THESIS

THE ROLE OF SOCIAL RELATIONSHIP FUNCTIONING IN SUICIDAL IDEATION AMONG ADOLESCENTS AT-RISK FOR ADULT OBESITY

Submitted by

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ABSTRACT

THE ROLE OF SOCIAL RELATIONSHIP FUNCTIONING IN SUICIDAL IDEATION AMONG ADOLESCENTS AT-RISK FOR ADULT OBESITY

Prevalence of child and adolescent obesity represents a public health crisis in the United States and globally. Having tripled over the last 50 years, current rates of obesity show that approximately 18% of children aged 2-19 years in the United States are affected. While metabolic health consequences of obesity are of great concern, including insulin resistance and impaired glucose, obesity also is related to a range of adverse psychological concerns, including depression and suicidal ideation. Indeed, there has been an alarming rise in adolescent suicidal ideation and behavior, and a possibility that heavier youth are at higher risk. Yet, theoretical and empirical data support the possibility that positive social relationship functioning may play an important moderating role, by buffering the effects of weight discrimination on suicidal ideation in youth with overweight and obesity. In the current master's thesis proposal, I conducted a secondary analysis of the cross-sectional associations among social relationship functioning, suicidal ideation, and metabolic health characteristics in 90 adolescents aged 12-17 years (50% girls) at-risk for adult obesity. Adolescents completed survey measures of social relationship functioning and survey/interview measures of depression and suicidal ideation. Height and fasting weight were collected to determine body mass index (BMI) indices, and body fat was measured via air displacement plethysmography. A fasting blood sample was analyzed for fasting insulin, fasting glucose, and insulin resistance. I explored the bivariate associations among social functioning, depression, BMI, metabolic indices, and without suicidal ideation. Then I tested BMI/metabolic indices, social relationship functioning, and their interactions as a

predictor of suicidal ideation, controlling for depression symptoms in order to evaluate the unique relation of BMI/metabolic indices and social functioning with suicide ideation. Nearly 30% of adolescents reported suicidal ideation. Contrary to hypotheses, results showed that neither BMI/body fat nor metabolic indices were related to suicidal ideation, nor did social act as a moderator of these associations. Accounting for age, sex, and BMI z, depression was robustly related to higher odds of suicidal ideation. Most dimensions of social functioning related in bivariate analyses to suicidal ideation, and some dimensions, even when accounting for depression symptoms and other covariates, showed a trend-level or significant association with suicidal ideation. These results point to the prevalence of suicidal ideation in adolescents at risk for adult obesity and suggest that elevated depression symptoms are the primary marker of risk for suicidal ideation in this population. Additional research with larger samples and longitudinal data are needed to further test the role of social functioning in mitigating, or perhaps mediating, suicidal ideation risk in adolescents at risk for adult obesity, as well as research into other possible protective factors.

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INTRODUCTION

Obesity (body mass index [BMI; kg/m^2] $\geq 95^{th}$ percentile) is a national health crisis for the adolescent population, impacting nearly 18% of youth aged 2-19 in the United States (Ogden et al., 2018). Research shows that obesity is related to a range of negative psychological outcomes, one of which is an increased likelihood of experiencing suicidal ideation (Amiri & Behnezhad, 2018; Pan et al., 2017). Additionally, obesity is related to adverse metabolic functioning (e.g., insulin resistance), and a small body of literature has connected metabolic functioning with suicidal ideation in adults. Of course, not all adolescents who have obesity endorse suicidal ideation and insufficient research exists to inform us of the factors that buffer an adolescent's likelihood of endorsing suicidal ideation, separate from having depression. Due to the importance of social support during adolescence, as well as the potential to be ostracized from social connections due to one's weight (Cook, Pont, Puhl, & Slusser, 2017), I hypothesized that BMI and metabolic health problems would be associated with an increased risk of suicidal ideation, but that positive social support may play an important role in this relationship by dampening the strength of these effects.

Problem of Adolescent Obesity

Obesity is a well-recognized health crisis in the United States and across the world (Holden, Mattox, Nemiary, & Shim, 2012). Obesity refers to excess body weight, or too much weight for one's health, and is estimated in adolescents using body mass index (BMI) scores standardized for age and sex. In adolescents, a BMI percentile of 85-94 is considered overweight, and a BMI percentile at or exceeding 95 is considered obese. An estimated 17.8% of youth aged 2-19 years are affected by obesity and risk is higher for non-Hispanic Black youth

(20.4%) and Hispanic youth (23.6%), compared with non-Hispanic White youth (14.7%; Ogden et al., 2018). Importantly**,** obesity is highly comorbid with numerous adverse metabolic characteristics in adolescents, including a heightened risk for type 2 diabetes, a serious condition related to shorter life expectancy by 15 years (Hoerger, Laffel, Lieu, Ludwig, Prosser, & Rhodes, 2012). Additional negative outcomes related to obesity include hypertension and cardiovascular disease (Holden, Mattox, Nemiary, & Shim, 2012). Yet, there are also co-morbidities of obesity with psychological distress, which have been gaining increasing attention.

Association of Obesity with Depression and Suicidal Ideation

Among adolescents, obesity has been linked to greater psychological distress, including increased rates of depression in particular, as well as related factors including anxiety, lower self-esteem, and lower perceived overall mental health (Baker, Cobley, Han, & Sanders, 2015; Holden, Mattox, Nemiary, & Shim, 2012). Depression is a particularly salient issue. With regard to depression, a recent systematic review and meta-analysis showed that children and adolescents who have obesity have a 26% increased risk of having elevated depression symptoms at one point in time and a 51% increased risk of developing elevated depression symptoms over time in longitudinal studies, as compared to their peers who do not have obesity, with relatively stronger associations in girls as compared to boys (Sutaria et al., 2019). Conversely, adolescent depression symptoms also have been shown in meta-analyses to increase the likelihood of developing obesity, particularly among adolescent girls (Blaine, 2008). It is likely that obesity and depression interact reciprocally, such that the burden of having obesity, including its associated stigma and discrimination (Cook, Pont, Puhl, & Slusser, 2017), contributes to increased depression, and having depression likely promotes excess weight gain and adverse

metabolic outcomes through factors such as emotional eating (Irigoyen Camacho, Lazarevich, Velázquez-Alva, & Zepeda, 2016) and physical inactivity (Raudsepp & Vink, 2018).

