JOURNAL OF
SCHOOL HEALTH

RESEARCH ARTICLE

Higher Weight, Lower Education: A Longitudinal Association Between Adolescents' Body Mass Index and Their Subsequent Educational Achievement Level?

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ABSTRACT

BACKGROUND: The purpose of this study was to examine the association between adolescents' body mass index (BMI) z-scores and their subsequent level of schooling, extending previous longitudinal research by using objectively measured weight and height data.

METHODS: A longitudinal study with 3 study waves (1-year intervals) involving 1248 Dutch adolescents (49% girls; mean age = 13.7 years) at schools providing different educational levels was used to determine adolescents who moved and did not move to a lower educational level in the first year, or in the second year, and to examine whether this movement could be predicted by BMI z-scores (zBMI), after controlling for a large range of potential confounding factors.

RESULTS: A total of 1164 Dutch adolescents continued in the same level of education, whereas 84 adolescents moved to a lower educational level (43 moved in the first and 41 in the second year). A higher zBMI significantly increased the risk of a general transition to a lower educational level, and of a transition in the first year, but not in the second year, after controlling for potential demographic, behavioral, and psychological confounds.

CONCLUSIONS: Findings suggest that a higher zBMI during adolescence immediately lowers educational achievement level during general secondary education.

Keywords: overweight; BMI; schooling; academic performance.

Citation: Larsen JK, Kleinjan M, Engels RCME, Fisher JO, Hermans RCJ. Higher weight, lower education: a longitudinal association between adolescents' body mass index and their subsequent educational achievement level? J Sch Health. 2014; 84: 769-776.

Received on January 9, 2014
Accepted on July 11, 2014

Obesity is a serious public health epidemic, associated with numerous negative health, social-emotional, and academic outcomes.[1] A number of causes of poor academic outcomes have been proposed. First, social skills and peer relationships of obese adolescents are compromised, which may be linked with less optimal school functioning and educational performance.[2] Second, medical problems may impede productive studying and school attendance. Finally, teachers may hold stereotyped beliefs of heavier students, which can foster a classroom environment that hinders optimal academic performance, or which may even translate into direct discrimination practices by giving students poorer grades.[3] It is important to examine the association between body mass index (BMI) and academic outcome, because poor school outcomes may threaten psychosocial development and may even permanently alter educational achievements in adulthood.

Existing research on the contributions of weight to academic functioning has mainly relied on cross-sectional associations between children's or adolescents' adiposity indices and measures of academic functioning, mostly students' grades.[3-5] Longitudinal research that utilizes direct measures of both adolescents' weight status and academic functioning is necessary to provide insight into the causal order of effects. This report builds on existing

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research by prospectively examining the association between baseline adolescents' BMI z-scores (zBMI), using objectively measured weight and height data, and their subsequent level of schooling.

To date, longitudinal research utilizing direct measures to assess weight status and academic functioning found no support for the association between baseline overweight status and future academic functioning among children at elementary schools.[6,7] It may be that the association between students' BMI and future academic functioning becomes stronger as children become older and are at (junior) high schools, given that the severity of weight-related problems increases with age[8] and the performance-focused school culture is higher at (junior) high compared to elementary level schools.[9] This performance-focused school culture at (junior) high schools, in combination with many classes with a different teacher in each, may enhance greater (weight) stigmatization biases compared to more task-focused elementary schools, usually containing a single class with a single teacher. Previous longitudinal studies have (partly) supported the link between BMI and academic outcome during adolescence.[10,11] One study found that the negative longitudinal association between risk of obesity and achievement (grades) was dependent upon the school-context, finding stronger evidence in schools in which obesity was likely to be stigmatized.[9] Another study, however, found consistent evidence of a negative relationship between BMI and grade point average for white females aged 14-17 at 1-year follow-up.[10] However, data of these 2 studies were limited by using both self-reported grades, as well as height and weight data.

Moreover, longitudinal findings that support the link between BMI and academic outcome could also be attributed to behavioral or psychological variables, indicating that having a higher BMI is a marker, but not a causal factor, of a decline in academic functioning. Most previous studies controlled for demographic confounders, including familial socioeconomic status, ethnicity, and sex. Yet, most studies did not control for behavioral variables reflecting poor dietary intake and physical inactivity, or for psychological variables, such as depressive symptoms or peer victimization; however, it is known that these factors relate to both adolescents' BMI[12,13] and their academic performance.[14-16] It is important that these factors should be controlled for.

