fifteen control formed the DSM-IV Total >65 group. When we compared children who scored high on the DSM-IV scale to those with no or minimal symptoms, reduced beta activity was found in frontal, central and temporal leads (Table 2) which is in line with Mann et al. findings and may reflect the inability for sustained mental effort in those children. That the elevated theta/beta ratio didn’t reach significance between the two groups- though approximated significance (Table 2) may be explained by the small number of participants compared to the many previous studies that have indicated differentiation between groups with large number of participants. Also our participants were evaluated under normal resting conditions while participants in other studies were evaluated while involved in scholastic tasks (e.g.: reading, listening, drawing) and the theta/beta ratio was affected by the type of task involved. The total score of the DSM-IV was predicted by the Cz relative theta power if the analysis was confined to the midline frequencies (Table 5). This is in line with Mann et al. and in line with Bresnahan et al. reporting significantly more activity in the theta power in ADHD groups than the normal controls. Bresnahan and colleagues analyzed midline leads spectral power across age in ADHD and control groups- found that relative theta showed fronto-central distribution with Cz activity greater than Fz/Pz in both ADHD and control groups.

When a person is in an inattentive, unfocused state, slow EEG frequencies (3.5–8.0 Hz or “theta”) are predominant over the prefrontal and frontal cortex and at certain midline locations (e.g., the vertex or Cz). Frequency bands and theta/beta ratio were examined at a single active site (Cz, the vertex) since prior research had indicated that hypoural was evident at Cz, as well as, at locations dispersed across the frontal lobes. When spectral power of children with high inattention symptoms were analyzed at Cz, our results showed that children who scored high on the inattention scale had more theta waves power at Cz compared to those who scored low. They also had a higher theta/beta ratio (Table 3) and the theta/beta ratio at Cz predicted the inattention score (Table 5). In ADHD children, elevated theta activity has been observed primarily in the frontal brain region and has been linked to a decrease in attention. Hermens et al. found that ADHD subjects manifested excessive theta power during resting conditions, particularly in (left) frontal regions that correlated with poorer performance in the signal detection (oddball) attention task.

Our results also show that children with hyperactivity had lower Beta1 power at Cz than those with less hyperactivity (Table 4). Callaway et al. reported significantly decreased beta activity in hyperactive children compared to age-matched normals. Bresnahan and colleagues examined, the relationship between the age-related changes reported in clinical observation and changes in EEG activity occurring in a group of ADHD patients ranging in age from 6 to 42 years. Theta activity was elevated in the ADHD groups across all age groups compared with the normal controls. The extent of the reduction in relative beta activity in the ADHD groups compared to normal controls decreased with increasing age. Given that the hyperactivity component in ADHD reduces with age while the impulsivity component remains, these data, in their opinion, suggest that decreased beta activity may be linked to hyperactivity and increased theta activity to impulsivity in ADHD which is in line with our results. The theta/beta ratio at Cz also predicted the scoring of the hyperactivity/impulsivity scale (Table 5). Meta-analysis of 9 well-controlled studies (involving 1498 participants) on PSA in ADHD has revealed a predominance of power at 3.5 to 8.0 Hz, compared with 13 to 30 Hz, and previous literature reviews indicate that approximately 90% of patients diagnosed with ADHD exhibit elevated theta/beta power ratios over frontal and central midline cortical regions. A minority of patients diagnosed with ADHD (~ 10%) exhibit excessive beta activity (and lower theta/beta ratios), primarily in these same regions which is in line with our results.

Clinical research is seeking to examine the validity of a simplified QEEG indicator as a laboratory test for ADHD. Monastra et al. calculated an average power ratio for each person (pW theta/ pW beta) of 482 participants over four tasks (termed the “Attention Index”). A normative database was developed, which served as the basis for classification of individuals aged 6 to 30 as ADHD or "non-ADHD". Test sensitivity of this QEEG-derived Attention Index was 86%; specificity.
was 98%. Monastra, Lubar, and Linden then examined the reliability and validity of this simplified QEEG Scanning Process in a series of experiments involving 469 participants, aged 6 to 20. The results indicated that the QEEG Scanning Process was a reliable measure (r = .96) which could differentiate patients with ADHD from non-clinical controls (p < .001). Test sensitivity was 90%; specificity was 94%. Studies have used the 1.5 standard deviation cutoff for the theta/beta ratio to differentiate ADHD vs. normal controls or other childhood/adolescent disorders. They found that in the detection of ADHD in a diverse clinical sample, rating scales and EEG were both sensitive markers, whereas only EEG was specific. One potential limitation in the accuracy of rating scales is that the outcome can be significantly influenced by the bias of the informant. A telling sign is that there is commonly disagreement between the results of teacher and parent scales, with frequent discrepancies having been reported. Another potential shortcoming of rating scales is that the behavioral symptoms identified by the scales are not necessarily specific to ADHD, but instead are common to numerous disorders. While parent or teacher identification of ADHD by rating scales was reduced in accuracy when applied to a diverse clinical sample, theta/beta ratio changes remained consistent with the clinician’s ADHD diagnosis.

