The adoption of risk-related factors through early adolescence: Associations with weight status and implications for causal mechanisms

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Abstract

Purpose—To examine cross-sectional and longitudinal associations between weight status and measures of risk and protective factors in youth.

Methods—Participants included 3010 students (72.1% white, 27.9% non-white), with a baseline mean age of 12.7 years from the Teens Eating for Energy and Nutrition at School (TEENS) study. Surveys were administered in seventh and eighth grade. Cross-sectional and longitudinal mixed-effects regression analyses were conducted to determine the association between body mass index z-score percentiles (BMI) and risk and protective factors (including substance use, depression, fighting, optimism, and spirituality).

Results—Only depression was associated with BMI at the beginning of seventh grade. However, by the end of eighth grade, binge drinking, ATOD (alcohol, tobacco, and other drug) use, fighting, and depression were all cross-sectionally associated with BMI. Longitudinally, BMI in seventh grade did not predict risk and protective factors in eighth grade. However, ATOD use, fighting, depression, and optimism in seventh grade predicted BMI in eighth grade.

Conclusion—This study suggests there is a notable co-occurrence of unhealthy factors (including weight status, ATOD, depression) which appears to develop during the critical transition period through early adolescence. Specifically, earlier ATOD use, depression, increased fighting, and decreased optimism may lead to unhealthy increases in weight status, whereas early indicators of increased weight status do not appear to predict increases in these factors. This work yields important insights into the causal mechanisms underlying adolescent behavior patterning and the progression with which these unhealthy risk factor profiles are adopted during this critical age.

Keywords

Obesity; risk and protective factors; substance use; depression

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Introduction

Overweight and obesity has been increasing among youth, with the prevalence of overweight among children and teens in the U.S. tripling since 1980[1]. In 2003–2004, 17.1% of U.S. youth were overweight [2]. The prevalence of other health compromising behaviors in 2006 was also high, with 33.6% of eighth graders using alcohol and 11.7% using marijuana in the past year and almost 10% smoking cigarettes in the past month [3]. Fighting was also common, with 43.5% of 9th graders having been in a physical fight at least once in the past year [4]. While health compromising behaviors are prevalent among youth, previous research suggests these behaviors may co-occur, and thus it is important to understand the patterning of these behaviors and their developmental progression [5–10]. In addition, it is important to understand the role of potentially health-protective attributes (e.g., spirituality and optimism), particularly within the context of these other health compromising behaviors; however, little work to date has explored such issues.

Research has explored the relationships between risk behaviors; however, the relationship between risk and protective factors and weight status among youth has not been well explored. Studies have shown the initiation of smoking is more likely among overweight female adolescents as compared to their healthy weight counterparts [11] and has been associated with trying to lose weight [11,12]. In addition, Lytle and colleagues (1995) found that smoking, poor food choices, and lower activity patterns clustered together among adolescents; prevalence rates for weekly smoking among 12th grade males was 8.8 times higher in males reporting poor eating and activity levels as compared to males reporting healthy eating and activity. Alcohol intake has also been associated with the over-consumption of calories [13], and previous research has shown that chronic heavy drinkers during the ages of 10–24 were nearly four times more likely to be overweight or obese and/or have high blood pressure at age 24 [14]. A recent study found that adolescents with alcohol use disorders were more likely to smoke and less likely to exercise regularly or eat a balanced diet [15]. However, they were not found to be more overweight than adolescents without these disorders [15].

While these studies have individually explored relationships between risk and protective factors and body mass index (BMI), an analysis of a wide range of these factors and BMI has not been conducted. As the prevalence of overweight and obesity continue to increase, it is important to explore potential mechanisms and correlates of this increase. To date, most research examining the covariance of behaviors has been cross-sectional in nature and lacks the ability to detect the temporality of the relationship. Longitudinal research may provide more insight into possible causal mechanisms responsible for any co-occurrence of these behaviors and may provide important clues to intervention needs to promote adolescent health.

Other important factors also may be interwoven in the development of adverse risk behavior patterns. For example, psychological distress has been associated with overweight among adolescents [16]. The Youth Risk Behavior Surveillance Study found overweight youth were 1.3 times more likely to have thoughts of suicide than youth of a healthy weight [17]. Dine and colleagues (2005) found depression in childhood to be positively associated with adult BMI, suggesting depression may lead to increases in BMI as youth age. To date, little research has examined the role of potentially protective factors (e.g., spirituality and optimism) in the development of these complex behavioral patterns; however in one study, increased importance of spirituality/religion among girls was found to decrease the risk of smoking and binge drinking [18]. While hopelessness has been found to predict risk behaviors [19,20], research on optimism has not been conducted and the influence of either construct on BMI has not been explored. Additional work is needed in order to provide a more comprehensive understanding of the relationships between risk and protective factors and weight status, as well as the development of these factors over time.

