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Original article

Childhood Obesity, Obesity Treatment Outcome, and Achieved Education: A Prospective Cohort Study

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A B S T R A C T

Purpose: Childhood obesity represents a social burden. This study aims to investigate whether achieved educational level differs in young adults who have suffered obesity in childhood compared with the general population and to determine how obesity treatment influences achieved educational level.
Methods: This prospective cohort study includes subjects from the Swedish Childhood Obesity Treatment Registry (BORIS, n = 1,465) who were followed up after 20 years of age. They were compared with a randomly selected matched population-based group (n = 6,979). Achieved educational level was defined as ≥12 years in school (completers). Covariates include sex, migration background, and attention deficit disorders for both groups. Furthermore, age and degree of obesity at start of obesity treatment, treatment duration, and efficacy were analyzed in the obese cohort.
Results: In the obese cohort, 55.4% were school completers, compared with 76.2% in the comparison group (adjusted odds ratio [OR] = .42, $p < .0001$). Subjects with moderate obesity had a completion rate of 64.4%, compared with 50.9% among subjects with morbid obesity (adjusted OR = .57, $p < .0001$). Successful obesity treatment was associated with increased future educational level, compared with those experiencing no treatment effect (61.9% vs. 51.3% completers; adjusted OR = 1.4, $p < .05$). In children with attention deficit disorder, obesity was not an extra risk for not completing 12 or more years of schooling, $p = .11$.
Conclusions: Obesity in childhood was associated with low educational level in early adulthood. Children and adolescents with obesity may require special support at school in addition to health care treatment to lose weight.

IMPLICATIONS AND CONTRIBUTION

Childhood obesity is associated with a broad range of social consequences. This study shows that obesity in childhood and adolescence is associated with a strikingly lower achieved educational level and that successful obesity treatment increases the likelihood of achieving 12 or more years of schooling.

Long-term social consequences of childhood obesity, such as lower income and lower marriage frequency, have been established for more than 20 years [1,2]. A potential relationship between obesity and school performance has also been suggested, but the association is still unclear. Being obese in childhood and adolescence has been associated with lower school performance and academic achievement both in school- and population-based studies [1-5]. However, other studies have been unable to confirm any association between academic achievement and obesity [6,7] or, as in one study, observed an association in females but not in males [1]. In addition to the complexity of such a relationship, methodological limitations,

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such as the use of self-reported data and cross-sectional design in some studies, have contributed to the uncertainty. Attention-deficit disorders (ADHD/ADDs) have been shown to be more common in obese subjects [8], and it is of importance to take ADHD/ADD into consideration when evaluating the effect of childhood obesity on school performance. Furthermore, it has not been shown whether weight loss is associated with improved school performance.

The aim of this study was to investigate whether the achievement of 12 or more years of schooling in young adults differ between subjects who have undergone childhood obesity treatment compared with a population-based matched comparison group. We also aimed to study how response to obesity treatment and other factors, such as sex, migration background, degree of obesity, and ADHD influence the level of educational achieved. We used data from the Swedish National Register for childhood obesity treatment and a population-based comparison group.

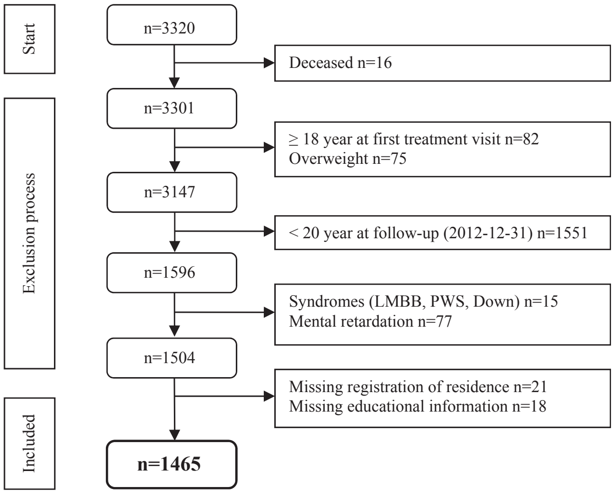

Figure 1. Flowchart of exclusion process. LMBB = Laurence-Moon-Bardet-Biedl syndrome; PWS = Prader-Willi syndrome, Down = Down syndrome.

