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Longitudinal Correlates of Health Risk Behaviors in Children and Adolescents with Type 2 Diabetes

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On behalf of the Treatment Options for Type 2 Diabetes in Adolescents and Youth (TODAY) Study Group*

Abstract

Objectives—To characterize, over a two-year period, the proportion of youth with type 2 diabetes (T2D) enrolled in the Treatment Options for Type 2 Diabetes in Adolescents and Youth (TODAY) study that reported ever at least trying smoking cigarettes and/or drinking alcohol.

Study design—Longitudinal data were examined for participants with T2D ages 10 to 18 years old at baseline. Youth psychosocial, parent/family, environmental, and biological correlates of trying health risk behaviors were tested via cross-sectional multivariate models at each time point. Longitudinal models were explored for selected factors.

Results—Data were obtained from the TODAY study's ethnically diverse participants at baseline (N=644), 6-month (N=616), and 24-month (N=543) assessments. Percent of youth ever trying only smoking remained stable at 4%, only drinking alcohol increased from 17% to 26%, and both smoking and drinking increased from 10% to 18% over the two-year period. Factors related to trying health risk behaviors were older age, male sex, non-Hispanic White race-ethnicity, lower grades, more depressive symptoms and stressful life events. Depressive symptoms, stressful life events, and BMI Z-score (the latter with smoking only) were related to engagement in health risk behaviors over time.

Conclusions—Youth with T2D who are already at risk for health complications and who reported engaging in activities that further increase the likelihood of life-threatening morbidities were characterized. Although most correlates of trying these risk behaviors are non-modifiable, intervention efforts may need to focus on potentially modifiable factors, such as depressive symptoms and lower grades.

Keywords

Type 2 Diabetes; Alcohol; Smoking; Health Risk; Youth

Youth with type 2 diabetes (T2D) may be at risk to develop comorbid complications, including hypertension, hyperlipidemia, and cancer, at an early age.^{1,2} Progression of complications could be exacerbated by duration of diabetes and the obesity that contributed to the initial diagnosis. Engaging in health risk behaviors such as smoking cigarettes and drinking alcohol may further jeopardize their health. Early initiation of smoking and drinking in youth, even in some cases if “just trying,” has been linked to later nicotine/alcohol use disorders and other health conditions.^{3–8} Published reports of smoking and alcohol use among youth with T2D are rare.⁹ Knowledge of the correlates of these health risk behaviors is limited to predominantly physically healthy youth and youth with type 1 diabetes (T1D). Demographic variables, e.g., age, sex, race/ethnicity, and socioeconomic status, have been related to youth health risk behaviors.^{9–12} Among psychosocial variables, lower grades, depressive symptomatology, stressful life events, and environmental factors are associated with youth substance use.^{10–13} Biological correlates of substance use risk behaviors are elevated body mass index (BMI) in youth with T1D¹⁴ and physically healthy

youth^{15,16} and compromised metabolic control (HbA1c) that is associated with smoking^{14,17} and drinking¹⁸ among youth with T1D.

The primary aim of the present study was to characterize youth with T2D reporting ever at least trying smoking cigarettes and/or drinking alcohol over a two-year period. The youth were enrolled in Treatment Options for type 2 Diabetes in Adolescents and Youth (TODAY) Study Group, a multicenter, randomized clinical trial.² The secondary aim was to test possible correlates of health risk behaviors. Hypotheses were that ever at least trying health risk behaviors would be related to older age, male sex, non-Hispanic White race/ethnicity, lower socioeconomic status, lower grades, more depressive symptoms and stressful life events, less perceived neighborhood safety, and higher BMI and HbA1c. Depressive symptoms and stressful life events were expected to predict both health risk behaviors across time, and higher BMI Z-scores were expected to be related to a greater likelihood of trying smoking.

Methods

A total of 644 of the 699 participants in the TODAY cohort provided data for this study; 52 were excluded because they belonged to “other” race-ethnicity. The multiple subcategories for this ethnic group were too heterogeneous to combine and the numbers for those belonging to any one specific racial/ethnic group within the ‘other’ category were too small to model. Three participants were excluded because of missing baseline outcome data.

The study design has been reported in detail, including containing a CONSORT flow chart.^{2,19} Briefly, the study group included 15 clinical centers, a data coordinating center and central laboratory. At baseline (July 2004 to February 2009), eligible individuals were 10–17 years of age with T2D diagnosed less than two years at time of randomization and with a BMI ≥85th percentile for age and sex. Participants were randomized to one of three treatment groups: (1) metformin alone, (2) metformin plus rosiglitazone, and (3) metformin plus an intensive lifestyle program. Outcome data were collected at baseline, 6 months, 12 months, and annually thereafter. The protocol was approved by an External Evaluation Committee convened by the NIDDK and the Institutional Review Boards for the Protection of Human Subjects of each institution. All participants provided informed consent; minor children confirmed assent. A Data and Safety Monitoring Board convened by NIDDK reviewed progress, safety, and interim outcome analyses.

