ATTENTION-DEFICIT/HYPERACTIVITY DISORDER IS NOT ASSOCIATED WITH OVERWEIGHT IN ADOLESCENCE BUT IS RELATED TO UNHEALTHY EATING BEHAVIOR AND LIMITED PHYSICAL ACTIVITY

Halt Anu-Helmi[a*], Hirvonen Taru-Tuulia[b], Koskela Jari[c] Kerkelä Martta[d], Hurtig Tuula[e]

a) ***Corresponding author:** Anu-Helmi Halt, MD, Ph.D., Clinical lecturer
Research Unit of Clinical Medicine, Psychiatry, University of Oulu, Oulu, Finland
Medical Research Centre Oulu, Oulu University Hospital and University of Oulu
Department of Psychiatry, Oulu University Hospital, Oulu, Finland
P.O.Box 5000, FI-90014 University of Oulu, Finland
tel +358-50-4488335
https://orcid.org/0000-0001-8994-3256
e-mail: anu-helmi.halt@oulu.fi

b) MD
Research Unit of Clinical Medicine, Psychiatry, University of Oulu, Oulu, Finland
P.O.Box 5000, FI-90014 University of Oulu, Finland
e-mail: Taru-Tuulia.Hirvonen@student.oulu.fi

c) MSc
Research Unit of Clinical Medicine, Psychiatry, University of Oulu, Oulu, Finland
P.O.Box 5000, FI-90014 University of Oulu, Finland
e-mail: jari.koskela@oulu.fi

d) MSc
Research Unit of Clinical Medicine, Psychiatry, University of Oulu, Oulu, Finland
P.O.Box 5000, FI-90014 University of Oulu, Finland
e-mail: martta.kerkela@oulu.fi

e) PhD, Associate Professor, University Lecturer
Research Unit of Clinical Medicine, Psychiatry, University of Oulu, Oulu, Finland
Medical Research Centre Oulu, Oulu University Hospital and University of Oulu
Clinic of Child Psychiatry, University Hospital of Oulu, Oulu, Finland
P.O.Box 5000, FI-90014 University of Oulu, Finland
tel +358-40-7181372, +358-40-6724683
e-mail: tuula.hurtig@oulu.fi

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ABSTRACT

Purpose

The aim of the study was to examine the possible relation between adolescent ADHD and high BMI, studying also eating behavior and physical activity.

Methods

The data were collected from the Northern Finland Birth Cohort 1986. The follow-up at the age of 16 consisted of a self-assessment form and clinical examination where height and weight were measured, and questionnaires on physical activity and eating habits were completed. ADHD diagnosis was based on a diagnostic interview with adolescents and parents according to DSM-IV-TR criteria. The participants were divided into the following study groups: individuals with adolescent ADHD (*n*=90), those with only childhood ADHD (*n*=40), and community controls (*n*=269).

Results

Results showed no significant differences in BMI, but adolescents with ADHD seemed to have unhealthier eating habits than controls; they ate less often vegetables and breakfast, devoured more often, and consumed more fast food, soft drinks, sweets, and potato crisps daily. Individuals with adolescent ADHD reported light exercise more often but strenuous exercise more seldom than controls. Those with only childhood ADHD did not significantly differ from community controls regarding health behaviors.

Conclusions

There was no relation between ADHD and high BMI but adolescents with ADHD had unhealthier eating habits than those without ADHD. It is conceivable that unhealthy eating behaviors in adolescence might be a risk factor for the development of later overweight; however, the longitudinal associations between ADHD, unhealthy eating behaviors and overweight have not been considered in the present study and remain to be examined further.

Keywords: ADHD, BMI, neuropsychiatric disorder

1. INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is a neuropsychiatric disorder that starts in childhood (American Psychiatric Association, 2013). ADHD is characterized by developmentally inappropriate and impairing levels of hyperactivity, impulsivity, and inattention. The disorder is most common in children, but in many cases, ADHD continues to adulthood. The estimated prevalence of ADHD in adolescents is 3.4%–7.2% worldwide (Polanczyk et al., 2015; Thomas et al., 2015). There are gender differences in the prevalence rates of ADHD, which are seen especially in childhood. When comparing boys and girls, the prevalence in boys is up to 9-fold higher in clinical samples and 4-5 folds higher in epidemiological samples (Quinn and Madhoo, 2014).

High body mass index (BMI) is a significant risk factor for cardiovascular diseases later in life (Callo et al., 2019). Physical activity and a good diet help maintain a healthy range of BMI. The symptoms of ADHD, e.g., hyperactivity and restlessness, have been assumed to have an increasing influence on daily physical activity (Seidell and Halberstadt, 2015). However, a relation between ADHD and high BMI has been found in previous studies (Kim et al., 2014). On the other hand, physical activity has positively impacted ADHD symptoms. In fact, physical exercise is considered a good treatment option for ADHD symptoms in underage adolescents. Exercising relieves not only the symptoms but also has a positive influence on social skills (Kamp et al., 2014).