Hence, the main aim of our longitudinal study was to examine whether adolescents' baseline BMI z-scores are associated with their subsequent level of schooling after controlling for potential demographic (ie, parental educational level, students' educational level, ethnicity, and sex), behavioral (ie, television [TV] viewing, breakfast skipping, snack consumption, smoking, and alcohol use), and psychological confounders (ie, depressive symptoms and peer victimization). It is expected that a higher zBMI is associated with a lower subsequent educational level after controlling for potential confounds during adolescence. As some previous findings suggest, associations between weight characteristics and academic performance are more important for girls or women compared with boys or men,[11,17,18] and weight stigmatization might be more prevalent in girls than boys.[19] Thus, the sex specificity of the association between zBMI and educational achievement level also was examined. However, we did not formulate a sex-specific hypothesis considering the lack of information with respect to sex-specific weight stigmatization at schools.

METHODS

Participants and Procedure

Data for the present study were drawn from a large-scale longitudinal investigation of mental health and health habits in Dutch youth, consisting of 3 waves with 1-year intervals.[20] Participants were recruited from 7 randomly selected secondary schools. Data collection took place at schools. Parents were informed about the study by mail and were asked to respond via telephone or e-mail if they did not want their child to participate in the study. We also asked parents to complete a short questionnaire, including information on their educational level. Of the 2216 students targeted, 92.6% (N = 2051) initially participated. All participants attended regular secondary education and were in either first or second grade at baseline (equivalent to grades 7 and 8 in the United States). In the Netherlands, there are different levels of general secondary education. Because the present analysis aimed to examine the link between adolescents' weight status and subsequent level of schooling, data from 2 schools that only covered 1 educational level were excluded, resulting into 1617 students at time 1:87% of these students (N = 1407) completed surveys at time 2, and 77.2% of students (N = 1248) completed surveys at time 3. Adolescents' mean age at baseline was 13.7 years (SD = 0.7). Boys (N = 632) and girls (N = 616) were represented

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This study was financed by the Netherlands Organization for Scientific Research (NWO) Veni Grant 451-05-013.

roughly equally. Three years after baseline (time 3), 23.3% attended junior general secondary education, 30.5% senior general secondary education, and 46.2% preuniversity education. Junior general secondary education lasts 4 years and prepares pupils for senior secondary vocational education and training; senior general secondary education lasts 5 years and prepares pupils for higher vocational education; and preuniversity education lasts 6 years and prepares pupils for higher vocational education or a university course.

Logistic regression analysis comparing adolescents participating at time 3 with those that dropped out (N = 369) showed that attrition was significantly predicted by sex (odds ratio [OR] = 0.76, $p < .05$, 95% confidence interval [CI] = 0.60-0.98), ethnicity (OR = 1.88, $p < .001$, 95% CI = 1.34-2.58), education level (OR = 0.82, $p < .001$, 95% CI = 0.75-0.89), depressive symptoms (OR = 1.03, $p < .01$, 95% CI = 1.01-1.04), and BMI (OR = 1.04, $p < .05$, 95% CI = 1.00-1.09). This means that girls, adolescents of Dutch origin, and those with higher education, lower levels of depressive symptoms and a lower BMI were overrepresented in the longitudinal sample. The Cox and Snell indicator of total explained variance was .043, suggesting that the predictor variables explained limited variance in attrition.

Instrumentation

Movement to a lower educational level. Participants' educational level was assessed on a 5-point scale at time 1 and time 2, where 1 = junior general secondary training, 2 = combined junior general secondary training and senior general secondary education, 3 = senior general secondary education, 4 = combined senior general secondary education, and university preparatory training, and 5 = university preparatory training. At time 2 or time 3, all participants following combined levels of education had chosen between junior general secondary training (level = 1), senior general secondary education (level = 3), or university preparatory training (level = 5); combinations of educational levels (at level 2 or 4) no longer existed. In the Netherlands, it is the normal procedure that combined educational levels disappear over time at schools providing different levels of general secondary education. Thus, pupils automatically change their educational level with 1 point (eg, from combined level 4 to definitive level 3 or 5). However, some pupils showed a 2-level decrease in educational level at time 2 or time 3. This reflects an unexpected decline in educational achievement level. That is why pupils who decreased in educational level with 2 or more points at time 2 or time 3 (movement to a lower educational level) were compared with those who did not (continued in the same educational level).

