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Original Contribution

Depressive Symptoms During Adolescence and Young Adulthood and the Development of Type 2 Diabetes Mellitus

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Although depression symptoms have been associated with type 2 diabetes mellitus (T2DM) among adults, little is known about the association of adolescent-onset depression and development of T2DM in young adulthood and whether the association differs by sex. We examined the association between high levels of depressive symptoms in adolescence and T2DM in adulthood in the National Longitudinal Study of Adolescent to Adult Health (n = 12,657). Adolescents completed the 20-item version of Center for Epidemiologic Studies Depression Scale during wave 1 (mean age, 16 years) and the 10-item version during follow-up (mean age, 29 years). A high level of depressive symptoms was defined as a score of 16 or higher on the 20-item version or 11 or higher on the 10-item version. T2DM was identified 13 years after baseline on the basis of either a glycated hemoglobin concentration of at least 6.5% or use of hypoglycemic medication (with or without insulin). Participants who reported taking insulin alone were classified as having type 1 diabetes mellitus and excluded. In models adjusted for demographic characteristics, women were at a higher risk of developing T2DM if they experienced high levels of depressive symptoms during both adolescence and adulthood (odds ratio = 1.96, 95% confidence interval: 1.23, 3.11) than were those who did not experience a high level of symptoms at either time point. No statistically significant associations were noted among men (odds ratio = 0.46, 95% confidence interval: 0.20, 1.05).

cumulative effects; depression; diabetes; life course; mental health; young adults

Abbreviations: Add Health, National Longitudinal Study of Adolescent to Adult Health; BMI, body mass index; CES-D, Center for Epidemiologic Studies Depression Scale; HbA_{1c}, glycated hemoglobin; T2DM, type 2 diabetes mellitus.

Adults with depression are more likely to develop type 2 diabetes mellitus (T2DM), as well as insulin resistance (1, 2). Existing studies have mainly considered the association between adult mental health and adult diabetes (2, 3), not taking into account the increasing evidence that mental (4), cardiovascular, and metabolic disorders (5) begin early in childhood and adolescence. Reliance on assessments in adulthood of both depression and T2DM has limited the ability of investigators in most studies to address temporality, which raises the possibility of reverse causation, in which subclinical T2DM risk factors contribute to both depression and clinical T2DM development later in life. Because risk factors and health behaviors known to affect obesity and diabetes can persist from childhood to adolescence and into adulthood (6, 7), a life-course framework for studying the etiology of T2DM is crucial.

Adolescence is an important period of development because many health behaviors are established during these formative years (8). Adolescent depression has been associated with overweight and obesity in adulthood (9, 10), and adolescent onset of depression is associated with both persistence of depression into adulthood and the development of other comorbid psychiatric disorders throughout the life course (11). To our knowledge, there have been only 2 studies in which the longitudinal relationship between adolescent mental health and the development of diabetes has been examined. In a small study of primarily overweight or obese children, Shomaker et al. (12) noted a significant association between depression symptoms in childhood and insulin resistance in adolescence. In a larger study based on the 1946 British Cohort Study, adolescent affective disorder was associated with diabetes mellitus at age 53 years (13). These results suggest

that factors during childhood and adolescence influence the trajectory of T2DM development. However, it is not known whether depression symptoms in adolescence influence T2DM risk in the absence of adult depression symptoms or whether it is the continuity of depression symptoms from adolescence to adulthood that most strongly influences risk.

Sex differences in the relationship between obesity and depression have been documented, with associations noted among women but not men (14). Recently, using data from the First National Health and Nutritional Examination Survey, Demmer et al. (15) reported an association between depressive symptomatology and incident diabetes among women but not men. Differential behavioral responses or physiological mechanisms might contribute to potential sex differences. Women might be more likely to cope with stress and mental health symptoms by engaging in obesogenic behaviors, and men might be more likely to cope by engaging in behaviors that do not promote obesity (16). Physiological responses to depression, such as hypothalamic-pituitary-adrenal axis dysregulation and inflammation, are also implicated in both depression and diabetes and have been noted to differ between sexes (17). Although the mechanisms for this relationship are not fully known, it is plausible that behavioral changes that accompany depression, such as changes in dietary choices, sleep patterns, and physical activity level, might play a role. In addition, inflammatory processes and hypothalamic-pituitary-adrenal axis dysregulation might be activated as a direct result of depression symptoms and in turn might affect diabetes risk (18–20).

In the present study, we examined the relationship of depression symptoms during adolescence and young adulthood with the development of T2DM in adulthood in data from the National Longitudinal Study of Adolescent to Adult Health (Add Health). We tested whether high levels of depressive symptoms experienced in adolescence only, adulthood only, or both developmental periods increased the odds of developing T2DM in adulthood. We also examined whether sex differences appeared in this association.

METHODS

Study population

Add Health is a nationally representative, school-based, longitudinal study of the health-related behaviors of adolescents and their outcomes in adulthood. A questionnaire was administered in 132 schools in the United States to a nationally representative sample of students in grades 7 through 12, plus selected oversampled minority groups, stratified by age and sex, during the 1994–1995 school year. Four waves of in-home interviews (wave 1, 1994–1995; wave 2, 1996; wave 3, 2001–2002; and wave 4, 2007–2008) were conducted. The study design has been described in detail previously (21). Briefly, a stratified random sample of public and private high schools that was representative of US schools was selected with respect to region of country, urbanicity, size, type, and ethnic makeup of the student body.