The reasons underlying the relation between ADHD and obesity have been studied recently. Possible explanations for this link could be a sedentary lifestyle and an increased time per day spent watching television. Another reason could be possible common genetic alterations in obesity and ADHD (Cortese and Tessari, 2017). An association between ADHD and binge eating has also been found in adults, both men and women (Brewerton and Duncan, 2016). Furthermore, ADHD symptoms have also been associated with emotional eating in preschool children (Leventakou et al., 2016). An unhealthy diet is also associated with ADHD (Kim et al., 2012).

In addition to findings in children, the relation between ADHD and high BMI has been found in adults (Davis et al., 2006; Strimas et al., 2008). ADHD and its association with BMI and the factors underlying the body mass index have not been studied as widely among adolescents as among children and adults.

In the present study, we investigated 16-year-old adolescents from the Northern Finland Birth Cohort 1986 (NFBC1986) to find out whether there is an association between ADHD and high BMI. We also studied eating habits and physical exercise among adolescents with ADHD compared to controls.

2. METHODS

2.1 Participants and procedure

The participants are derived from the Northern Finland Birth Cohort (NFBC) 1986 (Järvelin et al., 1993). The cohort is a population cohort of 9,432 children born alive in northern Finland whose expected date of birth was between July 1, 1985, and June 30, 1986 (Figure 1). The children have been studied prospectively since the prenatal period.

Insert Figure 1 about here

The 16-year-old follow-up questionnaire study for adolescents and their parents was conducted between April 2001 and February 2002. Altogether 7,344 (79.7%) of 9,215 adolescents filled the self-assessment forms (3,785 girls and 3,559 boys). The adolescents' questionnaire included questions on their family, friends, school, mental and physical health, exercise, behavior, nutrition, living habits, and hobbies. The parents' questionnaire included items on adolescent's health, development, and behavior as well as the Strengths and Weaknesses of ADHD-Symptoms and Normal-Behaviours (SWAN) rating scale for ADHD symptoms (Swanson et al., 2001). In total, 6,985 (75.8%) of the parents responded, and 6,622 (71.9%) of the completed questionnaires were used: 224 had missing data, and 119 refused to have their data used (Figure 1).

After the survey, all adolescents in the cohort were invited to clinical examination. The clinical examination for adolescents was conducted between August 2001 and June 2002 in all municipalities of Northern Finland and major cities elsewhere in Finland. The clinical examination included weight, height, and waist-hip measurements, blood samples, and questions about physical activity, nutrition, and eating habits. A written informed consent was received from parents and adolescents and the study has a statement from the Ethical Committee of the Northern Ostrobothnia Hospital District.

The participants to the clinical ADHD assessment were selected based on the SWAN score. It was used to identify probable ADHD cases among the NFBC adolescents. The SWAN has been validated in population-based samples with high sensitivity and specificity (Burton et al., 2019). All adolescents scoring above the 95th percentile in the distribution of the SWAN questionnaire (Swanson et al., 2001) and currently living in Northern Finland (N=487) and a random sample of adolescents scoring below the 90th percentile, group matched for gender, place of birth and year of birth (N=315) were invited to take part in a clinical examination (Smalley et al., 2007). The clinical assessment included a psychiatric evaluation using the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime version (K-SADS-PL), which is known to be a reliable and valid method for defining psychiatric diagnoses according to DSM-IV-TR criteria (Kaufman et al., 1997).

Based on the SWAN scores, 261 cases, and 196 controls, 457 in total completed the clinical assessment (Figure 1). Mental health specialists trained for the K-SADS-PL executed the interviews, first with the parent and then with the adolescent. After a thorough systematic evaluation process and consensus meetings with the child and adolescent psychiatrists working in Oulu University Hospital and the University of California, Los Angeles (UCLA), the current and lifetime (childhood) ADHD diagnosis was made (Smalley et al., 2007).

In this study, we categorized subjects into three groups: adolescent ADHD (n=90), childhood ADHD (n=40), and controls (*n*=269), (Table 1). The adolescent ADHD group consisted of individuals diagnosed with ADHD from childhood. The childhood ADHD group consisted of individuals who met the criteria in childhood but were in remission in adolescence. The control group included individuals with no current (i.e., adolescent ADHD) or lifetime (i.e., childhood ADHD). In addition, subthreshold ADHD cases were excluded from the study groups (n=58 for subthreshold ADHD). Individuals with ADHD were stimulant medication naïve.

