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Longitudinal Associations between Anhedonia and BMI Trajectory Groups among Adolescents

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Abstract

PURPOSE—Although evidence suggests that anhedonia—reduced ability to experience pleasure in response to rewarding stimuli—may predict weight gain during adolescence, it remains unclear whether changes in anhedonia during adolescence are associated with changes in body mass index (BMI). This study examines longitudinal associations between changes in anhedonia and developmental trajectories of BMI during adolescence.

METHODS—Self-report measures of anhedonia and BMI were collected at five semi-annual assessments amongst students from 10 Los Angeles, CA area high schools (N=3,396) followed from 9th grade to 11th grade. Four BMI trajectories were identified using growth mixture modeling: (1) *Stable Normative Weight*, (2) *Overweight to Normative Weight* (i.e., decreasing BMI); (3) *Overweight to Chronically Obese* (increasing BMI); (4) *Normative Weight to Overweight* (increasing BMI). Latent growth curve modeling estimated baseline level and changes in anhedonia. A multinomial logistic regression model tested associations of baseline level and slope of anhedonia with the four BMI trajectory groups.

RESULTS—Compared to the *Stable Normative* BMI trajectory group, each one-unit *SD* increase in anhedonia slope increased the odds of membership in the *Overweight to Chronically Obese* group (OR[95% CI]=1.29[1.09, 1.49]; $p<0.001$) and *Normative Weight to Overweight* group (OR[95% CI]=1.28[1.04, 1.53]; $p=0.006$), and decreased the odds of membership in the *Overweight to Normative Weight* group (OR[95% CI]=0.78[0.57, 0.95]; $p=0.01$).

CONCLUSIONS—Across a two-year period of high school, rate of change in anhedonia is associated with certain BMI trajectories linked with poorer metabolic health. Increasing anhedonia may be an important risk factor to consider in adolescent obesity prevention.

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Keywords

Anhedonia; Body Mass Index; Obesity; Adolescents; Trajectory

INTRODUCTION

Adolescent obesity has reached epidemic proportions in the U.S. (1), and is a serious public health concern due to acute physical (2) and mental health (3) consequences as well as increased risk of maintaining obesity into adulthood (4). Prior research has found that depressive symptomology is associated with increased risk of obesity in adolescence (5) and increased body mass index (BMI; kg/m²) in adulthood (6). While multiple studies suggest plausible mechanisms linking poor mental health and adiposity (e.g., stress hormones, poor diet, physical inactivity) (5), there is also evidence that poor mental health may not be a risk factor for increased BMI (7–9).

Often overlooked in considerations of the association of depression and obesity is that major depression is composed of a complex set of intermediate phenotypes (e.g., negative affect, psychomotor disturbances, anhedonia, changes in appetite) that have distinct psychosocial and biological determinants (10). Much of the literature has treated depression as a homogenous construct and has not focused on individual symptoms of depression. Parsing the role of specific depressive symptoms can identify underlying psychobiological mechanisms that contribute to increases in BMI and may elucidate the relationship between adolescent depression and obesity risk.

Recent advances in psychopathological science propose that cross-cutting intermediate phenotypes, such as underlying emotional traits, may increase vulnerability to certain subtypes of depression (but not others) as well as be implicated in other non-depressive psychiatric disorders (11). Anhedonia—a reduced ability to experience pleasure in response to rewarding stimuli—is one such phenotype. Anhedonia is psychometrically distinct from other facets of depressive symptomology (11) and can occur apart from major depression (12). Anhedonia is conceptualized as a transdiagnostic trait and state construct (13) that is implicated in various mental disorders (e.g., post-traumatic stress disorder, psychosis, borderline personality disorder, social anxiety disorder, attention deficit/hyperactivity disorder) (11) and included in the National Institute of Mental Health's (NIMH) Research Domain Criteria (14). Additionally, data suggest that an appreciable portion of youth and adults experience symptoms of anhedonia in the absence of major depression (15–17).