Suicidal ideation, referring to the non-fatal behavior of thinking about suicide, is one of the most concerning symptoms of depression among adolescents (Goldman, Allen, & Kaplan, 2018). Suicidal ideation is cause for particular concern in the adolescent age group, as suicide is ranked as the second-leading cause for death in individuals aged 10-24 years (Curtin, Hedegaard, & Warner, 2018) and suicidal behavior most often emerges in the adolescent years (Nock et al., 2008). The association between obesity and suicidal ideation specifically in adolescents has been far less researched than the obesity-depression link. Yet, existing studies investigating this topic have shown a connection. In particular, a systemic review and meta-analysis of the existing literature on the relation between BMI and suicidal ideation concluded that there is a positive association between the two, such that individuals who have obesity are more likely to experience suicidal ideation compared to individuals who do not have obesity (Amiri & Behnezhad, 2018). Additionally, in a large (N=1709) community sample of adolescents, researchers showed that adolescents who have both obesity and depression are three times more likely to experience suicidal ideation than depressed adolescents who did not have obesity (Pan et al., 2017).

As with depression, directionality in the relation between suicidal ideation and obesity is inconclusive. On the one hand, the stigma and discrimination associated with having obesity has been posited to deteriorate adolescents' mental health, including thoughts of suicide (Jenkins, Ratcliff, Reiter, & Zeller, 2013). Alternatively, it remains unclear if an observed BMI-suicidal ideation is explained by these factors' joint association with depression, or if BMI and suicidal ideation are related, even independent of adolescents' degree of depression symptoms. From a

systems theory framework, it is likely that multiple broader systems influence the interconnection of obesity and suicidal ideation (Haidari et al., 2015). For instance, engagement on social media and the type of feedback youth receive regarding their weight may influence suicidal ideation. Understanding these relations in adolescence is important, given that the emergence of depression and suicidal ideation often occurs in the second decade of life (Nock et al., 2008).

Association of Metabolic Functioning with Suicidal Ideation

In addition to the association of obesity with depression and suicidal ideation, a small body of research exists exploring the association of metabolic functioning and suicidal ideation. In adults experiencing depression, suicidal ideation was found to be associated cross-sectionally with higher fasting glucose (Leppänen, Kautiainen, Koponen, Mäntyselkä, & Vanhala, 2015). Also, in a large (N = 9,687) cohort of adults, fasting glucose and triglycerides were both related to depression symptoms and suicidal ideation (Han et al., 2019). Furthermore, research has found an association between suicidal attempts in adolescence and greater cardiovascular risk in young adulthood (Freeman, Linthicum, Schorpp, & Volpe, 2016). These intriguing preliminary studies suggest that suicidal ideation and metabolic functioning may be interconnected. Poor metabolic functioning could heighten suicide risk, or conversely, suicidal ideation might increase risk for cardiometabolic disease. While these studies are intriguing, no current research has examined this association in adolescents.

Role of Social Functioning

Although BMI has been related to both depression and suicidal ideation, it is important to note that adolescents who have overweight or obesity are a heterogeneous group with respect to mental health. Said differently, many adolescents with overweight or obesity do not suffer from

these psychological difficulties. While there are likely many factors influencing the degree of psychological distress in heavier adolescents, recent research has begun to focus on weight stigma and social functioning. Weight stigma, or the "societal devaluation of a person because he or she has overweight or obesity," is often experienced by adolescents in the form of teasing, bullying, and weight-based victimization and often includes the perpetuation of negative stereotypes, including that people with obesity are apathetic or unmotivated (Cook, Pont, Puhl, & Slusser, p. 2, 2017). Importantly, adolescents who experience greater weight-based victimization have lower quality of life (Janicke et al., 2007) and higher levels of self-harm and suicidal ideation than adolescents who do not have obesity (Daly, Robinson, Sutin, & Terracciano, 2018). Moreover, according to social information processing theory, negative peer interactions and weight-related stigmatizing experiences would be anticipated to influence the development of negative self-perceptions about oneself, which could lead to suicidal ideation (Crick & Dodge, 2008).

Yet, available data suggest that these processes are likely to be moderated by adolescents' degree of social functioning (**Figure 1**). A study examining the impact of social support on the effects of relational victimization showed that social support protected against the effects of relational victimization on suicidal ideation through increasing global self-worth (Austin et al., 2015). Findings from additional adolescent studies not specific to victimization/teasing or weight lend further evidence to support a moderating effect of social support on suicidal ideation. For instance, a cross-sectional study of African American adolescents showed that higher family and peer support related to less suicidal ideation, and further, that peer support interacted with depression symptoms in predicting suicidal ideation (Matlin, Molock, & Tebes, 2011). The

association between depression symptoms and suicidal ideation was weaker when peer support was relatively high, and conversely, was stronger in the presence of low peer

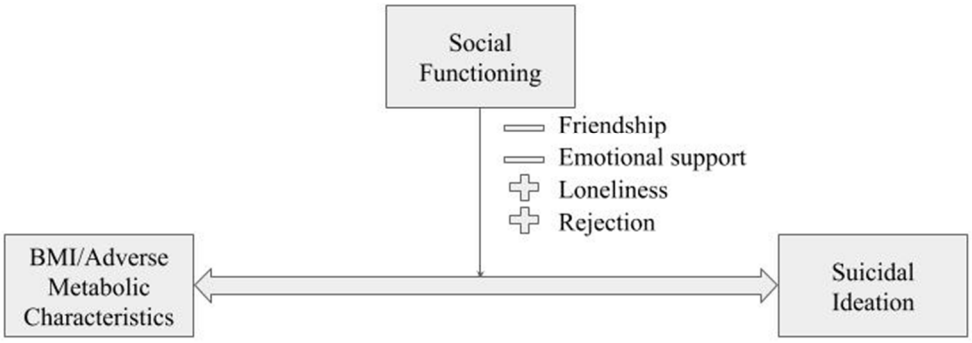

Figure 1. Theoretical model of how social functioning is anticipated to moderate the association between BMI/metabolic characteristics and suicidal ideation.

support (Matlin, Molock, & Tebes, 2011). Additionally, results from a community sample of adolescents found peer support to be a protective factor in the relation between disordered eating and suicidal ideation (Brausch & Decker, 2013). These findings align well with the Interpersonal Theory of Suicide, which posits that a person is most at-risk for suicide when he/she experiences the simultaneous presence of two interpersonal constructs—thwarted belongingness (i.e. "I am alone") and perceived burdensomeness (i.e. "I am a burden") (Van Orden et al., 2010). If a person has low levels of social support, they may be at highest risk for both feelings of loneliness and perceived burdensomeness, thereby putting them at higher risk for suicidal ideation.