BMI (z-scores). A research assistant measured each participant's height and weight following standard procedures. Height was measured to the nearest 0.5 cm using a stadiometer (Seca 206, Seca GmbH & Co., Hamburg, Germany), and weight was measured to the nearest 0.1 kg using a digital scale (Seca Bella 840, Seca GmbH & Co.). BMI and age- and sex-standardized BMI (zBMI) scores were calculated. Overweight was defined as zBMI from the 85th percentile[21,22] or a BMI at or above 25 kg/m^2.[23]

Potential confounders. The following measures administered at baseline were included as potential cofounders in the predictive association of initial weight status with subsequent educational achievement level. The Dutch version of the 20-item Center for Epidemiological Studies Depression inventory to measure depressive symptoms.[24] A single question from the Dutch version of the Olweus Bully/Victim Questionnaire (''How often did other children bully you in this school year?'') was used to measure peer victimization:[25] students who reported not being bullied or only 1 or 2 times were classified as ''not victimized'' (coded as 0), whereas those who reported being regularly bullied or more often were classified as ''victimized'' (coded as 1). Adolescents' smoking was measured by 1 single question asking them to report which stage of smoking applied to them.[26] On a 9-point scale, responses ranged from 1 (I have never smoked) to 9 (I smoke at least once a day). Individuals who scored 1 were categorized as nonsmokers, whereas those who scored between 2 and 9 were categorized as smokers.[26,27] Alcohol use was measured by asking adolescents: ''How often did you use alcohol in the past 4 weeks?'' Scores were recorded on a 6-point scale ranging from 1 (I have not been drinking) to 6 (drinking every day).[28] As this 6-point scale was rather skewed because a small percentage of students reported drinking alcohol every day, responses were collapsed in the following roughly equally distributed categories: (1) never drank alcohol, (2) had alcohol before but not in the past 4 weeks, and (3) drank alcohol in the past 4 weeks. Snack consumption was measured with the 5 questions of the Fat List, a brief food frequency questionnaire.[29] Students were asked to rate the amount of TV viewing with a self-made question assessing TV viewing separately for a regular school day and a weekend day, with responses being recalculated into the average number of minutes that the adolescent watched TV (details concerning these recalculations can be obtained from the first author). Finally, breakfast consumption was scored on an 8-point scale from 1 (never) to 8 (daily). Those who reported not to have breakfast everyday were conceptualized as breakfast skippers, as has been done previously in studies of adolescents.[30]

Data Analysis

First, students who moved and did not move to a lower educational level were compared by means of

Table 1. **Univariate Descriptives for Adolescents Who Were and Were Not Moved to a Lower Educational Achievement Level**

	Moved to a Lower Level Mean (SD)	Continued in Same Level Mean (SD)	Values t-tests	Effect Size Cohen's d
zBMI	0.28 (0.88)	−0.01 (0.90)	−2.78*	0.32
Depressive symptoms	10.67 (9.25)	8.14 (6.92)	−3.02*	0.37
Snack consumption	12.10 (4.95)	12.70 (5.53)	1.10	0.11
Television viewing (minutes per day)	111.51 (62.42)	104.85 (62.44)	−0.84	0.11
	Percentages	**Percentages**	**Chi-Square**	**Cramer's V**
Sex (% boys)	56.6%	50.2%	1.29	0.03
Ethnicity (% Dutch)	88.0%	88.8%	0.29	0.01
Overweight	18.4%	11.9%	2.81	0.05
Breakfast skipping	31.7%	19.2%	7.55*	0.08
Smokers	44.3%	19.8%	26.55**	0.15
Peer victimized	4.9%	5.0%	0.00	0.00
Alcohol use			15.40**	0.11
Never drank	18.8%	40.6%		
Did not drink in past 4 weeks	46.3%	36.0%		
Drank in past 4 weeks	35.0%	23.4%		
zBMI percentiles			15.39**	0.11
<25th percentile	33.3%	42.0%		
25-50th percentile	23.8%	26.2%		
50-75th percentile	22.6%	18.9%		
75th-85th percentile	14.3%	7.0%		
85th-95th percentile (or BMI ≥ 25)	2.4%	5.2%		
≥95th percentile (or BMI ≥ 30)	3.6%	0.8%		