Thus, the purpose of this study was to explore the associations between BMI and measures of risk and protective factors in both cross-sectional and longitudinal analyses, in order to better understand the co-variation of health behaviors as well as the temporal association of the relationships. Using data from a large, longitudinal cohort of early adolescents we examined three specific research questions: 1) Are BMI and measures of risk and protective factors correlated?; 2) Does BMI in seventh grade predict measures of risk and protective factors in eighth grade?; and 3) Do measures of risk and protective factors in seventh grade predict BMI in eighth grade?

Methods

Study Design and Sample

These data are drawn from the Teens Eating for Energy and Nutrition at School (TEENS) intervention [21]. TEENS was a two-year intervention study conducted in 16 middle schools in the Twin Cities, Minnesota metropolitan area (1997–2000). The primary goal of TEENS was to increase student's intakes of fruits/vegetables and lower fat foods. The intervention included classroom curricula, a family component, and school-level environmental changes [22]. Surveys were administered in the fall of seventh grade and the spring of eighth grade. Of 4,050 eligible seventh grade students 3,878 (95.8%) completed the baseline survey. At the end of eighth grade, 3,010 (77.6%) of baseline participants completed the follow-up survey.

Data for this study are limited to the cohort who completed both baseline and follow-up surveys. This resulted in a cohort of 3010 students (72.1% white, 27.9% non-white), with a baseline mean age of 12.7 years. Approximately 20% of students received free/reduced price lunch and 51.1% were male. Students who did not complete the follow-up survey were more likely to be minority students, from single-parent households, enrolled in the free/reduced price lunch program, less likely to have two parents working full-time, and less likely to have parents with higher educational attainment [21]. The Institutional Review Board at the University of Minnesota approved all study methods.

Measures

BMI—BMI was calculated using self-reported height and weight and transformed into age- and sex-specific BMI z-score percentiles (hereafter referred to as "BMI") using CDC/NCHS 2000 growth charts [1].

Risk Factors—Seven risk factors were assessed: smoking; marijuana use; alcohol use; binge drinking; alcohol, tobacco, and other drug use; fighting; and depression. Current smoking was assessed with one question asking the frequency of smoking cigarettes in the past 30 days. Seven response options ranged from not at all to two packs per day. Past month marijuana use and alcohol use were independently assessed, with possible response items for each of the two questions ranging from 0 to ≥40 times per month. Binge drinking was assessed with one item asking the student how many times s/he had ≥5 drinks in a row in the past two weeks. Seven response options ranged from none to ≥10 times. In addition to assessing alcohol, tobacco and other drug use independently, an alcohol, tobacco, and other drug use (ATOD) scale was also created (using past month alcohol, past month marijuana, and current smoking items as well as an item assessing past month inhalant use, with students being assigned a 1 for any use of each of the substances). This scale was used to determine if multi-substance conferred additional risk beyond the use of each individual substance.

Fighting was measured with 5 items assessing how often the student participated in fighting behaviors in the past year (ex. "how many times did you, hit or beat someone up?"). Response options ranged from never to ≥12 times and the scale score ranged from 5–25. Depression was

measured with the Center for Epidemiologic Studies Depression Inventory (CES-D). This was a 20-item scale and ranged from 0 to 60 [23,24]. A score of 16 is the recognized cut-point for depressive symptomology [24,25]. A higher score on each of the risk factors indicates increased participation in the behavior.

Protective Factors—Two protective factors were assessed, spirituality and optimism. Spirituality was measured with six items that assessed the extent to which spiritual/religious beliefs influenced the student's decisions regarding drinking or using drugs, eating well, being active, choice of friends, and choosing how to spend free time. The scale ranged from 0 to 12 and the response options were "not at all", "somewhat", and "a lot." A higher score indicates more influence of spirituality or religiosity. Optimism was measured with four items which assessed how likely the student would live to age 35, get HIV or AIDS, be a parent by 18, and ever get in trouble with the police.[26]. This scale ranged from 4 to 20 and the response options were "no chance", "some chance", "about 50/50", "pretty likely", and "it will happen." A higher score indicates low optimism.