Ultimately, these findings suggest that in the face of the ubiquitous, high socio-cultural stigma related to weight, adolescents at-risk for obesity may be at higher risk for suicidal ideation, yet positive social relationship functioning may protect against the depression symptoms and devaluation of self-worth that influence suicidal ideation. Social relationships, consequently, may be an important factor to consider when understanding the greater incidence

of depression and suicidal ideation in adolescents at-risk for excess weight gain. Elucidation of the role of social relationship functioning in suicidal ideation offers potential to help inform preventative interventions in this population.

CURRENT STUDY

In the current study, I aimed to further research in regard to social relationship functioning, suicidal ideation, and obesity using secondary analyses of a sample of adolescents at-risk for adult obesity. The first aim was to explore the associations of body measurements (BMI indices/body fat) and metabolic characteristics (fasting insulin/glucose/insulin resistance) with suicidal ideation in adolescents at-risk for adult obesity. I hypothesized that adolescents' higher BMI, adiposity, greater fasting insulin, glucose, and insulin resistance would be related to a higher likelihood of endorsing suicidal ideation. As discussed earlier, there is a small body of evidence to suggest that suicidal ideation is not only associated with BMI/obesity, but also to metabolic characteristics related to excess weight. Yet, because there have been no tests of suicidal ideation and metabolic risk in adolescents, the current study addresses this gap in the literature.

In the second aim, I sought to explore to what extent social functioning moderated the relations of body measurements and metabolic characteristics with suicidal ideation in adolescents at-risk for adult obesity. I hypothesized that social functioning would be a significant moderator, such that the relations of body measurements and adverse metabolic characteristics with suicidal ideation would be weaker with more positive social functioning (e.g., friendship quality, emotional support) and stronger with greater social difficulties (e.g., perceived rejection, loneliness, hostility). I anticipated that these effects would be present even after accounting for adolescents' depression symptoms and that the relations of metabolic characteristics with suicidal ideation would exist even after accounting for differences in BMI.

METHOD

Participants

In the present study, I performed secondary, cross-sectional analyses using baseline data of 90 adolescents who participated in a larger study examining adolescent eating behavior. Recruitment was conducted using a number of convenience sampling strategies in the community. Strategies included placing flyers in community settings, mailing information to potential volunteers, emailing community centers, and receiving referrals from physicians. Inclusion criteria were: (i) 12-17 years of age, (ii) adolescent BMI (at or above the 70^{th} percentile) or the existence of obesity (BMI greater or equal to 30 kg/m^2) in both parents, which indicated a future risk for having obesity as an adult, and (iii) good general health. Adolescents were excluded if: (i) they had been diagnosed with a significant medical condition (e.g., diabetes), (ii) had a psychiatric condition that would impeded compliance with study procedures, (iii) were taking medications that could impact weight gain/loss or mood, or (iv) in females, were pregnant. Parents/caregivers provided written consent, after a study coordinator described the study to them in the detail. Adolescents provided written assent. Adolescents were financially compensated for their time and effort in participating.

Procedures and Measures

Following a phone screen to determine potential eligibility, participants were seen at the Human Body Dimensioning Lab/Medical Nutrition Lab following an overnight fast. Body measurements (height and fasting weight) and body composition were assessed in a fasted state, and a fasting blood sample also was collected. A family health history was conducted with the parent. Participants completed psychological surveys to assess social functioning and

depression/suicidal ideation were assessed via both survey and interview. The following measures were evaluated as part of the current study.

BMI/body fat

Participant's height was measured in triplicate using a stadiometer and averaged. Fasting weight was assessed on a digital scale. Height and weight were used to determine BMI, BMI percentile, BMI z (standard) score, and weight status (lean: <84th percentile, overweight: 85-94th percentile, or obesity: ≥95th percentile; Dietz et al., 2002). BMI z, which is standardized for age and sex, was used in the primary analyses. Additionally, air displacement plethysmography (BodPod) was used to determine percentage body fat. This instrument has shown to have good test-retest reliability and convergence with other measurements of percentage body fat, including dual energy x-ray absorptiometry (Vicente-Rodriguez et al., 2012).

Metabolic characteristics

Participants provided fasting venous blood samples. Blood was assayed for fasting insulin and fasting glucose. Assays were performed by the University of Colorado School of Medicine's Clinical and Translational Research Center core laboratory. Serum insulin was analyzed with radioimmunoassay (Millipore, Billerica, Massachusetts) and glucose by Beckman Coulter or YSI analyzer. Fasting insulin and glucose were used to compute the homeostasis model assessment of insulin resistance, calculated as (fasting insulin [μU/mL] X fasting glucose [mmol/L])/22.5.