2.2 Measures

2.2.1 BMI

The clinical examination for adolescents included weight and height measurements. We computed the BMI as weight (kg)/height^2 (m^2) based on this clinical information. In the analyses regarding BMI, we considered only those participants who had clinically measured BMI. The data for BMI was available for 253 controls, 40 childhood ADHD cases, and 84 adolescent ADHD cases.

2.2.2 Physical activity and eating behaviors

The other variables used in data analysis were drawn from the adolescent self-reports in the 16-year-old follow-up study. The questions for adolescents concerning physical activity outside the school hours included: 1) How many hours per week do you spend doing light physical exercise (without getting out of breath or sweating)? 2) How many hours per week do you spend in strenuous physical activity (getting out of breath and sweating at least slightly)? 3) Do you belong to a sports club? 4) How often do you take part in individual or team sports? (Table 3).

Adolescents were asked about the consumption of various food items as described in Table 4. In addition, adolescents were required about their eating habits and emotional eating (Table 4). Please see the exact questions (University of Oulu, 1986). The answer options of the questions used are seen in tables 3 and 4. Also, the final numbers of study subjects with data available for each variable are seen in tables 3 and 4.

2.2.3 Confounding factors

Adolescents' gender and long-term illness, family type, and parental highest education were considered as potential confounding factors. Previous research shows that ADHD is more common among males and those with socioeconomic disadvantages (Faraone et al., 2015), in addition, healthy dietary habits has been reported to be related to age, sex, and SES (Johansson et al. 1999). Parental information was collected from the questionnaire sent to the parents in the 16-year-old follow-up study. The parental highest education is classified into two classes: 12 years or less and more than 12 years. Family type indicates the parent's relationship: two-parent (children's parents are married or living together) and one parent/other (divorced, unmarried, widowed, or other family type). Adolescent's long-term illness was combined from the questions to the parents: 'Does the participating child have a congenital or other heart defect?' and 'Does the child have some other long-term illness, handicap or disability diagnosed by a doctor?'.

2.3 Statistical analyses

We tested for difference in clinically measured BMI between the adolescent ADHD and controls or the childhood ADHD and controls, respectively, using Mann-Whitney U-tests. Moreover, we fitted the liner regression models to estimate the difference in BMI between the adolescent ADHD vs. controls and the childhood ADHD vs. controls. Crude and adjusted (adjusted with gender, parental highest education, long-term illness, and family type) linear regression models were fitted, and β with 95% confidence interval were reported.

For physical activity and eating behaviors, cross-tabulations were created, and Chi-Square tests were used to compare the adolescence ADHD vs. controls or the childhood ADHD vs. controls. All tests were two-tailed, and a 0.05 significance level was used. Holm-Bonferroni method was used to counteract the problem of multiple testing in physical activity items, food items and behaviours items. Statistical computations were performed using IBM's SPSS Statistics package version 24.

3. RESULTS

Table 1 shows the distribution of background factors and BMI among controls, childhood ADHD, and adolescent ADHD individuals. More males than females were in the adolescent ADHD group (75% vs. 25%) compared to controls (59% vs. 42%, p=0.010). More individuals lived with one parent in the adolescent ADHD group than controls (35% vs. 21%, p=0.017). Parents of those with adolescent ADHD reported education less than 12 years more often than parents of controls (89% vs. 77%, p=0.026). There was no significant difference in BMI between childhood ADHD group compared to controls nor between adolescent ADHD group compared to controls. The means and medians were almost the same in every group, but the range of BMI among individuals with adolescent ADHD was the widest. (Table 1).

Insert Table 1 here

Table 2 shows the association of BMI with the childhood ADHD and adolescence ADHD analyzed with the linear regression. There is no statistically significant difference in BMI between the childhood ADHD group and controls or between the adolescent ADHD group and controls after adjusting for gender, long-term illness, parental highest education, and family type (Table 2).

Insert Table 2 here

Table 3 shows the results of the questions regarding physical activity. Subjects with adolescent ADHD did more light exercise than controls (at least 4 hours a week 38% versus 26%, $p=0.032$). In strenuous physical exercise, the adolescent ADHD group had the most subjects who did very little, if any, exercise compared to controls (at least 20 min 3 times a month or less 40% versus 26%, $p=0.022$). Those with adolescent ADHD included more subjects who did individual sports less than three times a month compared to controls (23% versus 12%, $p=0.011$), and the same trend could also be seen in team sports (adolescent ADHD 33% versus controls 22%, $p=0.093$).

Insert Table 3 here

The results regarding diet and eating habits are shown in Table 4. There are more subjects in the adolescent ADHD group (26% versus 12%, $p=0.010$) and in the childhood ADHD group (25% versus 12%, $p=0.045$) who ate vegetables hardly ever compared with controls. Individuals with adolescent ADHD also ate more fast food daily than controls (9% versus 4%, $p=0.003$). Individuals with adolescent ADHD also consumed soft drinks, sweets, and potato crisps significantly more often compared to controls (soft drinks almost daily or daily 34% versus 16%, $p=0.002$; sweets almost daily or daily 25% versus 13%, $p=0.026$; potato crisps almost daily or daily 4% versus 2%, $p=0.009$).

