

# Comparison of the Predictive Validity of Hyperkinetic Disorder and Attention Deficit Hyperactivity Disorder

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## Abstract

**Introduction:** We compared the predictive validity of attention deficit hyperactivity disorder (ADHD; Diagnostic and Statistical Manual — IV Edition) and hyperkinetic disorder (HKD; International Classification of Diseases — 10th Edition) while controlling for the presence of comorbid psychopathology. **Method:** ADHD and HKD criteria were used to classify 804 clinic-referred children ages 6 to 16 years into one of four non-overlapping groups: HKD, ADHD combined subtype (ADHD-C), ADHD hyperactive-impulsive subtype (ADHD-HI), ADHD inattentive subtype (ADHD-IA). Groups were compared with each other and with normal controls (67) while controlling for age and intelligence on a range of criteria both before and after excluding cases with comorbidity. **Results:** Of the 804 clinic participants, 72 (8.9 %) met criteria for ICD-10 HKD, 353 (43.9 %) for ADHD-C, 142 (17.7 %) for ADHD-HI and 237 (29.5 %) for ADHD-IA. There were no differences among the four clinic groups in rate of comorbidity, neuro-developmental or psychosocial risk indices, inter-parental or parent-child discord, family history of ADHD, working memory, and academic or intelligence test scores, but all clinic groups differed from normal controls. By contrast, total number of symptoms, teacher-rated impairment and inhibitory control deficit were greatest in HKD and least in ADHD-C, ADHD-HI, ADHD-IA in that order. Results of the comparisons were essentially unchanged after excluding cases (75%) with a comorbid condition. **Conclusions:** HKD, ADHD-C, ADHD-HI and ADHD-IA had approximately equivalent predictive validity even when comorbidity was taken into account.

**Key words:** attention-deficit hyperactivity disorder, hyperkinetic disorder, DSM-IV, ICD-10, ADHD subtypes

## Résumé

**Introduction:** Nous comparons la validité prédictive du trouble de déficit d'attention avec hyperactivité (TDAH - DSM-IV) et du trouble d'hyperkinésie (HK; Classification internationale des maladies – 10e édition) après vérification des comorbidités.

**Méthodologie:** Huit cent quatre enfants âgés de 6 à 16 ans et référés par une clinique ont été classés selon les critères de TDAH et de HK dans quatre groupes indépendants les uns des autres: HK; TDAH combiné (TDAH-C); TDAH hyperactif-impulsif (TDAH-HI), TDAH inattentif (TDAH-IA). Ces groupes ont été comparés les uns aux autres et à un groupe témoin de 67 sujets selon certains critères, après vérification de l'âge et de l'intelligence des sujets. Les sujets qui présentaient une quelconque comorbidité ont été exclus. **Résultats:** Des 804 participants de l'étude clinique, 72 (8.9 %) souffraient d'hyperkinésie, 353 (43.9 %) de TDAH combiné, 142 (17.7 %) de TDAH hyperactif-impulsif et 237 (29.5 %) de TDAH inattentif. Il n'y avait pas de différence dans ces quatre groupes cliniques pour ce qui est de la comorbidité, des indices de risque neuro-développemental ou psychosocial, de discorde entre les parents ou entre les parents et les enfants, d'antécédents familiaux de TDAH, de mémoire opérationnelle, de résultats scolaires ou de tests d'intelligence. Toutefois, tous les groupes cliniques différaient du groupe témoin. Par contraste, le total des symptômes, le handicap et le manque d'inhibition noté par l'enseignant étaient plus marqués dans le groupe souffrant d'hyperkinésie que dans les groupes TDAH-C, TDAH-HI, TDAH-IA, dans cet ordre. **Conclusions:** La valeur prédictive de l'hyperkinésie, du TDAH combiné, du TDAH hyperactif impulsif et du TDAH inattentif était sensiblement identique, même lorsque la comorbidité était prise en compte.

**Mots clés:** trouble du déficit d'attention avec hyperactivité; DSM-IV, Classification internationale des maladies-10; sous-types du TDAH

Despite years of research into childhood hyperactivity, questions remain about the validity of the diagnosis. Validity is typically gauged by the ability of diagnostic criteria to predict important characteristics such as functional impairment, heritability, executive function deficit, exposure to neurobiological or psychosocial risk factors, risk for adverse outcomes and treatment response. At one extreme of the debate are those who assert that the diagnosis has no predictive validity regardless of what criteria are applied or that ADHD is an epiphenomenon of associated psychopathology. More often, however, the question about the predictive validity of hyperactivity is framed around the appropriate breadth and criteria for the diagnosis as reflected in the

number and type of symptoms necessary for the diagnosis.

