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BMI z-scores and Weight Status Predicts Conduct Disorder Symptoms in Adolescents

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Abstract

Purpose—This study's goal was to examine whether baseline body mass index (BMI) z-scores and weight status predicted conduct disorder (CD) symptoms in 368 adolescents (15–17 years).

Methods—Participants in the 10th and 11th grades completed self-report questionnaires at baseline and a two-year follow-up. Baseline BMI z-scores and weight status were derived from self-reports of height and weight. CD symptoms were assessed using a symptom checklist. Covariates included baseline demographics, depressive symptoms, alcohol consumption, drug use, and a retrospective report of CD symptoms before age 15.

Results—A cubic association was observed between baseline BMI z-scores and follow-up CD symptoms ($p=.047$), such that a positive association emerged only among adolescents with BMI z-scores of greater than ~ 1.5 . Adolescents who were obese at baseline reported more follow-up CD symptoms than non-overweight adolescents ($p=.008$). Higher baseline BMI z-scores were associated with increased odds of endorsing probable CD at follow-up ($p<.03$). Obese adolescents were more likely to report the presence of probable CD at follow-up than overweight and non-overweight adolescents ($p=.01$).

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Contributions: AV conceptualized the aims and hypotheses for the study, conducted analyses, and took primary responsibility for drafting the manuscript text and figures. CO designed the original study as principal investigator, collected the data, and provided feedback on the conceptual direction and text of the manuscript. All authors have approved the final article.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Implications and contribution: Higher baseline BMI z-scores and obese status predicted increased CD symptoms at a two-year follow-up in a community sample of adolescents. The relationship between nutritional status, particularly obesity, and CD symptoms should be monitored and addressed in adolescents.

Conclusions—Findings suggest that nutritional status, particularly high BMI-z scores and obese weight status, may contribute to elevated CD symptoms during adolescence, which should be dually addressed in screening and intervention efforts.

Keywords

obesity; overweight; BMI-z; conduct disorder; behavior problems; externalizing problems; adolescents

Adolescence is a vulnerable period for the development of obesity and conduct disorder (CD) [1]. Overweight and obesity have been associated with higher externalizing problems and CD in pediatric cross-sectional studies [1,2]. The temporal relationship between weight status and CD symptoms (CD-Sx) remains unclear, which has important implications for understanding their etiology and developing interventions. Prospective studies have found that adolescent CD predicts excess weight gain and obesity in adulthood [3,4], but there is a scarcity of research examining the opposite sequential pattern.

Pediatric obesity is associated with developmental factors that may promote risk for CD-Sx, including frequent teasing, low self-esteem, poor impulse control and self-regulation, abnormalities in serotonergic and dopaminergic signaling pathways, and environmental adversity [3,5]. Prospective studies have not found an association between childhood weight status and subsequent externalizing problems [5,6]. However, this relationship may not emerge until adolescence, when the potential mechanisms likely exert a more significant influence on CD-Sx relative to children. Yet, there are no known studies among adolescents investigating the role of weight status in the etiology of CD-Sx. Therefore, this study's objective was to examine whether body mass index (BMI) z-scores and overweight or obese weight status predicted subsequent CD-Sx in a community sample of adolescents.

Methods

Procedure

Detailed methods have been previously described [7]. All 10th and 11th grade students (15–17 years) enrolled at seven public high schools within 60 miles of the study site (Newark, Delaware, U.S.) were invited to participate in the study. All participants (N=368) completed surveys at school in 2007 (baseline) and 2009 (two-year follow-up). Participants received a movie pass upon completing surveys. Parents provided informed consent and adolescents provided assent before participation. Procedures were approved by the University of Delaware Institutional Review Board.

Measures

At baseline, adolescents reported on their demographic characteristics, depressive symptoms using the psychometrically sound Center for Epidemiological Studies Depression Scale for Children [8]; quantity and frequency of alcohol consumption in the past six months; and drug use frequency in the past six months. Adolescents reported their height and weight, which was used to calculate BMI z-scores adjusted for age and sex and determine weight

status (non-overweight=1st–84th BMI percentile; overweight=85–94th BMI percentile; obese 95th BMI percentile) [9].