Subjects and Methods

Subjects

In this prospective observational cohort study, the source of the obese cohort was subjects included in the Swedish National Registry for treatment of childhood obesity—BORIS (www.e-boris.se), from December 1994 until September 2010. Children who undergo obesity treatment are entered into BORIS by the local health care provider. Treatment is intended to be long term and primarily entails lifestyle modification. Registration in BORIS is approved by the families, and data are obtained from clinical settings. In Sweden, all health care is free of charge for children and adolescents under 18 years of age.

A comparison group, consisting of five individuals for each obese subject, randomly selected from the Swedish Total Population Register, was matched by sex, year of birth, and living area, at the initiation of childhood obesity treatment. Sweden, which comprises approximately nine million people, is divided into more than 2,500 living areas, which were used in the matching process to determine socioeconomical background. All regions of Sweden were represented. No information about body mass index (BMI) was available for the comparison group at baseline or for either of the groups in adulthood. Because all individuals in Sweden have been assigned a unique ID number [9], which was used in this linking, we risk no duplication of individuals in the cohorts.

The inclusion criteria were at treatment initiation below 18 years of age and obese according to the International Obesity Task Force definition; at follow-up (December 31, 2012) alive and age ≥20 years, which is at least 1 year after ordinary completion of the 12th grade in Sweden. The exclusion criteria in both groups were diagnosed mental retardation, obesity syndromes (Laurence-Moon-Bardet-Biedl and Prader Willi) and Down syndrome (Figure 1). The study was approved by the Ethics Committee of Stockholm, Sweden (No. 2011/632-31/4).

Educational and diagnostic information

Compulsory school education in Sweden, as regulated by law, consists of 9 years of schooling and is free of charge. In addition to free education, students also have access to free school health care and school lunches. The upper secondary school comprises three additional years, also free of charge, which individuals may elect to attend after completing compulsory school. To achieve the academic level of 12 years of schooling in Sweden, a set number of education points, approximately 90%, has to be achieved in combination with passed mandatory classes consisting of Swedish, English, mathematics, and degree project.

Through the unique national personal identity number, we initiated a register linkage of the obese cohort and the matched general population group to data on highest completed educational level from the National Education Registry. This was performed by Statistics Sweden. Diagnoses of mental retardation and excluded syndromes were collected from the Patient Registry and Data regarding psychostimulant drugs for ADHD/ADD were collected from the National Prescribed Drug Registry, held by the National Board of Health and Welfare.

Definitions

The primary outcome was the educational level achieved based on the International Standard Classification of Education [10]: completion of ≥12 years of schooling.

Migration background has been shown to affect school grades in Sweden [4]. Hence, to evaluate if migration background affects the primary outcome, the subjects were divided into two groups based on both the subjects' and their parents' countries of birth: Scandinavian—subjects born in Scandinavian countries (Sweden, Finland, Denmark, Norway, and Iceland) with one or two parents born in Scandinavia; and non-Scandinavian—subjects born outside Scandinavia or born in Scandinavia with two parents born outside Scandinavia. Data were retrieved from Statistics Sweden.

Age at the start of treatment was handled as a continuous variable. Data were retrieved from BORIS.

To compare the degree of obesity between children of different ages and sexes, an international age- and sex-dependent BMI standard deviation score (the BMI SDS) was used. Moderate and morbid obesity was classified according to Cole et al. [11] Anthropometric data were retrieved from BORIS.

Treatment effect was divided into three categories: responders, subjects who decreased their degree of obesity during at least 1 year of treatment; nonresponders, subjects who sustained or increased their degree of obesity during at least 1 year of treatment; and dropouts, subjects without clinical follow-up visits, or with less than 1 year between the first and last visit, because short-term treatment is associated with insufficient long-term results [12]. Data were retrieved from BORIS.

Treatment duration was treated as a continuous variable and data were retrieved from BORIS.

