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ORIGINAL CONTRIBUTION

On the link between attention deficit/hyperactivity disorder and obesity: do comorbid oppositional defiant and conduct disorder matter?

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Abstract The link between attention deficit/hyperactivity disorder (ADHD) and elevated body weight/obesity can be regarded as well established. Because oppositional defiant disorder (ODD)/conduct disorder (CD) has also been found to be associated with these characteristics and ADHD and ODD/CD often occur comorbidly, we investigated whether ODD/CD and ADHD are independently linked with body weight and obesity. The clinical records of 360 children, 257 (6–12 years) with diagnoses of ADHD, ODD/CD, or comorbid ADHD and ODD/CD and 103 children with adjustment disorder (as a control group) constituted the database. All children were seen for the first time in two outpatient psychiatric clinics. Associations of the psychiatric diagnoses (ADHD present vs. not present; ODD/CD present vs. not present) with the standard deviation scores (according to German reference data) of the child's body mass index (BMI-SDS) and presence of obesity were analyzed by ANCOVA and hierarchical logistic regression analysis, respectively. Children with ODD/CD showed higher BMI-SDS ($F = 7.67$, $p < 0.006$) and rate of obesity (Wald $= 4.12$, $p < 0.05$, OR $= 2.43$) while controlling for ADHD comorbidity. While adjusting for ODD/CD comorbidity, the links between ADHD and BMI-SDS or obesity did not reach statistical significance. Given a cross validation of these findings, future (preferably prospective longitudinal) research should analyze the mediating mechanism between the psychiatric conditions and obesity. This knowledge could be helpful for preventive interventions.

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Introduction

In recent years, broad evidence for an association between attention deficit/hyperactivity disorder (ADHD) and overweight/obesity was provided by many studies. Several large-scale, community-based studies revealed that individuals who report more symptoms of ADHD show higher body weight and are more frequently obese than those who describe less ADHD symptoms [7, 8, 11, 15, 28]. Other studies examined children [12] or adults [19] with ADHD diagnoses. These studies also found higher rates of obesity and higher body weight in individuals with ADHD. Mustillo et al. [18], however, failed to show an association between ADHD diagnosis and development of obesity between childhood and adolescence and Pagoto et al. [19] found no association between obesity and retrospectively assessed ADHD in childhood.

With respect to comorbidity ADHD is a complex and heterogeneous disease. Most frequently, ADHD is accompanied by oppositional defiant (ODD) and conduct disorder (CD). About 50 % of children with ADHD also show ODD or CD [4, 32]. There are only a few studies that have analyzed the association between ODD/CD symptoms and obesity. These few, however, revealed associations with chronic obesity [18] and found ODD symptoms to predict obesity in (early) adulthood [22, 26].

Of the abovementioned studies that analyzed the ADHD-obesity link there were only two that explicitly controlled for ODD/CD comorbidity. Holtkamp et al. [12] showed that children with pure ADHD do not differ in body weight from children with ADHD that is

accompanied by CD. However, ADHD cases with comorbid ODD had been excluded. Erhart et al. [8] used the Conduct Problems scale of the Strengths and Difficulties Questionnaire to adjust for comorbid ODD/CD symptoms and found the link between ADHD symptoms and overweight/ obesity not considerably affected.

Obviously, the associations between ADHD and ODD/CD with overweight and obesity should be further analyzed, especially at the level of clinical diagnoses. More specifically, it is not known whether and to what extent the association between ADHD and obesity holds after controlling for comorbid ODD and CD and vice versa. The present study, therefore, aims to contribute to these questions by analyzing whether children with an ADHD diagnosis and/or children with ODD/CD diagnoses show higher body weight and a higher rate of obesity than control children and whether the overlap between each specific psychiatric disorder and body weight/obesity is also shared with (i.e., can be statistically explained by) the comorbid disorder. We hypothesize that ADHD and ODD/CD are, independently of each other, assocaited with elevated body weight and obesity.

Methods

Participants

We analyzed the clinical records of patients who were seen for the first time at the two outpatient clinics of child and adolescent psychiatry of the University Hospital, Marburg, Germany between 1998 and 2009. Inclusion criteria were: age of child between 6 and 12 years, first consultation, ICD-10-diagnoses of "Disturbance of Activity and Attention" (ICD-10 code[1]F90.0), "Hyperkinetic Conduct Disorder" (ICD-10 code[2]F90.1), or CD or ODD (ICD-10 codes[3]F91.0, F91.1, F91.2, F91.3) [25, 31]. In the following, we refer to these groups as "pure ADHD," "comorbid ADHD + ODD/CD," and "pure ODD/CD" group.

