ORIGINAL ARTICLE

ADHD as a Risk Factor for Incident Unprovoked Seizures and Epilepsy in Children

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Background: Attention-deficit/hyperactivity disorder (ADHD) occurs more frequently than expected in prevalent cohorts with epilepsy. The association has been attributed to the epilepsy or its treatment, although it is impossible to determine in previous studies which condition occurs first.

Objectives: To conduct a population-based case-control study of all newly diagnosed unprovoked seizures among Icelandic children younger than 16 years to address the question of time order.

Design: Children with seizures were matched to the next 2 same-sex births from the population registry. The Diagnostic Interview Schedule for Children was used to make a *DSM-IV* diagnosis of ADHD in a standardized fashion among cases and controls aged 3 to 16 years.

Results: A history of ADHD was 2.5-fold more common among children with newly diagnosed seizures than among control subjects (95% confidence interval [CI], 1.1-5.5). The association was restricted to ADHD predominantly inattentive type (odds ratio [OR], 3.7; 95% CI, 1.1-12.8), not ADHD predominantly hyperactive-impulsive type (OR, 1.8; 95% CI, 0.6-5.7) or ADHD combined type (OR, 2.5; 95% CI, 0.3-18.3). Seizure type, etiology, sex, or seizure frequency at diagnosis (1 or >1) did not affect findings.

Conclusion: Attention-deficit/hyperactivity disorder occurs more often than expected before unprovoked seizures, suggesting a common antecedent for both conditions.

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THE RELATIONSHIP BETWEEN epilepsy and attention-deficit/hyperactivity disorder (ADHD) has been poorly described. Clinically, there is a perception that ADHD is more common among children with epilepsy, due to the epilepsy or its treatment.[1,2] In studies of children with prevalent epilepsy, 28.1% to 39% had "hyperactivity-impulsivity,"[3,4] 42.4% had problems with attention,[5] and 13.9% had ADHD.[6] These cross-sectional studies cannot examine the temporal relationship between ADHD and epilepsy, and standardized symptom profiles were seldom used to make diagnoses.

The largest studies[3,4] of the association between hyperactivity-impulsivity and prevalent epilepsy arise from the 1988 National Health Interview Survey. Hyperactivity assessed by the Behavior Problem Index was 5.7-fold more prevalent among 121 children with epilepsy (28.1%), aged 5 to 17 years, compared with 3950 control subjects (4.9%).[4] "Highly impulsive behavior," according to 4 questions, occurred among 39% of 118 children with a history of epilepsy, aged 6 to 17 years, compared with 11% of 11 042 children without a history of epilepsy.[3]

In 2 prior studies[7,8] of children with incident unprovoked seizure, behavioral disturbances before the onset of first seizure were more frequent than among controls. In the larger study of 148 children with first unprovoked seizure and 89 seizure-free sibling controls, attention problems as assessed by the Child Behavior Checklist were 2.4-fold more common before identification of the first seizure (8.1%) than in controls (3.4%).[7]

We undertook a population-based case-control study of newly diagnosed unprovoked seizures among Icelandic children younger than 16 years to address whether ADHD is associated with an increased risk for developing unprovoked seizures. An Icelandic translation of the Diagnostic Interview Schedule for Children[9] was adapted to ascertain symptoms of ADHD in a standardized fashion and to arrive at a *DSM-IV*[10] diagnosis.

METHODS

STUDY SUBJECTS

Cases

Our cases were drawn from an ongoing seizure surveillance system at regional health care centers, hospitals, emergency departments, ra-

diology laboratories, neurophysiology laboratories, and offices of pediatricians, neurologists, and neurosurgeons throughout Iceland. Study nurses maintained an active surveillance of seizure disorders at these facilities. Once a potential case was identified, the medical records were reviewed to verify the occurrence of an incident seizure disorder. *Unprovoked seizure* was defined as a seizure without an identified proximate precipitant (fever, head trauma, central nervous system infection, etc).[11] *Epilepsy* was defined as at least 2 unprovoked seizures regardless of seizure type. Definitions of seizure types are discussed in the "Measures and Assessments" subsection.