Suicidal ideation

Suicidal ideation, operationalized as presence versus absence, was assessed by survey and interview. The Children's Depression Inventory (CDI) is a widely used 27-item self-report measure. Each item is rated on a 3-point Likert scale, and participants are asked to choose the response that best describes their feelings. The item that addresses suicidal ideation provides the

following responses: (1) *I do not think about killing myself*, (2) *I think about killing myself but I would not do it*, and (3) *I want to kill myself*. Responding with option 2 or 3 resulted in coding "presence" for suicidal ideation. The CDI has been found to have good reliability and validity in adolescent samples (Degenhardt et al., 2014). In addition, suicidal ideation was assessed with the Schedule for Affective Disorders and Schizophrenia for School-Aged Children (K-SADS) by a trained interviewer. The K-SADS assesses for presence of suicidal ideation and suicidal ideation severity in the past 2 weeks (Kaufman et al., 2016). Responses are scored using a 4-point Likert scale, including: (0) = *No information*, (1) = *Not at all*, (2) = *Subthreshold*, and (3) = *Threshold*. Several studies provide evidence for the convergent and divergent validity, as well as strong inter-rater reliability, of the K-SADS (Arnkelsson, Jarbin, Ivarsson, & Råstam, 2010; Kolaitis, Korpa, Kolvin, & Tsiantis, 2003). In the current study, suicidal ideation was determined as the presence of any suicidal ideation, reported by either CDI survey or by KSADS interview, or absence, as determined by no suicidal ideation on either instrument. During assessments, any adolescent who endorsed suicidal ideation was assessed for intent or plan by a trained staff member, supervised by a licensed clinical psychologist, and was referred for treatment as indicated.

Social functioning

Several core dimensions of social functioning were characterized by adolescent report on the NIH Toolbox Social Relationships Battery (Cyranowski et al., 2019). The NIH Social Relationships Battery is comprised of five scales: (1) perceived rejection, (2) friendship, (3) loneliness, and (4) emotional support. The battery assesses these aspects over the past month. Each scale consists of five self-report questions, and all items are rated by adolescents on a Likert-scale ranging from "1" to "5": (1) = *Never*, (2) = *Rarely*, (3) = *Sometimes*, (4) = *Usually*,

and (5) = *Always*. Sample items for perceived rejection include: *In the past month I have people in my life who act like my problems aren't important*, or *who make me feel like I don't fit in*. Sample items for the friendship scale include: *I get invited to go out and do things with other people* and *I can find a friend when I need one*. Sample items for loneliness include: *I feel that I have nobody to talk to*, and *I feel alone and apart from others*. Finally, sample items for emotional support include: *I have someone who understands my problems*, and *I have someone who will listen to me when I need to talk*. Items are averaged for each respective scale. Higher scores on emotional support and friendship are more positive in valence, whereas higher scores on perceived rejection and loneliness are more negative in valence. The NIH Social Relationships Battery has been used in many studies with adolescents and has been found to have strong internal reliability and concurrent validity (Cyranowski et al., 2013).

Depression symptoms

A continuous measure of depression symptoms was determined using the 20-item Center for Epidemiologic Studies - Depression Scale (CES-D). The CES-D does not assess suicidal ideation. Sample items include: *I was lonely*, *I was bothered by things that don't usually bother me*, and *I felt depressed*. Four-point Likert scale response options include: (0) *rarely or none of the time*, (1) = *some or a little of the time*, (2) = *occasionally or a moderate amount of the time*, and (3) = *most or all of the time*. A total score is computed as the sum of all items. The CES-D has demonstrated good psychometric properties within the adolescent population (Degenhardt et al., 2014).

Analytic Plan

Prior to analyses, data were cleaned and adjusted for outliers. Valid outliers were windsorized to follow within the 25th or 75th percentile, less or plus 1.5 times the interquartile

range. Descriptive statistics were used to describe frequency of suicidal ideation for the sample. Demographics for the sample were described by suicidal ideation status (presence vs. absence), using independent samples t-tests or chi-square. Independent samples t-tests also were used to describe the bivariate differences in suicidal ideation status on BMI indices, body fat, metabolic characteristics, and social functioning. For descriptive purposes, correlations were used to describe associations among continuous variables. Hierarchical logistic regression then were conducted to test the associations of body measurements (BMI z score, body fat %) and metabolic characteristics (insulin, glucose, insulin resistance) with suicidal ideation (presence vs. absence), after controlling for age, sex, and depression symptoms. For models evaluating insulin, glucose, and insulin resistance as predictors, I also included BMI z score as a pre-specified covariate. Within each model, after testing main effects of body measurements and metabolic characteristics on suicidal ideation, I tested the main effects of social functioning dimensions and then the interactional effects of social functioning by body measurements/metabolic metrics on suicidal ideation status.

RESULTS

Descriptive information and preliminary analyses

In the current sample, 28.9% of adolescents endorsed suicidal ideation, by survey (CDI) or interview (K-SADS). There was significant ($p = .001$) overlap between the measures, with 61 endorsing no suicidal ideation on either measure, 8 adolescents endorsing suicidal ideation on both instruments, 3 youth reporting suicidal ideation on the CDI only, and 18 on the K-SADS only. **Table 1** displays descriptive information of study participants by suicidal ideation status, pre-specified as presence versus absence across the survey/interview assessments. There were no significant differences between participants who had and did not have suicidal ideation with regards to race, sex, weight status, age, or metabolic characteristics. As would be expected, adolescents who endorsed suicidal ideation had higher depression symptoms (16.76 ± 7.62 vs. 10.55 ± 6.43 $p < .001$). They also reported worse friendship quality (17.11 ± 3.58 vs. 20.04 ± 4.76, $p < .01$), higher loneliness (16.07 ± 5.25 vs. 11.88 ± 5.84, $p < .01$), and greater perceived rejection (10.50 ± 4.11 vs. 8.22 ± 3.74, $p = .02$) than those who did not report suicidal ideation.