The debate about number and breadth of criteria for a valid entity of childhood hyperactivity is actualized in the distinction between Hyperkinetic Syndrome (HKD) as defined in ICD-10 and attention deficit hyperactivity disorder (ADHD) as defined in DSM-IV. HKD and ADHD diagnoses are based on the same list of 18 symptoms, 9 of which are symptoms of inattention, 6 of which are symptoms of hyperac-

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tivity and 3 of which are symptoms of impulsivity. Moreover, both criteria require evidence of impairment and early, typically preschool onset. However, beyond these similarities, there are qualitative and quantitative differences between criteria for HKD and ADHD in the required number and type of presenting symptoms, the degree of situational pervasiveness, and the utilization of diagnoses for comorbid disorders.

A diagnosis of HKD requires that 5 inattentive, 3 hyperactive and 1 impulsive symptoms must be present in several major life situations typically at home or in the community according to parental report and also at school according to teacher report. A diagnosis of ADHD requires 6 or more symptoms of inattention, 6 or more symptoms from the combined list of hyperactivity and impulsivity symptoms or both. ADHD does not require that these specific symptom criteria be met *both* at home and at school, but rather requires that the symptomatic threshold be met in one setting (either home or school) and that "... some *impairment* from the symptoms [be] present in two or more settings (e.g., at school [or work] and at home)..." (Criterion C, pp 84). The details of this criterion are not specified in DSM and it is unclear how clinicians operationalize this criterion in clinical practice. In other words, the criteria for ADHD are met if a child presents with 6 or more impairing symptoms of inattention or of hyperactivity and/or impulsivity in one setting as long as there is evidence of impairment from these symptoms in another setting. The second major difference is that ICD limits the HKD diagnosis to those who exhibit symptoms of inattention, hyperactivity *and* impulsiveness whereas DSM-IV allows for a diagnosis of ADHD-inattentive subtype (ADHD-IA) when 6 of 9 inattention symptoms are met in the absence of 6 of 9 hyperactivity-impulsivity symptom and for a diagnosis of ADHD-hyperactive-impulsive subtype (ADHD-HI) when 6 of 9 hyperactive-impulsive symptoms are met in the absence of 6 of 9 inattention symptoms. When both are present, a diagnosis of ADHD-combined (ADHD-C) subtype is made. And third, ICD-10 allows for a category of hyperkinetic conduct disorder separate from HKD, but excludes the diagnosis in the presence of anxiety and mood disorder. DSM-IV, on the other hand, permits a diagnosis

for every disorder that is evident such as conduct disorder, anxiety disorder or dyslexia. Both criteria preclude a diagnosis in the presence of pervasive developmental disorder (PDD) and schizophrenia. Consequently, differences in predictive validity of HKD or ADHD could derive from the nature of presenting symptoms (e.g., inattention versus hyperactivity-impulsivity, vs. both), from variation in pervasiveness or from the presence of common comorbid disorders.

There have been few head to head comparisons of HKD as defined in ICD-10 and ADHD as defined by DSM-IV criteria despite the genuine possibility of differences in predictive validity of HKD and ADHD and the attendant public health and scientific implications. Santosh et al (2005) found that individuals meeting criteria for HKD were more responsive to stimulant medication and less responsive to psychosocial interventions than were those meeting ADHD-C criteria. Lahey et al found few differences in the predictive validity of HKD and ADHD: Both groups exhibited persistent ADHD symptoms and impairment over a six-year follow up. Lee et al. studied 419 cases drawn from the same clinic as the current sample on a range of variables. Lee found that ICD-10 and DSM-IV criteria delineated diagnostic entities with substantially different prevalence: There were ten cases with ADHD for every case with HKD. HKD criteria also delineated a group with a greater number of symptoms, greater teacher-rated functional impairment and more severe executive control deficit than did ADHD criteria. However, HKD and ADHD groups did not differ in risk for ADHD among first degree family members, rate of comorbid psychopathology, intelligence or academic attainment compared with each other or with unaffected controls. Lee et al. concluded that both ICD and DSM criteria delineated diagnostic entities with substantial, but largely similar predictive validity. However, Lee et al. did not undertake a comparison of ICD and DSM in the absence of comorbidity due to limited number of participants in each diagnostic group. Therefore, the goals of this study were to replicate and extend the findings of Lee et al. in a larger sample by comparing the characteristics of clinic-referred cases who meet ICD-10 criteria for HKD or DSM-IV criteria for ADHD on a

range of validity criteria and, for the first time, to compare the predictive validity of HKD and ADHD after excluding the possible confound of cases with a comorbid psychiatric disorder.