In Sweden, ADHD/ADDs are frequently screened for and children diagnosed with ADHD/ADD are often treated pharmacologically. Registration of ADHD/ADD in the National Patient Register, using International Classification of Diagnosis (ICD-10 F90), or a record of psychostimulant medication prescription in the National Prescribed Drug Registry for ADHD/ADD (ATC N06B), was therefore used as proxies for diagnosed ADHD/ADD, which is known to affect school performance.

Statistical analysis

SAS Statistical Software (version 9.4) was used for the statistical analyses. Descriptive statistics were performed using the chi-square test or t-test. To investigate the main outcome, achievement of ≥12 years in school logistic regression was applied. When comparing the BORIS cohort with the population-based comparison group, analyses were adjusted for sex, migration background, and the presence of ADHD/ADD. Secondary analyses were performed in the childhood obesity cohort, assessing for associations between obesity treatment–related factors (age and degree of obesity at start of treatment, treatment result, and treatment duration) and level of education. We adjusted for sex, migration background, presence of ADHD/ADD, age and degree of obesity at the start of treatment, and treatment effect. Results are presented with odds ratios (ORs) and 95% confidence intervals.

Results

In total, 1,465 individuals from the obese cohort and 6,979 in the comparison group were included in the study. The proportion of females was 50.1% in both groups, and the proportion of individuals of Scandinavian origin in each group was similar, 77.3% among the obese and 78.9% in the comparison group ($p = .2$). At treatment initiation, the age varied from 5.0 to 17.9 years and the BMI SDS varied from 2.21 to 4.95. The treatment outcome result varied from −3.12 to +1.05 BMI SDS units. Baseline characteristics for the obese cohort are presented in Table 1.

Experiencing obesity in childhood was associated with a 27.6% lower likelihood of completion of ≥12 years in school ($p < .0001$; Table 2). Of those not completing ≥12 years of schooling, 26.0% of the subjects in the obese cohort and 12.3% ($p < .0001$) in the comparison group left school after the mandatory 9 years of schooling. Furthermore, the proportions completing more than nine, but less than 12 years in school, i.e., dropping out of secondary education, were 18.6% and 11.5% ($p < .0001$) for the obese cohort and comparison group, respectively. Within the general population, girls were more likely to complete ≥12 years in school than boys (79.4% vs. 73.0%, $p < .0001$), and this was also observed among individuals with obesity (59.5% vs. 51.1%, $p = .001$). Within the general population, being of non-Scandinavian origin was associated with a lower achieved level of education (68.4% vs. 78.3%, $p < .0001$). However, this association was not seen among individuals with obesity in crude analysis (52.7% vs. 56.1%, $p = .3$). The proportion of subjects diagnosed with or medically treated for ADHD/ADD was greater in the obesity group than the comparison group (10.1% vs. 3.3%, $p < .0001$). However, there was no difference in age or the degree of obesity according to ADHD/ADD status in the obese cohort. ADHD/ADD was a strong predictor of not completing ≥12 years in school in both groups ($p < .0001$). However, subjects with ADHD/ADD achieved 12 years of schooling similarly in the obese and comparison groups (Table 2, $p = .11$). Logistic regression analysis, adjusted for sex, Scandinavian origin, and ADHD/ADD demonstrated that individuals with obesity were less likely to complete ≥12 years in school, with an OR of .42 (confidence interval: .37–.47; Table 2).

Factors of importance for achieved educational level in the obese cohort

Crude analysis. A higher degree of obesity at the start of treatment was negatively associated with completion of ≥12 years in school (OR = .57 [.46–.72]), which 50.9% of participants with morbid obesity achieved, compared with 64.4% of participants with moderate obesity ($p < .0001$). Of the subjects in the obese cohort, 47.2% were responders to treatment, i.e., experienced a decrease in BMI SDS during treatment, 21.2% were nonresponders, i.e., experienced no change or an increase in BMI SDS during treatment, and 31.7% were early dropouts. Responders were more likely to achieve ≥12 years in school in comparison to both nonresponders (OR = 1.53 [1.16–2.00]) and early dropouts (OR = 1.15 [.87–1.54]). Crude ORs are presented in Table 3.