Table 1. Baseline descriptive characteristics of adolescents who did and did not endorse suicidal ideation

Characteristic	Suicidal Ideation Present	No Suicidal Ideation	*p*
Female, *n* (%)	18 (62.1%)	27 (44.3%)	.11
Race/ethnicity, *n* (%)			.76
Non-Hispanic White	18 (62.1%)	42 (68.9%)	
Hispanic	11 (37.9%)	19 (31.1%)	
American Indian	0 (0%)	1 (1.6%)	
Asian	1 (3.4%)	1 (1.6%)	
Weight status, *n* (%)			.70
Lean	5 (17.2%)	11 (18%)	
Overweight	8 (27.6%)	12 (19.7%)	
Obesity	16 (55.2%)	38 (62.3%)	
Age, years	14.50 (1.50)	14.13 (1.71)	.32
BMI, kg/m^2	27.53 (4.18)	27.64 (5.11)	.92
BMI, z-score	1.6 (.56)	1.66 (.58)	.67
BMI, percentile	92.52 (7.07)	93.0 (7.21)	.77
Body fat, %	34.58 (7.00)	34.69 (7.06)	.42
Fasting insulin, uIU/mL	12.64 (7.71)	11.97 (6.58)	.71
Fasting glucose, mg/dL	78.34 (7.10)	79.48 (6.29)	.50
HOMA-IR	2.39 (1.53)	2.14 (1.27)	.47
Depression symptoms	16.76 (7.62)	10.55 (6.43)	<.001
Emotional support	25.5 (5.92)	28.22 (6.50)	.064
Friendship	17.11 (3.58)	20.04 (4.76)	.005
Loneliness	16.07 (5.25)	11.89 (5.85)	.002
Perceived hostility	11.53 (3.29)	10.26 (3.84)	.136
Perceived rejection	10.50 (4.11)	8.22 (3.74)	.016

Note: Mean (Standard Deviation) unless otherwise noted as percentage. Abbreviations: BMI = body mass index; HOMA-IR = homeostasis model assessment of insulin resistance. Suicidal ideation present: $n = 29$; No suicidal ideation: $n = 61$. With respect to missing data: $n = 4$ missing data points for body fat percentile, $n = 10$ for glucose, $n = 13$ for insulin, $n = 15$ for HOMA-IR, $n = 1$ for depression symptoms, $n = 2$ for emotional support, $n = 2$ for friendship, $n = 2$ for loneliness, $n = 2$ for perceived rejection, $n = 2$ for perceived hostility.

Correlations among continuous variables are displayed in **Table 2**. There were significant moderate-to-large negative correlations of adolescents' depression symptoms with emotional support (r = -.45, p < .001) and friendship (r = -.45, p < .001). There were significant moderate-to-large positive correlations of adolescents' depression symptoms with loneliness (r = .61, p < .001), hostility (r = .30, p < .001), and rejection (r = .58, p < .001).

Additionally, depression and fasting insulin were positively correlated (r = .24, p < .05). Emotional support (r = -.30, p < .01) and friendship (r = -.32, p < .01) were negatively correlated with fasting insulin, whereas loneliness (r = .26, p < .05) was positively correlated with fasting insulin. Similarly, there was an inverse correlation between emotional support and insulin resistance (r = -.31, p < .01) and a positive correlation between loneliness and insulin resistance (r = .26, p < .05).

Table 2. Correlations among continuous variables

	Age	Depression	Emotional Support	Friendship	Loneliness	Hostility	Rejection	BMI z	Body fat %	Insulin	Glucose
Age	--										
Depression	.16	--									
Support	.03	-.45***	--								
Friendship	-.14	-.45***	.60***	--							
Loneliness	.18	.61***	-.65***	-.77***	--						
Hostility	-.07	.30***	-.36***	-.35***	.31**	--					
Rejection	.05	.58***	-.55***	-.55***	.66***	.62***	--				
BMI z score	.11	.06	-.05	-.02	-.05	-.10	-.12	--			
Body fat %									--		
Fasting insulin	.04	.24*	-.30**	-.32**	.26*	.04	.05	.47***	.39***	--	
Fasting glucose	.20	.09	-.10	-.09	.14	-.15	-.06	.11	.18	.28*	--
HOMA-IR	-.04	.20	-.31**	-.19	.26*	.07	.12	.41***	.38***	.86***	.17

*** $p < .001$, ** $p < .01$, * $p < .05$.

N = 77-90.

Main and interactional effects of body measurements and social functioning on suicidal ideation status

BMIz score.

In logistic regressions predicting suicidal ideation presence, the only covariate in level 1 related to odds of adolescents' suicidal ideation presence was depression symptoms, with every one-unit increase in CES-D total score related to 13% greater odds of reporting suicidal ideation (Odds ratio: 1.13, 95% CI: 1.05, 1.22; **Table 3**).

With the addition of BMI z score in level 2, BMI z score was not related to suicidal ideation (Odds ratio: 0.74, 95% CI: 0.32, 1.75). In level 3, the main effects of social functioning were tested, accounting for covariates and BMI z score. Each social functioning dimension was evaluated in a separate model given the moderate to high degree of overlap in the social functioning dimensions. In these models, none of the social functioning domains related to suicidal ideation after accounting for age, sex, depression symptoms, and BMI z (p values > .19).

Level 4 models tested the interactions of each respective social functioning dimension by BMI z on suicidal ideation. No interactions were significant (p values > .13).

Table 3. Summary of logistic regressions evaluating the main and interactional effects of BMI z score and social functioning on suicidal ideation status

	Suicidal Ideation Status (Present)				
Predictor Variable	***B***	***SE***	***Odds Ratio***	***Odds Ratio 95% CI***	***p value***
Level 1					
Age	.06	.15	1.06	.79, 1.43	.70
Sex	-.10	.53	.91	.32, 2.57	.86
Depression	.12	2.27	1.12	1.05, 1.21	.002
Level 2					
BMI z score	-.30	.44	.74	.32, 1.75	.50
Level 3					
3a. Emotional support	-.02	.04	.99	.91, 1.07	.73
3b. Friendship	-.08	.06	.93	.83, 1.04	.19
3c. Loneliness	.05	.05	1.05	.95, 1.16	.34
3d. Perceived hostility	.04	.07	1.04	.91, 1.20	.55
3e. Perceived rejection	.02	.08	1.02	.89, 1.19	.77
Level 4					
4a. BMI z x emot supp	.03	.08	1.03	.89, 1.19	.73
4b. BMI z x friendship	.19	.12	1.20	.95, 1.53	.13
4c. BMI z x lonely	-.08	.08	.93	.79, 1.08	.33
4d. BMI z x hostility	-.03	.12	.97	.76, 1.24	.82
4e. BMI z x rejection	-.08	.13	.92	.71, 1.20	.54

Note. BMI z = body mass index standard score for age and sex. Missing data handled with listwise deletion; model N's ranged from 77-90.