Analyses

Cross-sectional and longitudinal mixed-effects regression analyses were conducted to assess the association between BMI and risk and protective factors. Mixed effects regression models are appropriate for studies where students are nested within schools [27,28]. Schools were specified as the nested random effect in the model to account for the variability between schools. All of the risk and protective variables were standardized (transformed to mean=0 and standard deviation=1) prior to analysis allowing for the direct comparison of the strength of association of each risk and protective factor [29]. Cross-sectional regression models were run to determine the association between the risk and protective factors and BMI at one point in time. We conducted two sets of cross-sectional analyses: (1) at the beginning of seventh grade, and (2) at the end of eighth grade. Longitudinal regression models were run to establish the temporality of the association between BMI and risk and protective factors. All analyses controlled for socioeconomic status (free/reduced lunch, parent work status), number of parents in home, gender, race/ethnicity, baseline values of outcome (for longitudinal analyses), and treatment status (intervention or control).

Of those completing the two surveys, missing data on individual survey items ranged from 0.003% (eighth grade 30-day alcohol use) to 4.6% (seventh grade spirituality). Missing data for self-reported height and weight was higher and ranged from 12.2–16.4%. Observations with missing data were excluded from models; thus while the total sample size was 3010, individual models do vary in sample size.

Results

Prevalence of Behaviors

The prevalence of risk and protective behaviors in seventh grade ranged from 3.3% (past month marijuana use) to 39.8% (past year fighting) (see Table 1). The mean depression score was 13, below the cut point for indicating depressive symptomology [24,25]. By eighth grade the prevalence of substance use behaviors nearly doubled for ATOD use and quadrupled for past month marijuana use (see Table 1). The prevalence of fighting remained high (44.3%) and the mean depression score increased to 14.2. The mean spirituality score was 4.3 (SD=3.3) at the beginning of seventh grade and 3.6 (SD=3.4) at the end of eighth grade. The seventh grade mean optimism score was 17.6 (SD=2.3) the eighth grade mean score was 17.3 (SD=2.7).

Cross-Sectional Associations

The cross-sectional mixed effects regression analyses at the beginning of seventh grade found that among the risk factors only depression was significantly associated with BMI (p=0.003) (see Table 2). The association was positive with higher levels of depression related to higher BMI. The association between fighting and BMI also approached significance (p=0.06). There were no significant relationships between protective factors and BMI at the beginning of seventh grade.

At the end of eighth grade, binge drinking; ATOD use; fighting; and depression were all significantly associated with BMI (p≤0.05). Again, higher scores on each of these variables were associated with higher BMI. As in seventh grade data, there were no significant associations between protective factors and BMI at the end of eighth grade.

Longitudinal Associations

BMI Predicting Subsequent Risk and Protective Factors—The longitudinal mixed effects regressions analyses regressing BMI at the beginning of seventh grade on risk and protective factors at the end of eighth grade found no statistically significant relationships (see Table 3). These models were adjusted for important socio-demographic characteristics (such as socioeconomic status, number of parents in the home, gender, race/ethnicity) and baseline values of the outcome variables (i.e., risk and protective factors).

Risk and Protective Factors Predicting Subsequent BMI—In contrast, the regression models examining the influence of risk and protective factors in seventh grade on BMI in eighth grade found that ATOD use (p=0.02); fighting (p=0.05); and depression (p<0.0001) predicted BMI at the end eighth grade (see Table 4); the direction of the association was positive, with higher levels of these variables at the beginning of seventh grade associated with greater BMI increases by the end of eighth grade. Again, these models were adjusted for socio-demographic characteristics and baseline (seventh grade) BMI. In addition, optimism predicted eighth grade BMI (p=0.001). Higher levels of optimism in seventh grade predicted lower BMI in eighth grade.

Discussion

Our findings yield important insights into the relationships between body weight status and risk and protective factors among adolescents. Cross-sectionally, BMI was only associated with depression at the beginning of seventh grade. However, by the end of eighth grade, cross-sectional analyses indicate that depression, binge drinking; ATOD use; and fighting were all significantly associated with BMI. These results suggest that as children age, the associations between increased levels of risk behaviors and increased body mass index become more pronounced. In addition, this transition through early adolescence appears to be a critical age for the development of these adverse behavioral profiles with dramatic increases of 200–400% across a number of substance use behaviors.

This study was also able to explore the temporality of the relationship between BMI and risk and protective factors. Longitudinally, increased levels of ATOD use, fighting, depression, and optimism at the beginning of seventh grade predicted greater increases in BMI by the end of eighth grade. However, BMI at the beginning of seventh grade did not predict the adoption of any of the risk and protective factors by the end of eighth grade. This may suggest that adolescents who have increased BMI z-scores compared to their peers are not more likely to begin engaging in risk behaviors or develop depressive symptoms over time. In addition, having a higher BMI in seventh grade does not appear to affect future changes in optimism or sense of spirituality. However, those adolescents who have higher rates of ATOD use, fighting,

and depression in seventh grade are more likely to experience greater gains in body mass indices in eighth grade than adolescents who have lower rates of these behaviors. In addition, adolescents who are less optimistic in seventh grade may also be at higher risk of larger increases in BMI z-score in eighth grade.