Significant differences were also seen in eating behavior. Individuals with adolescent ADHD ate breakfast less often on weekdays than controls (33% versus 21%, $p=0.033$), but the difference evened out on weekends. The same pattern could be seen as a trend towards statistical significance with snacks, but in this case, subjects with adolescent ADHD ate snacks more often than controls (85% versus 76%, *p*=0.099). Individuals with adolescent ADHD devoured more often than controls (at least once a week 17% versus 7%, *p*=0.020). There was also a trend towards statistical significance that controls devoured less often than individuals with childhood ADHD (hardly ever or less 62% versus 45%, *p*=0.066). Furthermore, individuals with childhood ADHD felt less often miserable after devouring than controls (13% versus 36%, *p*=0.034). There was no significant difference between the groups in answers regarding thinking about food and emotional eating (Table 4)

Insert Table 4 here

4. DISCUSSION

The current study explored the possible relation between childhood or adolescent ADHD and BMI, focusing on eating behavior and physical exercise. The study results suggest that ADHD patients' BMI is not higher than controls. The most distinguishable differences between the study groups can be found in eating habits. Those with adolescent ADHD eat unhealthier food and have more irregular mealtimes than controls. Individuals with adolescent ADHD eat significantly less vegetables and more unhealthy food items than controls. Subjects with only childhood ADHD eat less vegetables compared to controls. But otherwise, they seem to have close to normal eating habits, and their exercise habits seem to be almost exactly as healthy as those of the controls. Thus, it seems that eating behavior and physical activity may become practically normal in adolescence if ADHD is in remission, but future studies with larger sample sizes are needed to confirm this.

The main difference in mealtimes is that individuals with adolescent ADHD eat less regularly breakfast on weekdays and more snacks compared with controls. The association between regular mealtimes and ADHD or ADHD symptoms has not been studied much. Hartmann et al. (2012)

studied 10- to 14-year-old teenagers with ADHD symptoms and symptoms of loss of control (LOC) eating, and the subjects were compared to controls. In Hartmann's (2012) study, the ADHD group ate more snacks than the control group while watching a film. Plausible influencing factors could be negative mood, impulsivity, or negative urgency. According to Hilbert et al. (2018), 8- to 13-year-old children with ADHD and LOC overate when they were not hungry. In this study, when given free access to snacks and food, children with ADHD/LOC ate significantly more calories.

In the current study, we also examined variables concerning eating behavior and binge eating. Those with adolescent ADHD reported binge eating more often than the controls. Over half of current and childhood ADHD groups devoured food once a month or more frequently. The subjects with childhood ADHD also felt less often miserable after devouring.

Others have found a link between hyperactivity/inattention and eating disturbances. ADHD symptoms during late childhood were directly associated with eating disturbances in early adolescence and indirectly associated with binge eating during mid-adolescence. This means that the symptoms of ADHD in early adolescence may indicate an increased risk of becoming eating disordered later in life (Sonneville et al., 2015). Childhood ADHD has been found to be a predictive factor for obesity in adolescence, but unlike in our study, overeating was not associated with ADHD (Khalife et al., 2014).

In our study, 16.9% of adolescents with adolescent ADHD devoured at least once a week, meeting one of the criteria for BED. Several studies have also found a link between ADHD and BED or overeating. In children, the relation between ADHD symptoms, overeating/LOC, and obesity has been found in multiple studies (Khalife et al., 2014; Leventakou et al., 2016). In an Australian study of adolescents aged 14 to 15, boys with ADHD were at greater risk of binge eating disorder (Bisset et al., 2019). Higher rates of binge eating (Brewerton and Duncan, 2016; Cortese et al., 2007) and overeating (Davis et al., 2006) have also been reported in ADHD adults. In addition to binge eating, purging has a connection with ADHD (Bleck et al., 2015). Many other eating disorders have been associated with ADHD. Bulimia nervosa has been associated with adolescent girls with ADHD (Mikami et al., 2008) as well as adults with ADHD (Seitz et al., 2013).

Several theories explain the association between ADHD symptoms and overeating/binge eating. The common symptoms of ADHD, inattention, and impulsivity foster binge eating. Especially impulsivity has been found to best predict eating pathology (Mikami et al., 2008). Abnormal eating behaviors might be the cause of obesity in ADHD patients. In obese patients, impulsivity associated with binge eating might lead to ADHD (Cortese et al., 2008). ADHD patients' poor ability to limit food intake is consistent with impulsiveness (Davis et al., 2006; Egbert et al., 2018). Behavior such as poor planning for the future and failure to monitor one's behavior are examples of deficient inhibitory control associated with ADHD. This poor inhibitory control could lead to devouring. ADHD patients might not be concerned with their daily calorie intake. This kind of behavior is associated with rapid eating and eating when not hungry. ADHD patients with strong delay aversion will typically choose the most immediate options, such as fast food over home-cooked meals. Highly caloric food can also be self-medication since it activates dopamine in the common reward pathway (Davis et al., 2006).

