

Parental ADHD Status and its Association with Proband ADHD Subtype and Severity

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Objective To better understand the familial transmission of attention deficit hyperactivity disorder (ADHD), a highly heritable disorder, the effects of paternal and maternal ADHD status on probands' ADHD symptoms and subtypes were investigated.

Study design In 323 trios with ADHD, data from a structured interview and a self-report scale (score of >21) were used to determine ADHD probands' diagnostic status and parental ADHD status, respectively. Parental ADHD status on proband ADHD severity and subtypes was investigated.

Results ADHD criteria were endorsed by 23% of fathers and 27% of mothers, and by at least one parent in 41% of the cases. ADHD severity was higher for children whose parents had ADHD versus those whose parents were without it. Paternal ADHD was associated with an increased likelihood of ADHD combined subtype (odds ratio = 3.56) and a decreased likelihood of the inattentive subtype (odds ratio = 0.34) in male children.

Conclusions Parental ADHD status appears to confer different risks for the severity of hyperactive-impulsive and inattentive symptoms depending on parental sex; however, parental ADHD self-report scale score has low to negligible correlation with proband's ADHD severity. Biparental ADHD does not appear to have an additive or synergistic effect on the proband's ADHD severity. (*J Pediatr* 2010;157:995-1000).

Attention deficit hyperactivity disorder (ADHD) is highly heritable, but familial transmission is not well understood. Familial aggregation was observed in early ADHD studies, with higher rates reported in siblings of ADHD probands (20.8% vs 5.6% in control subjects),¹ among first-degree family members of male² and female probands^{3,4} with ADHD and in second-degree relatives.⁵ Shared genes rather than shared environment were suggested to be primarily responsible for transmitting ADHD according to adoption studies of children with ADHD, with reports of 18% ADHD in biologic versus 6% in adoptive parents.⁶

ADHD in siblings has been widely investigated through numerous studies that assessed heritability (estimated at 51% to 90%),⁷ as well as the role of proband sex.⁸⁻¹³ Adult ADHD has been investigated as well;¹⁴⁻¹⁶ however, the relationship between parental ADHD and proband's ADHD has not been widely explored. In a study of boys and girls with ADHD and a maternal history of ADHD compared with children with ADHD and a paternal history of ADHD, the maternal history group had greater levels of impairment than the paternal group, and girls' scores were lower than boys' scores in the paternal history group and equaled or exceeded boys' scores in the maternal history group.¹⁷ In another study of families with multiple members affected with ADHD, female probands were more likely to have at least one parent with ADHD than male probands.¹⁸ These findings differ from other reports in which the prevalence of ADHD in families did not differ in female and male cohorts.¹⁹ Subtyping, however, may be important as indicated by a recent study in which higher parental psychopathology was reported in families of girls but not of boys with combined ADHD compared with the inattentive subtype.²⁰

In this report, data from 323 trios were used to investigate the association between parental ADHD and ADHD proband severity and subtypes. We hypothesized that ADHD severity and subtype membership differs in ADHD probands depending on parental ADHD status.

Methods

This study included 323 trios (ADHD proband and both biologic parents), a subset of families from 500 trios with ADHD who were enrolled in a genetic ADHD

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|--------|---|
| ADHD | Attention deficit hyperactivity disorder |
| ANOVA | Analysis of variance |
| ASRS | ADHD Self-Report Scale |
| IQ | Intelligence quotient |
| K-SADS | Kiddie-Schedule for Affective Disorders and Schizophrenia |
| SES | Socioeconomic status |

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study. ADHD proband age ranged from 6 to 18 years, and all families were North American of European descent. Individuals of other ancestries were not included because this was a genetic study, and haplotype frequencies vary substantially across major world populations, lowering the power of the study to detect genetic association if multiple ethnic groups were included.

The 500 families with ADHD included 39 families with two siblings and 8 families with 3 siblings. In families with more than one sibling, only the first child (case A) evaluated was included, irrespective of age, leaving a total of 449 trios. Among 449 trios, complete adult ADHD Self-Report Scale (ASRS) data for both parents was available in 323 trios, and these are the data used for the analyses in this report.

The study was approved by the Institutional Review Boards of The Children's Hospital of Philadelphia and the University of Pennsylvania School of Medicine. Parents provided consent and children assent.