The diagnoses of first unprovoked seizure and incident epilepsy were made only after a complete interview with the parents. Therefore, the group with epilepsy includes children initially thought to have had a first unprovoked seizure in whom more detailed interview revealed prior unrecognized unprovoked seizures.

Cases in this analysis were all Icelandic children between 3 and 16 years of age with unprovoked seizures or epilepsy first diagnosed between December 1, 1995, and February 28, 1999. The participation rate was 96.5%.

Controls

Age-matched controls were selected from the population registry as the next 2 same-sex births who were alive, resided in Iceland at the time of the index seizure, and did not have a history of unprovoked seizure on the date of the case's incident seizure. Among controls, the participation rate was 94.1%.

MEASURES AND ASSESSMENTS

Psychiatric Assessment

After obtaining informed consent, a structured telephone interview was administered to parents of cases and controls. Within this interview, we used an Icelandic translation of the lifetime module of the Diagnostic Interview Schedule for Children to identify symptoms of ADHD among cases and controls 3 years and older and to make a *DSM-IV* diagnosis. Therefore, parents were asked whether their child had ever exhibited certain characteristic behaviors before the date of the cases' incident unprovoked seizure or epilepsy. Parents were also asked about the age at which these behaviors began; the age at which the behaviors ended; the effect of the behaviors on home, school, and friends; whether medical care had been sought because of the behaviors; and whether medication was given to treat the behavioral disorder. Diagnoses of ADHD, according to *DSM-IV*, were made: ADHD predominantly inattentive type (ADHD-I), ADHD predominantly hyperactive-impulsive type (ADHD-H), or ADHD combined type (ADHD-C). We also evaluated any inattention (ADHD-I or ADHD-C) and ADHD. We asked about symptoms beginning at age 3 years and analyzed our data with and without preschoolers, because *DSM-IV* omits preschoolers from the diagnosis of ADHD. In addition, we considered the number of ADHD symptoms as a continuous variable.

Neurological Assessment

Three of us (W.A.H., P.L., and E.O.) reviewed all information, including results of neuroimaging and electroencephalography, to classify cases by seizure type and etiology.

Seizure Type. The classification of seizure type was based on the description written by the attending medical personnel and information obtained from parents. Seizure type was categorized based on criteria of the International League Against Epilepsy[11] as generalized from onset or as partial from onset. *Generalized-onset seizures* included cases with generalized tonic, clonic, tonic-clonic, atonic, absence, or myoclonic seizures. *Partial seizures* included cases with simple or complex partial seizures with or without secondary generalization. If the clinical characteristics of the seizure could not be determined, seizures were characterized as "unknown" seizure type.

Etiology. Seizures were categorized as symptomatic or as idiopathic/cryptogenic, according to the recommendations of the International League Against Epilepsy Commission on Epidemiology.[11] Seizures were considered *symptomatic* in the presence of a history of a central nervous system insult associated with an increased risk of epilepsy (ie, stroke, head trauma, mental retardation, cerebral palsy, and meningitis). The interval between the seizure and the neurological insult had to be more than 1 week, but was usually months or years. Seizures were also considered symptomatic in the presence of nonstatic central nervous system conditions (central nervous system tumors and degenerative neurological diseases). Seizures were considered *idiopathic/cryptogenic* in the absence of an acute precipitating factor or a history of prior neurological insult.

PROCEDURES

Cases

Once the treating physician had given permission to contact parents or guardians for study purposes, an introductory letter explaining the purpose of the study was sent, followed by a telephone contact, at which time verbal agreement to participate in the study was obtained and a time scheduled to administer the structured interviews. No cases were lost because of failure of the treating physician to give permission to contact the family.