These findings suggest that early engagement in risk behaviors and higher levels of early depressive symptoms may be some of the first indicators of a youth's predisposition to engage in less healthful behaviors in general. Practitioners may play a key role in screening for these factors and discussing the hazards of health risk behaviors (such as substance use) with children and adolescents as a part of routine visits, as recommended by the American Academy of Pediatrics [30–33]. Other important interventions sites include home and schools, where parents and teachers may include discussions of these behaviors in their daily routines. In addition, other factors related to child development may be associated with the initiation of risk behaviors and help account for a clustering of riskier behaviors in adolescence. Unhealthy parent-child relationships, social isolation, or stress may stimulate a coping response that manifests as engaging in risk behaviors including ATOD use and then may develop into poor eating and activity behaviors leading to unhealthy excess weight gain.

Previous literature indicates that overweight adolescents report less favorable psychosocial characteristics, such as lower self-esteem [34]. By observing the cross-sectional associations between risk behaviors with higher BMI, one might be led to believe that heavier teens may demonstrate lower self-esteem and as a result are drawn into substance use and other risk behaviors as a coping mechanism. However, our longitudinal findings yield insights into this relationship and indicate that it is not overweight adolescents who begin to engage in risky behaviors, but rather that it is the teens engaging in risky behaviors who then experience larger gains in BMI (in comparison to their non-risky counterparts). Thus, it may be that risk-taking teens are drawn engaging in less healthy weight-related behaviors because of factors such as the norms within their social networks, decreased concern for overall health, and increased stress levels. Future research examining the mediators of these relationships (as well as the underlying characteristics differentiating who develops these unhealthy behavioral patterns as compared to who does not) will be key in better understanding the causal roots of behavioral patterning, and developing effective and targeted intervention strategies to promote overall healthy lifestyle characteristics at this critical age.

The time period from the beginning of seventh grade to the end of eighth grade appears to be a time of dramatic increases in the prevalence of substance use among these adolescents. The rates of use in this study were similar to national rates in the same year (2000) for smoking (14.9% vs. 14.6% respectively). However, in this study, rates of alcohol use (29.7% vs. 22.4%) and marijuana use (12.0% vs. 9.1%) were marginally higher while binge drinking was marginally lower (10.7% vs. 14.1%) in our sample compared with national data [3]. Therefore, this study may provide valuable insight into the time period when many adolescents first transition into substance use. These increases may suggest that during this time period youth are exposed to stressors which may trigger substance use behaviors as a way to cope with stress or other environmental stimuli. These early substance use behaviors may be the hallmark of poor coping skills, serving as an early warning sign for the later development of a wide array of risk behaviors, including not only substance use but also sedentary behaviors, poor eating habits, and other unhealthy characteristics. Furthermore, substantial evidence exists to indicate that risk behaviors (such as alcohol use) [35], as well as weight status [36] show a strong degree of tracking from adolescence into adulthood. Therefore, these adolescent behavior patterns are not transient in nature and likely have an important influence on long-term behavior patterns.

This research has several strengths. Using longitudinal models allowed us to move beyond the cross-sectional analyses to a more comprehensive view of the relationships between BMI and

measures of risk and protective factors. By examining the temporal association between risk and protective factors and BMI hypotheses regarding how risk behaviors may predispose youth for weight problems were developed and tested. The analyses accounted for school as a random effect and adjusted for baseline values in the longitudinal analyses. Additionally, this study utilized a large cohort of early adolescents to explore relationships not previously tested.

This study does have some limitations. The outcome variable in this study was based on the self report of BMI. While this measure is not the gold standard, self reported BMI has been found to be valid and highly reliable among both adolescents and adults [37]. Also, behaviors related to BMI, such as diet, caloric intake, and physical activity levels were not examined. Future studies may want to explore the associations of these variables with the risk and protective factors to determine if both eating and activity are related or if one variable drives the association. This study was only able to incorporate the use of two protective factors, spirituality and optimism, as these were the only protective factors measured on the survey. Future research should incorporate additional protective factors such as parenting, peer/social support, school and/or community involvement and self-esteem. Additionally, as the possible trigger factors for these behaviors may be stress and poor coping behaviors, studies which also measure these important potential exogenous variables are needed. While this was a longitudinal study, only two time points were used. Future studies should examine the temporal associations between BMI and these risk and protective factors for a longer time period into adolescence to see if the associations hold over time and possibly even grow in magnitude. This study was able to use a large cohort of early adolescents to explore the hypotheses tested; however, a majority of this sample was Caucasian limiting the generalizability of the findings. Additional studies in more diverse populations are needed to see if race/ethnicity moderates these associations.