Families were recruited from pediatric and behavioral health clinics in the Philadelphia area. Phone screenings were conducted to determine age range of 6 to 18 years, presence of ADHD symptoms, ancestry, availability and willingness to participate in a genetic study from both biological parents. Exclusionary criteria included gestational age <36 weeks, IQ scores <75, major medical diagnoses (excluding asthma), and neurologic issues (eg, seizures, fetal alcohol syndrome, plumbism). Some neuropsychiatric disorders, namely pervasive developmental disorders, bipolar disorder, major depressive disorder with symptoms starting before ADHD, or ADHD symptoms occurring primarily during depressed or psychotic episodes were also grounds for exclusion. Subjects with disruptive behavior disorders, other mood disorders, and anxiety disorders were not excluded. Siblings meeting inclusion and exclusion criteria were also invited to participate in the study, but their participation was not required.

The cohort of 500 trios was enrolled and completed the study from 2003–2008. Thirty-six subjects who had signed consent/assent were excluded from the study. Twenty subjects passed the phone screen but did not meet ADHD criteria on Kiddie-Schedule for Affective Disorders and Schizophrenia (K-SADS). Five subjects met criteria for ADHD; however, in 3 subjects these symptoms were considered to be due to a major depression, and in two subjects anxiety symptoms significantly contributed to the ADHD. Three other subjects who also met criteria for ADHD were excluded, one meeting criteria for cyclothymia, one for bipolar disorder, and one for psychotic symptoms. Five subjects were excluded because of medical history that became evident during the office visit and included one subject each for sleep apnea, intelligence quotient (IQ) <70, severe hypoglycemia at birth, absence seizures, and febrile seizures. Two children agreed to participate and signed assent but then did not want to answer K-SADS questions; this was interpreted as their way of retracting assent. One additional child had severe social anxiety that prevented him from completing the interview.

ADHD and psychiatric comorbidity were assessed by a semistructured interview, the Schedule for Affective Disor-

ders and Schizophrenia for School Age Children (K-SADS-IVR) administered by a child psychiatrist (J.E.) to the parents and child separately. This semistructured interview provides diagnoses occurring within the previous 12 months and for the previous week. This version of the K-SADS rates each symptom on a graded Likert-type severity scale (from 1 to 4; thus summing up inattention or hyperactivity-impulsivity score in ADHD may range from 9 to 36) thus allowing for a composite severity rating score.²¹ All ADHD symptoms are scored from 0 (no information) to 4 (severe/extreme). Scores of >3 are considered clinically significant. Intraclass correlations between the primary diagnostician and a clinician with extensive experience with this semistructured interview (P.J.A.) for the diagnostic symptoms of the major disorders were assessed through videotape reviews. All intraclass correlations values were highly significant with the following ranges: ADHD: 0.82; oppositional defiant disorder: 0.80; affective disorders 0.74–0.85; and anxiety disorders 0.75–0.92; ADHD: 0.82; oppositional defiant disorder: 0.80.

Available reports of IQ assessments for subjects tested before participation in the genetics study were reviewed. The Wechsler Abbreviated Scale of Intelligence IQ assessment was administered to a subset of children without previous IQ testing. Other children, included but not formally tested, were able to understand and complete the K-SADS. Data from the Wechsler Abbreviated Scale of Intelligence were available in 232 of the cases. Socioeconomic status (SES) was measured by the Hollingshead 4-Factor Scale.²²

Parents were given the 18-question World Health Organization ADHD Self-Report Scale (ASRS). This screener assesses the presence of ADHD symptoms in the subjects' parents on the basis of a numerical rating of 18 symptoms on a scale of 0–4 (0 = Never, 4 = Very Often). The questions are divided in two parts, Part A assessing symptoms of inattention and Part B assessing hyperactivity and impulsivity. The scale has been validated,^{23,24} and a score of >21 on Part A or B was accepted as criteria for positive parental ADHD because it is associated with a high (94.5%) rate of classification accuracy. Patients were asked to answer the questions using a 6-month recall period.

Analysis

ADHD probands were divided into 4 groups according to parental ADHD status (maternal and paternal affected; maternal and paternal not affected; paternal affected but maternal not affected; maternal affected but paternal not affected).