For the present report, data were obtained at baseline, 6 and 24 months and included health risk behavior outcomes, baseline demographic information, youth psychosocial variables, a parent/family factor, an environmental factor, and biologic variables (BMI, HbA1c). Age- and sex-specific BMI Z-scores were calculated using CDC 2000 criteria.²⁰ Except for baseline demographic data, all measures were collected at each assessment point.

Materials developed and used for the TODAY standard diabetes education program and the intensive lifestyle intervention program are available at <https://today.bsc.gwu.edu/>.

Outcome: Health risk behaviors

Youth were asked two questions: “Have you *ever* tried cigarette smoking, even one or two puffs?” (Yes/No), and “Have you *ever* had even one drink of alcohol?” (Yes/No). Once a participant responded positively to *ever* engaging in either risk behavior, all later time points reflected the affirmative response.

Predictors: Baseline demographics

Youth reported age (date of birth), sex, and race/ethnicity; a parent/guardian provided household annual income categorized as <\$25,000, \$25,000–\$49,999, or \$50,000.

Predictors: Youth psychosocial factors

Participants reported their academic performance (ie, grades earned during the last year [mostly As, Bs, Cs, or Ds and Fs]). Depressive symptoms were assessed with either the Children’s Depression Inventory (CDI)²¹ for participants 15 years or the Beck Depression Inventory II (BDI-II)²² for those 16 years. Scores were normalized to produce depressive symptomatology z-scores.

Predictors: Parent/family and environmental factors

Number of potentially stressful life events over the past year was determined by six items: change of household composition, serious illness or death of a close family member, moving, parent/guardian losing a job, parent/guardian getting a new job, and legal trouble or incarceration of a close family member. All positive responses were given a value of 1 and summed for a score of 0 to 6. As an environmental measure of *perceived personal safety*, participants reported the number of days in the last month they did not go to school because of feeling unsafe (0, 1, 2–3, 4–5, 6).

Predictors: Biologic factors

Height and weight were collected at all visits and used to calculate BMI. Height measurements were taken with a clinical stadiometer, and weight was measured in duplicate using a Seca scale (model 882, Seca USA, Hanover, MA) with a third measurement obtained if the first measurements differed >0.2 kg. BMI was calculated as weight (kg)/height² (m²). Glycated hemoglobin (HbA1c) concentration was measured using a dedicated HPLC method (TOSOH Biosciences Inc., South San Francisco, CA) certified by the National Glycohemoglobin Standardization Program. At baseline all participants were on oral medications and not insulin. At later assessments, participants who had failed to maintain glycemic control had transitioned to insulin.

Statistical Analyses

Descriptive statistics, including means and standard deviations for continuous variables and frequency and percent for discrete variables, were used to describe the cohort at each assessment point. Only the three racial/ethnic categories with adequate sample sizes were evaluated (Hispanic, non-Hispanic Black, non-Hispanic White). A single health risk behavior outcome variable combined both smoking and drinking risk behaviors into four categories: (1) never smoked or drank; (2) only tried smoking; (3) only tried drinking; or (4)

tried both smoking and drinking. The composite variable was used to examine initial associations between risk behaviors and variables of interest using a logistic model with cumulative logit. Treatment assignment was a priori included in a similar multivariate model in addition to variables significantly associated ($p<0.05$) with the risk behaviors for at least one assessment point in univariate analysis. The optimal multivariate logistic model was selected by evaluation of variable p-values and Akaike Information Criterion, excluding treatment. Longitudinal data were analyzed using a repeated measures logistic model with cumulative logit to account for the multiple observations per participant. The composite risk behavior (full behavior characterization) was modeled as a function of depressive symptom z-scores, stressful life events, and BMI Z-scores separately and jointly adjusting for age, sex, race/ethnicity, and treatment group. Similar analyses were done for outcome variables representing smoking only (Smoke, No Smoke) and drinking only (Drink, No Drink). The Statistical Analysis Software package (SAS, version 9.3, 2008, SAS Institute Inc., Cary, NC) was used for all analyses.

Results

Data were obtained from 644 participants of the TODAY study at baseline, 616 participants at the 6-month assessment, and 543 participants at the 24-month assessment (Table I).² At baseline, participants were on average 14.2 years old ($SD=2.1$; range=10–18); 64.27% female; 22% Non-Hispanic White, 43% Hispanic, and 35% Non-Hispanic Black. Mean BMI-for-age percentile was 97.8 ($SD=3.2$; range=70.4–100.0) with the majority classified as obese ($n=576$; 89.4%) and a much smaller percentage as overweight ($n=60$; 9.3%) with only 1.3% ($n=8$) in the normal weight category. Mean HbA1c was 6.05% ($SD=0.84$; range=4.3–10.9%), and all participants were on oral medications and not insulin at baseline. No difference existed between participants included and not included in the analysis at 6 months. At 24 months, those included in the analysis were on average younger (13.8 ± 2.0 years old vs. 14.7 ± 2.0 years old; $p\text{-value}<.0001$) and engaged in less risky behavior at baseline (9.8% Smoke & Drink, 3.3% Smoke Only, 16.3% Drink Only vs. 13.6% Smoke & Drink, 6.8% Smoke Only, 21.4% Drink Only; $p\text{-value}=0.0138$) compared with those not in the analysis.