## Method

### Participants

A total of 1213 clinic cases, age 6 to 16 years of age, were assessed for attention, learning or behaviour problems in a psychiatry clinic at the Hospital for Sick Children in Toronto from 1997 to 2006. Of these, 804 cases met inclusion and exclusion criteria as specified below. Some participants were excluded from the study ( $n = 303$ ) because they did not meet criteria for HKD or ADHD or because they did not meet minimum intelligence test criteria of a full-scale IQ greater than 80 ( $n = 106$ ). Of the 804 participants who met inclusion and exclusion criteria, 72 (8.9 %) met criteria for ICD-10 HKD, 353 (43.9 %) for ADHD-C, 142 (17.7 %) for ADHD-HI and 237 (29.5 %) for ADHD-IA. All of the HKD cases met criteria for ADHD-C subtype even though it is possible to meet criteria for HKD but fail to meet criteria for ADHD.

Eighty-four individuals volunteered in response to advertisements in local hospitals for normal controls. Of these, 67 met inclusion criteria specified below; 10 were excluded because they met criteria for ADHD and 7 failed to meet the IQ criterion.

Parent Interview for Child Symptoms (PICS; and Teacher Telephone Interview (TTI; were used to establish a diagnosis. The interviews were conducted by an experienced social worker or psychologist trained to 90% reliability before the study commenced. Parent interviewers were blind to the results of the teacher interview and vice versa. Both the PICS and TTI have demonstrated high inter-rater reliability for individual ADHD symptoms (kappa of .65 - .95) and for the diagnosis of ADHD with kappa coefficient of 0.85. Both PICS and TTI interviews generate symptom scores for each of the 18 ADHD criteria based on presence, persistence and severity of a particular behaviour and on impairment associated with each symptom according to specific criteria. Cases and controls were assessed in the same way. Children who were receiving psycho-stimulant medication discontinued drug treatment at least 48

hours before the day of the laboratory assessment because of the known impact of these medications on neuropsychological test performance and behavior. Based on the results of the PICS and TTI and using the criteria specified below, participants were assigned to the normal control group or to *one* of four "clinic" groups; HKD, ADHD-C, ADHD-HI or ADHD-IA.

Teachers and parents rated social and academic impairment over the last six months. Each child was tested on measures of inhibitory control (stop signal task) and working memory (digit span backwards). These executive functions are among the most sensitive and specific markers of ADHD. We used questionnaires and interviews to establish exposure to adverse psychosocial influences, history of neuro-developmental delay and occurrence of ADHD in first degree family members.

In order to evaluate the predictive validity of HKD and ADHD free from the influence of comorbid conditions, we repeated the comparisons of HKD, ADHD and control groups after excluding cases with any comorbid psychiatric, reading or language disorder.

### Diagnostic criteria

Children were diagnosed *with ICD-10 HKD* if *all* of the following criteria were met: 1. the child's score on the PICS *and* TTI indicated the presence of at least 6 (out of 9) inattention symptoms, 3 (out of 5) hyperactivity symptoms, and 1 (out of 4) impulsivity symptoms; 2. age of onset of disorder no later than 7 years of age; 3. evidence of significant impairment in social or academic functioning; and, 4. no concurrent or lifetime diagnosis of PDD or schizophrenia. We departed from the usual interpretation of ICD-10 criteria by allowing a diagnosis of HKD in the presence of a comorbid disorder in the first set of comparisons, but excluded comorbidity in the second set of comparisons.

Children were diagnosed *with DSM-IV ADHD* if *all* of the following criteria were met: 1. The child's score on PICS *or* TTI indicated the presence of at least 6 (out of 9) inattention symptoms *or* 6 (out of 9) hyperactive/impulsive symptoms which had persisted for at least 6 months prior to assessment; 2. significant impairment from ADHD symptoms in two or more settings was operationalized for the sake of this study as the presence of *at least* 4

symptoms of inattention, hyperactivity or impulsiveness *both* at home and at school; 3. age of onset of disorder no later than 7 years; and, 4. no concurrent or lifetime diagnosis of PDD or schizophrenia.

Children with DSM-IV ADHD diagnosis were sub-typed as follows: 1. *DSM-IV ADHD-IA*: The child's score on PICS or TTI indicated the presence *at least 6 (out of 9) inattention symptoms*, but fewer than 6 symptoms of hyperactivity-impulsivity which had persisted for at least 6 months prior to assessment either at home or at school. 2. *DSM-IV ADHD-HI*: The child's score on PICS or TTI indicated the presence *at least 6 (out of 9) symptoms of hyperactivity-impulsivity*, but fewer than 6 symptoms of inattention which had persisted for at least 6 months. 3. *DSM-IV ADHD-C*: The child's score on PICS or TTI indicated the presence of at least 6 (out of 9) symptoms of inattention *and* 6 (out of 9) symptoms of hyperactivity-impulsivity, which had persisted for at least 6 months prior to assessment.