Another hypothesis suggests that common neurobiological dysfunctions might underlie the association of obesity/binge eating and ADHD (Cortese et al., 2008; Cortese et al., 2007). The shared biological mechanism in ADHD and binge eating has been described as 'reward deficiency syndrome'. The natural dopamine-related reward system does not work normally, resulting in the use of immediate rewards, such as altered eating behavior and risk-taking. This syndrome has been found in ADHD and obese patients with abnormal eating behaviors. The relation between ADHD and obesity could be explained at least partly by common genetic dysfunctions in the dopaminergic system. Additionally, alterations in two dopamine receptors, receptors 2 and 4 (DRD2 and DRD4), have been reported in several studies in both ADHD and obese patients with abnormal eating behaviors (Cortese et al., 2008).

The possible neurobiological connection between obesity and ADHD has been researched. Albayrak et al. (2013) suggest that there may be two specific risk alleles linking obesity and ADHD. The first one is SNP rs206936, which is located in a member of the Nudix protein family (NUDT3). The second one, SNP rs6497416, can be found in GPRC5B, which is part of the superfamily of G protein-coupled receptors (GPCR). Furthermore, the possible shared genetic and neural correlates of ADHD, especially impulsivity, and BMI phenotypes have been researched. In their study, Barker et al. (2019) found that impulsivity phenotypes of ADHD and high BMI are associated with alterations in the same parts of the brain (e.g., in cerebellum, amygdala, hippocampus, orbitofrontal and inferotemporal cortex) which are related with impairments in inhibitory control and reward processing.

Individuals with adolescent ADHD report more light exercise but less strenuous exercise than the controls. Both ADHD groups do less team sports than controls. According to Khalife et al. (2014), inactivity seems to relate to ADHD and physical inactivity. Children with inattention may have problems with increased concentration, perception, and self-directedness, all of which are required in physical activities. Social impairments, e.g., rule-breaking, could have a negative effect on children’s participation in team sports in particular. These social impairments are strongly related to ADHD. Furthermore, children with ADHD symptoms may spend more of their free time playing video games or watching television. Future weight gain could result from the lack of physical activity due to these factors.

Problems with motor skills and developmental coordination disorder are often associated with young ADHD patients. Physical activities that may require these skills can be less appealing to adolescents with problems in these areas. ADHD often includes deficits in planning, motivation, persistence, and self-regulation. These deficits could create problems in committing to regular and demanding physical activity (Cook et al., 2015).

There is emerging evidence from short-term and long-term studies that physical exercise can help cope with ADHD symptoms. Physical activity seems to have a positive effect on executive function and motor skills as well as on cognitive, social, emotional, and behavioral outcomes (Hoza et al., 2016). According to Ng et al. (2017), physical activity helps cope with symptoms of ADHD in children and adolescents, primarily behavioral, physical, and cognitive symptoms. They also noted that the best results were reported for mixed exercise, particularly aerobic exercise, and physical activity did not negatively affect the ADHD symptoms. It seems that in young people with ADHD, 20–30-minute moderate-to-intense physical activity (intensity 40–75%) can alleviate symptoms in areas like planning and problem-solving. There are positive effects on attention and inhibition as well as on emotional control, behavior, and motor skills when physical activity is executed regularly (Suarez-Manzano et al., 2018).

In this study, the range of BMI in subjects with adolescent ADHD is wide, but the medians and means are almost the same in all study groups. Although our study did not find a relation between ADHD and high BMI in adolescents, others have found a connection in children and adults. In an extensive meta-analysis examining the possible link between obesity and ADHD, the association was found in children and adults (Cortese et al., 2016). On the other hand, Nigg et al. (2016) found in their extensive meta-analysis that the association between being overweight, and ADHD can be more robust in adolescent girls and adults. The association could have clinical significance in these populations, but no association was found in preadolescent boys. Another study found the association in preadolescent girls (Kerekes et al., 2015).

The findings of the current study are contradictory. We found no connection between ADHD and high BMI, but at the same time, there was an association between binge eating and ADHD. This might be due to several factors: our study focused on adolescents aged 16 while other studies have examined either younger or older adolescents. One plausible explanation behind our results could be that adolescents' height growth at the age of 16 compensates for the possible weight gain. Another plausible theory could be differences in metabolism between ADHD adolescents and controls. Adolescents with ADHD are typically more restless, cannot calm down, and are thus constantly using their energy resources.