Body fat percentage.

The series of logistic regressions examining the main and interactional effects of body fat percentage and social functioning are presented in **Table 4**. The addition of body fat percentage in level 2 indicated that body fat percentage was not related to suicidal ideation (Odds ratio: 1.00, 95% CI: 0.93, 1.08).

In level 3, the main effects of social functioning were added to the model. As with before, none of the social functioning domains significantly related to suicidal ideation status after accounting for age, sex, depression symptoms, and body fat percentage (p values > .17).

Level 4 included tests of the interactions of social functioning by body fat percentage. No interactions were significant (p values > .39).

Table 4. Summary of logistic regressions evaluating the main and interactional effects of body fat percentage and social functioning on suicidal ideation status

	Suicidal Ideation Status (Present)				
Predictor Variable	***B***	***SE***	***Odds Ratio***	***Odds Ratio 95% CI***	***p value***
Level 1					
Age	.06	.15	1.06	.79, 1.43	.70
Sex	-.10	.53	.91	.32, 2.57	.91
Depression	.12	.04	1.12	1.05, 1.21	<.01
Level 2					
Body fat %	.00	.04	1.00	.93, 1.08	.98
Level 3					
3a. Emotional support	.00	.04	1.00	.92, 1.09	.95
3b. Friendship	-.08	.06	.92	.82, 1.04	.17
3c. Loneliness	.06	.05	1.06	.92, 1.17	.30
3d. Perceived hostility	.06	.07	1.06	.92, 1.22	.40
3e. Perceived rejection	.04	.08	.61	.89, 1.21	.61
Level 4					
4a. Body fat x emot supp	-.01	.01	1.00	.98, 1.01	.39
4b. Body fat x friendship	.01	.01	1.01	.99, 1.03	.42
4c. Body fat x lonely	-.01	.01	1.00	.98, 1.01	.45
4d. Body fat x hostility	-.01	.01	.99	.97, 1.01	.51
4e. Body fat x rejection	.00	.01	1.00	.98, 1.02	.96

Note. Missing data handled with listwise deletion; model N's ranged from 77-90.

Main and interactional effects of metabolic functioning and social functioning on suicidal ideation status

Fasting insulin.

The series of logistic regressions examining the main and interactional effects of fasting insulin and social functioning are presented in **Table 5**. With the addition of fasting insulin in level 2, fasting insulin was not related to suicidal ideation, after controlling for the age, sex, depression symptoms, and BMI z (Odds ratio: 0.98, 95% CI: 0.89, 1.08).

In level 3, the main effects of social functioning were tested after accounting for age, sex, depression symptoms, BMI z, and fasting insulin. None of the social functioning domains related to suicidal ideation (p values > .07). There was trend-level association of friendship with suicidal ideation. Every one-unit increase in adolescents' reported friendship tended to be related to a 13% lower odds of reporting suicidal ideation (Odds ratio: 0.87, 95% CI: 0.75, 1.01, p = .07), after accounting for age, sex, depression symptoms, BMI z, and fasting insulin.

Level 4 tested the interactions of social functioning factors by fasting insulin on suicidal ideation status. No interactions were significant (p values > .10).

Table 5. Summary of logistic regressions evaluating the main and interactional effects of fasting insulin and social functioning on suicidal ideation status

	Suicidal Ideation Status (Present)				
Predictor Variable	***B***	***SE***	***Odds Ratio***	***Odds Ratio 95% CI***	***p value***
Level 1					
Age	.07	.15	1.07	.79, 1.45	.64
Sex	-.01	.54	.99	.34, 2.87	.98
Depression	.12	.04	1.13	1.05, 1.23	.001
BMI z	-.30	.44	.74	.32, 1.75	.50
Level 2					
Fasting insulin	-.02	.55	.98	.89, 1.08	.70
Level 3					
3a. Emotional support	-.08	.05	.92	.83, 1.02	.11
3b. Friendship	-.14	.08	.87	.74, 1.01	.07
3c. Loneliness	.08	.06	1.09	.96, 1.23	.20
3d. Perceived hostility	.06	.08	1.06	.91, 1.24	.45
3e. Perceived rejection	.07	.08	1.07	.91, 1.26	.41
Level 4					
4a. Insulin x emot supp	-.01	.01	.99	.98, 1.01	.36
4b. Insulin x friendship	.01	.01	1.01	.99, 1.02	.48
4c. Insulin x lonely	.00	.01	1.00	.99, 1.01	.89
4d. Insulin x hostility	.01	.01	1.01	.98, 1.04	.57
4e. Insulin x rejection	.02	1.03	1.03	1.00, 1.06	.10

Note. BMI z = body mass index standard score for age and sex. Missing data handled with listwise deletion; model N's ranged from 77-90

Fasting glucose.

The series of logistic regressions examining the main and interactional effects of fasting glucose and social functioning are presented in **Table 6**. In level 2, the of fasting glucose was not related to suicidal ideation, after controlling for age, sex, depression symptoms, and BMI z (Odds ratio: 0.95, 95% CI: 0.87, 1.03).

In level 3, none of the social functioning domains showed a main effect association with suicidal ideation (*p* values > .07). There was a trend-level effect for emotional support. Every one-unit increase in adolescents' reported emotional support tended to be related to a 9% lower odds of reporting suicidal ideation (Odds ratio: 0.91, 95% CI: 0.82, 1.01, $p = .07$), after accounting for age, sex, depression symptoms, BMI z, and fasting glucose.

Level 4 evaluated the interactions of social functioning by glucose on suicidal ideation. No interactions were significant (*p* values > .15).