Proband's age was compared between two sexes with a non-paired *t*-test. Association between parental ADHD and proband sex was tested by chi-square analysis. Proband demographic characteristics (age, IQ, SES) were compared among parental ADHD status groups by χ^2 or analysis of variance (ANOVA). Then, parental age at proband birth and parental ASRS total score as well as proband ADHD severity (K-SADS ADHD total symptoms score; Inattention symptoms score; and hyperactivity/impulsivity symptoms score) were compared among parental ADHD status groups with

Table II. Parental ADHD status and proband characteristics

| | Parents' ADHD status (n = 323) | | | | P value |
|-----------------------------------|--------------------------------|--------------------------|--------------------------|------------------------|---------|
| | Neither positive (n = 187) | Father positive (n = 49) | Mother positive (n = 62) | Both positive (n = 25) | |
| Proband sex (Ma/Fe) | 143/44 | 38/11 | 48/14 | 18/7 | .95 |
| Proband age Mean (SD) | 9.74 (3.09) | 9.87 (2.96) | 10.20 (3.03) | 10.24 (3.78) | .72 |
| Proband IQ (n = 232) Mean (SD) | 108.62 (14.15) | 110.27 (13.36) | 110.69 (12.02) | 109.06 (14.67) | .80 |
| SES (n = 306) Mean (SD) | 47.19 (11.05) | 46.96 (11.81) | 46.34 (11.47) | 50.77 (11.28) | .43 |

ANOVA. If there were any significant results in ANOVA, post hoc multiple comparisons were conducted.

To investigate the relationship between parental ADHD severity and probands' ADHD severity, correlation analyses between parental ASRS score and probands' total ADHD scores were conducted. In probands with only one parent having ADHD, age-adjusted odds ratios, given that subtype generally changes with age,²⁵ with 95% confidence intervals were calculated to evaluate the association between ADHD proband subtype and parental ADHD. In these analyses, probands with neither parents having ADHD were used as control subjects to investigate how parental ADHD exerts influence on proband subtype.

All data were entered and analyzed by using SPSS 16.0 (SPSS, Inc., Chicago, Illinois). All statistical tests were 2-tailed and used the .05 level of statistical significance.

Results

ASRS scores > 21 were reported by 23% of fathers and 27% of mothers. Significant symptoms were endorsed by either one or both parent in 41% of the parental cohort; 19% mothers only, 15% fathers only; 34% either parent and 7.7% in both. There was no significant difference in the rate of subtype in the fathers and mothers who met criteria for ADHD (df = 2; $\chi^2 = 5.40$, $P > .05$) (Table I: available at www.jpeds.com).

ADHD proband age, IQ and SES did not differ with regard to parental ADHD status (Table II). Across parental ADHD

status groups, female probands (n = 72, mean age = 10.88, S.D. = 3.58) were significantly older (df = 321, $t = 3.22$, $P = .001$) than male probands (n = 247, mean age = 9.59, S.D. = 2.99).

There was no significant difference in father's age at ADHD proband birth among the 4 groups. The biparental ADHD group was older with regard to mothers' age than the maternal ADHD group. As expected, there are significant differences in father/mother's ASRS score between father/mother without ADHD and father/mother with ADHD. With regard to probands' ADHD severity (as assessed by the K-SADS severity score), probands with only paternal ADHD or biparental ADHD had significantly higher ADHD total scores than probands without parental ADHD. Proband with biparental, paternal only, and maternal only ADHD had significantly higher inattention severity scores than probands without parental ADHD (Table III).

There was a significant association between parental ADHD status and probands' ADHD subtypes. The ratio of proband inattentive versus combined subtype was approximately 1:4 for paternal, 1:2 for maternal and 1:7 for both parents with positive ADHD status (Table III).

Differences in ADHD subtype were examined among ADHD probands with paternal only and maternal only ADHD and compared with age- and sex-matched ADHD probands without parental history of ADHD as a control group. The frequency of each subtype among probands in the control group was as follows: Inattentive = 59 (31.7%),