Strengths and limitations

The greatest strength of this study is our large general population-based sample. In the NFBC, recall and selection biases are limited, and the participation rates are excellent. Although some data were collected as self-reported, professionals composed the questionnaires. In addition, the height and weight data, which has the highest potential for misreporting, was based on clinical information. The subsample driven from the NFBC is comprehensive, well collected, and analyzed by competent professionals. Another strength of the current study is that subjects with ADHD were stimulant medication naïve. Even though our study is based on a large general population sample, the results of our study may not be directly generalized to other populations. Information of the representativeness of our final sample is limited. The case-control setting is challenging for the attrition analysis, as the controls are matched for gender, place of birth and year of birth. In the future, larger samples are needed to confirm our findings. The small sample size, particularly in the analysis regarding childhood ADHD, reduces the power of the analysis. Also, as the data were already collected in 2001 and 2002, ADHD diagnoses were based on DSM-IV-TR criteria, and in future it would be important to study whether the results also pertain to the current diagnostic criteria (i.e., DSM-5 criteria, especially in light of the changed age criterion).

Conclusions

Adolescents with ADHD had unhealthier eating habits than those without ADHD. It could be beneficial to inform the families of ADHD children more of the importance of maintaining healthy eating habits. The reasons underlying these study results need more investigation in the future. It is conceivable that unhealthy eating behaviors in adolescence might be a risk factor for the development of later overweight; however, the longitudinal associations between ADHD, unhealthy eating behaviors and overweight have not been considered in the present study and remain to be examined further.

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Declaration of interest

AHH, and TH have received funding from Terttu foundation. AHH has received travel fees (Lundbeck). MK, JK, and TH report no potential conflicts of interest.

Role of the funding source

The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Data Availability Statement

NFBC data is available from the University of Oulu, Infrastructure for Population Studies. Please, contact NFBC project center (NFBCprojectcenter@oulu.fi) and visit the cohort website (www.oulu.fi/nfbc) for more information. Permission to use the data can be applied for research via the electronic material request portal. In using data, we follow the Finnish Data Protection Act and the EU general data protection regulation (679/2016).

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Table 1. Distribution of background factors N (%) and BMI in the study groups

	Controls *n*=253	Childhood ADHD *n*=40	Childhood ADHD vs. controls		Adolescent ADHD *n*=84	Adolescent ADHD vs. controls	
			χ^2	*p*		χ^2	*p*
Gender			2.28	0.131		6.65	0.010
Male	148 (58.5)	29 (72.5)			63 (75.0)		
Female	105 (41.5)	11 (27.5)			21 (25.0)		
Family type			0.00	1.000		5.72	0.017
One parent/other	53 (21.3)	9 (22.5)			28 (35.4)		
Two Parent	196 (78.7)	31 (77.5)			51 (64.6)		
Parental highest education			1.55	0.213		4.93	0.026
12 years or less	195 (77.4)	35 (87.5)			75 (89.3)		
More than 12 years	57 (22.6)	5 (12.2)			9 (10.7)		
Long-term illness							
No	195 (78.3)	28 (75.7)	0.02	0.882	57 (69.5)	2.17	0.141
Yes	54 (21.7)	9 (24.3)			25 (30.5)		
			U	*p*		U	*p*
BMI kg/m^2			4901	0.750		10631	0.995
mean	21.09	21.07			21.43		
median	20.49	20.75			20.66		
Std. deviation	3.14	3.25			4.54		
minimum	14.3	15.32			13.53		
maximum	34.67	31.1			46.94		

Attention deficit and hyperactivity disorder (ADHD), body mass index (BMI).

Table 2. Association of BMI with the childhood ADHD and adolescence ADHD analyzed with linear regression

	Childhood ADHD vs. controls			Adolescence ADHD vs. controls		
	β	95% CI.	*p*			
Crude						
ADHD	-0.03	-1.10, 1.04	0.956	0.32	-0.56, 1.22	0.470
Adjusted						
ADHD	-0.33	-1.44, 0.77	0.555	0.52	-0.42, 1.48	0.273
Gender (Female)	0.15	-0.61, 0.92	0.698	0.75	-0.07, 1.59	0.072
Long-term illness	0.05	-0.86, 0.96	0.911	-0.21	-1.15, 0.74	0.667
Parental education (Low)	-0.17	-1.08, 0.75	0.718	-0.03	-1.01, 0.95	0.908
Family type (One parent/other)	-0.34	-1.50, 0.34	0.214	-0.15	-0.78, 1.11	0.736

Table 3. Physical activity and participation in sports in the study groups with χ^2 statistic

