



Quantitative Electroencephalographic changes in frontal areas during concentration in children with ADHD

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ABSTRACT

Background: Children with ADHD exhibit hypovolemia in the frontal lobe by anatomical imaging and reduced metabolism by functional imaging. They also produce more theta waves than the normal population. **Aim of the work:** detect the Quantitative Electroencephalography changes in the frontal areas during Continuous Performance Task (Test of variants of attention) in children with ADHD compared to normal children. **Methodology:** EEG was recorded for 2 groups of children each contained 15 children, a group of ADHD children and the other a normal control group during normal resting condition with eyes opened and during continuous positive task, the we compared the changes in the QEEG driven by concentration resulting from the CPT **Results:** Comparing both groups revealed statistically significant difference between the theta/beta ratio between the two groups in both conditions, also we found that the theta beta ratio decreased in normal group (during concentration) while in the ADHD group it increased. **Conclusion:** quantitative electroencephalographic markers namely the theta beta ration could play a role in the understanding or even diagnosis of attention deficit hyperactivity disorder. Aiming at identifying specific patterns of these findings can help develop a credible objective diagnostic test for ADHD.

Keywords: Theta/beta ratio, Frontal lobe, EEG (electroencephalography), CPT (Continuous Performance Task), TOVA (Test of variants of attention), ADHD (Attention deficit hyperactivity disorder), QEEG (quantitative electroencephalography).

Key words

Attention Deficit Hyperactivity Disorder (ADHD)

Theta/beta ratio

Electroencephalography (EEG)

Continuous positive task (CPT)

Quantitative Electroencephalography (QEEG)

Frontal lobe

Test of variants of attention (TOVA)

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List of Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
APA	American Psychiatric Association
CPRS-R-L	Conner's Parent Rating Scale-Revised; long version
CPT	Continuous positive task
CNS	Central Nervous System
DSM IV-TR	Diagnostic and Statistical Manual (fourth edition)- Text Revised
EC	Eyes closed condition
EEG	Electroencephalography
EO	Eyes open condition
ERP	Event Related Potential
HS	Highly significant
ICD - 10	International Classification of Diseases (tenth edition)
IQ	Intelligence Quotient
NS	Not significant
QEEG	Quantitative electroencephalography
RT	Reaction time
RT SD	Reaction time standard deviation
SD	Standard deviation
TOVA	Test of variants of attention

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INTRODUCTION

The EEG or electroencephalogram has long been used to record and study the electrical activity of the outermost layer of the brain – the cerebral cortex. It is usually thought of exclusively as a way to diagnose epilepsy (seizure disorders). In this routine EEG, a neurologist or electroencephalographer (EEG specialist) visually examines the traces of the oscilloscope which show the brain's electrical activity in the form of a line with repetitive wave-like activity. Hence the name “brainwaves” (*Hughes and John; 1999*).

It is well established that the speed of this EEG waveform, measured as the number of times per second that the wave goes from one peak to the next (cycles per second or cps), reflects the degree of activation of the area of the brain beneath the electrode. Slower waveform activity (fewer cycles per second), as in the delta, theta or alpha indicate lowered blood flow and fuel (glucose) use in that part of the brain. Faster activity as in the beta trace, shows increased brain activity. These types of brain electrical activity also reflect the level of arousal of the adult person: delta activity (2-4 cps) accompanies deep sleep, theta (4-7cps) states of drowsiness, alpha (8-11 cps) relaxed states. Beta range activity reflects an engaged or active brain, and, with very fast beta activity, an excited or urgent/emergency state of mind (*Loo & Barkley; 2005*).

In the last decade or so, a more advanced form of EEG has been developed, called quantitative EEG or qEEG, in which the signal is converted to digital form and compared to a database of individuals without any known neurologically based disorder. In this way, we are able to analyze the background activity with sophisticated statistical techniques to reveal patterns invisible to the naked eye. The results of these analyses can then be presented

in graphical form, resulting in topographical displays of brain electrical activity - sometimes called "brain maps" (*Hughes and John; 1999*).

Quantitative EEG (qEEG) involves computer-assisted imaging and statistical analysis of the EEG for detecting abnormalities, assisting the physician in making a diagnosis, and other purposes relating to patient care. Among the techniques of functional brain imaging, qEEG offers many advantages. It has an ideal temporal resolution in the millisecond time domain characteristic of neuronal information processing, employs no ionizing radiation, noninvasively images both excitatory and inhibitory cortical neuronal activity rather than secondary hemodynamic processes, and is relatively inexpensive and portable. Its formerly poor spatial resolution has increased dramatically as channel capacity has expanded from 20 a decade ago to 256 presently, with a 512-channel system expected for commercial release within the next year. Perhaps most importantly, several large qEEG normative (i.e., statistically representative) databases directly relevant to clinical psychiatry are available, and qEEG technology has advanced to the point where two systems have attained FDA approval (*Coburn et al; 2006*).

