






# High prevalence of neurodevelopmental problems in adolescents eligible for bariatric surgery for severe obesity

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## Abstract

**Aim:** To assess the prevalence of neurodevelopmental problems in adolescents with severe obesity and their associations with binge eating and depression.

**Methods:** Data were collected at inclusion in a randomised study of bariatric surgery in 48 adolescents (73% girls; mean age  $15.7 \pm 1.0$  years; mean body mass index  $42.6 \pm 5.2$  kg/m<sup>2</sup>). Parents completed questionnaires assessing their adolescents' symptoms of attention-deficit/hyperactivity disorder and autism spectrum disorder and reported earlier diagnoses. Patients answered self-report questionnaires on binge eating and depressive symptoms.

**Results:** The parents of 26/48 adolescents (54%) reported scores above cut-off for symptoms of the targeted disorders in their adolescents, but only 15% reported a diagnosis, 32% of adolescents reported binge eating, and 20% reported symptoms of clinical depression. No significant associations were found between neurodevelopmental problems and binge eating or depressive symptoms. Only a third of the adolescents reported no problems in either area.

**Conclusion:** Two thirds of adolescents seeking surgical weight loss presented with substantial mental health problems (reported by themselves or their parents). This illustrates the importance of a multi-professional approach and the need to screen for and treat mental health disorders in adolescents with obesity.

## KEYWORDS

adolescent, attention-deficit, bariatric surgery, hyperactivity disorder, neurodevelopmental problems, obesity

**Abbreviations:** 5–15, Five to Fifteen questionnaire; ADD, attention-deficit disorder; ADHD, attention-deficit/hyperactivity disorder; AMOS2, adolescent morbid obesity surgery 2; ASD, autism spectrum disorder; ASSQ, Autism Spectrum Screening Questionnaire; BDI-2, Beck Depression Inventory II; BED, binge eating disorder; BES, Binge Eating Scale; BMI, body mass index; IQR, interquartile range; LOC, loss of control; MBS, metabolic and bariatric surgery; RCT, randomised controlled trial.

**Trial registration:** NCT02378259, ClinicalTrials.gov

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## 1 | INTRODUCTION

Both adolescent obesity<sup>1</sup> and adolescent mental health disorders<sup>2</sup> have increased in the 21st century, and obesity and psychiatric disorders seem to be associated.<sup>3</sup> The causes, consequences or possible shared aetiological factors of this association are not fully understood, but adolescents with obesity seem more prone to mental health problems than those in the general population. Attention-deficit/hyperactivity disorder (ADHD), eating disorders and depression have been identified as the most common psychiatric comorbidities in adolescents with obesity,<sup>3</sup> but their possible interrelations have rarely been studied in those seeking treatment for severe obesity. Previous research has identified adolescents seeking metabolic and bariatric surgery (MBS) as a vulnerable group, especially from a mental health perspective.<sup>4</sup>

Obesity treatment focusing on lifestyle changes can be effective even in cases of severe obesity when initiated before puberty, while the results in adolescents are dismal.<sup>5</sup> Adolescents' poor results from lifestyle treatments and their risks for early complications of severe obesity make MBS an emerging treatment option, which shows positive results for weight loss and comorbidity resolution in this population similar to those in adult patients.<sup>6</sup>

A higher prevalence of ADHD has been reported in individuals with obesity than in those with normal weight,<sup>7</sup> although the association between ADHD and obesity might be less consistent in children and adolescents than in adults in population samples. A meta-analysis from 2016 showed a 40% increased pooled prevalence of obesity for children with ADHD over children without ADHD.<sup>7</sup> Another meta-analysis (also published in 2016), however, did not demonstrate any significant association between ADHD and obesity in children and adolescent boys, and the association between ADHD and obesity in adolescent girls was only seen with at least one other psychiatric comorbidity.<sup>8</sup>

The three available studies on the prevalence of ADHD in adolescents seeking MBS reported widely variable results. An Israeli study reported an ADHD prevalence of 28.6% in this population,<sup>9</sup> one American study reported only a 6% prevalence of ADHD,<sup>10</sup> and the other American study reported that 21% of adolescent MBS patients met the criteria for an ADHD diagnosis.<sup>11</sup>

ADHD presents in three different ways: combined presentation (deficits in both attention and hyperactivity-impulsivity), predominantly inattentive presentation, previously referred to as attention-deficit disorder (ADD) and predominantly hyperactive/impulsive presentation.<sup>12</sup> It is not known which, if any, of these presentations are more common in adolescents with severe obesity seeking MBS.