As a control group we intended to include children who were seen under the same conditions as the ADHD and ODD/CD groups. We, therefore, chose children also seen for the first time and in the same time period who received the diagnosis of an adjustment disorder (ICD-10 codes F43.20, F43.21, F43.22, F43.23, F43.25, F43.28). The adjustment disorder diagnosis seemed adequate because temperamental impulsivity (that might constitute a common endophenotype of externalizing disorders and obesity [23]) is not assumed to underlie this disorder and associations with body weight are unknown. However, we excluded three children with an adjustment disorder with disturbance of conduct (F43.24) because of completely overlapping symptoms. We found no difference in the standard deviation score of the BMI (BMI-SDS, definition see below) between these children with adjustment disorder (BMI-SDS: mean = 0.12, SD = 1.07) and the German age- and gender-related reference data ($t = 1.27$, $p = 0.201$), underscoring the adequacy of this group as a control group.

Exclusion criteria were IQ below 70, a second diagnosis in the area of pervasive developmental disorders or epilepsy, and physical diseases known to impact body weight (e.g., pituitary diseases). We also excluded 70 children who were previously prescribed stimulant medication [$n = 52$ (23 %) children of the pure ADHD group and 18 (21 %) children of the comorbid ADHD + ODD/CD group] and one child with an adjustment disorder and antidepressant medication. A further 48 children were excluded because of missing data on medication.

In all, 360 children fulfilled the inclusion criteria: 144 showed pure ADHD, 63 hyperkinetic conduct disorder (i.e., comorbid ADHD + ODD/CD), 50 pure ODD/CD[4]and 103 children an adjustment disorder.[5]Diagnoses were made according to ICD-10 by a child and adolescent psychiatrist or by medical doctors and psychologists supervised by an experienced child and adolescent psychiatrist. Clinical records were completed at the finish of the diagnostic process consisting of two to three visits of patients at the child and adolescent psychiatric outpatient clinics of the University of Marburg, Germany.

To assess the duration of the child's psychiatric problems, parents were asked for the year of their child's first visit to a medical doctor because of emotional or behavioral problems. In correspondence to diagnoses, children of the ADHD/ODD/CD groups showed significantly longer

[1] This ICD-10 F90.0 diagnosis corresponds to the ADHD combined type diagnosis 314.01 of the DSM-IV.

[2] For this diagnosis, the criteria for hyperkinetic disorder (F90) and a conduct disorder (F91.-) must be met. In ICD-10, ODD constitutes a subcategory of CD. Equivalent to DSM-IV, in ICD-10 ODD (F91.3) is defined by less severe symptoms that usually occur in younger children [25, 31]. Therefore this group is named "comorbid ADHD + ODD/CD".

[3] ICD-10 and DSM-IV contain equivalent diagnostic criteria and symptom lists for CD and ODD. CD diagnosis is completely equivalent, and all children who receive an ODD diagnosis by use of DSM-IV also receive this diagnosis on basis of ICD-10. The small subgroup of children who fulfill the ICD-10 but not the DSM-IV criteria is very similar to those who meet the criteria with respect to comorbidity, development and impairment [25]. Therefore the group is named ODD/CD.

[4] F91.0: $n = 6$, F91.1: $n = 11$, F91.2: $n = 10$, F91.3: $n = 20$, F91.8: $n = 3$.

[5] F43.20: $n = 11$, F43.21: $n = 5$, F43.22: $n = 11$, F43.23: $n = 58$, F43.25: $n = 17$, F43.28: $n = 1$.

Table 1 Group differences in control variables

	Pure ADHD	ADHD + ODD/CD	Pure ODD/CD	Adjustment disorder	
Age (years)					
Mean	8.80	9.26	10.12	10.11	$F = 13.73$
SD	1.67	2.02	2.21	1.67	$p < 0.001$
n	144	63	50	103	
Gender					
Male (%)	116 (80.6)	58 (92.1)	35 (70.0)	62 (60.2)	$Chi^2 = 25.03$
Female (%)	28 (19.4)	5 (6.7)	15 (30.0)	41 (39.8)	$p < 0.001$
Intelligence (IQ)					
Mean	98.6	96.7	97.4	98.2	$F = 0.26$
SD	12.5	12.4	15.7	12.9	ns
n	118	44	34	90	
Duration of psychiatric problems (years)					
Mean	0.97	1.73	1.54	0.73	$F = 5.24$
SD	1.65	2.29	2.02	1.49	$p < 0.002$
n	144	63	50	103	

SD standard deviation

time intervals between their first and the current consultation (Table 1). The four groups did not significantly differ in IQ, but they did differ in gender and age (Table 1).