*p < .01, **p < .001; only 5 students who were moved were above the 85th percentile.
BMI, body mass index.

t-tests and chi-square analyses. Second, correlations between all model variables were computed. Finally, we conducted logistic regression analyses using the software package MPLUS (Muthén & Muthén, 1998-2011, Los Angeles, CA) to examine whether zBMI explained whether subjects did or did not move to a lower educational level (overall as well as separately for the first and second year), after controlling for possible confounding variables (variables associated with outcome as determined by t-tests and chi-square analyses). MPLUS was used because of its ability to accommodate non-normality and ordinal variables without reliance on large samples.[31] For all regression analyses, we started out with a model without confounders. Next, the regression analysis for the different outcomes was controlled for possible confounders. In the first step, confounding variables were included. In a second step, zBMI was entered. We also examined interaction effects of sex with zBMI. Finally, we repeated our analyses among a subgroup of adolescents of whom also parental education level was known, to assure the robustness of the effect of zBMI. Missing values were substituted in MPLUS using full information maximum likelihood estimation.

RESULTS

Sample Characteristics

Table 1 shows the univariate descriptives for a general decline in education level between time 1 and time 3 (N = 84) versus those who continued in the same educational level over time (N = 1164). Compared with students who maintained their educational level from time 1 to time 3, students with decreased levels showed a significantly higher baseline zBMI, more depressive symptoms, more breakfast skipping, and more alcohol use and smoking. Cohen's d and Cramer's V suggested small to mediate effect sizes for these differences (Table 1). Baseline differences between groups were not found for sex, ethnicity, snack consumption, TV viewing, or peer victimization. Notably, differences between zBMI percentiles showed that students who continued in the same educational level were overrepresented in the lower zBMI percentiles compared with students who were moved to a lower educational level, whereas students who were moved were twice as likely (14.3%) to be at the 75th-85th zBMI percentile compared with students who continued in the same educational level (7.0%). As only a few students who moved were above the 85th percentile, no valid conclusions can be made with regard to differences in overweight or obesity percentages between the groups.

Correlations

Correlations between the model variables are presented in Table 2. These findings show that zBMI was significantly associated with all confounding variables, with the exception of alcohol use. A move to a lower educational level in general was associated

Table 2. **Spearman and Pearson Correlations Between Confounding and Dependent and Independent Variables**

	1.	2.	3.	4.	5.	6.	7.	8.	9	10.
1. Sex	—									
2. Ethnicity	.01	—								
3. Depressive symptoms	.18***	.12***	—							
4. Snack consumption	−.08***	.11***	.09***	—						
5. Television viewing	−.01	.07	.07**	.25***	—					
6. Breakfast skipping	.10***	.17***	.25***	.03	.07**	—				
7. Alcohol	−.06*	−.14***	.13***	.11***	.13***	.17***	—			
8. Smoking	−.03	.02	.14***	.10***	.14***	.26***	.40***	—		
9. Peer victimization	−.06	.06*	.17***	−.02	.07*	.08**	−.03	.02	—	
10. zBMI	.05*	.14***	.08**	−.23***	.05*	.14***	.04	.09**	.08**	—
11. Decline in education level	−.04	.02	.07*	−.03	.03	.08**	.11***	.14***	.00	.08**

†p = .06, *p < .05, **p < .01, ***p < .001.

with more depressive feelings, breakfast skipping, alcohol use, and smoking.