Children with autism spectrum disorder (ASD) have a heightened risk for developing obesity.<sup>13</sup> However, few studies have reported the prevalence of ASD in children and adolescents seeking obesity treatment. One study screening patients for neuropsychiatric disorders at a paediatric obesity unit in Sweden showed that 13% had a diagnosis of ASD, which is approximately tenfold higher than in the general population.<sup>14</sup>

### Key Notes

- Adolescents with severe obesity slated for bariatric surgery have high rates of neurodevelopmental problems and mental health problems such as depression and binge eating, but little is known about how these problems are associated.
- Parents rated more than half the teens positive for neurodevelopmental problems, and a marked minority of patients self-reported substantial symptoms of binge eating and/or depression; overlap with neurodevelopmental problems was not significant.
- Adolescents with severe obesity need treatment adapted to their high burden of various mental health problems.

Adolescents in obesity treatment rarely fulfil the diagnostic criteria for binge eating disorder (BED), as fully developed BED normally has its onset in early adulthood.<sup>15</sup> However, loss of control (LOC) eating is commonly reported in adolescents with obesity and is thought to be a precursor of BED. More than a quarter of children and adolescents with overweight and obesity report LOC eating, which has been suggested as a mediating factor between ADHD and obesity.<sup>16</sup>

A few studies have assessed LOC and binge eating in adolescents seeking MBS. In one American study, 27% reported LOC and 7% reported BED at baseline,<sup>17</sup> and in a previous Swedish study, 37% of the adolescents reported substantial binge eating symptoms at inclusion.<sup>18</sup> The possible association between neurodevelopmental problems and eating-related problems in adolescents seeking MBS therefore needs further study.

Neurodevelopmental disorders convey an increased risk of general internalising mental health problems such as depression and anxiety.<sup>19</sup> In some studies, adolescents with severe obesity seeking MBS report substantially more symptoms of depression than their same-aged peers in general population samples.<sup>20</sup> A little yet is known about a possible overlap between neurodevelopmental problems and depressive symptoms in adolescents seeking MBS.

In the present study, we report the parent-assessed prevalence of neurodevelopmental problems in adolescents with severe obesity presenting for a randomised controlled trial (RCT) comparing MBS and intensive non-surgical treatment.<sup>21</sup> The aim was to describe the frequency of positive screening for ADHD (combined presentation, problems mainly with inattention or hyperactivity/impulsivity) and ASD in the study group. A further aim was to explore how parent-reported neurodevelopmental problems were associated with the adolescents' self-assessments of binge eating and depressive symptoms. Based on previous research, we hypothesised that adolescents who screened positive for neurodevelopmental problems would report more problems with binge eating and more symptoms of depression than adolescents without reported neurodevelopmental problems.

## 2 | PATIENTS AND METHODS

### 2.1 | Participants

All participants were included in the Swedish Adolescent Morbid Obesity Surgery 2 (AMOS2) study. AMOS2 is a multicentre RCT comparing MBS to non-surgical intensive treatment for adolescents with severe obesity. All adolescents included in AMOS2 accepted the design and were willing to undergo MBS. The inclusion criteria were age 13 to 16 years, body mass index (BMI)  $\geq 35$  kg/m<sup>2</sup>, at least 1 year documented comprehensive conventional treatment, and puberty status Tanner stage  $\geq 3$ . Recruitment ran from 2014 to 2017 and included adolescents from three Swedish tertiary childhood obesity units in Malmö ( $n = 22$ ), Gothenburg ( $n = 19$ ) and Stockholm ( $n = 9$ ). A paediatrician and a clinical psychologist assessed all participants and a steering committee approved the participation of all patients before inclusion.