In the following, we controlled statistically (introduction as co-variables) for the potential influences of gender, age, and duration of psychiatric problems. Because of the similarity of the groups in IQ we refrained from a statistical control of this variable.

Variables

Body weight and obesity

Body weight and height of all children were measured using the same calibrated scales and stadiometers. All children were weighted in light clothing without shoes. Body Mass Index (BMI) was calculated. On the basis of German reference data for children [14], BMIs were transformed into standard deviation scores (BMI-SDS) using the method by Cole [5]. This BMI-SDS approximates the deviation of an individual BMI from the median of the age- and gender-related reference group expressed in units of the standard deviation. In correspondence with the German S3 guideline for the treatment of obesity in childhood and adolescence [27], a child was classified as obese if his/her BMI-SDS was at or exceeded the 97th age- and gender-related percentile of the German reference data [14].

Intelligence level

Intelligence level of child was considered for controlling purposes. The IQ is associated with type of school and school performance (criteria of the validity of an intelligence test) and therefore, might approximate differences in education and education-related life style. The typically lower intelligence level of children with ADHD and ODD/CD [17] might, therefore, impact weight gain.

In 56.9 % ($n = 205$) of cases the child's intelligence quotient was assessed by the use of the German version of the Culture Fair Test (CFT-20) by Weiss [30]; in 12.8 % ($n = 46$) the Wechsler Intelligence Scale for children (WISC; German version by Petermann and Petermann [21]), and in 9.8 % ($n = 35$) the Kaufmann Assessment Battery for Children (K-ABC; Kaufman et al. [13]) were administered. In 20.6 % ($n = 74$) of cases the child's intelligence level was judged by the psychiatrist in scope of the psychiatric examination.

Test-retest reliability estimates of the CFT-20 were between 0.80 and 0.82 over a 3 month period. Validity was shown by demonstrating high correlations (on average 0.64) with other intelligence tests (for example the WISC) and school marks in math (between 0.50 and 0.57) [30]. The WISC shows an overall reliability of 0.97. Good criterion and factorial validity were established [29]. The K-ABC also shows high reliability (split-half reliability estimates were between 0.83 and 0.98) and proved valid by showing high correlations with other intelligence tests (with the WISC between 0.57 and 0.79; [13]). Raw scores were transformed into IQ-scores on the basis of the respective German norms of the tests. Ratings of the psychiatrists were handled as missing data.

Statistical analysis

To analyze whether children with and without ADHD and children with and without ODD/CD differ in BMI-SDS, we conducted 2 × 2 ANCOVA. ADHD present (pure ADHD

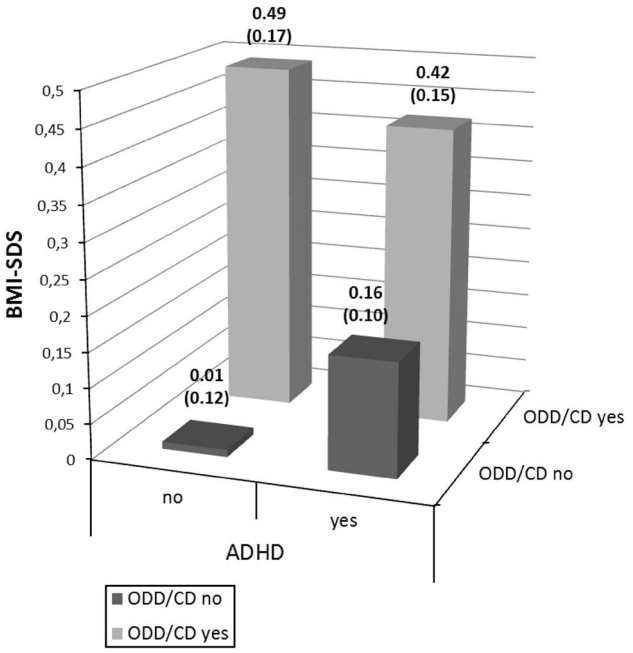

Fig. 1 Comparisons between groups by 2 × 2 ANCOVA. Note: Depicted are mean (SE) of BMI-SDS adjusted for age and gender ANCOVA effects: Main effect ADHD ($F_{ADHD} = 0.10$, ns) Main effect ODD/CD ($F_{ODD/CD} = 7.67$, $p < 0.006$) Interaction effect ($F_{ADHD \times ODD/CD} = 0.66$, ns)