Controls

A letter was sent to parents or guardians of potential controls explaining our study. This was followed by a telephone contact to determine willingness to participate. If permission was not granted, the next eligible control was identified and the same procedure followed until 2 controls agreed to participate. Potential controls were excluded if they had a history of unprovoked seizure or were a sibling of the case.

Institutional Review Board

The study was reviewed and approved by the Icelandic Data Protection Commission (Tolvunefnd Rikisins), Ethics Committee of the Chief Medical Officer of Iceland, Medical Ethics Board of the National University Hospital of Iceland (Landspitalinn), Institutional Review Board of the College of Physicians & Surgeons of Columbia University, and the Review Board of the National Institutes of Health, Bethesda, Md.

STATISTICAL ANALYSIS

We used *t* test to compare continuous variables and χ^2 statistic to compare categorical variables. We evaluated the prevalence of ADHD by age at seizure diagnosis of the case and the matched control. Age categories were 3 to 5, 6 to 10, and older than 10 years.

Data were analyzed with SAS,[12] using conditional logistic regression for matched sets as formulated by Breslow and Day.[13] Using unprovoked seizure as the dependent variable, models were constructed for the whole study population and separately by seizure type, etiology, and sex. The following variables were evaluated as potential confounders of the association between ADHD and unprovoked seizures: a first-degree family history of unprovoked seizure or epilepsy, head injury, prematurity (<266 days' gestational age), and past febrile seizures. Confounders were variables that changed the natural logarithm of the odds ratio (OR)

for ADHD by at least 10%. Only one case was diagnosed as having a neurodevelopmental abnormality present from birth; therefore, this condition was not examined as a confounder. Adjustment for a history of febrile seizures changed the natural logarithm of the OR for ADHD-H by more than 10%, but did not substantially alter the natural logarithm of the OR for ADHD-I or ADHD-C. The confounding effect of a history of febrile seizures may have been due to chance given the number of potential confounders tested; therefore, this variable was eliminated from the final model.

RESULTS

One hundred nine cases and 218 controls were 3 years or older. The mean age for cases and controls was 9.2 years (**Table 1**). Forty-six cases were identified owing to a single incident unprovoked seizure and 63 were owing to incident epilepsy. Most cases were male. Partial-onset seizures occurred in 51.4% of cases, and most cases were idiopathic/cryptogenic. Seizure type at diagnosis was unknown in 1 case. Imaging abnormalities on computed tomography or magnetic resonance imaging were present in 10.1% of cases, and 64.2% of cases showed electroencephalographic abnormalities.

Two cases with symptoms of ADHD otherwise meeting *DSM-IV* criteria were classified as unexposed for the analyses because their symptoms of ADHD had not persisted for at least 6 months before the onset of seizures.

RISK OF UNPROVOKED SEIZURES AFTER ADHD

Attention-deficit/hyperactivity disorder was associated with an increased risk for developing incident unprovoked seizure. This association was significant for ADHD-I, but not for ADHD-H or for ADHD-C. As shown in **Table 2**, there was a 2.5-fold increased risk for unprovoked seizure in children with ADHD (95% confidence interval [CI], 1.1-5.5). Having ADHD-I increased the risk for unprovoked seizure 3.7-fold (95% CI, 1.1-12.8). Any inattention (ADHD-I or ADHD-C) increased the risk for unprovoked seizure 3.3-fold (95% CI, 1.1-10.1; data not shown). This pattern was observed among children with partial-onset seizures, generalized-onset seizures, and idiopathic/cryptogenic seizures, but was significant only for the group as a whole. Cells in which the controls were unexposed prevented calculation of the OR for remote/progressive symptomatic seizures (Table 2). Restricting our analysis to children 5 years and older, the risk of unprovoked seizures was increased 2.1-fold for ADHD.