Exclusion criteria were untreated severe mental illness (including psychotic disease, substance use disorder, severe depression or suicide attempt, regular or severe self-harm and/or self-induced vomiting during the last year) and/or substantial problems adhering to treatment programmes. Neurodevelopmental disorders and mild intellectual disabilities were not grounds for exclusion provided the adolescent was deemed able to consent and participate in the study.

A majority of the 50 patients included in AMOS2 were female ( $n = 37$ ; 74%). Mean age was 15.7 years (range: 13.3–16.9), BMI 42.6 kg/m<sup>2</sup> (range: 35.7–54.9) and BMI-SDS 3.45 (range: 2.9–4.1). Baseline characteristics of the participants and the study protocol have been presented in detail elsewhere.<sup>21</sup>

### 2.2 | Ethical approval and consent

AMOS2 was approved by the regional ethics committee in Gothenburg (#578-13) and conducted according to the Declaration of Helsinki. Both participants and parents provided written informed consent.

### 2.3 | Neurodevelopmental problems

Neurodevelopmental problems were assessed on the Autism Spectrum Screening Questionnaire (ASSQ<sup>22</sup>) and the Five to Fifteen (5–15) questionnaire.<sup>23</sup> ASSQ is a questionnaire asking parents about their children's ASD symptoms through 27 items rated on a three-point scale (0–2). A total score of  $\geq 19$  out of a maximum of 54 was used as a screening cut-off for substantial symptoms of ASD.<sup>22</sup> The 5–15 questionnaire is another parental questionnaire assessing ADHD and related symptoms, such as difficulties with reading and writing, numeracy, motor skills, executive functions and social skills. The 5–15 questionnaire has 181 questions divided into 8 domains and 22 subdomains. The 90th percentiles in the domains *attention*

*and concentration* and *over-activity and impulsivity* were used as screening cut-offs for a positive result for ADHD (on one or both of the scales). Parents who were not fluent in Swedish were assisted in answering the questionnaires by a professional interpreter.

### 2.4 | Binge eating

Symptoms of binge eating were assessed using the Binge Eating Scale (BES; 24). BES is a 16-item self-report questionnaire assessing thoughts, feelings and behaviours related to binge eating. BES is a valid screening tool for binge eating in patients undergoing MBS, and a total score  $> 17$  indicates binge eating.<sup>24</sup>

### 2.5 | Depression

The Beck Depression Inventory II (BDI-2) was used to assess symptoms of depression. The BDI-2 is a self-report instrument assessing symptoms of depression during the past 2 weeks in adolescents  $\geq 13$  years and adults.<sup>25</sup> The BDI-2 consists of 21 items, and total scores range from 0 to 63. Higher scores represent more symptoms of depression, with 0–13 indicating minimal depression, 14–19 mild depression, 20–28 moderate depression and 29–63 severe depression. A total score of  $\geq 17$  is suggested in clinical studies as a conservative marker for probable clinical depression.<sup>25</sup>

All questionnaires were administered in writing on the day of study inclusion.

### 2.6 | Previous diagnosis of neurodevelopmental disorder

During the medical history interview, the adolescents and their caregivers were explicitly asked whether the adolescent had ever been diagnosed with any neuropsychiatric disorder.

### 2.7 | Statistical methods

Descriptive statistics are presented as median and interquartile range (IQR). Independent-samples Mann–Whitney *U* test was used to test differences between groups for continuous variables and Fisher's exact test to analyse categorical variables. All *p*-values are two-tailed and  $p < 0.05$  is regarded as significant. All statistical analyses were carried out using SPSS 26.0 (IBM Corp).

## 3 | RESULTS

The parents of 48/50 adolescents (96% of the RCT sample) filled out and returned the ASSQ ( $n = 45$ ) and/or the 5–15 ( $n = 48$ ), and those 48 participants were included in the present study.

### 3.1 | Neurodevelopmental problems

The parents of 26/48 (54%) adolescents scored their children's symptoms over the cut-off for ADHD, ASD or both (Figure 1). The 25 adolescents who screened positive for ADHD fell into three groups: 7 (28%; 6 girls [86%]) above cut-off on *attention and concentration* only, 7 (28%; 5 girls [71%]) on *over-activity and impulsivity* only, and 11 (44%; 9 girls [82%]) on both domains. There were no significant differences in sex, age or BMI in the groups that screened positive or negative for ADHD and ASD (Table 1).