To be included as controls, volunteers could not meet criteria for HKD or ADHD, and had to have an IQ above 80.

### **Criterion Instruments and Measurements**

*Ontario Child Health Study (OCHS) scales.* Using items from the OCHS scales, we calculated scales reflecting parent and teacher rated global impairment (standardized for age and gender using general population norms), psychosocial risk, neurodevelopmental risk, aversive parenting practices, and inter-parental conflict.

*Family history for ADHD.* During the parent interview, parents were asked about the current and past behaviour, medical and psychiatric history of each first degree family member (parents and siblings). A family history of ADHD was coded as present if ADHD was reported in the mother, father or sibling(s) of the participant.

*Intelligence and academic achievement.* A clinical psychologist assessed intellectual ability (WISC-IV), reading and arithmetic ability (Woodcock Reading Mastery Test-Revised, WRMT-R; Woodcock, 1987), Word Identification and Word Attack subtests of the Wide Range Achievement Test 3rd ed. (WRAT-3; Wilkinson, 1993); Wechsler Individual Achievement Test

(WIAT, Wechsler, 1991). A speech pathologist assessed language ability (Clinical Evaluation of Language Fundamentals 3rd edition, CELF-III; Semel, 1995).

*Cognitive measures.* We tested each child on the stop signal task in order to assess response inhibition (Logan, Schachar, & Tannock, 1997). The Stop Signal Task permits estimation of the latency of the inhibition process (stop signal reaction time, SSRT) (Logan & Cowan, 1984): Longer SSRT indicates poorer inhibitory control. ADHD children have significantly longer SSRT than non-ADHD children and those with other disorders (Schachar, Mota, Logan, Tannock, & Klim, 2000; Willcutt et al., 2005). We also tested each participant on a measure of working memory – digit span backward (Kaplan, Fein, Kramer, Delis, & Morris., 1999). Participants were read lists of numbers of increasing length and their task was to reverse the order of the numbers and state the numbers in reverse order. Age norms were used to generate a standard score for working memory for each participant.

*Comorbidity criteria.* We defined comorbid psychiatric disorders (conduct disorder, CD; oppositional defiant disorder, ODD; separation anxiety disorder, SeAD; generalized anxiety disorder, GAD) using DSM-IV criteria. Reading disability (RD) was defined by scores of at least 1.5 standard deviation (SD) below the mean for age on at least one of the three standardized tests of single word and non-word reading (WRMT-R Word Attack, Word Identification, WRAT-3 Reading) or by scores that were at least 1.0 SD below the mean for age on at least two of the three tests. Language impairment was defined as a score below 85 on the CELF-III total language score.

### **Statistical Analysis**

Diagnostic groups were compared using chi-square analysis for categorical variables or ANOVA for continuous scores. For continuous variables, planned comparisons with four contrasts were used to test specific predictions about diagnostic group differences: HKD versus ADHD-C; ADHD-HI versus ADHD-IA; HKD and ADHD-C versus ADHD-HI and ADHD-IA; and Controls versus all ADHD subtypes plus HKD group. For categorical variables (gender, family history and comorbidity), significant  $\chi^2$  analy-



ses were followed by multi-nominal logistic regression to identify source of significance. Critical  $\alpha$  was maintained at .05 (two-tailed) for all analyses. All analyses were covaried for age and intelligence except for analyses of measures that were age standardized which we covaried for intelligence. Analyses were repeated after excluding cases with a comorbid diagnosis of any of the following disorders — ODD, CD, GAD, SeAD, reading disability or language impairment.

## Results

### ***Demographic and clinical features***

There were significant differences among diagnostic groups in mean age and mean full scale IQ. Consequently, further comparisons were covaried for age and IQ except when age standardized scores were analyzed. The clinic groups included a greater proportion of boys than the control group and the HKD group had more males than ADHD-IA group.

All four clinic groups had significantly greater parent- and teacher-rated symptom scores than did the control group with highest scores in the HKD group and lowest scores in the ADHD-IA group. The pattern was similar for parent- and teacher-rated impairment except that the HKD and ADHD-C groups did not differ in the parent ratings of impairment. Psychosocial risk scores were higher in the clinic groups than in the control group, but no differences among the clinic groups were noted. Neuro-developmental risk scores differed significantly among the groups although planned comparisons were not significant. The clinic groups had higher scores for inter-parental conflict than controls. Parent-child conflict scores were higher, reflecting greater conflict, in the clinic groups than in the control group and the HKD and ADHD-C had greater conflict scores than the ADHD-IA and ADHD-HI groups. More than 40% of HKD, ADHD-C, ADHD-HI and ADHD-IA participants had a first degree family member with ADHD, but the four clinic groups did not differ significantly.