Compared with controls, cases had a greater mean number of symptoms of ADHD-I (2.4 vs 0.9, $P<.001$), ADHD-H (1.4 vs 0.6, $P=.01$), and ADHD-C (3.7 vs 1.5, $P<.001$), regardless of *DSM-IV* diagnoses of these disorders. The OR for unprovoked seizure for each unit increase in the number of symptoms was 1.17 (95% CI, 1.08-1.26) for ADHD-I, 1.15 (95% CI, 1.04-1.27) for ADHD-H, and 1.10 (95% CI, 1.05-1.16) for ADHD-C.

We examined our data to determine whether unrecognized absence seizures or delayed diagnosis of complex partial seizures contributed to the diagnosis of ADHD-I. There were 8 children with absence seizures: none met criteria for ADHD-I, 1 met criteria for ADHD-H, and none met criteria for ADHD-C. There were 37 children with complex partial seizures: 3 met criteria for ADHD-I, 3 met criteria for ADHD-H, and none met criteria for ADHD-C. Among the 3 children with ADHD-I and complex partial seizures, 1 had epilepsy with 8 days separating the first seizure from the second seizure, and 2 had 1 seizure only (one prolonged with an accompanying Todd paralysis and the other with secondary generalization). Excluding cases with complex partial seizures and their controls from the analyses did not change the results.

We also examined our data to determine whether the interval between the first unprovoked seizure and diagnosis might explain the results. Results were unchanged when children with a single unprovoked seizure at diagnosis were analyzed separately from children with recurrent unprovoked seizures at diagnosis (ie, epilepsy) (Table 2). In addition, among children with epilepsy, the median time between first unprovoked seizure and epilepsy diagnosis was 61 days (interquartile range, 12-367 days).

No children in our study had experienced a head injury before the first unprovoked seizure. Adjusting for a first-degree family history of unprovoked seizure or epilepsy, or for prematurity, did not alter the association between ADHD and unprovoked seizures. Electroencephalographic abnormalities were not associated with ADHD ($P=.81$).

Table 1. Characteristics of Cases and Controls*

Factor	Cases (n = 109)	Controls (n = 218)
Single unprovoked seizure	41.3	NA
Epilepsy	58.7	NA
Mean ± SD age, y†	9.2 ± 3.5	9.2 ± 3.5
Sex		
Male	56.9	56.9
Female	43.1	43.1
Family history of afebrile seizure		
Yes	9.2	4.6
No	90.8	95.4
Past febrile seizures		
Yes	11.9	7.8
No	88.1	92.2
Prematurity (<266 days' gestation)		
Yes	6.4	4.1
No	93.6	95.9
Past head injury		
Yes	0.0	0.0
No	100.0	100.0
Seizure type		
Partial-onset	51.4	NA
Generalized-onset	47.7	NA
Unclassifiable	0.9	NA
Etiology		
Idiopathic/cryptogenic	89.0	NA
Remote/progressive symptomatic	11.0	NA
EEG abnormality		
Yes	64.2	NA
No	33.0	NA
EEG not done	2.8	NA
MRI or CT abnormality		
Yes	10.1	NA
No	72.5	NA
Imaging not done	17.4	NA

Abbreviations: CT, computed tomography; EEG, electroencephalographic; MRI, magnetic resonance imaging; NA, not applicable.
*Data are given as percentages unless otherwise indicated.

Table 2. Attention-Deficit/Hyperactivity Disorder as a Risk Factor for Incident Unprovoked Seizure in Icelandic Children