Of the 26/48 adolescents (21 girls, 5 boys) whose parents scored them positive for ADHD or ASD, only 7 (15%; 5 girls [71%]) had a reported neurodevelopmental diagnosis in the medical history interview.

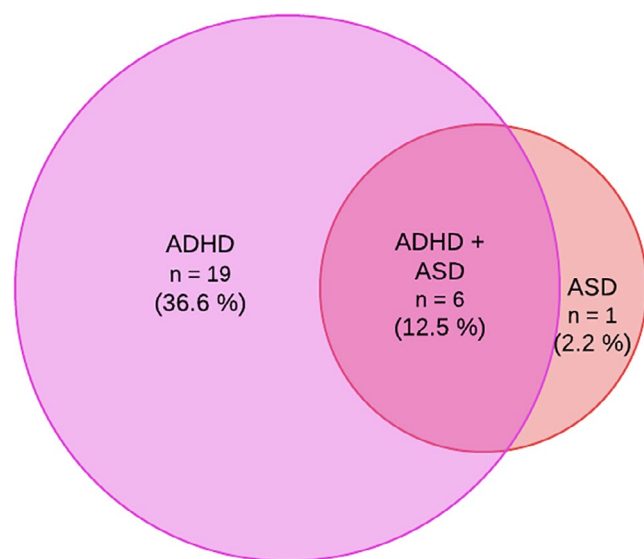
### 3.2 | Binge eating

Fourteen patients of 44 (32%) reported binge eating above the cut-off on the BES. There were no significant differences in binge eating between adolescents who screened positive or negative for neurodevelopmental problems (Table 1).

### 3.3 | Depression

On the BDI-2, 33/46 (72%) indicated minimal depression, 8 (17%) mild depression, 2 (4%) moderate depression and 3 (6%) severe depression. In total, 9/46 (20%) had a total score of  $\geq 17$  indicating symptoms of clinical depression.

No significant differences in depressive symptoms were found between adolescents with or without parent-reported neurodevelopmental problems (Table 1).



**FIGURE 1** Number (%) of adolescents who screened positive for attention-deficit/hyperactivity disorder (ADHD) and/or autism spectrum disorder (ASD)

### 3.4 | Numbers of areas with elevated mental health problems

Two thirds of adolescents reported one or several areas of elevated mental health problems (screening above cut-off for ADHD/ASD, reporting binge eating or reporting symptoms of clinical depression). In total, 16 adolescents (33.3%) reported no elevated symptoms in any assessed area, 17 (35.4%) reported elevated symptoms in one area, and 15 (31.2%) reported problems in two or all three areas (Figure 2).

## 4 | DISCUSSION

In the present study of adolescents with severe obesity participating in an RCT comparing MBS to intensive non-surgical treatment, more than half the participants were rated positive for ADHD and ASD by their parents. Combined with self-report data from the adolescents, as many as two thirds had substantial symptoms of neurodevelopmental problems, binge eating or depression. The findings add to previous studies showing that adolescents with severe obesity constitute a vulnerable group, not least from a mental health perspective.<sup>4</sup>

The frequency of ADHD symptoms (52%) was higher than previously reported in other cohorts of adolescents seeking MBS.<sup>9-11</sup> One explanation might be differences in assessment, as previous studies used a clinical interview, while we present data from parental questionnaires. Previous papers have reported different, and much lower, prevalences of ADHD ranging from 6% to 29%, indicating the high variability of ADHD prevalence between different samples.

There are, however, studies from other obesity treatment settings more in line with our findings.<sup>14</sup> In an Israeli study of children and adolescents hospitalised for obesity treatment, 58% fulfilled the criteria for an ADHD diagnosis, with 60% of those having the combined presentation and 40% the predominantly inattentive presentation.<sup>26</sup> In our study, we found the combined presentation in 44% of the adolescents screened positive, and the predominantly inattentive presentation in 28%. Inattention can contribute to obesity by making it more difficult to recognise and respond to signals of hunger and satiety and easier to choosing sedentary over vigorous activities.<sup>27</sup>