At the two-year follow-up, a CD-Sx checklist including items derived from the Semistructured Assessment for the Genetics of Alcoholism [10] assessed recent CD-Sx. To provide a measure of baseline CD-Sx, a retrospective self-report of CD-Sx present before age 15 was obtained. For current and retrospective reports, the 11 CD-Sx items were summed to generate a continuous total CD-Sx score (Cronbach's $\alpha=.76-.78$). Both total CD-Sx scores (current, retrospective) demonstrated good construct validity with parent reports of adolescent CD-Sx ($r=.22-.46$, $ps<.01$) and convergent validity with adolescent reports of externalizing behaviors ($r=.17-.42$, $ps<.01$) in the current study. The endorsement of four or more CD-Sx was defined as "probable CD," which was a conservative threshold selected to indicate clinical significance (vs. the diagnostic threshold of three or more CD-Sx) since there was no information provided about functional impairment.^a

Statistical Analyses

Hierarchical regression models examined whether baseline BMI z-scores and weight status predicted the continuous total CD-Sx score (logarithm-transformed to achieve a normal distribution) at the two-year follow-up. Linear, quadratic, and cubic relationships between BMI z-scores and the total CD-Sx score were evaluated in the same model. Binary logistic regression models examined whether baseline BMI z-scores and weight status predicted the binary presence of probable CD at the two-year follow-up. Covariates included baseline gender, age, race/ethnicity, parent education attainment, depressive symptoms, total alcohol consumption, drug use frequency, and the retrospective report of total CD-Sx before age 15. Results were statistically significant when p values were $< .05$.^b

Results

Participant characteristics are depicted in Table 1.

Total CD-Sx

The fully adjusted hierarchical regression models including baseline BMI z-scores and weight status as predictors significantly accounted for 25.3% and 26.9% of the variance in total CD-Sx present at the two-year follow-up, respectively.

There were no significant associations between baseline BMI z-scores and follow-up total CD-Sx when examining a linear relationship ($B=0.11$, 95% CI= $-0.15-0.36$; $p=.41$) or a quadratic relationship ($B=-0.03$, 95% CI= $-0.21-0.49$; $p=.79$). A significant cubic relationship was observed between baseline BMI z-scores and total CD-Sx at the two-year follow-up ($B=0.11$, 95% CI= $0.01-0.21$, $p=.047$, $R^2 = 3.1\%$; Figure 1).

Adolescents who were obese at baseline reported significantly more CD-Sx at follow-up than adolescents who were non-overweight at baseline ($B=0.64$, 95% CI= $0.17-1.12$; $p=.008$;

^aPattern of results remained the same whether probable CD was coded as having 3 vs. 4 or more CD-Sx.

^bExploratory post-hoc moderator analyses revealed that there were no significant gender or race/ethnicity differences in any of the observed associations.

$R^2=2.3\%$). There were no significant differences in follow-up total CD-Sx between adolescents who were obese and overweight at baseline ($B=0.61$, 95% CI=-0.18–1.40; $p=.13$; $R^2=2.4\%$) or those who were overweight and non-overweight at baseline ($B=0.00$, 95% CI=-0.29–0.29; $p=.99$; $R^2=0.0\%$).

Presence of Probable CD

The fully adjusted binary logistic regression model examining baseline BMI z-scores as a predictor explained between 10.5% (Cox-and-Snell R^2) and 26.8% (Nagelkerke R^2) of the variance in probable CD classification at the two-year follow-up, $\chi^2(9, N=368)=32.49$, $p<.001$. Adolescents with higher baseline BMI z-scores had increased odds of reporting the presence of probable CD at follow-up, Wald $\chi^2(1, N=368)=4.70$, $p=.03$; AOR=2.0, 95% CI=1.1–3.7.