For establishing prevalence estimates in this cohort, at baseline 10.4% had ever tried both smoking cigarettes and drinking alcohol, which increased over time (13.5% at 6 months, 17.9% at 24 months). Percent trying smoking only was similar across time (ranging 3.9–4.1%), and percent trying only alcohol increased (17.1% at baseline, 20.8% at 6 months, 26.2% at 24 months). The majority reported not ever trying smoking cigarettes or drinking alcohol at baseline (68.6%), 6 months (61.7%), and 24 months (52.1%).

Analysis of covariates was undertaken examining smoking only, drinking only, and a composite variable of both smoking and drinking (Tables II–IV; Tables II and III available at www.jpeds.com). In general, the modeling results did not differ among the three methods for grouping outcomes, but exceptions are noted in Results and Discussion sections. Cross-sectional analyses of associations for health risk behaviors using univariate (ie, unadjusted) models were conducted for youth psychosocial, parent/family, environmental, and biological factors. P-values for the association of independent factors separately with health risk

behaviors were examined at each time point. Of all of the variables, only three (household income, perceived personal safety, and HbA1c) were not statistically significant at any time point ($p < 0.05$) and were dropped from further analyses.

Multivariate modeling indicated that age was significantly related to risk behaviors at every time period in the positive direction in all of the models (composite, smoking, and drinking) ($p < 0.001$); i.e., older participants were more likely to report trying risk behaviors. Males were significantly different from females by the 24-month assessment in the composite outcomes model ($p = 0.0256$); 70.2% of females and 29.8% of males had never tried either behavior. At baseline, almost twice as many non-Hispanic Whites had tried both smoking and drinking (15.5%) compared with Hispanics (7.9%), with non-Hispanic Blacks in between the other groups (10.2%) ($p = 0.0328$). A different pattern occurred at baseline in the smoking model with non-Hispanic blacks reporting having tried smoking at the highest percentage (non-Hispanic Whites 32.1%, Hispanics 28.6%, non-Hispanic Blacks 39.3%; $p = 0.021$). Depressive symptomatology z-scores were associated with health risk behavior reporting in the composite model at the last two assessment points ($p = 0.0443$ at 6 months, $p = 0.0329$ at 24 months) and in the smoking model at baseline ($p = 0.017$) only. Having worse grades was related to health risk behaviors in the composite model at baseline ($p = 0.0492$), drinking at baseline ($p = 0.035$), and smoking at 6 months ($p = 0.027$). Experiencing more stressful life events was associated with having tried cigarettes/alcohol at 24 months only ($p = 0.0090$), smoking at baseline ($p = 0.002$), and drinking at 6 months ($p = 0.041$). Finally, BMI z-scores were associated with having tried smoking ($p = 0.04$) at the 6-month assessment only.

Table V shows the output from the longitudinal analyses of health risk behaviors conducted separately and then combined for depression z-scores, stressful life events, and BMI Z-scores, adjusting for age, sex, race/ethnicity, and treatment group. Higher depressive symptomatology z-scores were significantly related to greater health risk behavior engagement over time for the composite outcome and for drinking. More stressful life events were significantly related to engagement in health risk behaviors over time in all of the models. Higher BMI Z-scores were related to greater reporting of having tried smoking cigarettes over time but were not related to health risk behaviors in the composite health risk behavior or drinking-only models. As hypothesized, a youth psychosocial variable (depressive symptomatology), parent/family variable (stress), and biologic variable (BMI Z-score) (the latter with smoking only) were significantly related to trying health risk behaviors over time.

Discussion

Despite already elevated health risks, a subset of youth with T2D in our sample reported engaging in activities that further increase the likelihood of life-threatening morbidities. Prevalence of trying smoking is lower than in a sample of youth with T2D participating in the SEARCH for Diabetes in Youth study.⁹ Reynolds et al found that 35.9% (N=579) of 10 to 22 year olds with T2D reported ever trying smoking compared with approximately 14–22% in our slightly younger sample.⁹ Our prevalence estimates are generally in line with the Centers for Disease Control and Prevention's (CDC) 2009 Youth Risk Behavior Survey

(YRBS) of high school students for which 19.5% had smoked cigarettes in the past 30 days, even though the CDC survey was conducted with an older sample and characterized current use rather than ever just trying smoking.²³ For ever trying alcohol, our prevalence estimates (28–44%) are close to the CDC current use data with 41.8% reporting that they had drank alcohol in the past 30 days.²³ In general, prevalence for at least trying smoking or drinking in this sample of youth with T2D is at the lower end of estimates that vary from 19.5–90% depending upon age, race, and operationalization of health behavior.^{9,23,24} To our knowledge, no prevalence data exist for alcohol consumption in youth with T2D. Our study is unique in characterizing health risk behaviors for youth with T2D enrolled in a longitudinal research trial.