	Controls (n=269)	Childhood ADHD (n=40)	Childhood ADHD vs. controls		Adolescent ADHD (n=90)	Adolescent ADHD vs. controls	
	n (%)	*n* (%)	χ^2	*p*	*n* (%)	χ^2	*p*
Light physical exercise/week	259	40			77		
1h/week or less	99 (38.2)	15 (37.5)	0.06	0.969	32 (41.6)	6.86	0.032
2-3 h/week	92 (35.5)	15 (37.5)			16 (20.8)		
4 h or more	68 (26.3)	10 (25.0)			29 (37.7)		
Strenuous physical exercise at least 20 min	260	40			77		
3 times a month or less	68 (26.2)	13 (32.5)	1.30	0.522	31 (40.3)	7.66	0.022
1-3 times a week	115 (44.2)	14 (35.0)			22 (28.6)		
4 times or more	77 (29.6)	13 (32.5)			24 (31.2)		
Strenuous physical activity altogether	261	40			76		
1 h/week or less	99 (37.9)	16 (40.0)	0.19	0.910	37 (48.7)	4.88	0.087
2-3 h/week	67 (25.7)	9 (22.5)			11 (14.5)		
4h or more	95 (36.4)	15 (37.5)			28 (36.8)		
Individual sports	260	40			77		
3 times a month or less	30 (11.5)	7 (17.5)	1.41	0.493	18 (23.4)	8.95	0.011
1-3 times a week	107 (41.2)	17 (42.5)			34 (44.2)		
4 times or more	123 (47.3)	16 (40)			25 (32.5)		
Team sports	260	40			77		
3 times a month or less	57 (21.9)	15 (37.5)	4.67	0.097	25 (32.5)	4.74	0.093
1-3 times a week	119 (45.8)	14 (35.0)			26 (33.8)		
4 times or more	84 (32.3)	11 (27.5)			26 (33.8)		
Belong to a sports club	260	40			78		
no	196 (75.4)	31 (77.5)	0.08	0.772	62 (79.5)	0.56	0.455
yes	64 (24.6)	9 (22.5)			16 (20.5)		

Attention deficit and hyperactivity disorder (ADHD).

Table 4. Diet and eating behaviors in the study groups with χ^2 statistic

	Controls (n=269)	Childhood ADHD (n=40)	Childhood ADHD vs. controls		Adolescent ADHD (n=90)	Adolescent ADHD vs. controls	
Food items	*n* (%)	*n* (%)	χ^2	*p*	*n* (%)	χ^2	*p*
vegetables	259	40			77		
0 days a week	31 (12.0)	10 (25.0)	6.20	0.045	20 (26.0)	9.16	0.010*
1-5 days a week	200 (77.2)	24 (60.0)			51 (66.2)		
almost daily or daily	28 (10.8)	6 (15.0)			6 (7.8)		
fast food	259	40			77		
a couple times or less a month	140 (54.1)	18 (45.0)	3.16	0.206	26 (33.8)	11.66	0.003*
1-5 times a week	110 (42.5)	22 (55.0)			44 (57.1)		
almost daily or daily	9 (3.5)	0 (0.0)			7 (9.1)		
soft drinks	258	40			77		
a couple times or less a month	53 (20.5)	6 (15.0)	0.82	0.662	9 (11.7)	12.17	0.002*
1-5 times a week	163 (63.2)	28 (70.0)			42 (54.5)		
almost daily or daily	42 (16.3)	6 (15.0)			26 (33.8)		
sweets	258	40			77		
a couple times or less a month	21 (8.1)	3 (7.5)	0.29	0.867	3 (3.9)	7.33	0.026*
1-5 times a week	204 (79.1)	33 (82.5)			55 (71.4)		
almost daily or daily	33 (12.8)	4 (10.0)			19 (24.7)		
potato crisps	256	40			76		
a couple times or less a month	191 (74.6)	29 (72.5)	0.84	0.658	43 (56.6)	9.52	0.009*
1-5 times a week	61 (23.8)	11 (27.5)			30 (39.5)		
almost daily or daily	4 (1.6)	0 (0.0)			3 (3.9)		
Eating behavior							
breakfast on weekdays	260	40			77		

