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Quantitative EEG analysis in dexamphetamine-responsive adults with attention-deficit/hyperactivity disorder

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Abstract

Attention-deficit/hyperactivity disorder (AD/HD) is recognized as a disorder affecting children and adolescents and has more recently been documented to continue into adulthood in a proportion of patients. One of the common treatments for AD/HD is the use of stimulant medications. Numerous studies have examined the therapeutic effects of stimulant medications in children, adolescents and adults with the disorder, reporting improvements in attention, concentration, and hyperactive and impulsive behaviours. Several studies have also examined the effects of stimulants on the electroencephalograph (EEG) of children and adolescents with the disorder, but to date, there have been no studies examining the effects of stimulant medication on the EEG of adults with AD/HD. In the present study, we aimed to replicate previous EEG findings in adults with AD/HD relative to controls and to examine whether there was any change in this profile following treatment with dexamphetamine. The EEG was recorded at rest in an eyes-open condition from 50 adults diagnosed with AD/HD and assessed as good responders to treatment, both before and after treatment with dexamphetamine, and 50 control subjects. The pre-medication results are similar to those found in previous research that compared the EEGs of adults with AD/HD and control subjects. Following medication, there was a significant reduction in slow wave activity in the AD/HD group to levels similar to those in the control group. These results suggest that changes in brain function of good responders to dexamphetamine, as reflected in the EEG, may underlie the behavioural improvements observed in the clinical setting.

Keywords: Adults; Stimulants; Medication; AD/HD

1. Introduction

The DSM-IV (American Psychiatric Association, 1994), while acknowledging that attention-deficit/hyperactivity disorder (AD/HD) is not restricted to children, is limited in not providing a specific list of symptoms directed at the adult population. At this time, AD/HD in adults is viewed as involving two major symptom dimensions, (1) Inattention and (2) Hyperactive–Impulsive behaviour (Barkley, 1997), and ultimately, diagnosis of the disorder in the adult population remains dependent on the skills and knowledge of the diagnostician.

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EEG studies have provided a more objective means of quantifying differences between younger subjects with AD/HD and controls. There are numerous studies reporting differences in the electrophysiological measures of children and adolescents with AD/HD and age-matched controls (Chabot and Serfontein, 1996; Matsuura et al., 1993). The most commonly reported findings are increased low-frequency activity (predominantly theta) and decreased high-frequency activity (predominantly beta) compared with age-matched normals. Mann et al. (1992) reported increased theta and decreased beta 1 in a sample of 25 boys diagnosed with AD/HD without hyperactivity. Using discriminant analysis, they demonstrated that low-frequency activity (theta) discriminated the target group with greater than 80% accuracy. Clarke et al. (1998, 2001b,d, 2002) reported increased levels of frontal theta activity and reduced posterior beta activity in AD/HD children compared with controls; but it should be noted that there are also reports of increased beta in some children with AD/HD (Clarke et al., 2001c,e). A recent review of the literature in this area by Barry et al. (2003) reported consistencies across several frequency bands in relation to AD/HD, supporting this approach as an objective diagnostic tool. But there is much evidence that EEG activity changes systematically as a function of age (Matousek and Petersen, 1973; John et al., 1980; Clarke et al., 2001a). In this context, it is important to clarify the EEG profiles of adults with AD/HD.

Bresnahan et al. (1999) was the first study to investigate the EEG profiles of children, adolescents and adults with AD/HD. The results indicated that slow wave activity (absolute and relative theta) remained elevated from childhood through adolescence into adulthood, with a systematic decrease in relative beta activity with age. Bresnahan and Barry (2002) subsequently examined whether this EEG profile was specific to adults with AD/HD. EEG was recorded from a group of adults with AD/HD and another group of non-AD/HD adults who presented with some of the symptoms of the disorder but failed to meet the diagnostic criteria. The AD/HD group differed from both the non-AD/HD patient and normal control groups on the basis of elevated theta activity.

Drug therapy is the most common form of treatment for children and adolescents with AD/HD. The first controlled trial reporting the calming effect of amphetamines in children with AD/HD was published in 1937. Psychostimulant medication increases the arousal or alertness of the central nervous system (Barkley, 1990; Lawrence et al., in press), which results in the therapeutic effect. Many studies have documented the efficacy of stimulant medication in reducing the core symptoms of AD/HD (inattention, hyperactivity and impulsivity) and improving behavioural, academic and social function (Barkley, 1977). Overall, results indicate that stimulant drugs such as methylphenidate, pemoline and dexamphetamine significantly diminish the core symptoms of AD/HD. Further, these drugs are also reported to improve academic and occupational function, self-esteem and social interaction (Wilens and Biederman, 1992). There are fewer studies investigating therapeutic effects of stimulant treatment in adults with AD/HD. In the main, these have examined the effect of methylphenidate (Wood et al., 1976; Wender et al., 1981), but more recent studies (Paterson et al., 1999; Horrigan and Barnhill, 2000) have examined amphetamine. A reduction in motor activity, impulsivity and inattention in response to stimulants has been clearly documented (Spencer et al., 1996). Observed variability between studies has been attributed to differences in dosage levels, comorbidity factors and the diagnostic criteria used.

A number of studies have also examined the effect of stimulant medication on EEG measures in children, but results have been somewhat inconsistent. Lubar et al. (1999) reported no global changes in the EEG resulting from medication. Loo et al. (1999) reported that children with a positive medication response showed a reduction in theta and alpha activity and an increase in beta in the frontal regions, i.e., good responders to methylphenidate demonstrated normalization of the EEG. Clarke et al. (2002, 2003a) also reported medication changes in the EEG approaching normalization. Their unmedicated AD/HD groups showed greater absolute delta and theta activity, less beta activity posteriorly and less relative alpha activity. Following treatment with stimulant medication, there were reductions in absolute and relative theta activity and an increase in relative beta. Rowe et al. (2005) reported a trend towards reduction in relative theta and alpha power with stimulant medication in a small group of AD/HD adolescents. It is interesting to note that Hermann and Kubicki (1981) found that amphetamines produced increases in alpha power