Among the responders, 61.9% achieved ≥12 years in school, which is still significantly lower than the comparison group ($p < .0001$). Of the nonresponders, 51.6% achieved ≥12 years in school, compared with 48.1% among early dropouts (not significant). Worse still, among those with severe obesity and either an insufficient treatment effect or early dropout, only 46.5% achieved ≥12 years in school.

Initiating treatment at an early age was positively associated with completing ≥12 years in school, OR = .94 (.90–.98) (Table 3). As an illustration, of those children who started obesity treatment before 10 years of age (n = 91), 63.7% achieved ≥12 years in school, whereas the corresponding proportion for those who started obesity treatment from 10 to 13.9 years (n = 529) was 59.7%, from 14 to 15.9 years (n = 413) was 52.5 and in late adolescence, i.e., 16–18 years (n = 432), was only 50.9% (p for trend = .001).

Crude analysis demonstrated a longer treatment duration to be associated with a higher likelihood of achieving ≥12 years in school (OR = 1.09 [1.04–1.15] $p = .001$).

Adjusted analyses. Adjusted analysis showed that the degree of obesity at the start of treatment was significantly associated with the education level achieved ($p < .0001$). As seen in Table 3, model 1, those with morbid obesity at treatment initiation were almost half as likely to achieve ≥12 years in school compared with those with moderate obesity ($p < .0001$).

A decrease in BMI SDS was associated with increased odds of achieving ≥12 years in school ($p < .0001$).

Initiating treatment at an older age was significantly associated with a lower achieved education level. However, when treatment effect was added to the model (Table 3, model 2), age at the start of treatment was no longer significantly associated

Table 1
Characteristics of the obese cohort at baseline

	n (%)	Mean	Median	IQR
Age at treatment initiation (years)				
Total	1,465	14.2	14.6	3.8
Degree of obesity at treatment initiation (BMI SDS)				
Group				
Obesity	486 (33.2)	2.63	2.65	.23
Morbid obesity	979 (66.8)	3.30	3.248	.42
Total	1,465 (100)	3.08	3.06	.60
Treatment response (ΔBMI SDS[a])				
Group				
Responders	691 (47.2)	−.44	−.24	.57
Nonresponders	310 (21.2)	.22	.17	.26
Early dropout (<1 year in treatment)	464 (31.6)	−.02	.00	.01
Total	1,465 (100)	−.17	−.02	.26
Treatment duration (years)				
Group				
≥1 year in treatment (1.0–12.2 years)	1,001 (68.3)	3.54	3.01	2.98
Early dropout (<1 year in treatment)	464 (31.7)	.29	.00	.61
Total	1,465 (100)	2.51	1.92	3.21

BMI SDS = BMI standard deviation score; IQR = interquartile range.
BMI SDS by Cole et al. [11].
[a] Change in BMI SDS between last and first treatment visit.

with educational level achieved ($p = .08$), whereas treatment response was associated ($p < .0001$). This suggests that the observed effect of an earlier age at onset of treatment is mediated by a greater likelihood of treatment response in the young, in comparison to treatment initiation at a later age. ORs are presented in Table 3.

In a third model, treatment duration was added, and logistic regression was performed on a group comprising those who had undergone at least 1 year of treatment. In this model, treatment duration did not significantly influence the likelihood of achieving ≥12 years in school ($p = .2$). However, the other predictors, detected within model 2, persisted: sex, degree of obesity, ADHD/ADD, and treatment response.

Discussion

In this prospective cohort study, obesity in childhood and adolescence was associated with a strikingly lower achieved educational level in early adulthood compared with a population-based matched comparison group. The differences between groups were not dependent on sex, migration background, or living area. In the cohort with obesity, a decrease in BMI SDS during childhood was associated with a higher achieved educational level compared with individuals in whom obesity treatment was ineffective. Of the additional investigated factors among the children with obesity, male sex and a greater degree of obesity at the start of treatment were associated with a lower achieved educational level. Initiation of treatment at an early age appeared beneficial to the educational level achieved.