There is emerging evidence that anhedonia and related constructs, such as reward sensitivity, may be associated with increases in BMI (18, 19). Cross-sectional evidence indicates that anhedonia is associated with obesity in community samples of adolescents, as obese youth report higher levels of anhedonia than overweight and normal-weight youth (20, 21). Among healthy adults, anhedonia was found to be prospectively associated with weight gain over a year- long follow-up period, and anhedonia has been shown to amplify the association between depression and long-term weight gain (22). However, it remains unclear whether anhedonia and BMI are associated across longer periods of follow-up, and if specific BMI trajectories are associated with changes in anhedonia during adolescence.

The association of anhedonia with changes in BMI during adolescence has different public health implications depending on adolescents' initial BMI levels. For example, stable BMI during high school indicates positive metabolic health for individuals who begin high school with a normative BMI, but indicates adverse metabolic health for adolescents who begin high school with obesity. Therefore, person-centered statistical techniques for analyzing longitudinal data, such as growth mixture modeling (GMM), which permit characterization of qualitatively distinct developmental trajectories can provide parsimonious classification of heterogeneity in BMI trajectories over time that have great practical utility. Studies of BMI trajectory groups using GMM have generally identified four distinct groups: (1) a normative group that maintains stable and normative levels of BMI throughout adolescence (roughly 80% of adolescents); (2) a chronically obese group that maintains high levels of BMI throughout adolescence (roughly 10% of adolescents); (3) a group that displays increases in BMI from normative to overweight or obese levels (roughly 5% of adolescents); and (4) a group that displays decreases in BMI from overweight or obese to normative levels during adolescence (roughly 5% of adolescents) (23, 24).

The current study investigated whether baseline anhedonia level at the outset of high school was associated with BMI trajectory group membership during the first two years of high school. We also tested whether changes in anhedonia were associated with BMI trajectories during this period. We hypothesized that high baseline level and increasing anhedonia would be positively associated BMI trajectories indicative of poor metabolic health.

METHODS

Participants

Participants were 9th grade students recruited from 10 high schools in the greater Los Angeles metropolitan area. Among the 40 public high schools that were approached to participate in the study because of their diverse demographic characteristics and proximity, 10 participated in this study (characteristics of participating schools in reference to Los Angeles county public schools appear in eTable 1 in the online supporting information). All 9th grade, English-speaking students not enrolled in special education classes were eligible to participate in a longitudinal survey of adolescent development and health ($N=4,100$). Of these, 3,396 students and their parents provided active written or verbal assent and consent, respectively. Paper-and-pencil surveys were administered beginning at the start of 9th grade through the beginning of 11th grade and involved five semi-annual assessments: baseline (fall of 9th grade, 2013; $N=3,383$, 99.6%), 6-month (spring 9th grade, 2014; $N=3,292$, 96.9%), 12-month (fall 10th grade, 2014; $N=3,281$, 96.6%), 18-month (spring 10th grade, 2015; $N=3,251$, 95.7%), and 24-month (fall 11th grade, 2015; $N=3,232$, 95.2%) follow-ups. Researchers informed students that their responses would be kept confidential and would not be shared with their parents, teachers, or school staff. Each school was compensated approximately \$2,500 for their participation in the study; students were not individually compensated for participation, but were given small incentives (e.g., pens, key chains). At each assessment, participants spent approximately one hour completing paper-and-pencil surveys during a regularly scheduled class period. Students not in class during data

collections completed surveys by telephone, Internet, or mail (<7.6%). The University of Southern California Institutional Review Board approved the study.

Measures

Anhedonia—At each assessment anhedonia was assessed with the Snaith-Hamilton Pleasure Scale (SHAPS) (13), a 14-item self-report measure which includes statements of pleasure response to rewarding sensory stimuli, social activities, and hobbies (e.g., “I would be able to enjoy a beautiful landscape or view”), that has been psychometrically validated in adolescent populations (25). Responses to each item were scored on a 4-point scale (from 0 [“Strongly Agree”] to 3 [“Strongly Disagree”]). The total score was summed, with a higher score indicating greater levels of anhedonia (Cronbach’s α across waves > 0.89). Among adolescents, the SHAPS has exhibited a unidimensional factor structure and strong convergent and discriminant validity (26).