Table 6. Summary of logistic regressions evaluating the main and interactional effects of fasting glucose and social functioning on suicidal ideation status

	Suicidal Ideation Status (Present)				
Predictor Variable	***B***	***SE***	***Odds Ratio***	***Odds Ratio 95% CI***	***p value***
Level 1					
Age	.07	.15	1.07	.79, 1.45	.64
Sex	-.01	.54	.99	.34, 2.87	.98
Depression	.12	.04	1.13	1.05, 1.22	.001
BMI z	-.30	.44	.74	.32, 1.75	.50
Level 2					
Glucose	-.06	.04	.95	.87, 1.03	.21
Level 3					
3a. Emotional support	-.09	.05	.91	.82, 1.01	.07
3b. Friendship	-.11	.07	.90	.79, 1.03	.12
3c. Loneliness	.07	.06	1.07	.96, 1.20	.23
3d. Perceived hostility	.01	.08	1.01	.87, 1.17	.92
3e. Perceived rejection	.02	.08	1.02	.88, 1.20	.77
Level 4					
4a. Glucose x emot support	.00	.01	1.00	.99, 1.01	.91
4b. Glucose x friendship	.01	.01	1.01	.99, 1.02	.45
4c. Glucose x lonely	.00	.01	1.00	.99, 1.01	.97
4d. Glucose x hostility	.00	.01	1.00	.97, 1.03	.84
4e. Glucose x rejection	.01	.01	1.01	1.00, 1.03	.15

Note. BMI z = body mass index standard score for age and sex. Missing data handled with listwise deletion; model N's ranged from 77-90.

Insulin resistance.

The series of logistic regression examining the main and interactional effects of insulin resistance and social functioning are presented in Table 7. In level 2, with the addition of insulin resistance, insulin resistance was not related to suicidal ideation, after controlling for age, sex, depression symptoms, and BMI z (Odds ratio: 1.06, 95% CI: 0.80, 1.00).

In level 3, the main effects of social functioning were evaluated, after accounting for age, sex, depression symptoms, and insulin resistance. Emotional support was significantly related to suicidal ideation, such that every one-unit increase in reported emotional support was related to 11% lower odds of reporting suicidal ideation (Odds ratio: 0.89, 95% CI: 0.80, 1.00).

Level 4 tested the interactions of social functioning by insulin resistance on suicidal ideation. No interactions reached statistical significance (*p* values > .18).

Table 7. Summary of logistic regressions evaluating the main and interactional effects of social functioning by fasting HOMA-IR on suicidal ideation status

	Suicidal Ideation Status (Present)				
Predictor Variable	***B***	***SE***	***Odds Ratio***	***Odds Ratio 95% CI***	***p value***
Level 1					
Age	.07	.15	1.07	.79, 1.45	.64
Sex	-.01	.54	.99	.34, 2.87	.98
Depression	.12	.04	1.13	1.05, 1.22	.001
BMI z	-.30	.44	.74	.32, 1.75	.50
Level 2					
HOMA-IR	.06	.24	1.06	.66, 1.71	.81
Level 3					
3a. Emotional support	-.12	.06	.89	.80, 1.00	.04
3b. Friendship	-.11	.07	.90	.78, 1.03	.12
3c. Loneliness	.07	.06	1.07	.95, 1.21	.27
3d. Perceived hostility	.04	.08	1.04	.89, 1.22	.62
3e. Perceived rejection	.07	.08	1.07	.91, 1.26	.42
Level 4					
4a. IR x emot support	-.05	.04	.95	.89, 1.03	.21
4b. IR x friendship	-.04	.04	.97	.89, 1.05	.40
4c. IR x lonely	.00	.03	1.00	.93, 1.07	.94
4d. IR x hostility	.00	.07	1.00	.87, 1.15	.98
4e. IR x rejection	.09	.07	1.09	.96, 1.24	.18

Note. BMI z = body mass index standard score for age and sex. HOMA-IR = homeostasis model assessment of insulin resistance. IR = insulin resistance estimated as HOMA-IR. Missing data handled with listwise deletion; model N's ranged from 77-90.

DISCUSSION

In this cross-sectional, secondary analysis of adolescents at risk for excess weight gain, I found that, in contrast to my hypotheses, neither BMI indices nor body composition related to depression symptoms or suicidal ideation risk status in bivariate or multivariate analyses. These null results are inconsistent with previous literature, which has shown an association between BMI or weight status and level of depression symptoms in both cross-sectional and longitudinal studies (Baker, Cobley, Han, & Sanders, 2015; Blaine, 2008; Holden, Mattox, Nemiary, & Shim, 2012; Sutaria et al., 2019), as well as some prior research that has shown an associations between BMI and suicidal ideation (Daly, Robinson, Sutin, & Terracciano, 2018; Jenkins, Ratcliff, Reiter-Purtill, & Zeller, 2013). There are a number of possible explanations to this null finding. First, the somewhat restricted variability in BMI by design – all adolescents were selected for being at risk for adult obesity – might have limited our ability to detect effects, in contrast to other studies with a broader range of BMI (Holden, Mattox, Neimary, & Shim, 2012). Second, although nearly 30% of adolescents endorsed suicidal ideation, the sample was relatively small (<100 adolescents), and thus, there was a relatively small raw number of participants who endorsed suicidal ideation within the study. Sample size limited power to detect small effects. Third, it is possible that factors other than degree of BMI or body fat are important for suicidal ideation risk status in adolescents at risk for adult obesity. Additional predictors of suicidal ideation not examined in the study include temperament characteristics such as inattention (Goldsmith, Sarkisian, & Van Hulle, 2019), affective or self-regulatory difficulties such as emotion regulation (Gili et al., 2018), weight or body image perception (Jenkins, Ratcliff, Reiter-Purtill, & Zeller, 2013), peer victimization (Austin et al., 2017), self-esteem (Wild, 2004). These

factors warrant investigation in future studies to understand risk for suicide in adolescents at risk for adult obesity. Likewise, although adolescents' depression symptoms were positively associated with fasting insulin, which is consistent with previous research (Holden, Mattox, Neimary, & Shim, 2012; Shomaker et al., 2010), no dimension of metabolic functioning related to suicidal ideation in simple bivariate or multivariate analyses. The association of depression and higher fasting insulin may be explained by stress-related behavioral and physiological mechanisms, such as emotional eating, physical inactivity, and/or chronic inflammation (Markowitz et al., 2008). Yet, the aim of the current study to investigate the association of metabolic functioning with suicidal ideation was exploratory. Some research has found evidence for an association between metabolic functioning and suicidal ideation in adults (Ko, 2019), though prior studies did not account for depression symptoms, making it possible that the metabolic functioning-suicidal ideation association is actually an artifact of both of these factors' relationship with depression. As noted with the BMI/body composition-suicidal ideation null results, lack of findings could have been tied to the relatively small sample size and number of participants endorsing suicidal ideation.