Many predictions based on findings from the prior literature were confirmed, including from school- and community-based studies as well as studies of youth with T1D.^{9–14} In multivariate modeling at each assessment point (ie, cross-sectional adjusted analyses), demographic factors related to increased risk for at least trying health risk behaviors are older age, male sex, and non-Hispanic White race-ethnicity for the composite health risk behaviors and non-Hispanic Black race-ethnicity for smoking. Child/family factors include lower grades, more depressive symptoms, and stressful life events. Of those, the most potentially modifiable factors warranting early identification and treatment are lower academic achievement and depressive symptoms. BMI Z-scores related to smoking at one time period. Previous research on the relationship between BMI z-scores and smoking among youth with T2D are difficult to interpret. BMI Z-scores were not significantly related to cigarette smoking status in the Reynolds study with youth who have T2D;⁹ however, Reynolds et al found a significant difference between cigarette smoking variable levels for waist circumference ($p=0.0198$), with current smokers having the largest circumference.⁹ Finally, as expected, treatment group assignment was not related to engagement in health risk behaviors. The intensive lifestyle program arm focused on weight control and not on health risk behaviors and all three treatment groups received the same health risk prevention education.

Contrary to our a priori hypotheses, household income, perceived neighborhood safety, and HbA1c were not significantly related to ever having tried cigarettes and alcohol in cross-sectional multivariate analyses. The absence of a relationship between SES and health risk behaviors in our study is not unique. The national Monitoring the Future Study reported weak or negligible relationships between SES and alcohol/cigarette use.²⁵ Reynolds et al found SES to be predictive of smoking among youth with T1D but not among those with T2D.⁹ The fact that our youth were generally from families of low education level and low annual household income and were therefore rather homogeneous with regard to SES may also have influenced our findings.²⁶ The lack of a relationship of perceived personal safety with health risk behaviors may be partially related to the low variability of this measure. Approximately 7–11% of the sample reported across the three assessment periods that there were one or more days that they had not gone to school because of feeling unsafe; these data are in line with national averages. In the 2009 CDC survey, only 5% of high school-aged children had not gone to school on at least one day due to safety concerns, and this percentage was slightly greater for younger children.²³ Finally, we found that HbA1c was not associated with health risk behaviors in the cross-sectional models. In the Reynolds

study, current smokers were more likely to have poor glycemic control than were non-smokers.⁹ Our sample was distinctive in that participants had been recruited for a treatment trial, and achieving glycemic control on oral medications via a rigorous run-in period was a requirement for enrollment.

The TODAY study offered the unique opportunity to explore longitudinal associations over a two-year period between selected predictors and our outcome of ever having tried smoking/drinking or either one in separate models. Our findings fit with prior research with physically healthy youth in that depressive symptomatology and life stressors significantly predicted trying health risk behaviors.¹² Finally, the finding that BMI Z-scores significantly predicted smoking over time is novel. As smoking has been reported to be a weight control technique in samples of physically healthy youth,¹⁵ it is possible that youth with T2D might be more likely to try this strategy as their BMI Z-scores increase. We would expect that weight management would be only one of a myriad number of potential reasons for these youth to try smoking cigarettes.

Our findings must be interpreted with a number of limitations in mind. The primary data analytic strategy adopted was to put together smoking/drinking into one composite, categorical variable. However, our hypotheses were also tested in separate models for smoking only and drinking only with relevant findings highlighted in the text and all of these analyses presented in Tables II and III. Another limitation is that this is an exploration of reports of trying health risk behaviors rather than the frequency and quantity of use. This decision was made due to the wording of the questions: “Have you ever tried cigarette smoking, even one or two puffs?” and “Have you ever had even one drink of alcohol?” Based on prior research, early initiation of smoking and drinking in youth, even in some cases of “just trying,” is an important metric to examine due to its relationship with a number of later adverse outcomes including nicotine/alcohol use disorders and other health conditions.^{3–8, 24} This is particularly concerning for our vulnerable sample of youth with T2D. Another study limitation relating to the outcome variable is that the exact age at initiation is not known due to the wording of the questions and the timing of the assessments. In addition, we do not have data on other health risk behaviors, including the use of marijuana or other drugs. For the longitudinal analyses, causation cannot be assumed between the predictors (depressive symptomatology, life stressors, and BMI Z-scores) and outcome (health risk behaviors) even though these variables were significantly related over time. Finally, when interpreting findings in cross-sectional and longitudinal models, it must be noted that at baseline all participants were on oral medications and not insulin. At the subsequent assessments, those who had failed to maintain glycemic control had transitioned to insulin. This means that the baseline study group was the most homogenous in terms of the treatment regimen.

Future research in samples of youth with T2D should include expanded measurement of these health risk behaviors to increase knowledge of the age of first trying, prevalence, frequency/severity, and incidents of binge drinking in addition to the use of other forms of tobacco, marijuana and other drugs. Our finding that BMI Z-scores significantly predict smoking over time merits further study to explore the interplay between T2D, obesity and engagement in specific types of health risk behaviors. Similarly, additional work is needed

to better understand how engagement in health risk behaviors may have a greater impact on this group of youth and young adults compared with their physically healthy peers and also how these behaviors map onto other health behaviors (e.g., dietary intake, physical activity) that are part of the treatment regimen for T2D.