Body Mass Index (BMI)—Raw BMI scores were calculated (i.e., weight in kilograms [converted from pounds] divided by height in meters-squared) from participants’ self-reported height and weight at each assessment (27). BMI z-scores and percentiles were derived by using age- and sex-specific norms from the Centers for Disease Control and Prevention (CDC) growth charts (28). According to the CDC’s definitions, obesity was defined as a BMI $\geq 95^{\text{th}}$ percentile, overweight as a BMI between the 85^{th} and 95^{th} percentiles, normal weight as a BMI between the 5^{th} and 85^{th} percentiles, and underweight as a BMI < 5^{th} percentile (28). Based on this procedure, participants were coded with four BMI levels (0=*Underweight*, 1=*Normative*, 2=*Overweight*, 3=*Obese*). The rationale for utilizing the percentiles (rather than raw BMI score) was to standardize BMI variability across age and sex, and reason for reclassifying the percentiles into four levels was facilitate interpretation by placing youth on a classification scheme with a limited number of increments based on nomenclature utilized in clinical and public health settings (e.g., overweight, obese). We applied the CDC cut-offs for extreme weight-for-age, height-for-age, weight-for-height, and BMI z-score-for-age to remove biologically implausible values (BIVs), resulting in the exclusion of 58 adolescents (1.7%) who reported any BIVs across the five assessments (28). As in previous research, these values are based on recommendations by the World Health Organization and are calculated by taking half of the distance between 0 and ± 2 z-scores (29). Finally, participants without *any* available data to calculate BMI level values across all assessments were also excluded ($N=76$; 2.2%).

Covariates—Demographic characteristics such as age, sex, race/ethnicity (White, Hispanic, Black, Asian, Other Race), and highest level of parental education (i.e., 8th grade, some high school, high school graduate, some college, college graduate, graduate degree) were included in the adjusted models. Baseline depressive symptoms were measured using the Center for Epidemiologic Studies Depression Scale (CESD), which has been well-validated for use in adolescents and shows convergent validity with clinician-rated symptoms of depression (30). The 20-item composite sum score assessed past week frequency of experiencing depressive symptoms on a 4-point response scale (range: 0 [rarely or none of the time; 0–1 day] to 3 [most or all of the time; 5–7 days]; Cronbach’s α in this sample = 0.84). Depressive symptomology was included to parse the unique association of

anhedonia with BMI over and above other non-specific forms of emotional and psychiatric distress, such as negative emotions, somatic features, and interpersonal problems, which are captured using the CESD. Including this covariate permits ruling out whether anhedonia may be associated with BMI because it is merely a proxy for non-specific affective stress, as multi-symptom depressive symptom scales have demonstrated moderate-sized correlations with anhedonia in previous samples ($r = .22$) (31).

Data Analysis

We first conducted a series of growth mixture modeling (GMM) analyses to identify classes of BMI growth trajectories (i.e., differences in initial levels and rates of change) across the five assessments among students with valid BMI level data ($N=3,262$). The number of classes that best fit the available BMI data was selected based on model fit comparisons using a series of standard fit indices (i.e., Bayesian Information Criterion [BIC], sample-size-adjusted BIC [SSABIC], Akaike Information Criterion [AIC]). We also utilized the Lo–Mendell–Rubin likelihood ratio test (LMR-LRT), which compared the estimated model to a model with one less profile, and entropy, which refers to average accuracy in assigning individuals to profiles. Participants were assigned to the class in which they had the highest estimated posterior probability. Complex analysis was used to adjust parameter standard errors for interdependence in the data (i.e., clustering within schools) and missing data were managed with full information maximum likelihood estimation (FIML).

After the BMI trajectory profiles were identified, preliminary analyses calculated descriptive statistics and tested BMI trajectory group differences in study variables. We then examined associations between longitudinal changes in anhedonia and BMI trajectory groups. Latent growth curve modeling was applied to estimate a baseline level (based on intercept) and linear slope (rate of change across the five assessments) for anhedonia. A multinomial logistic regression model tested whether baseline level and slope of anhedonia were each associated with the four BMI trajectory groups. In these models, baseline level and slope of anhedonia were entered simultaneously into a multinomial structural equation logistic regression model; the four BMI trajectories were treated as nominal variables with the Stable Normative Weight class serving as the reference group. Analyses were conducted in Mplus version 7 and SPSS version 24.