Interventions to alter risk and protective factors at younger ages may have an effect on excess weight gain later in life. The results of this study also show that the time period between the beginning of seventh grade and the end of eighth grade may be critical for substance use interventions as the prevalence of these behaviors doubled to quadrupled during this time. Future studies are needed to replicate these findings as well as extend the analyses into later ages to see how these relationships change or remain the same as youth move into high school. Finally, studies that explore how the associations are moderated by various individual-level characteristics, such as gender and race/ethnicity, are needed to determine if there are important sub-group differences in the relationships between weight status and health promoting and health compromising behaviors.

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Table 1

Prevalence of risk factors among adolescents (n=3010)

	7th Grade Estimate	8th Grade Estimate
Risk Factors		
% Past month smoking	6.3	14.9
% Past month alcohol use	13.2	29.7
% Past month marijuana use	3.3	12.0
% Binge drinking (past 2 weeks)	3.5	10.7
% Past month ATOD use	18.1	35.3
% Past year ever fought	39.8	44.3
% Depressed	34.2	35.4
BMI		
% >=85%ile BMI-for-age z-score	20.9	22.9

Table 2

Cross-sectional associations between Risk/Protective and BMI* n=3010[+]

Risk/Protective Factor	7th Grade BMI Estimate	SE	p-value	8th Grade BMI Estimate	SE	p-value
Risk Factor						
Month smoking	0.080	0.06	0.19	0.071	0.07	0.26
Marijuana use	0.104	0.07	0.12	0.126	0.07	0.07
Alcohol use	0.079	0.06	0.17	0.019	0.06	0.77
Binge drinking	0.001	0.06	0.98	**0.132**	**0.07**	**0.05**
ATOD	0.111	0.06	0.07	**0.154**	**0.07**	**0.03**
Fighting	0.121	0.06	0.06	**0.176**	**0.06**	**0.004**
Depression	**0.198**	**0.07**	**0.003**	**0.287**	**0.07**	**<0.0001**
Protective Factor						
Spirituality	−0.076	0.07	0.28	−0.054	0.07	0.45
Optimism	−0.025	0.06	0.67	−0.126	0.07	0.06

*
Adjusted for socioeconomic status, number of parents in home, gender, race/ethnicity, and treatment.

[+]
Sample size varies in individual models due to missing data.

Table 3

BMI in 7th Grade Predicting self-reported Risk/Protective (R/P) factors in 8th Grade[*] n=3010[+]

Risk/Protective Factor	8th Grade R/P Estimate	SE	p-value
Risk Factor			
Month smoking	−0.094	0.07	0.17
Marijuana use	−0.022	0.07	0.75
Alcohol use	−0.106	0.07	0.11
Binge drinking	−0.057	0.07	0.41
ATOD	−0.068	0.07	0.30
Fighting	−0.049	0.06	0.46
Depression	0.053	0.06	0.38
Protective Factor			
Spirituality	0.065	0.07	0.32
Optimism	0.060	0.06	0.33

[*] Adjusted for socioeconomic status, number of parents in home, gender, race/ethnicity, baseline values of outcome (i.e., risk and protective factors in 7th grade), and treatment.

[+] Sample size varies in individual models due to missing data.

Table 4

Self-reported Risk/Protective factors in 7th Grade Predicting BMI in 8th Grade[*] n=3010[+]

Risk/Protective Factor	8th Grade BMI Estimate	SE	p-value
Risk Factor			
Month smoking	0.001	0.005	0.81
Marijuana use	0.007	0.004	0.12
Alcohol use	0.001	0.005	0.84
Binge drinking	0.0001	0.005	0.99
ATOD	**0.011**	**0.005**	**0.02**
Fighting	**0.009**	**0.005**	**0.05**
Depression	**0.021**	**0.005**	**<0.0001**
Protective Factor			
Spirituality	0.004	0.004	0.36
Optimism	**−0.016**	**0.005**	**0.001**

[*] Adjusted for socioeconomic status, number of parents in home, gender, race/ethnicity, baseline values of outcome (i.e., BMI in 7th grade), and treatment.

[+] Sample size varies in individual models due to missing data.