The likelihood is high that smoking cigarettes and/or drinking alcohol may have synergistic effects coupled with the already serious health consequences of T2D and overweight/obesity to hasten the further physical deterioration of this cohort.² Therefore, the baseline and follow-up data available from the TODAY study provide an opportunity to explore the prevalence of these health risk behaviors in youth with T2D and the relationships between demographic, youth psychosocial, parent/family, environmental, and biologic predictors and these health risk behaviors. These models identify risk/protective factors for substance use among adolescents and youth with T2DM that are potentially modifiable, depressive symptomatology and school performance, and these may need to become targets for treatment interventions. Monitoring depressive symptomatology and life stressors in these youth takes on greater importance when considering of their longitudinal associations with health risk behaviors. Finally, increasing weight status (ie, BMI Z-scores) may be related to greater risk for trying smoking in this already vulnerable population.

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Abbreviations

BDI-II	Beck Depression Inventory II
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CDI	Children's Depression Inventory
HBA1c	Glycated Hemoglobin
NIDDK	National Institute of Diabetes and Digestive Kidney Diseases
T1D	Type 1 diabetes
T2D	Type 2 Diabetes

TODAY Treatment Options for Type 2 Diabetes in Adolescents and Youth
YRBS Youth Risk Behavior Survey

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Appendix 1

Individuals and institutions associated with the TODAY Study Group include (* indicates principal investigator or director):

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Other--Hospital for Sick Children, Toronto: M. Palmert Medstar Research Institute, Washington DC: R. Ratner; Texas Tech University Health Sciences Center: D. Dremaine; University of Florida: J. Silverstein.

Table 1

Anthropometric, Laboratory, and Survey Descriptive Statistics at Baseline, 6 Months and 24 Months

	Baseline (N=644) Mean $\pm$ SD or %	6 Months (N=616) Mean $\pm$ SD or %	24 Months (N=543) Mean $\pm$ SD or %
<i>BMI Z-Score</i>	2.23 $\pm$ 0.46	2.20 $\pm$ 0.51	2.16 $\pm$ 0.55
<i>HbA1c*</i>	6.05 $\pm$ 0.77	6.42 $\pm$ 1.48	7.34 $\pm$ 2.39
<i>Depression Z-Score</i>	-0.50 $\pm$ 0.84	-0.66 $\pm$ 0.74	-0.68 $\pm$ 0.76
<i>Grades in school in last year</i>			
<i>Mostly As</i>	21.0%	24.5%	22.7%
<i>Mostly Bs</i>	43.3%	41.4%	42.2%
<i>Mostly Cs</i>	28.7%	27.0%	27.3%
<i>Mostly Ds and Fs</i>	7.0%	7.1%	7.8%
<i>Number of days did not go to school because felt unsafe</i>			
<i>0 days</i>	89.2%	92.6%	92.5%
<i>1 day</i>	4.4%	2.5%	1.7%
<i>2 or 3 days</i>	2.7%	3.4%	3.3%
<i>4 or 5 days</i>	2.2%	0.7%	1.4%
<i>6 or more days</i>	1.6%	0.8%	1.2%
<i>Stressful Life Events</i>	1.46 $\pm$ 1.27	1.00 $\pm$ 1.01	0.96 $\pm$ 1.07
<i>Risk Behaviors</i>			
<i>Smoke & Drink</i>	10.4%	13.5%	17.9%
<i>Smoke Only</i>	3.9%	4.1%	3.9%
<i>Drink Only</i>	17.1%	20.8%	26.2%
<i>Neither Smoke nor Drink</i>	68.6%	61.7%	52.1%
<i>Smoking</i>	14.3%	17.5%	21.7%
<i>Drinking</i>	27.5%	34.3%	44.0%

* HbA1c at baseline was prior to any participants beginning insulin; 8.6% (N=53) were on insulin at 6 months and 30.2% (N=164) were on insulin at 24 months.

Table 2

Overall Multivariate Model P-values and Means $\pm$ SD or % for Smoking at Each Time Point