RESULTS

Preliminary Analyses

In Table 1, we present the sample descriptive statistics for demographics and chi-squared and one-way ANOVA tests for differences across the four BMI trajectory groups. There were significant differences in BMI scores across four BMI trajectory groups ($p < 0.001$), indicating that these groups had distinctive BMI levels from each other across 5 waves. There were significant differences in the sex, race/ethnicity and levels of parental education of participants across the four BMI trajectories ($p < 0.001$). We also tested differences in baseline sample characteristics between the analytic sample and the 134 adolescents with BIVs ($N=58$) and without available data to calculate BMI level values ($N=76$) across five assessments, who were excluded from the analyses. There were no significant differences in

demographic characteristics and study variables among eligible participants and those excluded from the analyses ($ps=0.07-0.37$).

BMI Trajectory Groups

In the sample of 3,262 eligible participants, a series of growth mixture models identified classes of adolescents with similar BMI trajectories from ages 14 to 17 years old. We selected a 4-class model based on the SSA-BIC values, LMR-LRT hypothesis tests and interpretability (SSA-BIC=14766.96, Entropy=0.92, LMR- $p=0.037$; see eTable 2 in the online supporting information). Although the SSA-BIC score of 5-class model (SSA-BIC=14032.11) was smaller than 4-class model, the LMR-LRT test was non-significant and included a very small subset of participants (2.1%; detailed information is provided in the Online Supporting Materials). We named the four classes based on their trajectories and previous research: (1) Stable Normative Weight (reference group); (2) Overweight to Normative Weight; (3) Overweight to Chronically Obese; (4) Normative Weight to Overweight (23, 32, 33).

The *Stable Normative Weight* group included the majority of the sample ($n=2,358$, 72.3%) who maintained normal BMI levels across ages 14 to 17 (initial level mean=1.009; $p<0.001$; Slope mean=-0.002; $p=0.37$; raw BMI *Mean[SD]* = 19.74[2.24] at age 14 and 20.88[2.50] at age 17). The *Overweight to Chronically Obese* group ($n=529$; 16.2%) had the highest BMI level at the baseline assessment (initial level mean=2.629; $p<0.001$) with increasing slope (slope mean=0.016, $p=0.02$) and had raw BMI scores over 25.0 at age 14 (*Mean[SD]* = 28.65[4.16]) as well as at age 17 (*Mean[SD]* = 30.74[4.35]). The *Normative Weight to Overweight* group contained 193 adolescents (5.9%) whose BMI increased from a normal level at the baseline to overweight at the fifth follow-up (initial level mean=1.311, $p<0.001$; Slope mean=0.276, $p<0.001$; raw BMI *Mean[SD]* = 22.77[2.36] at age 14 and 28.88[3.54] at age 17). The *Overweight to Normative Weight* group consisted of 182 adolescents (5.6%) with decreasing BMI trajectories, as their BMI level decreased across the five time points (initial level mean =2.472, $p<0.001$; Slope mean=-0.297, $p<0.001$; raw BMI *Mean[SD]* = 26.57[2.55] at age 14 and 24.10[2.03] at age 17).

Longitudinal Associations between Anhedonia and BMI Trajectory Groups

The univariate latent growth curve model of baseline and slope anhedonia that included a linear slope for anhedonia displayed better fit of the data than quadratic models. The linear growth model showed good model fit ($\chi^2=40.01$, $df=8$, $p<0.001$, CFI=0.99, RMSEA=0.03), and the mean slope of anhedonia was significantly larger than zero ($b=0.14$, $p=0.04$). We observed significant variability in initial anhedonia levels (variance of intercepts=28.27, $p<0.001$) and in rates of change over time (variance of slopes=1.345, $p<0.001$).