The fully adjusted binary logistic regression model examining baseline weight status as a predictor explained between 12.2% (Cox-and-Snell R^2) and 31.1% (Nagelkerke R^2) of the variance in probable CD classification at follow-up, $\chi^2(10, N=368)=38.07$, $p<.001$. Results are depicted in Table 2. Adolescents who were obese at baseline had significantly higher odds of reporting the presence of probable CD at follow-up relative to overweight, AOR=8.8, 95% CI=1.5–32.7, and non-overweight, AOR=8.6, 95% CI=2.3–22.0, adolescents. Adolescents who were overweight at baseline were not more likely than non-overweight adolescents to report probable CD at follow-up, AOR=1.0, 95% CI=0.2–4.5.

Discussion

Findings suggest that nutritional status, particularly high BMI z-scores and obesity, may contribute to elevated CD-Sx during adolescence. A non-linear relationship was observed between baseline BMI z-scores and total CD-Sx present at the two-year follow-up, such that a positive association was only observed among adolescents with baseline BMI z-scores greater than ~1.5. Adolescents who were obese at baseline reported greater follow-up CD-Sx than those who were non-overweight at baseline, but did not differ from overweight adolescents. There were likely no differences between the obese and overweight groups because of the non-linear association between continuous measures. Indeed, elevated follow-up CD-Sx were observed in some (BMI z-scores ~1.5–1.6), but not all (BMI z-scores ~1.0–1.4), adolescents who were overweight at baseline. Similarly, higher baseline BMI z-scores and being obese at baseline (versus overweight or non-overweight) were predictive of higher odds of having probable CD at the two-year follow-up.

Findings from the current study contrast research in childhood that did not observe any relationship between weight status and subsequent conduct problems [5,6]. However, these earlier studies did not examine non-linear relationships and/or included broad measures of general externalizing symptoms. Findings support the hypothesis that obesity-related mechanisms conferring vulnerability for CD-Sx may not emerge significantly until adolescence. Obesity-related neuroendocrine abnormalities that also impair emotional and behavioral self-regulation may become exacerbated during adolescence due to gonadal hormone-induced neural changes during puberty [3]. The increased salience of peers intensifies weight-related teasing and stigma among obese adolescents [1], which may

worsen self-esteem, irritability, and acting out. In sum, these novel preliminary findings suggest that it may be useful for providers to monitor and address the relationship between adolescent weight status, particularly obesity, and CD-Sx.

Study strengths include the focus on adolescence, the diverse community sample, the prospective design, and the inclusion of salient covariates. Limitations include the reliance on self-report measures, the retrospective report of baseline CD-Sx, and the limited follow-up duration. Future research should confirm study findings with clinical interviews and objective body composition measurements. Studies examining the impact of weight loss interventions on CD-Sx in obese adolescents would illuminate potential behavioral mechanisms and clinical recommendations. Should findings from the current study be replicated with gold standard assessments and in clinical samples, it will be crucial to evaluate underlying mechanisms so that providers can identify obese adolescents at greatest risk for CD-Sx and implement more effective intervention strategies that simultaneously improve deleterious weight and behavior outcomes in adolescents.

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Abbreviations

BMI	body mass index
BMI-z	BMI standard scores adjusted for age and sex
CD	conduct disorder
CD-Sx	conduct disorder symptoms

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Figure 1.

Significant cubic relationship between baseline BMI z-scores and total conduct disorder (CD) symptoms present at the two-year follow-up.

Notes: Total CD symptoms were back-transformed from the logarithm-transformed total CD symptoms score included in the hierarchical regression model. Models adjusted for baseline age, gender, race/ethnicity, parental educational attainment, depressive symptoms, total alcohol consumption, total drug use frequency, and a retrospective report of CD symptoms present prior to age 15.

Table 1

Participant characteristics compared across baseline weight status categories.