Diagnosis	No. of Cases	No. of Controls	Odds Ratio* (95% Confidence Interval)
Whole group (109 cases and 218 controls)			
ADHD-I	7	4	3.7 (1.1-12.8)
ADHD-H	6	7	1.8 (0.6-5.7)
ADHD-C	2	2	2.5 (0.3-13.3)
ADHD	15	13	2.5 (1.1-5.5)
Referent	94	205	1.0 (Referent)
Partial onset (56 cases and 112 controls)†			
ADHD-I	3	1	5.2 (0.5-50.4)
ADHD-H	4	5	1.7 (0.4-7.0)
ADHD-C	0	2	NA
ADHD	7	8	1.9 (0.6-5.9)
Referent	49	104	1.0 (Referent)
Generalized onset (52 cases and 104 controls)†			
ADHD-I	4	3	2.7 (0.6-11.9)
ADHD-H	1	2	1.0 (0.1-11.0)
ADHD-C	2	0	NA
ADHD	7	5	2.8 (0.9-8.8)
Referent	45	99	1.0 (Referent)
Idiopathic/cryptogenic (97 cases and 194 controls)			
ADHD-I	4	4	2.1 (0.5-8.6)
ADHD-H	6	6	2.2 (0.7-7.2)
ADHD-C	2	2	2.2 (0.3-16.2)
ADHD	12	12	2.2 (0.9-5.0)
Referent	85	182	1.0 (Referent)
Remote symptomatic (12 cases and 24 controls)			
ADHD-I	3	0	NA
ADHD-H	0	1	NA
ADHD-C	0	0	NA
ADHD	3	1	6.0 (0.6-57.7)
Referent	9	23	NA
Epilepsy (64 cases and 128 controls)			
ADHD-I	5	2	5.0 (1.0-25.8)
ADHD-H	4	4	2.3 (0.5-10.4)
ADHD-C	1	1	2.0 (0.1-32.0)
ADHD	10	7	3.1 (1.1-8.6)
Referent	54	121	1.0 (Referent)
Single unprovoked seizure (45 cases and 90 controls)			
ADHD-I	2	2	2.3 (0.3-17.7)
ADHD-H	2	3	1.3 (0.2-8.0)
ADHD-C	1	1	2.6 (0.1-45.9)
ADHD	5	6	1.7 (0.5-6.2)
Referent	40	86	1.0 (Referent)

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ADHD-C, ADHD combined type; ADHD-H, ADHD predominantly hyperactive-inattentive type; ADHD-I, ADHD predominantly inattentive type; NA, not applicable.

*Conditional, adjusted for age and sex.

†One case with unknown seizure type missing.

Among cases, epileptiform electroencephalographic abnormalities were present in 71.4% with ADHD-I, 50.0% with ADHD-H, and 50.0% with ADHD-C; no children with ADHD had rolandic spikes on the electroencephalogram. The ORs did not differ for the different forms of ADHD when separate analyses were conducted among cases with epileptiform electroencephalographic abnormalities and among cases without epileptiform electroencephalographic abnormalities (data not shown).

PREVALENCE OF ADHD

A lifetime history of ADHD-I occurred in 6.4% of 109 cases (n=7) and 1.8% of 218 controls (n=4). A lifetime history of ADHD-H occurred in 5.5% of cases (n=6) and 3.2% of controls (n=7). A lifetime history of ADHD-C occurred in 1.8% of cases (n=2) and 0.9% of controls (n=2).

The age distribution of ADHD differed for cases and controls; however, the differences were not statistically significant. Among cases younger than 5 years (**Figure 1**), ADHD-I was more common among cases than controls (7.7% vs 0.0%). Cases aged 5 to 10 years were more likely than their matched controls to meet criteria for ADHD-I (7.0% vs 0.9% for ADHD-I, 7.0% vs 3.5% for ADHD-H, and 3.5% vs 0.9% for ADHD-C). There was no difference in the frequency of ADHD diagnoses between cases and controls older than 10 years. Among cases and controls (**Figure 2**), there was a nonsignificant increase in the lifetime prevalence of ADHD-I and ADHD-H for boys compared with girls.