In the fully-adjusted multinomial logistic regression model depressive symptoms were positively associated with baseline anhedonia level ($\beta=0.30$, $p<0.001$), but depression was not significantly associated with any of the BMI trajectory group outcomes ($p>0.08$; see eTable 3 in the online supporting information). After controlling for baseline sociodemographic covariates and depression symptoms, baseline anhedonia level was only associated with membership in the Overweight to Normative Weight group. Compared to the

Stable Normative Weight BMI trajectory group, each one-unit *SD* increase in baseline anhedonia level increased the odds of inclusion in the Overweight to Normative Weight group by 19% (OR[95% CI]=1.19[1.02, 1.36]; $p=0.03$). Baseline levels of anhedonia were not significantly associated with the Overweight to Chronically Obese group (OR[95% CI]=1.01[0.97, 1.06]; $p=0.27$) or the Normative Weight to Overweight group (OR[95% CI]=1.01[0.93, 1.09]; $p=0.76$).

Rate of change in anhedonia over time (i.e., slope) was associated with membership in each of the three BMI trajectory groups. Compared to the Stable Normative BMI trajectory group, each one *SD* increase in anhedonia slope significantly increased the odds of membership in groups with an escalating BMI trajectory: the Overweight to Chronically Obese group (OR[95% CI]=1.29[1.09, 1.49]; $p<0.001$) and Normative Weight to Overweight group (OR[95% CI]=1.28[1.04, 1.53]; $p=0.006$). On the contrary, each one *SD* increase in anhedonia slope significantly decreased the odds of membership in the Overweight to Normative Weight group by 22% (OR[95% CI]=0.78[0.57, 0.95]; $p=0.01$), which had decreasing BMI trajectory over time.

Sensitivity Analyses

To determine whether operationalization of the observed BMI indicators impacted our GMM classification results of BMI trajectory groups using BMI level indicators, we conducted an analysis using the raw BMI scores, which yielded results consistent with primary analysis. To parse the bidirectional relation between changes in anhedonia and BMI, we conducted a series of cross-lagged models. As presented in eFigure 1a and 2a in the online supporting material, we detected stronger associations from anhedonia and changes in BMI level compared to the paths from BMI to anhedonia (see Online Supporting Material).

DISCUSSION

Adolescence is a critical period of development during which pubertal changes in adiposity influence BMI trajectories throughout the lifespan (4). While previous research has primarily focused on examining the relation between multi-symptom clinical phenotypes, such as major depressive disorder and BMI, recent evidence suggests that anhedonia may be a unique risk factor for weight gain among adolescents (20, 21). The current study provides new evidence by analyzing both initial level and changes in anhedonia across adolescence as well as by modeling qualitatively unique BMI trajectories based on GMM. The results show that changes in anhedonia may be more closely linked with BMI trajectories indicative of poor metabolic health during the first two years of high school than static levels of anhedonia at the beginning of high school, per se.

Increases in anhedonia over time were associated with membership in the two trajectories that involved weight gain (i.e., increased odds of membership in the *Overweight to Chronically Obese* and *Normative Weight to Overweight* groups), suggesting that teens who exhibit increases in anhedonia across the first half of high school may be more likely to be on a trajectory of weight gain. Higher baseline anhedonia was associated with increased odds of membership in the *Overweight to Normal Weight* group (vs. Stable Normative BMI group), and rate of change in anhedonia over time was inversely associated with this

Overweight to Normal Weight group, which showed a trajectory of weight loss. While teens with higher levels of anhedonia at the beginning of high school were more likely to be overweight or obese, they were not necessarily more likely to have persistently high or increasing BMIs. Rather, teens who started with high levels of anhedonia and then exhibited declines in anhedonia during the first half of high school were more likely to be on a trajectory of weight loss during this period. If this association is causal and originates from anhedonia, interventions that alleviate anhedonia among youth who begin high school as anhedonic may benefit metabolic and cardiovascular health.

Anhedonia may contribute to increases in BMI via affective states and changes in brain reward circuitry that influence eating behavior and the motivational processes needed to regulate energy balance and maintain a healthy lifestyle (34). While we found a direct longitudinal association between both baseline and slope anhedonia and BMI trajectories, prior studies with cross-sectional designs have suggested possible mechanisms through which anhedonia could impact weight gain. Anhedonia is associated with a variety of health-damaging behaviors (e.g., physical inactivity (35), excessive food consumption, and emotional eating (34)) and psychological processes (e.g., stress (22), and sleep (36)) that may contribute to weight gain and obesity during adolescence.