In the present study, we unexpectedly found a significant minority of adolescents (28%) screened above cut-off on *over-activity and impulsivity* only, suggesting a predominantly hyperactive/impulsive presentation. It has been suggested that the deficits in inhibitory control typical of impulsivity can lead to overeating, consuming high-calorie foods, and delay aversion (eating in the absence of hunger, not monitoring eating patterns, preference for quick solutions such as 'fast food' rather than planned meals).<sup>27</sup>

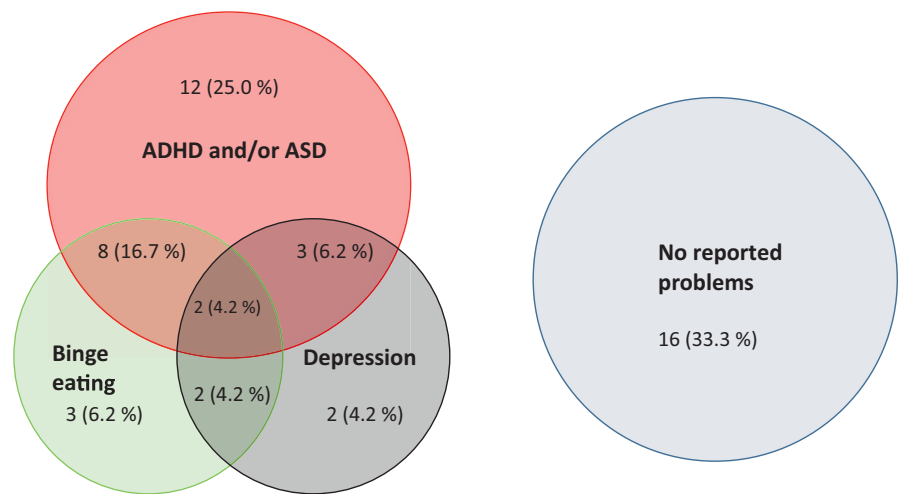
The frequency of parentally reported ASD symptoms in the adolescents in our study was also high (14.5%). All but one in this group also screened positive for ADHD, which may be because different neurodevelopmental disorders often co-occur. Few previous studies have assessed ASD or symptoms of ASD in adolescents seeking MBS,

**TABLE 1** Baseline characteristics by presence of neurodevelopmental problems (defined as screening positive for attention-deficit/hyperactivity disorder and/or autism spectrum disorder) in parental questionnaires

	Screened positive for ND (total <i>n</i> = 26)	Did not screen positive for ND (total <i>n</i> = 22)	<i>p</i>
Sex (girls) <i>n</i> (%)	21 (80%)	14 (63%)	0.210
Age median (IQR)	15.6 (1.4)	15.6 (1.4)	0.820
BMI median (IQR)	41.5 (7.0)	41.7 (6.5)	0.702
BMI-SDS median (IQR)	3.42 (0.41)	3.42 (0.47)	0.590
BES total score median (IQR)	14.5 (13.0) ( <i>n</i> = 22)	10.0 (9.0) ( <i>n</i> = 20)	0.252
BDI-2 Depression median (IQR)	10.0 (13.0) ( <i>n</i> = 25)	5.0 (9.0) ( <i>n</i> = 21)	0.077

Abbreviations: BDI-2, Beck Depression Inventory II; BES, binge eating scale; BMI, body mass index; BMI-SDS, body mass index standard deviation score; IQR, inter quartile range; ND, neurodevelopmental problems.

**FIGURE 2** Proportion of adolescents reporting none, one or several areas with elevated problems. Number (%) of adolescents screened positive for attention-deficit/hyperactivity disorder (ADHD) and/or autism spectrum disorder (ASD), binge eating and/or depressive symptoms at a clinical level



but one US study reported that 1% of their sample had an ASD diagnosis of.<sup>11</sup> Like ADHD, ASD is associated with altered perceptions that can affect the sensation of hunger or satiety, thus increasing the risk for obesity. Children with ASD can also react with aversion to different smells, textures and tastes leading to selective eating, with a high preference for a limited number of foods (often calorie-dense and low in nutrition) and avoidance of others.<sup>28</sup> Selective eating may partly explain the high rates of obesity seen in children with ASD.<sup>13</sup>