and comorbid ADHD + ODD/CD) vs. not present (pure ODD/CD and adjustment disorder) and ODD/CD present (pure ODD/CD and comorbid ADHD + ODD/CD) vs. not present (pure ADHD and adjustment disorder) are used as between-subjects factors, while using gender, age, and duration of psychiatric problems as co-variables. However, because controlling for duration of psychiatric problems (that is by definition lowest in control children) also suppresses meaningful group differences, we report all results with and without controlling for this variable.

To analyze whether obesity rates are associated with ADHD and ODD/CD diagnoses, we used logistic regression analyses with obesity present vs. not present as the criterion variable and ADHD (present vs. not present) and ODD/CD (present vs. not present) as predictor variables. We controlled for the influences of age and gender by introducing these variables into the regression equation in a first step. In a second step, ADHD diagnosis and ODD/CD diagnosis are introduced. In this final model, the Wald statistics of ADHD and ODD/CD diagnoses indicate the unique contribution of the specific diagnosis to the prediction of the criterion (i.e., the association between the diagnosis and obesity adjusted for the other diagnosis and the control variables introduced in the first step). In an additional regression analysis, we also controlled for duration of psychiatric problems.

Table 2 Prediction of obesity rates by ADHD and ODD/CD diagnoses

Step/ model	Variables entered	Model 2 statistics		
		Change: Chi^2 (*df*)	Wald	Odds ratio (95 % CI)
1	Control variables	3.77 (2)		
	Gender (boys)		0.06	0.89 (0.35–2.28)
	Age		3.37^t	1.23 (0.99–1.54)
2	Diagnoses	4.60^t (2)		
	ADHD (present)		0.70	1.49 (0.59–3.79)
	ODD/CD (present)		4.12*	2.43 (1.03–5.73)
3	Interaction	0.55 (1)		
	ADHD × ODD/CD		–	–

Significance: $^t p < 0.10$; * $p < 0.05$

Results

Comparisons of body weight

In the 2 × 2 ANCOVA (while correcting for age and gender of child) we found a significant "main effect" of ODD/CD, indicating that children with ODD/CD showed higher BMI-SDS than children without ODD/CD. We found no difference in BMI-SDS between children with and without ADHD (Fig. 1). Further correction for duration of psychiatric problems did not considerably change the results ($F_{ADHD} = 0.04$; $F_{ODD/CD} = 5.80$, $p < 0.02$; $F_{ADHD \times ODD/CD} = 0.61$).

Comparisons of obesity rates

Overall, 6.7 % ($n = 24$) of the children in the present sample were obese. Rates in the pure ADHD, comorbid ADHD + ODD/CD, pure ODD/CD, and control group were 5.7, 11.8, 11.5, and 3.9 %, respectively.

In the logistic regression analysis, ODD/CD was significantly associated with obesity, i.e., children with ODD/CD showed a higher obesity rate than those with no ODD/CD while controlling for age, gender, and ADHD. The association between ADHD and obesity (while controlling for age, gender and ODD/CD) failed to reach statistical significance (Table 2). We repeated this analysis with duration of psychiatric problems as a third control variable. In this case, neither the ADHD (Wald = 0.83) nor the ODD/CD (Wald = 2.61) effect proved to be statistically significant.

Discussion

We compared children with pure ADHD, pure ODD/CD, comorbid ADHD and ODD/CD and control children to analyze whether ADHD and ODD/CD are independently linked with body weight and obesity. In extension of previous research we analyzed the reciprocally adjusted links between the psychiatric diagnoses and body weight/obesity. We found children with ODD/CD to show the highest body weight and highest rates of obesity, irrespective of the presence of an ADHD diagnosis. While controlling for ODD/CD, we found no association between body weight and ADHD. Thus, while the expected independent association between ODD/CD and body weight/obesity could be confirmed, we could not demonstrate an independent link between ADHD and body weight/obesity.

We statistically controlled for the influences of age and gender. Groups did not differ in IQ. Controlling for duration of psychiatric problems did not change the significance of the link between ODD/CD and elevated body weight. But the link with obesity considerably decreased and was no longer statistically significant. As mentioned, controlling for duration of psychiatric problems in part suppresses meaningful group differences (i.e., differences associated with diagnosis). Nevertheless, this decrease might also indicate that children with a comparably longer duration of problems are more frequently obese. A highly significant correlation between duration of problems and obesity ($r_{pb} = 0.19$, $p < 0.006$) within the three ADHD/ODD/CD groups underscores this assumption.