	Baseline			6 Months			24 Months					
	Smoke	No Smoke	Univariate Model p-value	Multivariate Model p-value**	Smoke	No Smoke	Univariate Model p-value	Multivariate Model p-value**	Smoke	No Smoke	Univariate Model p-value	Multivariate Model p-value**
Age	15.3 ± 1.6	13.8 ± 2.0	<.0001	<.0001	15.6 ± 1.7	14.2 ± 2.0	<.0001	<.0001	16.9 ± 1.6	15.5 ± 2.0	<.0001	<.0001
Sex			0.4581	*			0.1292	*			0.0815	*
Female	66.7%	64.3%			57.6%	64.3%			55.6%	65.7%		
Male	33.3%	35.7%			42.4%	35.7%			44.4%	34.3%		
Race/Ethnicity			0.0318	0.0480			0.3301	0.2830			0.1406	0.0531
Black	39.3%	34.8%			36.4%	33.2%			36.1%	34.1%		
Hispanic	28.6%	44.1%			39.4%	45.3%			37.0%	45.1%		
White	32.1%	21.2%			24.2%	21.5%			26.9%	20.8%		
Household Income			0.6036	*			0.6107	*			0.3825	*
<\$25,000	34.2%	40.0%			39.8%	40.7%			39.4%	40.9%		
\$25,000 – \$49,999	41.1%	33.3%			36.4%	33.1%			38.3%	32.5%		
\$50,000	24.7%	26.8%			23.9%	26.2%			22.3%	26.6%		
BMI Z-score	2.3 ± 0.5	2.2 ± 0.5	0.0106	0.1211	2.3 ± 0.5	2.2 ± 0.5	0.0010	0.0404	2.2 ± 0.6	2.1 ± 0.5	0.1079	0.5439
HbA1c#	6.0 ± 0.7	6.0 ± 0.8	0.8370	*	6.4 ± 1.4	6.4 ± 1.5	0.9115	*	7.5 ± 2.5	7.2 ± 2.3	0.4038	*
Depression Z-Score	−0.3 ± 1.0	−0.6 ± 0.8	0.0201	0.0169	−0.6 ± 0.8	−0.7 ± 0.7	0.0059	0.0561	−0.6 ± 0.8	−0.7 ± 0.7	0.1265	0.1866
Grades			0.0014	0.4404			0.0004	0.0274			0.0328	0.3578
Mostly As	11.9%	22.5%			9.2%	27.7%			13.5%	25.0%		
Mostly Bs	40.5%	43.8%			44.9%	40.6%			43.8%	41.8%		
Mostly Cs	34.5%	27.7%			33.7%	25.6%			34.4%	25.5%		
Mostly Ds & Fs	13.1%	6.1%			12.2%	6.0%			8.3%	7.7%		
# of Days Missed School for Safety			0.8653	*			0.7581	*			0.6285	*
0 Days	88.1%	90.0%			92.7%	92.9%			91.7%	92.7%		
1 Day	7.1%	3.7%			2.1%	2.6%			0%	2.3%		
2–3 Days	2.4%	2.7%			3.1%	3.4%			4.2%	3.1%		
4–5 Days	2.4%	2.0%			0%	0.9%			1.0%	1.3%		
6+ Days	0%	1.6%			2.1%	0.2%			3.1%	0.5%		

Table 3

Overall Multivariate Model P-values and Means $\pm$ SD or % for Drinking at Each Time Point

	Baseline				6 Months				24 Months			
	Drink	No Drink	Univariate Model p-value	Multivariate Model ** p-value	Drink	No Drink	Univariate Model p-value	Multivariate Model ** p-value	Drink	No Drink	Univariate Model p-value	Multivariate Model ** p-value
Age	15.0 ± 1.7	13.6 ± 2.0	<.0001	<.0001	15.4 ± 1.8	14.0 ± 2.0	<.0001	<.0001	16.6 ± 1.7	15.2 ± 1.9	<.0001	<.0001
Sex			0.2628	0.3422			0.0440	0.3504			0.0024	0.0558
Female	63.1%	65.2%			57.1%	66.3%			55.8%	69.6%		
Male	36.9%	34.8%			42.9%	33.7%			44.2%	30.4%		
Race/Ethnicity			0.1597	*			0.3776	*			0.0529	*
Black	35.1%	35.5%			32.3%	34.5%			32.6%	36.0%		
Hispanic	37.5%	43.6%			43.9%	44.5%			40.2%	45.9%		
White	27.4%	20.9%			23.7%	21.0%			27.2%	18.0%		
Household Income			0.5235	*			0.2017	*			0.1267	*
<\$25,000	36.4%	40.3%			37.2%	42.2%			35.9%	44.1%		
\$25,000 – \$49,999	33.1%	34.8%			33.1%	33.9%			34.4%	33.2%		
\$50,000	30.5%	24.9%			29.7%	23.9%			29.7%	22.7%		
BMI Z-score	2.2 ± 0.5	2.2 ± 0.5	0.5002	*	2.2 ± 0.5	2.2 ± 0.5	0.5032	*	2.2 ± 0.6	2.2 ± 0.5	0.9173	*
HbA1c#	6.0 ± 0.7	6.0 ± 0.8	0.9458	*	6.4 ± 1.3	6.4 ± 1.6	0.6041	*	7.3 ± 2.3	7.3 ± 2.4	0.9894	*
Depression Z-Score	−0.5 ± 0.9	−0.5 ± 0.8	0.1224	*	−0.7 ± 0.7	−0.7 ± 0.7	0.1995	*	−0.7 ± 0.7	−0.8 ± 0.7	0.0675	*
Grades			<.0001	0.0351			0.0127	0.6056			0.0330	0.3352
Mostly As	10.2%	25.2%			19.0%	27.4%			17.5%	26.8%		
Mostly Bs	44.9%	42.7%			42.1%	41.0%			44.8%	40.2%		
Mostly Cs	36.5%	25.6%			33.3%	23.6%			30.2%	25.0%		
Mostly Ds & Fs	8.4%	6.5%			5.6%	7.9%			7.5%	8.0%		
# of Days Missed School for Safety			0.5693	*			0.5259	*			0.4809	*
0 Days	92.8%	88.6%			92.8%	92.9%			92.4%	92.6%		
1 Day	3.0%	4.7%			2.1%	2.7%			1.4%	2.2%		
2–3 Days	1.8%	3.0%			4.1%	3.0%			4.3%	2.6%		
4–5 Days	2.4%	1.9%			1.0%	0.5%			0.5%	1.8%		
6+ Days	0%	1.9%			0%	0.8%			1.4%	0.7%		