A possible explanation for discrepancies between studies reporting the prevalence of neurodevelopmental disorders in adolescents seeking MBS might be related to the selection of surgical candidates. Swedish health care is publicly funded, making selection bias due to economic reasons unlikely, and evidence suggests an association between socioeconomic disadvantage and ADHD.<sup>29</sup> In another Swedish study of adolescents undergoing MBS, a relatively higher prevalence of mental health problems was reported than in studies from the US, suggesting that there may be between-country differences in the targeted populations.<sup>4</sup>

In this study, fewer than one in five patients and their parents reported that the adolescent had been diagnosed with a neurodevelopmental disorder. In contrast, more than half of the parents rated their

adolescents with substantial symptoms of ADHD or ASD. Of note is the high proportion of girls (80%) among participants screened positive by their parents. Neurodevelopmental disorders are more common in boys than in girls,<sup>12</sup> but it is also known that neurodevelopmental problems have a less salient pattern in girls than in boys, and so can go undetected for a longer time.<sup>30</sup> A previous study of adolescents seeking MBS found more boys than girls with ADHD,<sup>11</sup> that is more in line with findings from population samples.

All the adolescents who were scored positive may not meet the formal criteria for a neurodevelopmental disorder in a rigorous assessment. However, it is important to note that parents very frequently perceive substantial problems with attention, activity, impulse control or social interaction in their adolescents eligible for MBS. Such problems can put strain on the family and negatively affect cooperation between parents and the adolescent, including in regard to weight-related issues. Problems related to attention and self-regulation that affect the patient's capacity to plan, set agreements and delay gratification can create barriers in all forms of obesity treatment.<sup>31</sup>

In line with other studies, we found elevated levels of binge eating and depressive symptoms in this group of adolescents with

severe obesity. However, contrary to our hypothesis, we did not find more such problems in those rated positive for ADHD or ASD by their parents. This might be explained by how neurodevelopmental problems were assessed in our sample, but might also be explained by the multifactorial aetiology of obesity: it is possible that different, and not overlapping, problems contribute differently to obesity in different individuals.

Our analysis shows that two thirds of the adolescents in the AMOS2 study reported elevated symptoms in one area or more. This highlights the importance of a multi-professional team in clinics treating adolescents with severe obesity in close collaboration with the child and adolescent psychiatry. Obesity treatment in adolescents should recognise that a majority of these patients present with additional problems that are likely to affect their ability to comply with the treatment. Even with successful weight loss, these problems will not just vanish. Eating-related problems can be expected to decrease after MBS, but general mental health problems will normally remain for most adolescents, and their mental health might even deteriorate.<sup>4</sup> The effect of MBS in adolescents with neurodevelopmental problems is not yet known, but studies in adults suggest improved cognitive functions after MBS.<sup>32</sup>

#### 4.1 | Strengths and limitations

An important limitation in this study was the use of questionnaires for assessing neurodevelopmental disorders without clinical examination by psychiatric experts for formal diagnosis. Having elevated symptoms is not equal to meeting diagnostic criteria, and screening questionnaires are not appropriate for differential diagnostics. Other mental problems such as post-traumatic stress disorder and general learning disabilities can also lead to symptoms resembling those of ADHD, and this was not accounted for in this study. Also, other obesity-related comorbidities such as sleep apnoea can result in further problems with attention. Another limitation was the low number of participants, which carries the risk of missing important associations due to the lack of power. A strength of this study, however, was the broad investigations of the patients' mental health with valid questionnaires commonly used in clinical settings. All adolescents in the present study had already been enrolled in the AMOS2 at assessment, lowering their risk impression management, as in underreporting symptoms that might be perceived to reduce the chance of inclusion.

#### 5 | CONCLUSION

Two thirds of adolescents with severe obesity presenting for treatment at tertiary obesity clinics have substantial mental health problems as reported by themselves or their parents. This indicates the importance of a multi-professional approach to adolescent obesity treatment and the necessity to screen these patients and initiate treatment for any concurrent mental health disorders

they may have. The obesity treatment offered might also need to be tailored for better effectiveness in the presence of neurodevelopmental problems.

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#### CONFLICT OF INTEREST

The authors report no conflicts of interest related to this work.

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