### ***Intelligence, academic achievement and stop task performance***

The four clinic groups had lower scores than controls on measures of reading and

mathematics achievement (WRAT-3 Reading and Arithmetic; WRMT-R Word Identification, Word Attack, and WIAT Reading Comprehension and Mathematic Reasoning) even after controlling for full scale IQ. The HKD, ADHD-C, ADHD-HI and ADHD-IA groups did not differ among themselves on academic test scores except on WRAT-3 Arithmetic performance. Although not clinically significant, the ADHD-HI and ADHD-IA had scores on WRAT-3 Arithmetic that were statistically higher than those in the HKD and ADHD-C groups.

Groups differed significantly in inhibitory control: Mean SSRT was longer, reflecting less efficient inhibitory control, in the clinical groups than in controls and SSRT was longer in ADHD-C and HKD than in ADHD-IA and ADHD-HI groups. Controlling for age and IQ did not alter these inter-group differences. Controls achieved higher age standardized scores for the working memory measure (digit span backwards) than did the combined HKD, ADHD-C, ADHD-IA and ADHD-HI groups.

### ***Comorbidity***

Comorbidity was common. Three quarters of the participants in all clinical groups met criteria for at least one comorbidity. ODD, GAD, SeAD, RD and language impairment were each more prevalent in the clinical groups than in controls, with no significant differences among the groups. By contrast, CD was significantly less prevalent in the ADHD-IA group than in the other clinical groups. A greater proportion of HKD and ADHD-C cases than ADHD-HI and ADHD-IA cases had at least one of these comorbidities (Table 3). Of the 67 controls, 1 met criteria for CD, 2 for ODD, and 6 for GAD.

Reanalysis of each of the validity criteria after excluding cases with a comorbid ODD, CD, SeAD, GAD, RD or language impairment did not alter the main pattern of inter-group differences (data available upon request). The inter-group differences in age and gender were no longer evident. Similarly the ADHD-HI and ADHD-IA groups no longer differed in teacher rated ADHD symptom scores. The parent and teacher rating of impairment, neurodevelopmental risk, IQ scores, working memory and SSRT continued to differentiate clinical and control groups, but the clinical groups no longer differed among themselves. ADHD-HI and

**Table 1: Clinical characteristics of HKD, ADHD - C, ADHD - IA, ADHD - HI and Normal Control groups**

Measures mean (SD)	HKD (n = 72)	ADHD - C (n = 353)	ADHD - HI (n = 142)	ADHD - IA (n = 237)	NC (n = 67)	F/ $\chi^2$	Planned comparisons
<b>Age</b>	8.2 (1.7)	8.8 (1.9)	8.6 (2.2)	9.3 (2.2)	9.8 (2.7)	8.7***	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC; HKD < ADHD - C; ADHD - IA > ADHD - HI; ADHD - C, HKD < ADHD - IA, ADHD - HI
<b>Intelligence</b> WISC - III-R / IV Full IQ	101.4 (13.0)	100.6 (12.8)	104.8 (13.6)	101.7 (12.1)	118.4 (10.9)	30.3***	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC; HKD, ADHD - C < ADHD - IA, ADHD - HI; ADHD - IA < ADHD - HI
<b>Gender</b> (% male)	87.5	79.9	78.2	71.7	46.3	42.5***	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC
<b>ADHD symptoms - Parent</b>	14.9 (1.8)	13.0 (3.4)	10.1 (2.5)	8.6 (2.8)	1.0 (1.4)	303.7***	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC; HKD, ADHD - C > ADHD - IA, ADHD - HI; ADHD - HI > ADHD - IA
<b>ADHD symptoms - Teacher</b>	13.8 (1.5)	9.9 (3.6)	8.6 (3.2)	7.7 (2.7)	0.7 (1.4)	135.9***	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC; HKD, ADHD - C > ADHD - IA, ADHD - HI; HKD > ADHD - C; ADHD - HI > ADHD - IA
<b>Impairment – Parent</b>	6.8 (3.0)	6.4 (3.6)	6.5 (3.4)	5.2 (3.3)	0.8 (1.7)	40.9***	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC; HKD, ADHD - C > ADHD - IA, ADHD - HI; ADHD - HI > ADHD - IA
<b>Impairment – Teacher</b>	6.6 (2.9)	5.3 (3.1)	5.8 (3.2)	4.8 (3.0)	0.6 (1.6)	39.4***	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC; HKD, ADHD - C > ADHD - HI, ADHD - IA; HKD > ADHD - C; ADHD - HI > ADHD - IA
<b>Psychosocial Risk Index</b>	2.5 (2.3)	2.5 (2.2)	2.3 (2.2)	2.2 (1.9)	1.4 (1.4)	3.7**	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC
<b>Neurodevelopmental Risk Index</b>	2.1 (1.7)	2.6 (2.0)	2.2 (1.8)	2.0 (1.6)	1.9 (1.4)	3.2*	
<b>Inter - parental conflict</b>	2.1 (1.9)	1.7(1.6)	1.7(1.6)	1.8(1.6)	1.1(1.4)	3.1*	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC
<b>Parent - child conflict</b>	2.5(0.8)	2.6(0.9)	2.3(0.8)	2.4(0.8)	1.9(0.9)	10.6***	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC; HKD, ADHD - C > ADHD - IA, ADHD - HI
<b>Family history of ADHD (%)</b>	35 (51.5)	144 (44.0)	50 (39.7)	91 (41.0)	3 (4.8)	37.9***	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC

Note: HKD = Subjects meeting ICD - 10 HKD; ADHD - C = ADHD combined subtype; ADHD - HI = ADHD hyperactivity - impulsivity subtype; ADHD - IA = ADHD inattentive subtype, NC = normal control group. SD = standard deviation; \* = p < .05; \*\* = p < .01; \*\*\* = p < .001. The comparison column shows the results of the planned comparisons specified in the text: HKD, ADHD - C, ADHD - HI, and ADHD - IA versus NC; HKD vs ADHD - C; ADHD - HI vs ADHD - IA; and, HKD and ADHD - HI vs ADHD - C vs ADHD - HI and ADHD - IA except for gender and family history where multi-nominal logistic regression was used to identify source of significance.

**Table 2: Intelligence and Academic achievement of HKD, ADHD - C, ADHD - HI and Normal Control groups**

Measures mean (SD)	HKD (n = 72)	ADHD - C (n = 353)	ADHD - HI (n = 142)	ADHD - IA (n = 237)	NC (n = 67)	F	Planned comparisons
<b>Academic achievement</b>							
WRMT - R Word Identification	95.0 (15.1)	95.6 (16.2)	97.2 (16.6)	96.0 (14.9)	114.2 (13.4)	21.3***	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC
WRMT - R Word Attack	94.6 (14.4)	92.8 (14.8)	93.8 (15.3)	94.4 (13.2)	106.9 (12.1)	13.8***	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC
WRAT - 3 Reading	98.6 (13.0)	97.4 (15.6)	98.1 (15.7)	97.6 (13.2)	111.9 (11.6)	14.8***	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC
WRAT - 3 Arithmetic	93.1 (11.5)	92.3 (13.8)	95.8 (13.1)	93.0 (11.7)	106.4 (12.2)	18.3***	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC; ADHD - IA < ADHD - HI
WIAT Reading Comprehension	98.0 (13.8)	98.3 (16.1)	99.0 (16.0)	98.7 (14.6)	115.6 (13.0)	19.2***	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC
WIAT Mathematics	95.6 (12.2)	97.8 (13.0)	98.2 (14.1)	98.9 (12.7)	114.1 (12.5)	24.2***	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC
<b>Cognitive tests</b>							
Stop task: SSRT	375.1 (217.6)	339.5 (156.1)	318.5 (130.4)	317.8 (148.1)	249.8 (104.2)	5.2***	HKD, ADHD - C, ADHD - HI, ADHD - IA > NC; HKD, ADHD - C > ADHD - IA, ADHD - HI
Digit span: backward	8.8 (3.4)	9.4 (3.2)	9.5 (3.4)	9.1 (3.7)	12.0 (2.8)	5.1**	HKD, ADHD - C, ADHD - HI, ADHD - IA < NC

Note: WRMT - R = Woodcock Reading Mastery Test-Revised; WRAT - 3 = Wide Range Achievement Test-3<sup>rd</sup> ed; WIAT = Wechsler Individual Achievement Test; HKD = Subjects meeting ICD - 10 HKD diagnosis; ADHD - C = combined subtype; ADHD - HI = hyperactive - impulsive subtype; ADHD - IA = inattentive subtype, NC = normal control group; SD = standard deviation; \* P < .05; \*\* P < .01; \*\*\*P < .001. The comparison column shows the results of the planned comparisons specified in the text: HKD, ADHD - C, ADHD - HI, and ADHD - IA versus NC; HKD vs ADHD - C; ADHD - HI vs ADHD - IA; and, HKD and ADHD - C vs ADHD - HI and ADHD - IA, \*\* = p < .01; \*\*\* = p < .001.