Continuous Variable	Non-Overweight (n = 248)			Overweight (n = 75)		Obese (n = 45)		Test Statistic	
	M ± SD			M ± SD		M ± SD		F value	p value
Age (years)	16.02 ± 0.69			15.85 ± 0.64		16.02 ± 0.85		1.80	.17
BMI z-score	0.03 ± 0.64			1.31 ± 0.17		2.00 ± 0.28		319.39	< .001
BMI percentile	51.67 ± 22.02			90.21 ± 2.97		97.29 ± 1.36		198.38	< .001
Depressive Symptoms	15.20 ± 10.29			15.09 ± 11.49		16.61 ± 11.05		0.31	.73
Total Alcohol Consumption ^{a,b}	4.70 ± 12.37			5.34 ± 13.00		4.39 ± 13.00		0.68	.51
Total Drug Use Frequency ^b	0.69 ± 2.14			0.77 ± 2.21		0.54 ± 1.55		0.17	.84
Total CD Symptoms Present Before Age 15 ^b	0.65 ± 1.36			0.71 ± 1.37		0.93 ± 2.21		0.66	.52
Categorical Variable									
	% (n)			% (n)		% (n)		χ ² value	p value
Gender (% Female)	66.5 (165)			61.3 (46)		44.4 (20)		7.83	.02
Race/Ethnicity (% Non-Hispanic White)	74.2 (184)			56.0 (42)		53.3 (24)		13.44	.001
Probable CD Prior to Age 15 (% Present)	7.3 (18)			9.3 (7)		11.1 (5)		0.27	.88

Notes: BMI = body mass index; BMI-z = BMI standard scores adjusted for age and sex; Non-overweight = 1st-84th BMI percentile; Overweight = 85-94th BMI percentile; Obese = 95th or higher BMI percentile; χ² = Pearson chi-square test statistic. All variables were assessed at baseline, with the exception of total CD symptoms and probable CD present before age 15 that were retrospectively reported at the two-year follow-up assessment.

^aTotal alcohol consumption was derived from multiplying quantity and frequency scores.

^bMeans are back-transformed from the logarithm-transformed means that were used in analyses.

Table 2

Results from binary logistic regression model examining baseline weight status as a predictor of the presence of probable conduct disorder (CD) at two-year follow-up.

Predictor Variable	<i>b</i>	SE (<i>b</i>)	OR	95% CI (OR)	χ^2	<i>p</i> value
Constant	−4.36	6.38	0.01	–	38.07	<.001
Age	0.02	0.38	1.02	0.48 – 2.14	0.01	.96
Gender ^a	−1.22	0.61	0.30	0.09 – 0.97	4.05	.04
Race/Ethnicity ^a	0.08	0.67	1.09	0.29 – 4.07	0.02	.90
Parent Education	0.19	0.28	1.21	0.69 – 2.11	0.34	.51
Depressive Symptoms	0.03	0.02	1.03	0.98 – 1.08	1.34	.25
Total Alcohol Consumption ^b	0.07	0.13	1.07	0.83 – 1.38	0.26	.61
Total Drug Use Frequency ^b	0.37	0.18	1.45	1.01 – 2.09	4.12	.04
Probable CD Before Age 15 ^a	1.89	0.65	6.26	1.87 – 23.44	8.60	.003
Weight Status: OW (vs. NW)	0.01	0.76	1.01	0.23 – 4.49	0.00	.99
Weight Status: OB (vs. NW)	2.15	0.67	8.57	2.29 – 22.01	10.20	.001
Weight Status: OB (vs. OW)	2.17	0.82	8.75	1.45 – 32.70	6.61	.01

Notes: *b* = unstandardized regression coefficient; SE = standard error; OR = odds ratio; CI = confidence interval; χ^2 = obtained chi-square value of the Wald test; *p* = probability; NW = non-overweight; OW = overweight; OB = obese. The presence of probable CD was indicated by endorsement of four or more CD symptoms. All predictor variables, with the exception of the retrospective report of probable CD present before age 15, were assessed at baseline.

^aThese variables were coded dichotomously. Gender was coded as 1 = female and 0 = male. Race/ethnicity was coded as 1 = non-Hispanic white and 0 = other race/ethnicity. Probable CD before age 15 was coded as 1 = present and 0 = absent.

^bThese variables were logarithm-transformed to achieve a normal distribution.