The mechanisms underlying these results are both complex and multifactorial (Figure 2). The associations between low socioeconomic status (SES) and obesity are well established [13], and low SES is also known to directly affect school performance. It is, therefore, difficult to evaluate the extent to which obesity contributes to school performance in the context of variation in SES. Children and adolescents with obesity face significant stress and prejudice across multiple domains, including school and relationships [14], and these factors likely contributed to the present results. However, both bullying and depression can also affect the risk of developing obesity [13]. We found that those with the best weight improvements during obesity treatment were more likely to complete school. Explanatory models for the relationship might include reduced stigmatization and improved self-esteem after successful weight loss [3,5,15,16], but a well-structured life is beneficial both for behavioral weight loss and school effort, which makes the causality uncertain.

However, a number of factors lead us to believe that obesity directly contributed to insufficient school performance. The association between the degree of obesity and SES has previously been shown to be modest [17], whereas the degree of obesity in the present study was markedly associated with school completion. A non-Scandinavian ethnic origin was associated with a low achieved educational level, as has been demonstrated previously [4], but that relationship was less pronounced in the obese cohort, suggesting that the impact of obesity outweighs the effect of migration background. The initiation of obesity treatment at an early age was associated with a higher achieved educational level. This appeared to be a result of the superior treatment success rate seen with earlier treatment initiation, as demonstrated both in this and previous studies [18,19], and indicating that obesity treatment effect, rather than family circumstances, was of importance for school completion. In

Table 2
Proportion of subjects completing ≥12 years in school, divided by gender, ethnicity and ADHD/ADD, and adjusted odds ratios

	Obese cohort (% of 1,465)	Comparison group (% of 6,979)	p	Crude odds ratio n = 8,444	Adjusted odds ratio (95% CI) n = 8,444
Total	55.4	76.2	<.0001		
Obese versus comparison group				.39 (.34–.44)*	.42 (.37–.47)*
Sex					
Girl	59.5	79.4	<.0001		
Boy	51.2	73.0	<.0001		
Girls versus boys				1.40 (1.27–1.54)*	1.40 (1.26–1.54)*
Migration background					
Scandinavian	56.1	78.3	<.0001		
Non-Scandinavian	52.7	68.4	<.0001		
Non-Scandinavian versus Scandinavian				.65 (.158–.73)*	.62 (.55–.70)*
ADHD/ADD					
Non-ADHD/ADD	58.1	77.5	<.0001		
ADHD/ADD	31.1	39.1	.11		
ADHD/ADD versus non-ADHD/ADD				.19 (.16–.24)*	.22 (.17–.27)*

CI = confidence interval.
Odds ratios were adjusted for belonging to obese versus comparison group, gender, ethnicity, and ADHD.
*$p < .0001$.

Table 3
Crude and adjusted odds ratios for completing ≥12 years in school in the obese cohort

	Crude estimates, n = 1,465		Model 1, n = 1,465		Model 2, n = 1,465	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Sex (girls vs. boys)	1.40**	1.14–1.73	1.41**	1.14–1.75	1.38**	1.11–1.71
Migration background (non-Scandinavian vs. Scandinavian)	.87	.68–1.11	.79	.61–1.02	.79	.62–1.03
Age at treatment initiation (per later year)	.94**	.90–.98	.93**	.89–.97	.96	.92–1.00
Degree of obesity (morbid vs. moderate)	.57***	.46–.72	.57***	.45–.71	.57***	.45–.72
ADHD/ADD (Yes vs. No)	.33***	.27–.47	.31***	.22–.45	.31***	.21–.45
Treatment responders versus early dropouts	1.76***	1.39–2.23			1.67***	1.29–2.16
Treatment responders versus nonresponders	1.53**	1.16–2.00			1.37*	1.04–1.82
Treatment nonresponders versus early dropouts	1.15	.87–1.54			1.22	.90–1.65

CI = confidence interval.
Without (model 1) and with (model 2) treatment effect included.
Degree of obesity: moderate obesity and morbid obesity according to Cole et al. [11] Treatment effect: early dropouts, completion of <1 year in treatment, responders decreasing BMI SDS during treatment, and nonresponders unchanged or increased BMI SDS during treatment.
**p* < .05; ***p* < .01; and ****p* < .0001.

addition, children who did not respond to treatment had the same odds of achieving 12 or more years of schooling as early dropouts (Table 3, model 2), indicating that a reduction in degree of obesity is of great importance for accomplishing school.