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	Baseline				6 Months				24 Months			
	Univariate Model		Multivariate Model		Univariate Model		Multivariate Model		Univariate Model		Multivariate Model	
	Drink	No Drink	p-value	p-value**	Drink	No Drink	p-value	p-value**	Drink	No Drink	p-value	p-value**
Stress Score	1.6 ± 1.3	1.4 ± 1.3	0.0598	0.1193	1.1 ± 1.0	0.9 ± 1.0	0.0218	0.0406	1.0 ± 1.0	0.9 ± 1.0	0.0112	0.0811

HbA1c at baseline was prior to any participants beginning insulin; 8.6% (N=53) were on insulin at 6 months and 30.2% (N=164) were on insulin at 24 months.

* Variable not included in the multivariate model.

** Multivariate model adjusted for treatment assignment.

Table 4
Overall Univariate and Multivariate Model P-values and Means ± SD or % for Full Characterization of Health Risk Behaviors at Each Time Point

	Baseline						6 Months						24 Months					
	Smoke & Drink	Smoke Only	Drink Only	Neither	Univariate Model p-value	Multivariate Model** p-value	Smoke & Drink	Smoke Only	Drink Only	Neither	Univariate Model p-value	Multivariate Model** p-value	Smoke & Drink	Smoke Only	Drink Only	Neither	Univariate Model p-value	Multivariate Model** p-value
Age	15.5 ± 1.4	14.7 ± 1.9	14.7 ± 1.8	13.5 ± 2.0	<.0001	<.0001	15.9 ± 1.5	14.7 ± 1.8	15.1 ± 1.9	13.9 ± 2.0	<.0001	<.0001	17.1 ± 1.5	16.1 ± 1.7	16.2 ± 1.8	15.1 ± 1.9	<.0001	<.0001
Sex					0.2352	0.1467					0.0202	0.7920					0.0025	0.0256
Female	66.7%	66.7%	61.1%	65.1%			56.6%	60.9%	57.4%	66.7%			54.4%	61.1%	56.7%	70.2%		
Male	33.3%	33.3%	38.9%	34.9%			43.4%	39.1%	42.6%	33.3%			45.6%	38.9%	43.3%	29.8%		
Race/Ethnicity					0.0443	0.0328					0.3363	0.3291					0.0633	0.0221
Black	38.3%	41.7%	33.3%	35.1%			34.2%	43.5%	31.1%	33.9%			33.3%	50.0%	32.1%	35.1%		
Hispanic	28.3%	29.2%	42.6%	44.5%			40.8%	34.8%	45.9%	45.1%			36.7%	38.9%	42.5%	46.4%		
White	33.3%	29.2%	24.1%	20.4%			25.0%	21.7%	23.0%	21.0%			30.0%	11.1%	25.4%	18.5%		
Household Income					0.7303	*					0.3709	*					0.3000	*
<\$25,000	33.3%	36.8%	38.1%	40.4%			39.7%	40.0%	35.6%	42.3%			38.5%	43.8%	34.2%	44.2%		
\$25,000 – \$49,999	38.9%	47.4%	29.9%	34.2%			35.3%	40.0%	31.7%	33.5%			38.5%	37.5%	31.6%	32.9%		
\$50,000	27.8%	15.8%	32.0%	25.4%			25.0%	20.0%	32.7%	24.1%			23.1%	18.8%	34.2%	22.9%		
BMI Z-score	2.3 ± 0.5	2.4 ± 0.5	2.2 ± 0.5	2.2 ± 0.5	0.0623	0.2588	2.3 ± 0.5	2.4 ± 0.5	2.2 ± 0.6	2.2 ± 0.5	0.0205	0.1012	2.2 ± 0.6	2.2 ± 0.5	2.1 ± 0.6	2.2 ± 0.5	0.3451	0.7024
HbA1c#	5.9 ± 0.8	6.2 ± 0.7	6.1 ± 0.7	6.0 ± 0.8	0.8085	*	6.3 ± 1.2	6.7 ± 1.9	6.5 ± 1.4	6.3 ± 1.5	0.4670	*	7.4 ± 2.3	8.2 ± 3.1	7.2 ± 2.2	7.2 ± 2.4	0.5994	*
Depression Z-Score	−0.4 ± 0.9	−0.2 ± 1.1	−0.5 ± 0.8	−0.6 ± 0.8	0.0220	0.0546	−0.6 ± 0.8	−0.4 ± 0.8	−0.7 ± 0.7	−0.7 ± 0.7	0.0209	0.0443	−0.6 ± 0.7	−0.6 ± 1.0	−0.7 ± 0.7	−0.8 ± 0.7	0.0493	0.0329
Grades					<.0001	0.0492					0.0017	0.1172					0.0144	0.1944
Mostly As	6.7%	25.0%	12.1%	25.2%			10.7%	4.3%	24.2%	29.0%			12.5%	18.8%	20.5%	27.3%		
Mostly Bs	48.3%	20.8%	43.0%	44.0%			41.3%	56.5%	42.5%	40.0%			45.0%	37.5%	44.7%	40.4%		
Mostly Cs	35.0%	33.3%	37.4%	25.2%			37.3%	21.7%	30.8%	23.8%			35.0%	31.3%	27.3%	24.6%		
Mostly Ds & Fs	10.0%	20.8%	7.5%	5.7%			10.7%	17.4%	2.5%	7.2%			7.5%	12.5%	7.6%	7.7%		
# of Days Missed School for Safety					0.6666	*					0.6363	*					0.2979	*
0 Days	90.0%	83.3%	94.4%	88.9%			94.5%	87.0%	91.7%	93.3%			91.3%	93.8%	93.1%	92.6%		
1 Day	5.0%	12.5%	1.9%	4.2%			2.7%	0%	1.7%	2.9%			0%	0%	2.3%	2.3%		
2–3 Days	3.3%	0%	0.9%	3.2%			2.7%	4.3%	5.0%	2.9%			5.0%	0%	3.8%	2.7%		
4–5 Days	1.7%	4.2%	2.8%	1.7%			0%	0%	1.7%	0.6%			1.3%	0%	0%	2.0%		