Attention Deficit Hyperactivity Disorder (ADHD):

It is the most frequently diagnosed neurobehavioral disorder in childhood. Although ADHD usually first presents in childhood, many persons with the disorder continue to experience symptoms throughout life. ADHD in adults is fairly common, though it often goes unrecognized. According to the American Academy of Pediatrics the prevalence in childhood is estimated at between 6 and 9%. Dennis Cantwell concluded "studies now suggest that as many as 60-70% of the children with this syndrome have continuing symptomatology in adult- hood" (*Wender; 1995*). This would mean that almost 5% of the adults are affected. According to (*Barkley; 1997*), clinically, ADHD in adults is

viewed as involving two major symptom dimensions: (a) Inattention and (b) Hyperactive-Impulsive behavior. This disorder may be co-morbid with some psychiatric disorders, especially with alcohol and drug abuse.

Diagnosis of the disorder in the adult population remains dependent on the skills and knowledge of the doctor. At present, no reliable objective measures of ADHD exist. In the last decade many studies have tried to define the neural correlates of ADHD, particularly changes in quantitative EEG (QEEG). Most of the studies concern the ADHD children and summarize that they have a reduced power in alpha and beta bands and an increased power in the delta and theta bands in comparison with the healthy control groups (*Clarke et al; 1998, Clarke et al; 2001a, Clarke et al; 2001b and Barry et al; 2003*). Furthermore, the theta/beta ratio has been introduced by *Lubar et al. 1991 and Monastra et al. 1999* as a diagnostic marker in ADHD children and *Clarke et al. 2001a, 2001b, 2002 and Pop-Jordanova et al. 2005* are several authors who have demonstrated that the children with ADHD have a higher theta/beta ratio than normal children.

Findings concerning the adolescent population with ADHD showed similar results. Namely, Hobbs et al. 2007 investigated EEG abnormalities in male adolescents with ADHD during an eyes-closed resting condition and found absolute dominance of delta and theta activity and a higher theta/beta ratio compared to the control subjects. Similar results (with increased theta activity, along with decreased beta power) but in eyes- open resting condition in adolescents with ADHD has been described by *Lazzaro et al; 1999*.

Opposite to the studies with children and adolescents, until now only a few EEG studies with adult ADHD patients have been carried out with different results. Thus, *Clarke et al.;2008* found global increase in the relative theta, with a decrease in the absolute delta activity, and midline reductions in the beta activity. While *Koehler et al.; 2009* confirmed increased alpha and slow wave

(theta) power in eyes-closed, along with no differences in the beta and delta power between ADHD adults and normal subjects. In the other two studies of ***Bresnahan et al.; 2002, 2006*** adult ADHD patients were investigated in an eyes-open condition and an increased power in the slow frequency bands (delta and theta power) as well as an elevated theta/beta ratio compared to the normal control subjects was described.

AIM OF THE WORK

The general aim of the present study is to detect the Quantitative Electroencephalography changes in the frontal areas during Continuous Performance Task in children with Attention deficit hyperactivity disorder compared to normal children.

Chapter one

Attention Deficit Hyperactivity Disorder

Introduction and definition

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common disorders in pediatric psychiatry. It is an impairing neuropsychiatric, neurodevelopmental debilitating disorder with preschool onset and persistent childhood condition. (*Faraone, et al., 2003*)

It is characterized by symptoms of developmental, inappropriate hyperactivity, inattention and impulsive behavior. (*Talaei et al., 2010*)

These symptoms can be translated into inappropriate behaviors for children with attention deficit hyperactivity disorder including but not limited to excessive talking, interrupting others, difficulty taking turns, excessive motor activity, and taking unnecessary risks. (*Barnard et al., 2010*)

Attention Deficit Hyperactivity Disorder is most commonly of the combined type (both inattention and hyperactivity present) and less commonly of the predominantly inattentive type ('ADD minus H') or the predominantly hyperactive-impulsive type; the latter two are quite likely to be underdiagnosed. (*Paul and Azra, 2008*)

Studies demonstrated that attention deficit hyperactivity disorder is a chronic condition with symptoms persisting into late adolescence and even adulthood. (*Hechtman, 2006; Kordon et al., 2006; Raggi and Chronis, 2006*)

AD/HD refers to a variable cluster of hyperactivity, impulsivity, and inattention symptoms, the occurrence of which substantially affects normal cognitive and behavioural functioning of the individual. Children and adolescents with AD/HD are at risk for later delinquency problems (*Satterfield et al; 1982*), and some symptoms may persist through the lifespan (*Weiss et al;*