Our findings point that QEEG in ADHD is not yet a distinctive diagnostic test but may be a promising aid to the diagnosis. The theta / beta ratio may reflect alertness and behavior control in those children. We recommend the development of normative data of the theta/beta ratio both during resting baseline condition and task intervention in different age groups using a large number of control subjects who have been thoroughly evaluated for the absence of psychiatric disorders. This normative data will allow for the evaluation of the theta/beta power ratio as a diagnostic tool of ADHD and to compare its validity against rating scales and clinical evaluation. Further research requires the inclusion of large number of children and the standardization of the conditions under which the QEEG findings are obtained.

[Disclosure: Authors report no conflict of interest]

REFERENCES


Amer et al.: QEEG in children with ADHD


المختص العربي

رقم المخ الكمي الرقمي في الأطفال المصابين بفرط الحركة المصحوب بنقص الانتباه

بحثت الدراسة وجود نمط مميز لرسم المخ للأطفال المصابين باضطربات فرط الحركة المصحوب بنقص الانتباه باستخدام رسم المخ الكمي الرقمي. تم تقسيم رسم المخ للأطفال بمرتين طفلاً مصاباً باضطراب فرط الحركة المصحوب بنقص الانتباه وثلاثين طفلاً كонтراستية، وذلك بالتحليل الطيفي لقيم ترددات الفرقة (تيرا، تيرا، آلفا، بيتا) المطلقة ونسبة وربطها بنظام قياس كونرز لتقييم سلوك الطفل "تقييم الوالدين" - الميزة المطلقة المراجعة. أظهرت النتائج زيادة تردد بيتا ونقص قوة تردد Áلفا في المنطقة الأمامية خاصة، وذلك في عينة الدراسة بناءً على مقياس الانتباه DMS-IV.

كما أظهرت الدراسة أن الأطفال الذين سجلو أكثر من 65 على مقياس كونرز (DMS-IV) - من العينة الكليّة - لديهم قوة تردد بيتا 1 أقل في المنطقة الأمامية والعقلية والصداعية مقارنةً بسجلا أقل من 65. وعدد التحليل الراوي لمتافات التردد النسبية عند خط المنصف، بيتا بالنتيجة على المقياس مقارنة بسوق تردد بيتا النسبية عند Cz، وضع دراسة وحقاق (DMS-IV) أيضًا على مقياس (DMS-IV) الرسم الطيفي عند 65 على مقياس كونرز (DMS-IV) - من العينة الكليّة - لديهم قوة تردد بيتا أكثر ومقدمة بيتا أليّة. وضع دراسة وحقاق (DMS-IV) الذهين ملخص بلUTURE ثابت بيتا أعلى عند 65 على مقياس كونرز (DMS-IV) مقارنة بمعدل نسب على سجال أقل من 65، وأن الأطفال الذين سجلوا أكثر من 65 على مقياس كونرز (DMS-IV) معدل نسب سترا بالنتيجة على المقياس عند 65 عند خط المنصف.

وقد خلصت الدراسة إلى أن التحليل الكمي لرسم المخ للأطفال المصابين باضطراب فرط الحركة المصحوب بنقص الانتباه يظهر زيادة قوة الترددات المنخفضة وقلة قوة الترددات المرتفعة وزيادة نسبة بيتا، والتي قد تستعمل كمؤشر مساعد في التشخيص. وينظف عمل مقياسا لهذه النسبة في الأطفال الطبيعين كقاعدة للبحث القادم في دراسة فانثي في تشخيص اضطراب فرط الحركة المصحوب بنقص الانتباه.