	Baseline						6 Months						24 Months						Multivariate Model p-value
	Univariate Model p-value			Multivariate Model** p-value			Univariate Model p-value			Multivariate Model** p-value			Univariate Model p-value			Multivariate Model** p-value			
	Smoke & Drink	Smoke Only	Neither	Drink Only	Smoke Only	Neither	Smoke & Drink	Smoke Only	Neither	Drink Only	Smoke Only	Neither	Smoke & Drink	Smoke Only	Neither	Drink Only	Smoke Only	Neither	
6+ Days	0%	0%	2.0%	0%	8.7%	0.3%	0%	1.1 ± 1.0	1.1 ± 1.0	0%	0.8%	2.5%	6.3%	0.4%	0.8%	0.8%	0.4%		
Stress Score	2.0 ± 1.5	1.9 ± 1.2	1.4 ± 1.3	1.4 ± 1.2	1.1 ± 1.0	0.9 ± 1.0	1.1 ± 1.0	1.1 ± 1.0	1.1 ± 1.0	1.1 ± 1.0	1.0 ± 1.0	1.1 ± 1.1	1.3 ± 1.4	0.8 ± 1.0	1.0 ± 1.0	1.0 ± 1.0	0.8 ± 1.0	0.0013	
																		0.0099	

HbA1c at baseline was prior to any participants beginning insulin; 8.6% (N=53) were on insulin at 6 months and 30.2% (N=164) were on insulin at 24 months.

* Variable not included in the multivariate model.

** Multivariate model adjusted for treatment assignment.

Table 5

Longitudinal Multivariate Modeling of Health Risk Behaviors

	Full Characterization Model* (Smoke & Drink, Smoke, Drink, Neither)			Smoking Model** (Smoke, No Smoke)			Drinking Model*** (Drink, No Drink)		
	β	Standard Error	Overall p-value	β	Standard Error	Overall p-value	β	Standard Error	Overall p-value
<i>Depression Z-Score Only Model</i>									
<i>Depression Z-Score</i>	0.2895	0.0770	0.0005	0.3605	0.0918	0.0009	0.1977	0.0845	0.0228
<i>Stress Score Only Model</i>									
<i>Stress Score</i>	0.2265	0.0495	<.0001	0.2560	0.0628	0.0002	0.1745	0.0537	0.0013
<i>BMI Z-Score Only Model</i>									
<i>BMI Z-Score</i>	0.2467	0.1525	0.1025	0.4997	0.2011	0.0101	0.0933	0.1668	0.5755
<i>Joint Model</i>									
<i>Depression Z-Score</i>	0.2485	0.0780	0.0030	0.3026	0.0937	0.0047	0.1659	0.0862	0.0604
<i>Stress Score</i>	0.1928	0.0505	0.0003	0.2119	0.0648	0.0022	0.1541	0.0547	0.0053
<i>BMI Z-Score</i>	0.2221	0.1559	0.1498	0.4845	0.2083	0.0165	0.0779	0.1693	0.6450

* Model evaluating relationship with outcome of the full 4 health risk behavior categories (Smoke & Drink, Smoke Only, Drink Only, Neither)

** Model evaluating relationship with outcome of smoking only (Smoke, No Smoke)

*** Model evaluating relationship with outcome of drinking only (Drink, No Drink)

All models adjusted for age, sex, race/ethnicity and treatment assignment.