Contrary to my hypothesis, social functioning did not moderate the relationship of BMI/body fat or metabolic health with suicidal ideation. One likely possibility is that psychological distress in adolescents at-risk for adult obesity is more complicated than social functioning and degree of obesity alone, and multiple factors may be involved, interacting in complex ways. For instance, it is highly possible that more important than actual BMI/body fat is adolescent perception of weight, or the subjective perception of one's body image, and shape. In one previous study, perceived weight fully mediated the association between obesity and depression, such that obesity related to greater depression through perceived weight (Duong &

Roberts, 2016). As such, it is possible that in regard to suicidal ideation in adolescents at risk for adult obesity, perceived weight, as opposed to true weight, is perhaps more related to suicidal ideation. This possibility, as well as other previously mentioned risk factors for suicidal ideation, merits testing. Additionally, exploration of mediation and moderation models in order to determine protective factors and best points of intervention will be important.

As expected, I found that depression symptoms were related to suicidal ideation status, with nearly 30% of the sample reporting suicidal ideation. Comparing this statistic to the community samples of adolescents, this percentage is quite high (e.g., nearly doubled), as studies suggest about 17.4% of Colorado adolescents experience suicidal ideation and 17.7% of adolescents experience suicidal ideation nationally (Keeney, 2016). The higher rate of suicidal ideation in this sample is important to consider in light of the increasing attention to difficult stigma and discriminatory experiences that youth may face as a result of their heavier weight, including explicit weight-based victimization (Austin et al., 2017; Janicke et al., 2007) and other weight-based stigma (Cook, Pont, Puhl, & Slusser, 2017). Such experiences are thought to have an impact on psychosocial outcomes, including suicidal ideation (Jenkins, Ratcliff, Reiter, & Zeller, 2013). Due to the increased social stigma and psychosocial vulnerabilities, effective mental health screening, including thorough screening for depression as well as suicidal ideation, is crucial for all adolescents (Xiao, 2019) including in particular those with heavier weight (Gupta & Sagar, 2018).

Despite the lack of findings for social functioning as a moderator, several aspects of social functioning were significantly related to suicidal ideation. In bivariate tests, adolescents who reported suicidal ideation reported significantly lower friendship quality and more loneliness. This is consistent with previous literature demonstrating that aspects of social

functioning, in particular aspects of friendship, play a role in adolescent suicidal ideation risk (Pakasarian, Ries Merikangas, & Van Meter, 2019). Friendship negativity has been related to higher likelihood of suicidal ideation, whereas friendship positivity has been protective against suicidal ideation (Pakasarian, Ries Merikangas, & Van Meter 2019). Furthermore, loneliness has been identified as a risk factor for suicidal ideation in adolescence (Pandey et al., 2018). In the current study, these aspects of social functioning were no longer significantly related to suicidal ideation status after accounting for depression symptoms. One exception was the model predicting suicidal ideation from insulin resistance and emotional support. Even when accounting for depression symptoms, as well as insulin resistance, age, sex, and BMI z-score, emotional support was related to a lower odds of endorsing suicidal ideation. This result is consistent with evidence showing an association between emotion regulation and suicidal ideation (Fonseca-Pedrero et al., 2018). Although this association requires replication in a larger sample and was not robustly significant in other models, it is intriguing in light of data suggesting that emotion regulation is related to suicidal ideation through sleep quality as a mediator (Xiao, 2019). This data suggest that addressing sleep quality in adolescents with emotion regulation difficulties may help in preventing suicidal ideation, and may be an important point of intervention (Xiao, 2019).

The present study has a number of limitations. The present study relied on cross-sectional data, which limits the ability to make predictions about future outcomes or to draw cause and effect conclusions. Additionally, there is limited external validity. As participants were selected to be at risk for adult obesity, generalizability of the findings are limited to youth who meet this criterion. Likewise, there was limited representation of racial/ethnic minority adolescents (~30% Latino), which – although reflective of the demographic of Northern Colorado – limits

generalizability to other racial/ethnic groups disproportionately affected by obesity and T2D. Additionally, the present analyses used listwise deletion to handle missing data; sensitivity analyses using more sophisticated methods such as imputation or maximum likelihood estimation should be considered in future analyses. As noted earlier, the sample size was relatively small, as was the raw number of teens who endorsed suicidal ideation.

The study, however, does have a number of strengths. Suicidal ideation prevalence within a vulnerable population is an important topic and offers important implications for best practices in mental health screening. The novelty of this research in distinguishing the associations of BMI/fat/metabolic health and social functioning with suicidal ideation, even accounting for depression, also makes a meaningful contribution to the literature. Moreover, the study included both BMI/body fat and metabolic functioning, allowing for a contribution to the very small body of research on metabolic functioning and suicidal ideation, particularly in adolescents. Additionally, the present study used both interview and survey assessments to characterize suicidal ideation.

Future research should build upon the current findings by exploring additional constructs that might be of relevance to suicidal ideation in youth at risk for adult obesity such as body image. Additionally, it will be important to characterize both general, core dimensions of social functioning, as well as specific aspects of the lived social experience for youth who are heavier, such as experiences of discrimination and weight-related stigma. This line of inquiry offers the prospect of providing both researchers and clinicians with a more nuanced perspective of suicidal ideation risk in adolescents who are at risk for adult obesity, and ultimately, how best to detect risk and intervene.

CONCLUSION

This study provides further investigation into the psychological distress experienced in adolescents at risk of obesity, as well as the quality and importance of aspects of social functioning. In particular, this study demonstrates the importance of screening for depression and suicidal ideation in all adolescents, with special attention paid to those at risk for adult obesity. Although in this study, hypotheses around the moderating role of social functioning on the relationship between BMI/body fat and suicidal ideation were not supported, further investigation exploring other models highlighting prominent risk factors is warranted.

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