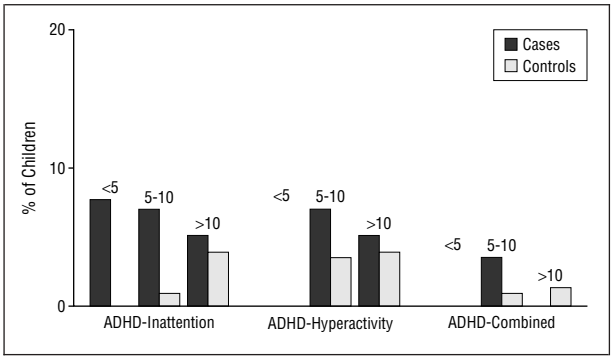

Figure 1. Lifetime prevalence of attention-deficit/hyperactivity disorder (ADHD) by age (in years).

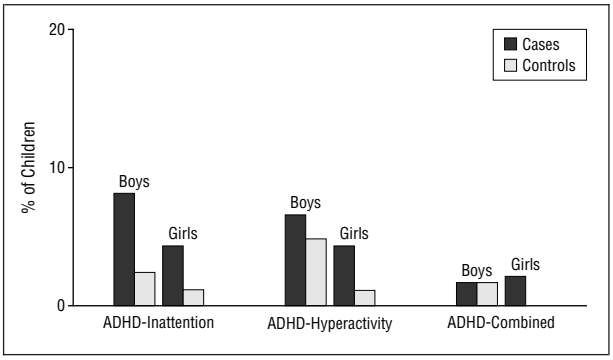

Figure 2. Lifetime prevalence of attention-deficit/hyperactivity disorder (ADHD) by sex.

Medication for ADHD was prescribed to 7 children with ADHD: 4 cases with ADHD and 3 controls with ADHD. Among cases, unspecified medications were prescribed to 2, methylphenidate hydrochloride to 1, and fluoxetine hydrochloride and promethazine hydrochloride to 1. Among controls, thioridazine hydrochloride was prescribed to 1, amitriptyline hydrochloride to 1, and methylphenidate, moclobemide, and clomipramine hydrochloride to 1.

COMMENT

Children with incident unprovoked seizure were 2.5-fold more likely than age- and sex-matched controls to have a parent-reported history of ADHD, meeting *DSM-IV* criteria before seizure onset. The association was restricted to ADHD-I. Neither ADHD-H nor ADHD-C was associated with an increased risk for unprovoked seizure. Power was limited for analyses of subgroups.

Among controls, we found a lifetime prevalence for ADHD of 6.0% and an excess of boys. This is similar to reports from other population-based research.[14] The lifetime prevalence of ADHD among cases was twice that of controls, and an earlier onset seems likely among cases.

There is no doubt that ADHD exists among preschoolers,[15-17] but diagnosis is more difficult in this age group because of overlap with normal age-related behavior. Among children meeting criteria for ADHD as preschoolers, between 50%[15] and 77%[17] have persistent symptoms later in childhood. When we analyzed our data excluding preschoolers, we found the same pattern of risk for unprovoked seizures and epilepsy.

In cross-sectional studies,[1-6] hyperactivity and inattention have been attributed to epilepsy or its treatment. One prior study[7] found that inattention was more common among children with new-onset seizures than sibling controls. This study was not population-based, it did not diagnose ADHD, and 33.9% of the children with seizures had prior unrecognized seizures.

Attention-deficit/hyperactivity disorder and seizures may be comorbid conditions. That is, the 2 disorders may occur together owing to a causal relationship between them or owing to an underlying vulnerability to both disorders. A history of prior ADHD-I increased the risk for developing unprovoked seizures: 6.4% of our cases had ADHD-I before their seizures. Dunn et al[18] reported that 24% of children with prevalent epilepsy had ADHD-I and 2.3% had ADHD-C. Children with ADHD-I before their diagnosis of epilepsy were not excluded in the study by Dunn et al. However, the proportion with ADHD-I was substantially greater than we observed before the occurrence of seizures. Taken together, these studies may suggest a common underlying vulnerability to unprovoked seizures and ADHD-I.