As this study was observational and anhedonia slope and BMI trajectory were modeled over a simultaneous time period, it is also possible that persistent and escalating adiposity increases anhedonia. Evidence from the neuroscience literature suggests that changes in body mass may precede changes in reward sensitivity (37, 38), however more recent studies support the inferred directionality of the association between anhedonia and increased BMI (39, 40). Additional supplemental cross-lagged models that assessed the directionality of the relation between anhedonia and BMI are more concordant with an interpretation that anhedonia is associated with changes in BMI rather than BMI leading to anhedonia.

Strengths of the study include the large, demographically diverse sample and high rates of retention. The longitudinal design and multiple follow-up assessments extends the extant cross-sectional research on the relation between anhedonia and BMI, and offers initial evidence that changes in anhedonia may be modeled as predictors of BMI trajectories. Limitations of the study are the use of self-report measures of height and weight to calculate BMI and absence of objective measures. Participants were not instructed to assess their weight in advance of the survey and we did not assess if the participants regularly measured their weight or the date of their most recent weighing. Thus, it is possible that the percentage of adolescents with stable normative weight may be due to self-report assessment and underestimation of weight change. Additionally, self-report of weight and height could also have increased the number of students who were excluded for reporting biologically implausible BMI values. We attempted to statistically control for relevant covariates (e.g., demographic characteristics and baseline depression), however, it remains possible that other unmeasured factors (e.g., pubertal timing/changes, body dissatisfaction (20)) could explain a portion of the association between changes in anhedonia and BMI trajectories.

CONCLUSIONS

The results of this study indicate that increased anhedonia over a two-year period is associated with adverse BMI trajectories among high school students. Increasing levels of anhedonia may be a particularly important risk marker to consider in adolescent obesity prevention. Parsing anhedonia from other facets of psychiatric distress may elucidate key phenotypes that impact weight gain throughout adolescence, informing more precise treatments. Future research is needed to identify the causal direction of the association between anhedonia and increased BMI as well as possible mediating mechanisms involved.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Access to Data and Data Analysis: The JC and AML had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Author contributions: JC was principal investigator responsible for study conception and directing data collection. JC conducted the analyses. JC, NIG, and MSP lead the conceptualization of the study and wrote most the manuscript text. RK, MSB, GFD, BRB and AML aided in study conceptualization and provided feedback on drafts. JC oversaw data management and processing.

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Implications and Contribution

Changes in anhedonia, a unique facet of psychiatric distress, over a two-year period is associated with BMI trajectories among high school students. Increasing levels of anhedonia during this critical developmental period may be an important risk factor for weight gain and should be considered in adolescent obesity prevention.

Figure 1.

Growth Mixture Model of BMI Across Five Time Points

Note. $N = 3,262$. W1 = baseline (mean age[SD] = 14.6[.40] years), W2 = 6-month follow-up, W3 = 12-month follow-up, W4 = 18-month follow-up, W5 = 24-month follow-up.

*Significant slope mean estimate ($p < .05$). **Significant slope mean estimate ($p < .01$).

Figure 2.

Standardized Baseline Anhedonia Level and Slope Effects on BMI Trajectory Groups

Note. $N = 3,262$. Reference group = Stable Normative Weight group. Adjusted for parental education level, youth age, sex, ethnicity, and baseline depression. Odds ratios were shown on paths between anhedonia and BMI groups.

* $p < 0.05$. ** $p < 0.01$.