Accordingly, the relatively short duration of psychiatric problems in our comparably young sample (6–12 years) could be one reason for the non-significant association between ADHD and elevated body weight/obesity. Most other studies included adolescents besides children or studied adults. Pagoto et al. [19] confirmed an association between ADHD diagnosis and obesity in adults, but failed to show this association for retrospectively assessed ADHD in childhood. Moreover, Erhart et al. [8] analyzed the association between ADHD (yes vs. no) and body weight (underweight, normal, and overweight) in three different age groups between 7 and 17 years and only found a statistically significant association in the oldest group (14–17 years).

Another explanation for the non-significant independent association between ADHD and elevated body weight is that this link might be stronger in combination with ODD and CD. A reason might be that specifically individuals who show ADHD with comorbid ODD/CD show especially pronounced impulsivity and/or deviations in reward processing [6, 23] that have been assumed to constitute common endophenotypes (reflecting a common genetic basis) of the psychiatric diseases (i.e., ODD/CD and ADHD) and obesity [1, 3, 16]. However, our findings have to be cross-validated before any conclusions can be drawn.

The positive association between ODD/CD and body weight is in line with previous findings [18, 22]. In this study, we could show that the association holds after adjusting for comorbid ADHD. The mediating processes are probably complex and diverse. High impulsivity [23], an inclination to addictive behavior [2], psychological stress [24], and specific eating pattern [20] might contribute to this link. A further possibility is that children develop aggressive behavior and ODD/CD in reaction of being teased and socially excluded because of overweight/obesity. However, in a post hoc analysis we found the link between ODD/CD and body weight also present in the range of normal body weight (i.e., we repeated the 2×2 ANCOVA after excluding children who exceeded the 90th age- and gender-related percentile of BMI-SDS. Though this lowered the link, it still proved statistically significant; $F = 4.17$, $p < 0.045$). Moreover, von Stumm et al. [26] and Pine et al. [22] found ODD/CD symptoms to developmentally precede obesity in adulthood.

Our study has some limitations. Because stimulant medication has previously been shown to impact weight and height development [9] children with medication (or missing data on medication) at their first admission to the outpatient clinics had been excluded. However, data on potential past periods of stimulant treatment were not available. We cannot completely rule out the possibility that such past periods mattered. However, on the one hand it seems unlikely that past treatment periods exclusively appeared in the pure ADHD patients, but not in children with comorbid ADHD + ODD/CD. On the other hand controlling for duration of psychiatric problems did not increase the link between ADHD and elevated body weight/obesity. We controlled for IQ of children to approximate differences in education and familial socialization, but we used no direct measures of these variables. Moreover, the number of missing data in IQ (i.e., intelligence level judged by clinician) was relatively high. However, on the basis of the available results of intelligence tests, groups proved largely equivalent. Even though the BMI is widely used and well validated for an assessment of obesity it does not allow for distinguishing between lean mass and fat mass [10]. In future research, methods that allow for such a distinction should, therefore, be preferred. We analyzed clinical records. Corresponding psychiatric diagnoses were made in the scope of a supervised, however, not completely standardized diagnostic process at a university hospital. Advantages of our approach lie in blinded assessments (with respect to hypotheses) and the availability of a large data pool that allowed selecting homogenous groups.

To summarize, this study found ODD/CD linked with elevated body weight and obesity in 6- to 12-year-olds who had been referred for the first time to a psychiatric outpatient clinic, but failed to show a statistically significant independent association between ADHD and elevated body weight/obesity. In corresponding previous studies comorbidity was not explicitly analyzed. Therefore, a cross validation by further studies is needed before any final conclusions can be drawn. In future research it would be compelling to analyze developmental processes of psychiatric diseases, body weight, and the potential mediating variables. Given the serious health threatening effects of overweight and obesity, this research could be instructive with respect to prevention and treatment of overweight and obesity in children suffering from ADHD and ODD/CD.

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Conflicts of interest Ursula Pauli-Pott, John Neidhardt, Monika Heinzel-Gutenbrunner: none to declare. Katja Becker: is/has been involved in research/clinical trials with Eli Lilly and Shire, is on the Advisory Board of Eli Lilly/Germany, and was paid for public speaking by Eli Lilly and Shire.

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