Regression Analyses

General decline in educational level. In the unadjusted model, zBMI was significantly associated with a decline in educational level (OR = 1.46, 95% CI = 1.11-1.91), with an explained variance of Nagelkerke $R^2 = .03$. Adjusted models (Table 3) showed that alcohol use and having ever tried smoking significantly increased the risk of a decline in educational level. The confounders explained 10% of the variance. Above and beyond those confounders, higher zBMI significantly increased the risk of a decline in educational level after controlling, explaining an additional 2% of the variance for a decline in educational level.

Movement to a lower educational level in the first year. The regression model without the confounders showed that zBMI was significantly associated with a decline in educational level in the first year (OR = 1.65, 95% CI = 1.13-2.42), with an explained variance of Nagelkerke $R^2 = .06$. In a second regression analyses, the baseline confounders that significantly differentiated between adolescents who were moved to a lower academic stream and those who were not were entered in the first step (Table 3). Results showed that alcohol use and having ever tried smoking significantly increased the risk of a decline in educational level. The confounders explained 14% of the variance for a decline in educational level. Step 2 of the regression showed that zBMI explained an additional 3% of the variance for a move to a lower educational level.

Movement to a lower educational level in the second year. In the regression model without the confounders, zBMI was not significantly associated with a move to a lower educational achievement level in the second year (OR = 1.26, 95% CI = 0.91-1.76), with an explained variance of Nagelkerke $R^2 = .01$. In the controlled regression analyses, none of the confounders entered in step 1 was significantly associated with a decline in educational level. The confounders explained 8.0% of the variance for a decline in educational level. Step 2 of the regression showed that zBMI was not significantly associated with a move to a lower educational level; moreover, zBMI did not explain any additional variance.

Interaction with sex. Interaction effects of sex with zBMI in determining a lower educational achievement level were calculated. No significant interaction effect was found (OR = 1.09, 95% CI = 0.64-1.87, p = .73), suggesting that the relation between zBMI and a decline in educational level is not different for boys and girls.

Table 3. **Odds Ratios and 95% Confidence Intervals for a Decline in Educational Level (1 = Yes; 0 = No)**

	General Decline in Education Level (N = 84)			Movement to a Lower Educational Level in the First Year (N = 43)			Movement to a Lower Educational Level in the Second Year (N = 41)		
	Nagelkerke R^2−Change	OR	95% CI	Nagelkerke R^2−Change	OR	95% CI	Nagelkerke R^2−Change	OR	95% CI
Step 1	.10			.14			.08		
Breakfast skipping		1.04	0.56-1.96		0.86	0.38-1.98		1.16	0.49-2.74
Smoking		2.30**	1.27-4.14		3.04**	1.48-5.59		1.66	0.67-4.10
Alcohol use		1.41*	1.02-1.95		1.61*	1.06-2.44		1.28	0.78-2.10
Depressive feelings		1.02	0.99-1.06		1.01	0.97-1.05		1.04	0.99-1.09
Step 2	.02			.03			.00		
zBMI		1.36*	1.02-1.82		1.51*	1.02-2.42		1.15	0.80-1.65

*p < .05, **p < .01.
OR, odds ratio; CI, confidence interval.

Additional regression analysis to assure the robustness of the effect of zBMI. A potential confounder of the effect of zBMI on a decrease in education level is parents' educational level. For 60% of our sample, we had information on parental educational level ($N = 791$). Parental education was defined as the education level of the parent who indicated completing the highest level of education. Chi-square difference tests showed that parental education level did not significantly differ between adolescents who were moved to a lower level and adolescents who continued in the same educational level ($\chi^2 = 4.58$, $df = 4$, $p = .60$). This logistic regression analysis was also run with parental education level as a confounder for a general decline in education level in the subsample. Results of this regression were similar to the results reported in Table 3 and supported the same conclusions.

DISCUSSION

Previous studies supporting negative associations between adolescents' weight characteristics and their academic functioning during adolescence have been limited by cross-sectional designs and/or self-reported data. The current study extends previous work by using a longitudinal design and objective measurements of weight and educational level. In line with our expectations, we found that higher BMI z-scores independently increased the risk of a decline in educational level after controlling for a range of potential confounding factors. The potential consequences of having a higher zBMI on the risk of a decline in educational level appear to manifest themselves immediately, given that adolescents were more likely to move to a lower educational achievement level in the first year, but not in the second year. This suggests that a higher zBMI during adolescence immediately lowers educational achievement level during general secondary education.