Table 1

Sample Demographics, BMI and Anhedonia by BMI Class

	Overweight to Normative weight	Overweight to Chronically obese	Normative weight to Overweight	Stable Normative weight	Total	Difference (<i>p</i>)
Sociodemographics						
Sex ^a	182 (5.6)	529 (16.2)	193 (5.9)	2358 (72.3)	3262 (100.0)	<0.001
Male	97 (6.4)	300 (19.7)	91 (6.0)	1038 (68.0)	1526 (100.0)	
Female	85 (4.9)	229 (13.2)	102 (5.9)	1320 (76.0)	1736 (100.0)	
Age ^b	14.25 (.39) ²	14.57 (.41) ^{1, 2}	14.60 (.42) ¹	14.57 (.40) ^{1, 2}	14.58 (.40)	.21
Race/ethnicity ^a	177 (5.6)	514 (16.1)	189 (5.9)	2305 (72.4)	3185 (100.0)	<0.001
White	22 (4.4)	62 (12.3)	30 (6.0)	390 (77.4)	504 (100.0)	
Hispanic	95 (6.4)	287 (19.3)	98 (6.6)	1009 (67.8)	1489 (100.0)	
Black	13 (8.3)	24 (15.3)	13 (8.3)	107 (68.2)	157 (100.0)	
Asian	20 (3.8)	57 (11.0)	20 (3.8)	423 (81.3)	520 (100.0)	
Other	27 (5.2)	84 (16.3)	28 (5.4)	376 (73.0)	515 (100.0)	
Parental education ^a	152 (5.4)	463 (16.4)	171 (6.1)	2035 (72.1)	2821 (100.0)	0.001
8 th grade	10 (9.3)	19 (17.6)	8 (7.4)	71 (65.7)	108 (100.0)	
Some high school	15 (5.9)	55 (21.7)	22 (8.7)	161 (63.6)	253 (100.0)	
High school graduate	20 (4.2)	90 (19.0)	28 (5.9)	336 (70.9)	474 (100.0)	
Some college	31 (5.6)	103 (18.7)	37 (6.7)	381 (69.0)	552 (100.0)	
College graduate	52 (5.8)	138 (15.4)	44 (4.9)	664 (73.9)	898 (100.0)	
Graduate degree	24 (4.5)	58 (10.8)	32 (6.0)	422 (78.7)	536 (100.0)	
Body Mass Index (BMI) score						
BMI W1 ^b	26.57 (2.55) ²	28.65 (4.16) ¹	22.77 (2.36) ³	19.74 (2.24) ⁴	21.65 (4.31)	<0.001
BMI W2 ^b	26.29 (2.41) ²	29.43 (4.22) ¹	24.16 (2.28) ³	20.19 (2.28) ⁴	22.20 (4.40)	<0.001
BMI W3 ^b	25.48 (2.49) ²	29.91 (4.22) ¹	25.23 (3.06) ²	20.37 (2.28) ³	22.38 (4.48)	<0.001
BMI W4 ^b	24.60 (2.36) ³	30.39 (4.35) ¹	26.69 (3.20) ²	20.69 (2.30) ⁴	22.80 (4.60)	<0.001
BMI W5 ^b	24.10 (2.03) ³	30.74 (4.35) ¹	28.88 (3.54) ²	20.88 (2.50) ⁴	23.09 (4.92)	<0.001
Psychological factors						
Depression W1 ^b	15.16 (13.21) ¹	14.78 (11.98) ¹	15.39 (13.16) ¹	14.35 (11.52) ¹	14.53 (11.80)	0.52

	Overweight to Normative weight	Overweight to Chronically obese	Normative weight to Overweight	Stable Normative weight	Total	Difference (<i>p</i>)
Anhedonia W1 ^b	24.74 (7.37) ¹	24.60 (7.11) ¹	23.73 (6.91) ^{1, 2}	23.31 (6.74) ²	23.62 (6.87)	<0.001
Anhedonia W2 ^b	24.98 (9.13) ¹	24.63 (8.80) ¹	24.63 (7.94) ¹	23.92 (7.86) ¹	24.14 (8.10)	0.11
Anhedonia W3 ^b	24.22 (8.50) ^{1, 2}	25.07 (9.02) ¹	24.38 (8.85) ^{1, 2}	23.88 (8.12) ²	24.13 (8.35)	0.03
Anhedonia W4 ^b	23.30 (7.79) ³	25.86 (9.34) ¹	24.73 (8.72) ²	24.28 (8.60) ^{2, 3}	24.50 (8.70)	0.001
Anhedonia W5 ^b	23.01 (7.78) ³	25.39 (9.43) ¹	24.78 (8.79) ²	23.55 (7.93) ³	23.88 (8.27)	<0.001

Note.

^a *n* (%). Based on χ^2 test of association.

^b Mean (*SD*). Based on ANOVA test of association.

^{1, 2, 3, and 4} LSD post-hoc analyses results. At W1, anhedonia Mean (*SD*) = 22.47 (6.46) among students who did not have depressive symptoms (*n*=2,074)