Table III. Parental ADHD status and proband characteristics, parental characteristics, and proband ADHD severity

| | Parents' ADHD status (n = 323) | | | | P value |
|---|--------------------------------|---------------------------|---------------------------|---------------------------|---------|
| | Neither positive (n = 187) | Father positive (n = 49) | Mother positive (n = 62) | Both positive (n = 25) | |
| Father's age at birth | 32.98 (5.32) | 31.73 (5.50) | 31.93 (6.40) | 34.16 (5.38) | .28 |
| Mother's age at birth | 30.83 (5.05) | 30.04 (5.00) | 29.72 (4.86)* | 33.35 (4.40)* | .04 |
| Father's ASRS total score | 21.05 (8.08) [†] | 40.88 (7.12) [†] | 22.84 (6.94) [†] | 42.36 (7.91) [†] | .001 |
| Mother's ASRS total score | 21.44 (7.84) [†] | 22.10 (6.49) [†] | 43.03 (7.62) [†] | 45.80 (7.72) [†] | .001 |
| Proband ADHD subtype (IA/H-I/C) | 59/25/102 | 8/2/39 | 20/1/41 | 3/1/21 | .001 |
| Proband ADHD total score | 51.24 (6.18) [†] | 54.76 (6.00) [†] | 53.50 (6.75) | 55.80 (6.56) [†] | .001 |
| Proband inattention score | 26.74 (3.50)* [†] | 28.51 (3.44) [†] | 28.52 (3.04) [†] | 28.72 (3.14)* | .001 |
| Proband hyperactivity/impulsivity score | 24.50 (5.04) | 26.24 (3.95) | 24.98 (5.31) | 27.08 (4.43) | .03 |

IA, Inattentive subtype; H-I, hyperactive-impulsive subtype; C, combined subtype.

* < .05.

[†] < .01.

Table IV. Association of parental ADHD status with proband ADHD subtype

| Parents' ADHD status | Proband Sex | Proband ADHD subtype | OR adjusted for age | 95% CI | P value |
|------------------------|---------------|----------------------|---------------------|-------------|---------|
| (only) Father positive | Male (n = 39) | IA (n = 5) | 0.34 | 0.12 - 0.95 | .04 |
| | | H-I (n = 2) | 0.34 | 0.07 - 1.56 | .17 |
| | | C (n = 31) | 3.56 | 1.47 - 8.65 | .005 |
| (only) Mother positive | Male (n = 48) | IA (n = 14) | 1.02 | 0.49 - 2.15 | .96 |
| | | H-I (n = 1) | 0.17 | 0.02 - 1.30 | .09 |
| | | C (n = 33) | 1.51 | 0.75 - 3.02 | .25 |

In logistic regression analyses each parental ADHD group (fathers only, mothers only) was compared to a control group of non ADHD parents (IA = 45, H-I = 19, C = 79 in male probands) when odds ratios were calculated.
IA, Inattentive; H-I, hyperactive-impulsive; C, combined.

Hyperactive-Impulsive = 25 (13.4%), Combined = 102 (54.8%). The odds ratios indicated that presence of paternal only ADHD significantly increased the probability of ADHD combined subtypes and decreased the probability of the inattentive subtype in male probands. The odds ratios indicated that maternal only ADHD status was not associated with an increased or decreased risk of any of the ADHD subtypes among probands (Table IV).

The association between parental ADHD severity and proband ADHD severity (males only) was low to negligible among each of the parental ADHD status groups. Because sample sizes for females were very small in some of the cells, these correlations were not conducted for females. There was no strong or moderate association between parental ADHD severity and probands ADHD severity (Table V).

Discussion

Consistent with previous findings, one or both parents reported significant ADHD symptoms in 41% of our cohort, which is similar to the findings of Goos et al¹⁷ in a clinically referred group. We suspect that this is an underestimation of the prevalence of parental ADHD because parents with ADHD may have been disproportionately represented in the subgroup who failed to provide self-report ratings on the ASRS, which was slightly higher for fathers than for mothers. Parental ADHD subtypes consisted of 23% for combined, 60% for inattentive, and 17% for hyperactive-impulsive for fathers and 40%, 47%, and 13%, respectively, for mothers, which are consistent with rates reported in adolescent²⁶ and adult ADHD studies.²⁷ Male and female ADHD probands in our cohort had similar rates of parental ADHD, which is also consistent with previous results.^{19,28} The relatively small sample sizes for females and the signifi-

cant difference in age between females and males precluded us from conducting any further analyses on the basis of sex.