Studies both in adolescents and adults have shown that obesity is associated with cognitive dysfunction, which is of potential importance for school performance. Adolescents with severe obesity have impairment of executive function compared with peers of normal weight [20]. It has been reported that women with obesity have modified cerebral metabolism when compared with normal weight women [21], and slight cortical brain alterations have been demonstrated in adolescents with obesity, without comorbidities compared with normal-weight peers [22]. Obesity-related comorbidities such as the metabolic syndrome [23,24], type 2 diabetes mellitus [25,26], and low-grade inflammation [27], have also been associated with school performance, cognition, and memory. In these cross-sectional studies, it is difficult to evaluate whether observed brain dysfunctions are caused by obesity. However, rodents who develop obesity, insulin resistance, and other obesity-related comorbidities due to a high fat diet have been shown to develop cognitive deficits [28]. It has also been shown in humans that executive function can be improved by weight loss [29]. Taken together, these results indicate that obesity and obesity comorbidities can affect cognitive functions.

Neuropsychiatric dysfunctions, such as ADHD/ADD, are more prevalent in obese individuals [13], a finding mirrored in the present study. In addition, weight development could be affected by ADHD and by the pharmacological treatment [30]. In fact, ADHD/ADD contributed to an insufficient school performance both in the obese cohort and in the comparison group of the

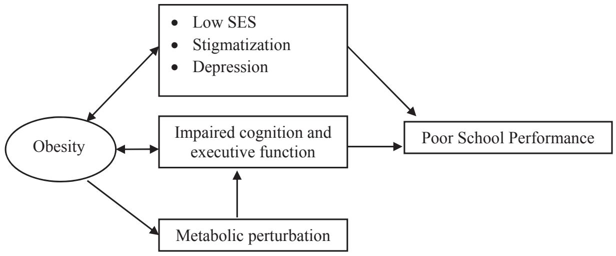

Figure 2. The relationship between obesity and poor school performance is both complex and multifactorial. SES = socioeconomic status.

present study. However, the observed differences between the cohorts remained after adjustment for ADHD/ADD. Mental retardation of course markedly affects school performance, and this group was excluded in the present study.

In Sweden, the school and school lunches are free of charge up to 12th grade. Hence, our finding does probably not have a direct financial ground. We believe therefore our findings could be applied to other countries than Sweden despite that the characteristics of schools across the globe might differ.

Strengths and limitations

We acknowledge a number of potential limitations within this study. We did not have data relating to some potential confounding factors that have been implicated in insufficient school achievement, such as parental education level and family income [31]. However, the comparison subjects were matched according to the living geographical area, which is likely to have reduced the risk of marked differences in SES. The ethnic similarity between groups also supports the assertion that the groups were comparable. The matched comparison group consists of a normal population, meaning that overweight and obese subjects are included. Neither baseline data nor reliable epidemiological estimates of obesity prevalence are available for this group. Therefore, we cannot exclude an underestimation of the effects of obesity on achieved educational level. Furthermore, we lack data on mental health such as depression, which also can affect the body composition. As thoroughly discussed previously, causality of our observed results has yet to be determined.

The major strength of this study is the large cohort of individuals from all parts of Sweden who were obese during childhood and adolescence, in combination with obesity treatment outcome data. Furthermore, the comparison group is large and is matched on variables of importance. In addition, the register of education is almost complete, with missing data encountered for only 18 subjects.

Regardless of causality, these results suggest that the young obese population requires special attention and support in school. Being obese in childhood and adolescence was associated with a lower achieved educational level in early adulthood and, particularly for individuals with morbid obesity, the differences were substantial. A reduction in degree of obesity was associated with a greater likelihood of school completion. Thus, this study adds school performance to the list of reasons supporting the urgent treatment of childhood obesity at an early age.

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Author contribution: E.H. contributed in register linkage, data handling, statistical analysis, result interpretation, and made the first draft of the paper; P.D. helped in result interpretation and made the first draft of the paper; V.S. edited and reviewed the manuscript; L.B. is a statistical expertise; A.E. helped in study design and critical revision of the paper; C.M. in study initiation, study design, and result interpretation. All authors contributed to writing and revising the manuscript and approved the final draft.

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