Our prospective findings add to previous prospective research showing that being obese during adolescence is associated with fewer years of self-reported schooling and lower levels of education during young adulthood.[18,32] Our findings suggest that these long-term effects of BMI on achievement in early adulthood may occur through the relative immediate impact of BMI on a decline in educational level during adolescence. However, that our small percentages of adolescents with overweight or obesity did not allow for separate analyses among overweight subgroups. In terms of effect sizes, our small but consistent effects for continuous zBMI scores are similar to those reported in recent cross-sectional research.[3]

Potential explanations for an association of adolescents' BMI and future academic achievement remain relatively unexplored but are thought to include medical problems, problematic peer relationships, and teachers' prejudices. Moreover, shorter sleep duration has been associated with weight gain and has been suggested to be involved in links between adolescent BMI and academic functioning.[33] Furthermore, adolescents with higher zBMIs also may display less effective self-regulation and more impulsivity, with (academic) self-regulation being an important psychosocial factor associated with future grade point average.[34] Thus, sleeping problems and impulsivity characteristics may explain the link between adolescents' BMI and academic functioning, with these potential mechanisms being notably associated among heavier adolescents.[35] Identifying potential mechanisms is important to the development of effective risk assessment and interventions to influence academic success during adolescence. For example, if problems with self-regulation play an important role, adolescents may be referred to cognitive remediation therapy, as has been proposed by Smith et al,[36] by helping them maintaining a healthy lifestyle. However, if teachers may hold biased perceptions of obese students, then preventive interventions should manipulate and change these expectations[37] and related teaching practices to see whether and how this might affect students' academic achievements and future educational training route. Whereas our study did not assess sleep duration or dimensions of self-regulation, a large range of potential confounders were considered.

Limitations

The following limitations warrant discussion. First, the study only assessed a decline in educational level and did not consider other important aspects of achievement such as grades from school records or grade repetition. However, the measure employed is a robust and objective measure of educational achievement during adolescence, which has a high potential to permanently alter academic achievement. Second, this study relied on a healthy sample of adolescents who attended a relatively high level of education and who were mostly from the same age range and cultural background. Consequently, findings may not generalize to other populations that differ with regard to race, BMI ethnicity, education, or psychiatric impairments. Third, use of BMI as a measure of adiposity rather than a direct measurement of obesity, such as skin-fold thickness, could be considered a final limitation. However, BMI has been strongly correlated to measures of adiposity and is considered a validated marker of adiposity in children and adolescents.[38] Finally, effects of zBMI were found over 1 year, but not over 2 years. The effects of other covariates (ie, substance use) showed a similar pattern. This might be explained by the relatively low stability of zBMI and substance use during adolescence, being a period characterized by increases in zBMI and onset of substance use.

Conclusions

In conclusion, identifying adolescents at risk for negative educational outcomes involves an understanding of which factors might contribute to poor outcomes. Our study reveals that higher BMI z-scores independently increased subsequent risk of a decline in educational level among adolescents, when taking into account a wide range of potentially confounding factors. Future research should further examine the mechanisms underlying this association in the interest of identifying important targets for preventive intervention.

IMPLICATIONS FOR SCHOOL HEALTH

Our findings revealed that, while controlling for potential demographic, behavioral, and psychological confounds, higher BMI z-scores increased the risk of a general transition to a lower educational level. For this reason, the impact of weight status on educational achievement level should be considered in current school policies. Comprehensive health education is needed in which the possible negative consequences of weight-related problems on achievement are acknowledged. Teachers should be made aware that a higher zBMI during adolescence could lower educational achievement level during general secondary education. Although the exact mechanisms underlying this effect are still unknown, teachers, for instance, should try to avoid biased perceptions of students having a higher weight, as this might accelerate the negative effects of students' higher BMI. Instead, they might help students by early intervention of possible peer victimization and/or self-regulatory problems during the school year to avoid academic degradation at the end of the school year.

Human Subjects Approval Statement

Approval was received from the Ethics Committee of the Faculty of Social Sciences of the Radboud University, Nijmegen.

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