Does it matter whether the risk comes from the father or mother? Our study suggests that it might. Paternal ADHD symptom severity was significantly associated with global ADHD severity in probands, whereas maternal ADHD symptom severity was not significantly related to proband ADHD severity. On the other hand, for inattention severity, paternal and maternal ADHD effects on proband's ADHD are equal. This suggests that both parents may confer risks for both subtypes, with fathers conferring greater risk for severity of hyperactivity-impulsivity. These results differ from those reported in the study by Goos et al¹⁷ in which greater levels of impairment were found in ADHD probands with ADHD maternal history versus paternal history.

Is having two parents with ADHD worse than having one parent with ADHD? Our results suggest that there is no additive or synergic effect on probands' ADHD severity when both parents have ADHD in comparison to when only one parent has ADHD. Goos et al¹⁷ excluded biparental history of ADHD from their study on parent-of-origin effects in ADHD, hypothesizing that risks are not necessarily additive. We confirmed this in our study. In addition, there does not appear to be a correlation between parent's ASRS score and proband's ADHD severity, which means there is no simple linear relationship between them. This implies that there may be other factors conferring risk for severity.

Is parental ADHD status associated with greater risk for certain ADHD subtypes among probands? In our cohort, the hyperactive-impulsive subtype was highest in ADHD probands who did not have either parent with ADHD, whereas the combined subtype was higher for probands in which fathers or both parents were affected. This suggests

Table V. Correlations between male proband's ADHD severity and parent's ASRS score by parents' ADHD status controlled for proband's age

| | Father's ASRS score | | | | | Mother's ASRS score | | | | |
|--------------------------------------|---------------------|-----------|----------|----------|--------|---------------------|-----------|----------|----------|--------|
| | Total | Neither + | Father + | Mother + | Both + | Total | Neither + | Father + | Mother + | Both + |
| Proband's ADHD total score in K-SADS | 0.28* | 0.19† | 0.18 | 0.18 | 0.00 | 0.22* | 0.18† | -0.07 | 0.20 | 0.03 |

*Significant correlation at the 0.01 level.

†Significant correlation at the 0.05 level.

that the inattentive symptoms are more likely affected by parental ADHD.

Our findings that having a parent with ADHD increases the severity of ADHD in the proband may be useful in guiding future genetic studies. Given that ADHD is considered a continuum of normally occurring traits,²⁹ it would be logical to consider genetic or epigenetic factors that increased or decreased “amount” or “severity” as being key to the disorder rather than the gene for the specific trait. In the clinics, it might be useful for clinicians to know that if children with ADHD has a parent with ADHD, their ADHD symptoms might be more severe or in turn, if children with ADHD show severe symptoms of ADHD, the probability of parental ADHD might increase.

The study sample is not representative of the general ADHD population or even clinical ADHD groups because it only included ADHD probands of European descent for which both biological parents were available and willing to participate in a genetics study. Significantly higher frequency of DSM-IV ADHD-combined type and a trend for higher total ADHD symptom score has been reported in duos, that is, children with ADHD and one parent,³⁰ suggesting that data from ADHD trios may be biased toward less-severe symptoms. This study is also limited by parental data derived from self-reports,¹⁵ which could be influenced by parental sex, self-awareness, advanced knowledge of ADHD, comorbid psychopathology and socioeconomic levels. More comprehensive and structured assessment and larger samples should be used to further investigate the relationship between parental ADHD and proband’s ADHD.

In conclusion, parental status appears to confer different risks for the severity of hyperactive-impulsive versus inattentive symptoms depending on parental sex, and parental ADHD is significantly associated with probands’ ADHD severity (especially inattention symptoms). Parental level of ADHD severity generally has low to negligible correlation with probands’ level of ADHD severity. ■

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Table I. Parental ADHD self-report ratings (n = 323)

| | Fathers | Mothers | Both parents |
|-----------------------|-------------|-------------|--------------|
| ADHD positive ratings | 74 (22.9%) | 87 (26.9%) | 25 (7.7%) |
| C-Subtype | 17 (23%) | 35 (40%) | |
| I-Subtype | 44 (60%) | 41 (47%) | |
| H-I Subtype | 13 (17%) | 11 (13%) | |
| ADHD negative ratings | 249 (77.1%) | 236 (73.1%) | 187 (57.9%) |

Parental ADHD status defined by Adult Self-Report Scale score ≥ 21 .
C, Combined; I, inattentive; H-I, hyperactive-impulsive.