no	54 (20.8)	11 (27.5)	0.93	0.336	25 (32.5)	4.53	0.033
yes	206 (79.2)	29 (72.5)			52 (67.5)		
breakfast on weekends	258	38			64		
no	53 (20.5)	10 (26.3)	0.66	0.417	20 (27.0)	1.41	0.235
yes	205 (79.5)	28 (73.7)			54 (73.0)		
snacks on weekdays	248	38			73		
no	60 (24.2)	10 (26.3)	0.08	0.777	11 (15.1)	2.73	0.099
yes	188 (75.8)	28 (73.7)			62 (84.9)		
snacks on weekends	250	35			67		
no	45 (18.0)	6 (17.2)	0.02	0.901	11 (16.4)	0.09	0.763
yes	205 (82.0)	29 (82.9)			56 (83.6)		
devour large amounts of food	256	40			77		
hardly ever or less	158 (61.7)	18 (45.0)	5.44	0.066	38 (49.4)	7.83	0.020
once a month	80 (31.3)	20 (50.0)			26 (33.8)		
once a week or more	18 (7.0)	2 (5.0)			13 (16.9)		
feel miserable after devouring	121	23			45		
no	78 (64.5)	20 (87.0)	4.50	0.034	32 (71.1)	0.65	0.421
yes	43 (35.5)	3 (13.0)			13 (28.9)		
cannot think about anything except food	256	40			73		
no	228 (89.1)	35 (87.5)	0.09	0.770	66 (90.4)	0.11	0.742
yes	28 (10.9)	5 (12.5)			7 (9.6)		
try to make yourself feel better by eating	256	38			74		
no	187 (73.0)	29 (76.3)	0.18	0.670	55 (74.3)	0.05	0.827
yes	69 (27.0)	9 (23.7)			19 (25.7)		

Attention deficit and hyperactivity disorder (ADHD). *p<0.05 after Holm-Bonferroni correction

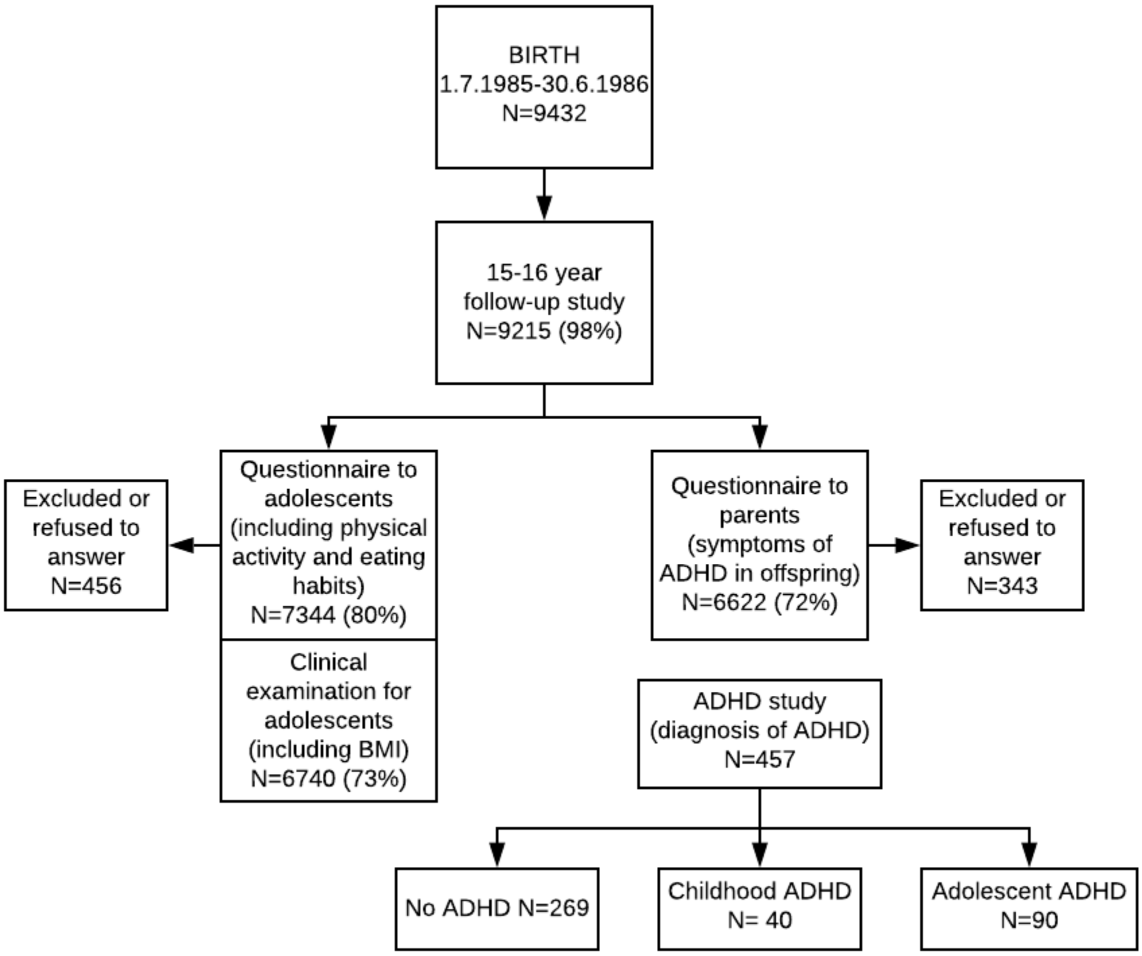

Figure 1. The Northern Finland 1986 Cohort data collection and ADHD project