Studies[19-22] examining the risk of developing seizures in children with a diagnosis of ADHD have not been population-based. These studies have reported small numbers of ensuing unprovoked seizures during short follow-up. Nonetheless, the percentage who develop unprovoked seizures (0.2%-2%[19,20,22]) is greater than the expected rate, because the average annual incidence of seizures is approximately 0.05 per year in children aged 5 to 16 years.[23] Therefore, these studies suggest an increased risk of developing seizures in children with ADHD that is far in excess of the 3-fold increase we observed in our study.

We found that epileptiform electroencephalographic abnormalities were common in children with ADHD and unprovoked seizures, but failed to find a difference in the increased risk for seizures associated with ADHD when analyses were conducted separately for cases with and without electroencephalographic abnormalities. Others have found epileptiform electroencephalographic abnormalities in 14.6% to 30%[19,22] of children with ADHD and rolandic spikes in 5.6%.[21]

MECHANISM

Although noradrenergic systems have not generally been implicated in epileptogenesis, the area has not been extensively studied. Evidence for a relationship comes from genetic models of audiogenic seizures.

The mechanism of ADHD-I may share a common underlying antecedent with unprovoked seizure through a hypothesized link to deficits in the central norepinephrine system. Among boys with ADHD-I, urinary epinephrine levels were significantly lower during 3 hours of cognitive testing compared with a non-ADHD group.[24] Others have suggested that the central norepinephrine system may be dysregulated in ADHD so that it does not prime the cortical anterior executive attention system effectively.[25] Seizures may also be under the control of the noradrenergic system.[26] In the genetically epilepsy-prone rat, there is a heritable susceptibility to audiogenic and other induced seizures. These rats have deficits in the noradrenergic system,

including reduced norepinephrine content in several brain regions.[27]

LIMITATIONS

Misdiagnosis of ADHD-I, recall bias, and interviewer bias are unlikely explanations of our results. Misdiagnosis of ADHD-I was unlikely because this diagnosis was independent of absence seizures or complex partial seizures.

Recall bias was unlikely for 2 reasons. First, as expected from population-based prevalence studies,[28,29] the lifetime prevalence of ADHD was greater in boys than girls for cases and controls. Second, the association is specific for ADHD-I and not ADHD-H. Recall bias would predict that the association would be seen for all subtypes of ADHD. Third, there was no difference in the lifetime prevalence of ADHD between cases and controls older than 10 years. This is the age group most prone to recall bias, because the onset of ADHD symptoms would be expected in younger children.

Interviewer bias was also unlikely for the following reasons: interviewers were unaware of the hypotheses; the diagnosis of ADHD does not depend only on collected symptoms, but on duration of symptoms, age at first symptoms, and impairment in at least 2 settings, and the interviewers were unaware of these diagnostic criteria; the association was specific for ADHD-I, whereas interviewer bias would predict an association for all subtypes; and interviewer bias would predict a greater endorsement of all factors on the interview, especially those known to be related to epilepsy. However, we did not find an association between head injury and seizures in our data. Finally, of the 28 children with ADHD identified by our screening procedure, 11 children had been seen by a developmental pediatrician, whose records confirmed the appropriate diagnosis in all.

Ascertainment of ADHD was retrospective among the older children in this study. This may account for the decreasing lifetime prevalence of ADHD with increasing age that we observed among cases. Others have reported a decrease in prevalence with increasing age.[30] This has been attributed to underreporting of lifetime history due to remission or effective use of medication in the older age group. In our study, parents of older children may have reported on current symptoms rather than current and past symptoms.

CONCLUSIONS

Attention-deficit/hyperactivity disorder was associated with an increased risk for incident unprovoked seizure. Therefore, ADHD precedes the development of epilepsy, and ADHD or its determinants must be considered risk factors for epilepsy. The association was specific for ADHD-I and not ADHD-H. Attention-deficit/hyperactivity disorder may occur with a greater frequency than expected after the diagnosis of epilepsy, but appropriate population-based studies excluding preexisting ADHD have not yet been done to address this question, to our knowledge.

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