**Table 3: Prevalence of common comorbidities in HKD, ADHD - C, ADHD - IA and ADHD - HI groups**

n (%)	HKD n = 72 (9 %)	ADHD - C n = 353 (43.9 %)	ADHD - HI n = 142 (17.7 %)	ADHD - IA n = 237 (29.5 %)	$\chi^2$	All types N = 804
Oppositional defiant disorder	26 (36.1)	108 (30.8)	37 (26.1)	59 (24.9)	4.8	230 (28.7)
Conduct disorder <sup>a</sup>	27 (37.5)	125 (35.6)	53 (37.3)	37 (15.6)	34.1***	242 (30.2)
Separation anxiety disorder	10 (14.1)	57 (16.2)	14 (9.9)	26 (11.0)	5.2	107 (13.3)
Generalized anxiety disorder	11 (15.5)	37(10.5)	11(7.7)	24 (10.1)	3.1	48 (11.5)
Reading disorder	13 (18.1)	93 (26.3)	37 (26.1)	55 (23.2)	2.6	110 (26.3)
Language impairment	6 (8.3)	33 (9.3)	22 (15.5)	27 (11.4)	4.9	44 (10.5)
One or more comorbidity	59 (81.9)	288 (81.6)	107 (75.4)	150 (63.3)	27.7	604 (75.1)

Note: HKD = Subjects meeting ICD - 10 HKD; ADHD - C = ADHD combined subtype; ADHD - HI = ADHD hyperactivity - impulsivity subtype; ADHD - IA = ADHD inattentive subtype; <sup>a</sup> denotes significant difference in chi - square test, \*\*\* =  $p < .001$ . Multi-nominal logistic regression was used to identify source of significance (see text).

ADHD-IA groups had greater scores on WRAT-III Arithmetic than did the HKD and ADHD-C groups.

### Discussion

The goals of this study were to replicate and extend the findings of Lee et al. in a larger sample by comparing the characteristics of clinic-referred cases who met ICD-10 criteria for HKD and DSM-IV criteria for ADHD on a range of validity criteria and, for the first time, to compare the predictive validity of HKD and ADHD after excluding the possible confound of cases with a comorbid psychiatric disorder. Despite the importance of these questions from a clinical and public health perspective there have been few direct comparisons of the predictive validity of these two diagnostic criteria. Available evidence indicates that the distinction between narrow and broad definitions of hyperactivity has implications for prevalence and treatment response, but not for prognosis. In a previous analysis of part of the current sample, Lee et al. concluded that, for the most part, HKD, ADHD-C, ADHD-HI and ADHD-IA differed from normal controls, but did not differ among themselves in crucial characteristics such as psychosocial impairment, risk for ADHD in first degree family members, rate and type of comorbidity, and in executive function (inhibitory control and working memory).

Diagnostic criteria can be broad or narrow based on their consideration of comorbidity. Both ICD-10 and DSM-IV exclude from the diagnosis of HKD or ADHD those individuals with

pervasive developmental disorder or schizophrenia. ICD-10 discourages the diagnosis in the presence of other psychiatric conditions such as anxiety or depression, but has a category for HKD plus CD. DSM-IV could be construed as broader in that it permits a diagnosis of ADHD even if the presentation is complicated by ODD, anxiety, mood, learning disability or language impairment. Consequently, ADHD in particular is open to the criticism that its predictive validity derives from the presence of various comorbid conditions and not from ADHD per se. An additional aim, therefore, of the current study was to determine whether the predictive validity of HKD and ADHD was affected by the exclusion of cases with a comorbid disorder. The large clinical sample assembled for this study, for the first time, permitted strict control over comorbidity when making these comparisons.

As expected, ICD-10 criteria required a greater number of symptoms for a diagnosis of HKD than did DSM-IV for a diagnosis of ADHD. Consequently, there were 10 ADHD cases for every HKD case in this sample. Overall impairment in everyday functioning as judged by parents and teachers paralleled total symptom scores with the HKD group being most impaired followed by the ADHD-C, ADHD-HI and the ADHD-IA groups in that order. Parent-child discord was more severe in the HKD and ADHD-C groups than in the ADHD-HI and ADHD-IA groups, and inhibitory control performance followed the same gradient. This pattern of findings fits the model of a quantitative trait.



Greater symptom severity predicted greater exposure to risk factors and consequences of childhood hyperactivity in a graded, quantitative manner with the least exposure and fewest symptoms in the ADHD-IA group followed by the ADHD-HI and ADHD-C groups with the HKD group being most affected.

By contrast, no similar quantitative tendency was evident in any of the other indices of risk or dysfunction including prevalence of comorbidity, neurodevelopmental risk, psychosocial risk, inter-parental discord, family history, working memory, or academic, language and intelligence test scores. On these markers of risk or impairment, the pattern was more consistent with the model in which all groups, HKD, ADHD-C, ADHD-HI and ADHD-IA, define diagnostic entities that exceed clinical threshold with little to separate them except those features mentioned above. The other possibility is that neither ICD-10 nor DSM-IV defines a true clinical entity because all individuals in these groups are essentially normal. This interpretation of the results would be difficult to support given the highly atypical scores for parent and teacher rated impairment, which were approximately three standard deviations above the mean for the control group, and the high rate of comorbidity of various impairing disorders. From these results, it would be difficult to argue that HKD alone delineates a valid, clinically relevant entity, but that ADHD does not. It is possible that an even lower threshold than was applied in the current study could be justified. Lee et al. (in press) found that the predictive validity of ADHD was undiminished by lowering the threshold for pervasiveness and others have found the same for adult psychiatric disorders.

