Childhood Attention-Deficit/Hyperactivity Disorder Symptoms Are Risk Factors for Obesity and Physical Inactivity in Adolescence

Natasha Khalife, MSc, Marko Kantomaa, PhD, Vivette Glover, PhD, Tuija Tammelin, PhD, Jaana Laitinen, PhD, Hanna Ebeling, MD, Tuula Hurtig, PhD, Marjo-Riitta Jarvelin, MD, PhD, Alina Rodriguez, PhD

Objective: To prospectively investigate the association and directionality between attention-deficit/hyperactivity disorder (ADHD) symptoms and obesity from childhood to adolescence in the general population. We examined whether obesogenic behaviors, namely, physical inactivity and binge eating, underlie the potential ADHD symptom–obesity association. We explored whether childhood conduct disorder (CD) symptoms are related to adolescent obesity/physical inactivity. **Method:** At 7 to 8 years (n = 8,106), teachers reported ADHD and CD symptoms, and parents reported body mass index (BMI) and physically active play. At 16 years (n = 6,934), parents reported ADHD symptoms; adolescents reported physical activity (transformed to metabolic equivalent of task [MET] hours per week) and binge eating; BMI and waist–hip ratio (WHR) were measured via clinical examination. Obesity was defined using the International Obesity Task Force (IOTF) cut-offs for BMI and the 95th percentile cut-off for WHR. **Results:** Childhood ADHD symptoms significantly predicted adolescent obesity, rather than the opposite. Inattention-hyperactivity symptoms at 8 years were associated with indices of obesity at 16 years (obese BMI: odds ratio [OR] = 1.91, 95% confidence interval [CI] = 1.10–3.33; 95th percentile WHR: OR = 1.71, 95% CI = 1.05–2.78), adjusted for gender, baseline BMI, physical activity, family structure change, and maternal education. Child CD symptoms associated with indices of adolescent obesity. Reduced physically active play in childhood predicted adolescent inattention (OR = 1.61, 95% CI = 1.16–2.24). Childhood ADHD and CD symptoms were linked with physical inactivity in adolescence (inattention-hyperactivity; OR = 1.60, 95% CI = 1.20–2.13), but not binge eating. Physical inactivity mediated the associations. **Conclusions:** Children with ADHD or CD symptoms are at increased risk for becoming obese and physically inactive adolescents. Physical activity may be beneficial for both behavior problems and obesity. J. Am. Acad. Child Adolesc. Psychiatry, 2014;53(4):425–436. **Key Words:** attention-deficit/hyperactivity disorder symptoms, conduct disorder symptoms, disruptive behavior, obesity, physical inactivity

A growing number of studies report an association between obesity and attention-deficit/hyperactivity disorder (ADHD).[1-4] According to a recent review, most studies are limited by use of clinical and/or cross-sectional data.[1] Furthermore, it is unclear whether the association is specific to ADHD, that is, independent of other behavioral disorders—in particular, conduct disorder (CD),[5-8] one of the primary psychiatric comorbidities of ADHD.[9] Importantly, studies have not examined potential underlying mechanisms or the direction of the ADHD–obesity association.[1] Research has mainly examined ADHD as a risk factor for obesity.[10,11] However, it is plausible that the association may be driven from the direction of obesity to ADHD, as factors linked with obesity, for example, leptin (an appetite-regulation hormone) and a sugar-rich diet may contribute to ADHD-like behaviors.[12,13] Moreover, the association may be bi-directional because of a third underlying factor associated with both obesity and ADHD.[14-17] Although it

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is impossible to fully decipher the direction of the association in human beings, prospective longitudinal and epidemiological studies can provide valuable information concerning the general population. Because of the lack of such studies, the direction of the potential link remains unevaluated.

Recently, Cortese *et al.* reported a long-term link between childhood ADHD and adult obesity, albeit in a small clinical sample (n = 207) of men only.[7] The same authors, using data from the National Epidemiological Study on Alcohol and Related Conditions, found a significant association, but only for women (retrospective reports for ADHD and self-reports for weight/height).[18] These discrepant findings may be attributed to differences in study design, including possible referral bias in the clinical versus population samples. It is necessary to prospectively examine the early developmental trajectory of the potential ADHD–obesity link from childhood to adolescence, because these disorders manifest early in life.[19,20] The few longitudinal studies of children/adolescents provide inconsistent results, are limited by small sample size, and do not examine directionality.[21-23] One study in toddlers (i.e., 2-year-olds) reported a link between behavioral difficulties and obesity over a 3.5-year period[21]; however, other studies in older children have not confirmed the association.[22,23] Another limitation is the sole use of body mass index (BMI),[21,22] which may not adequately reflect adiposity.[24] Indicators of abdominal obesity, such as waist–hip ratio (WHR), provide additional measures of adiposity, and may more accurately identify individuals at risk for health consequences of overweight.[24]

Inattention and/or impulsivity symptoms may confer a risk for certain obesogenic behaviors, including physical inactivity and binge eating.[1] The impact of hyperactivity symptoms remains unclear.[1] To date, only a few population studies have examined the association between ADHD and physical inactivity in children and/or adolescents, and have yielded conflicting results.[25-27] There are a few small clinical studies reporting improved behavior in children diagnosed with ADHD after a short-term period or acute bout of physical activity.[28-30] However, the long-term impact of physical activity on behavior is still unevaluated. Some evidence suggests an association between binge eating and behavioral impulsivity.[31,32] A recent study found that symptoms of ADHD were significantly, but not differentially, greater in obese patients with and without binge eating behaviors.[33] Therefore, the extent to which obesogenic behaviors underlie the ADHD–obesity association is unclear.

In this study, we investigated the association and directionality between core ADHD symptoms and obesity (BMI and WHR), from childhood to adolescence, in a large population cohort. We also examined the bi-directional associations between ADHD symptoms and physical activity, and the impact of ADHD symptoms on binge eating, from childhood to adolescence. We hypothesized that there would be a significant association between ADHD symptoms (at a clinically relevant level) and obesity from childhood to adolescence, and that physical inactivity and/or binge eating would mediate this link. Finally, we explored whether CD symptoms, commonly associated with ADHD, are related to obesity, and whether the ADHD symptom–obesity link is independent of CD.

METHOD

Participants

Participants came from the Northern Finland Birth Cohort (NFBC) 1986. Children with an expected date of birth between July 1, 1985 and June 30, 1986 were eligible; 99% (N = 8,954 live-born singletons) participated. The ethics committee of Northern Ostrobotnia Hospital District approved the study, and both parents and adolescents gave written informed consent.

Postal questionnaires, which included a wide range of health- and lifestyle-related questions, were sent to parents, teachers, and adolescents. At 7 to 8 years (n = 8,106; 91%), data were gathered via parental and teacher reports. At 16 years (n = 6,934; 77%), data were gathered via parental reports and adolescent self-reports. In addition, adolescents (n = 6,156) attended health examinations, which included growth measurements. The NFBC 1986 is a stimulant-naive population sample,[34] with the exception of 1 boy who received methylphenidate (Ritalin) for a few months at age 12 years to treat ADHD.

Measures

Behavior. Teachers assessed child behavior of 8-year-olds using the Rutter B2 scale,[35] a well-validated screener for childhood mental health. Each of the 26 items is rated as it "certainly applies" (scored 2), "applies somewhat" (scored 1), or "does not apply" (scored 0), yielding a total score between 0 and 52. Screening as "probable combined inattention-hyperactivity disorder" is defined as a total score of $\geq$9 and sum of all 3 inattention-hyperactivity items $\geq$ 3.[36] We also examined the core ADHD symptoms individually, that is,