



## Attention-deficit/hyperactivity disorder (ADHD) and being overweight/obesity: New data and meta-analysis



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### HIGHLIGHTS

- ADHD and obesity may be associated but effect moderators are unclear.
- A meta-analysis of 43 studies was conducted.
- A reliable overall ADHD-to-obesity association was found with a small effect size.
- The effect was larger in adults over 18 years old than in children.
- This association may be of minimal clinical impact in children but more in adults.

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### ABSTRACT

**Background:** Literature has suggested that ADHD may be associated with increased risk of obesity. If so, this would have important clinical implications.

**Objective:** To clarify the size of the association between ADHD and obesity and to evaluate key moderators of the association including medication, gender, age, and psychiatric comorbidity.

**Method:** Two preliminary studies are presented to supply critical additional data for the meta-analysis: a two-year longitudinal study of an ADHD case-control sample of 313 children aged 7–11, and a national survey study of 45,309 families in the United States using the 2012 National Survey of Children's Health. Formal meta-analysis was then conducted. The identification procedure yielded 43 studies, reporting 225 comparisons or effect sizes, studying 703,937 participants. An overall effect size was estimated with a random effects model (after pooling within study using a modified fixed effects model). Effect size was then examined in relation to medication, gender, age, and psychiatric comorbidity.

**Results:** The new study of children revealed no reliable association of ADHD and body mass index at any age or time point. In the national survey, ADHD was associated with obesity only in adolescent girls but not in children or boys; this effect was statistically accounted for by covarying of depression and conduct disorder. In the meta-analysis, the composite effect size was OR = 1.22 (95% CI = 1.11–1.34); 22 studies provided effects with medication controlled, yielding a composite effect size of OR = 1.30 (95% CI = 1.12–1.50). Pooled across age the association without covariates was reliable in females (OR = 1.19 [1.01–1.41]) but not males (OR = 1.10 [0.95–1.23]) although males and females did not statistically differ. Pooled across gender, the association was significantly larger in adults (>18 years) (OR = 1.37 [1.19–1.58]) than in youth (OR = 1.13 [1.00–1.27]),  $p = .04$ . **Conclusions:** ADHD has a small overall association with obesity, but this effect is moderate in adults. The effect is likely to be of no clinical significance in children, possible clinical significance in adolescent girls with comorbid disorders, and of clinical relevance by adulthood.

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**Abbreviations:** ADHD, attention-deficit/hyperactivity disorder; BMI, body mass index.

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## 1. Introduction

In the past decade, an important claim has been made asserting an association between ADHD and overweight or obesity (Chen, Kim, Houtrow, & Newacheck, 2010; Cortese & Angriman, 2008; Cortese & Morcillo Penalver, 2010; Fuemmeler, Ostbye, Yang, McClernon, & Kollins, 2011; Pagoto et al., 2009; Taurines et al., 2010; Waring & Lapane, 2008). Exploring this claim, the literature offers a number of hypotheses as to the putative association between ADHD and obesity. Two of the symptoms central to ADHD, impulsivity and inattention, may increase the risk of obesity through separate, but related, means (Cortese, Faraone, Bernardi, Wang & Blanco, 2013). Relatedly, the reward deficiency hypothesis, which suggests that the etiology of ADHD is due, in part, to the insufficiency of brain dopamine (Blum et al., 2000), may play an interrelated role as well. Impulsivity is thought to contribute to obesity through disordered eating patterns (Davis, Levitan, Smith, Tweed, & Curtis, 2006), both in quantity, such as binge eating (van Egmond-Fröhlich, Widhalm, & de Zwaan, 2012) and type of foods consumed (e.g. high calorie, nutrient poor) (van Egmond-Fröhlich, Weghuber, & de Zwaan, 2012). Dysregulation of dopamine may mediate consumption of high caloric, low nutrient foods (Tanofsky-Kraff & Yanovski, 2004) as well as impulsivity, in turn contributing to the consumption of high caloric foods, low in nutrient value (i.e. processed or fast foods) and contributing to overweight or obesity (Davis et al., 2006). Binge eating behaviors, unmoderated by the impulsivity associated with ADHD, may compensate for the dopamine deficiency thought to be present in individuals with ADHD (Wang et al., 2001). These hypotheses are supported by the efficacy of stimulant medication, which reduces impulsivity, suppresses appetite (Faraone, Biederman, Morley, & Spencer, 2008) and increases synaptic dopamine availability by blocking the dopamine transporter (Schulz, Fan, Bédard et al., 2012; Spencer et al., 2005). Stimulant medication has been associated with lower BMI in early puberty (Poulton et al., 2013), reflecting its appetite suppressing qualities (Faraone et al., 2008).

Inattention, in turn, may play a role in obesity by diminishing an individual's receptivity to internal satiation cues (Cortese & Vincenzi, 2012) or contributing to difficulty in maintaining regular patterns of eating, thus leading to disordered consumption habits (Davis et al., 2006). Further, poor planning and self-regulation deficits may interfere with follow-through on activities requiring effortful control and planning, such as

exercise and dietary changes, which promote healthy weight (Cortese & Vincenzi, 2012). Finally, individuals with ADHD tend to have more mood lability than their non-disordered counterparts (Oliver, Nigg, Cassavaugh, & Backs, 2012). This fluctuating negative affect may contribute to a propensity to choose pleasurable, high caloric foods to “medicate” the low mood (Davis, Strachan, & Berkson, 2004; Wang et al., 2004).

Despite the plausibility of an association between ADHD and overweight/obesity, recent reviews (Cortese & Vincenzi, 2012; Korczak, Lipman, Morrison, Duku, & Szatmari, 2014) have been rather mixed on its robustness. The literature suggests that the clinical importance of this association may depend on moderators. A number of putative, but rarely tested factors have been noted for their association between ADHD and overweight/obesity. Age effects have rarely been tested directly, but when they were, differential age effects were reported. For example, two studies (Fliers et al., 2013; van Egmond-Fröhlich et al., 2012) found that effects were smaller in younger than older children, although Fliers et al. found a curvilinear effect with age. These findings suggest that effects may be most apparent in adulthood, rather than in childhood. However, we know of only three studies that reported results for samples limited to children under age 10; all controlled for medication effects and still found that ADHD or ADHD symptoms were associated with lower, not higher BMI (Ebenegger et al., 2012; Fliers et al., 2013; van Egmond-Fröhlich et al., 2012). It may be ADHD's effect on obesity is gradual and does not emerge until the natural weight and fat gain of adolescence and adulthood relative to childhood amplifies a subtle ADHD effect. This would be relevant to the developmental timing of any secondary prevention proposals for obesity in youth with ADHD.

Second, only a handful of studies have tested differential effects by gender of the participant. In the two most methodologically rigorous studies, which directly compared effects in adolescents (Cortese, Faraone, et al., 2013; van Egmond-Fröhlich et al., 2012), both concluded that effects were confined to females. These findings need support from additional data and then clarification in a pooled analysis with other studies. It may be that, because girls normatively gain more body fat than boys after puberty due to differential hormonal development, girls with ADHD are more vulnerable to excess weight gain in adolescence and adulthood.

The putative confounders of age, gender, or their combined effects are of importance for several reasons. ADHD is most commonly diagnosed in boys, tends to modulate in adolescence, with some

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