The second question under investigation was the predictive validity of HKD and ADHD in the absence of comorbidity. In accord with previous studies, comorbidity of one disorder or another was the rule rather than the exception for HKD and ADHD. However, the large initial sample size in this study allowed, for the first time, for a statistically powerful comparison of HKD and ADHD subtypes without comorbid conditions. The results indicate that, compared to non-ADHD control cases, comorbidity-free cases of HKD, ADHD-C, ADHD-HI and ADHD-IA are more impaired, exposed to greater psy-

chosocial and neurodevelopmental risks, experience greater parent-child conflict and inter-parental discord, have higher risk of ADHD in their families, lower academic attainment and poorer inhibitory control and working memory. In other words, the predictive validity of HKD and all the ADHD subtypes do not derive solely from the psychopathologies that are commonly associated with them.

Interestingly, diagnostic sub-groups did not differ significantly in family risk for ADHD, a rate that is in line with the results of prior family history studies of ADHD. This finding indicates that risk for ADHD to first degree family members is not dependent on the severity of the ADHD proband.

These results also bear on the validity of the ADHD subtypes. The ADHD subtypes were similar to each other yet distinct from normal controls across a range of important variables such as exposure to psychosocial adversity, academic attainment, risk for comorbidity other than CD, impairment in executive function and recurrence risk for ADHD in family members. However, ADHD-IA cases had fewer total ADHD symptoms, were somewhat less impaired, and had a lower rate of comorbid CD. There was a trend toward more females in the ADHD-IA group. The lower risk for CD and greater proportion of females among ADHD-IA cases supports previous research. However, the ADHD-IA group did not exhibit the inferior executive function (inhibition and working memory), comorbid RD, and language impairment that has been reported in some, but not all previous research. Finally, the current results do not support the view that ADHD-HI is an uncommon and less impairing variant of ADHD that occurs, for the most part, in younger individuals.

The clinical implication of these observations is that the treatment needs of all ADHD subtypes are important: Exclusive reliance on HKD criteria would fail to identify the clinical needs of the vast majority of affected and impaired individuals. Similarly, ignoring ADHD-IA because it is associated with fewest symptoms, least impairment and lowest risk for CD would overlook the needs of about one-third of clinic referred cases. However, given the importance of comorbid CD for outcome, it would seem possible that ADHD-IA may have a unique developmental trajectory.

The study findings have implications for research as well as clinical practice. In some areas such as the study of executive function deficit in ADHD, the specific nature of a research sample might have an effect on results. Studies that include higher proportions of HKD than ADHD-IA cases are more likely to yield differences in cognitive task performance. Nevertheless, all clinic groups showed executive function deficit. In other areas such as family genetics research, sample composition may have little or no effect. Researchers are advised to describe the specific diagnostic criteria that are applied and the resulting characteristics of their study samples. Based on these results, there is no justification for exclusion of any ADHD sub-type from neuropsychological or genetic research.

### Summary

We compared the predictive validity of narrow diagnostic criteria for childhood hyperactivity as defined by ICD-10 criteria for HKD with broader criteria defined by DSM-IV criteria for ADHD. Application of HKD and ADHD criteria in this large data set allowed comparison of the predictive validity of non-overlapping groups of HKD, ADHD-C, ADHD-HI and ADHD-IA cases on a range of criteria. DSM-IV and ICD-10 criteria generate substantial variation in prevalence and the expected differences in severity based on total symptom counts. However, ICD-10 and DSM-IV criteria did not clearly delineate groups with different predictive validity. The few comparisons where differences among HKD, ADHD-C, ADHD-HI and ADHD-IA groups were observed such as inhibition deficit and teacher-rated impairment, appeared to be a function of symptom severity, with HKD being more severe than ADHD-C, followed by ADHD-HI and ADHD-IA in turn. Nevertheless, all of the DSM-IV subtypes were characterized by significant impairment, family conflict, and academic and executive function deficits compared with controls even after controlling for age and intelligence. This was true even after excluding cases with comorbidity. Finally, it should be noted that all of the cases that received a diagnosis of HKD would have received a diagnosis of ADHD according to DSM-IV criteria. Consequently, the current comparisons underestimate impairment in ADHD.

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