Eligible schools included an 11th grade and enrolled more than 30 students. The first wave of in-home interviews was conducted between 1994 and 1995, and approximately 20,745 adolescents between the ages of 12 and 18 years completed the in-home questionnaire. During wave 4 of follow-up, 15,701 participants were interviewed. In the present analyses, participants were excluded if data were missing for sampling weights (n = 901), glycated hemoglobin (HbA_{1c}) concentration (n = 1,290), high levels of depressive symptoms at either time point (n = 101), or covariates of interest (n = 237) or if they reported a pregnancy during wave 4 (n = 444) or a diabetes diagnosis before age 16 years (n = 34). Participants who were taking insulin alone in adulthood (n = 37) were also excluded from the analyses because they were more likely to have type 1 diabetes mellitus.

Our study sample included 12,657 participants who completed waves 1 and 4 and met inclusion criteria. Sample weights designed for analyzing Add Health data include baseline selection probabilities and school-level clustering, as well as inverse probability weights to account for longitudinal attrition (22). Add Health was approved by the Institutional Review Board of the University of North Carolina, Chapel Hill. The Institutional Review Board of Columbia University, New York, approved these analyses.

Diabetes

During wave 4 (mean age of participants, 29 years), an in-home assessment was conducted. HbA_{1c} was assayed from spots of dried capillary whole blood collected from finger pricks during the home visit. HbA_{1c} concentration measured from dried blood samples has been shown to have good agreement with fresh whole blood samples (23). Participants reported use of medications for diabetes (categories included sulfonylureas, nonsulfonylureas, insulin, α-glucosidase inhibitors, thiazolidinediones, meglitinides, antidiabetic combinations, and miscellaneous antidiabetic agents) anytime during the previous 4 weeks. T2DM was defined as an HbA_{1c} concentration of at least 6.5% (n = 429) or use of diabetes medication with or without insulin (n = 123). Participants who reported a diabetes diagnosis before the age of 16 years were excluded from the analyses. Self-report of a diabetes diagnosis is considered a valid method for identifying diabetes (24–26). As in previous studies (27), we classified participants who reported taking insulin alone as having type 1 diabetes mellitus and excluded them from the analyses.

Depression symptoms

Participants completed the Center for Epidemiologic Studies Depression Scale (CES-D) at 2 time points. The 20-item version (CESD-20) was administered in wave 1 (mean age, 16 years), and the 10-item version (CES-D-10) was administered in wave 4 (mean age, 29 years) (28). The CES-D is a widely used measure with well-documented reliability and validity (29–32). Depression was defined as a score of 16 or higher on the CES-D-20 or 11 or higher on the CES-D-10 as per established guidelines (33). Symptoms of depression during the 13-year study period were characterized as occurring in adolescence only, in both adolescence and adulthood, or in adulthood only or as not occurring in either time period.

Covariates

Wave 4 questionnaires contained questions about sociodemographic factors, including age, sex, race/ethnicity, and

highest level of education achieved. In adulthood, the categories for highest level of education were less than high school, high school graduate, some college, and college graduate or higher. Tobacco use, alcohol consumption, sleep duration, and physical activity were assessed at both wave 1 (adolescence) and wave 4 (adulthood). In both adolescence and adulthood, current daily smoking was defined as smoking at least 1 cigarette per day in the previous 30 days. Physical activity was defined by the number of bouts of moderate to vigorous physical activity per week based on self-report in both adolescence and adulthood. Alcohol consumption in adolescence was defined as any episode of heavy drinking in the previous year, characterized for men as 5 or more drinks per drinking occasion and for women as 4 or more drinks per drinking occasion. Alcohol consumption in adulthood was defined for men as consuming more than 2 drinks per drinking occasion and for women as consuming more than 1 drink per drinking occasion.

At wave 1, adolescents were asked, "How many hours of sleep do you usually get?" The current sleep recommendations for adolescents range from 8 to 9 hours of sleep per night, depending on the entity that issued the recommendations (34). Short sleep duration in adolescence was defined as fewer than 8 hours of sleep per night. In adulthood, short sleep duration was defined as fewer than 6 hours of sleep per night.

In adolescence and adulthood, height and weight were measured by trained study staff in the participants' homes. Body mass index (BMI; weight (kg)/height $(m)^2$) was calculated from measured height and weight. If measured height or weight data were missing, self-reported height and weight were used for BMI calculations. Because some of the adolescents were younger than 18 years of age, we calculated BMI percentiles, which account for the child's sex and age and are considered to be more appropriate than the World Health Organization classification of obesity for adults based on BMI (35). The Center for Disease Control and Prevention 2000 BMI growth references (36) were used to determine age- and sex-specific BMI percentiles. In adulthood, BMI was calculated from height and weight measured during home visits by trained study staff.

Statistical analyses

After excluding 34 participants who reported a diabetes diagnosis in adolescence, we used logistic regression models stratified by sex to estimate the associations of high levels of depressive symptoms in adolescence, adulthood, and both adolescence and adulthood with T2DM in adulthood. The incidence of diabetes in the study sample was low (3.4% among men and 3.8% among women).

We ran 3 models. The first model was adjusted for sociodemographic factors (age, educational level, and race/ethnicity). The second model was adjusted for sociodemographic factors, BMI, smoking, alcohol consumption, physical activity, and sleep duration during adulthood. The third model was adjusted for sociodemographic factors, BMI, smoking, alcohol consumption, physical activity, and sleep duration in adolescence and adulthood. All models were stratified by sex, accounted for US region of residence and clustering at the school level, and were weighted to account for the sampling design (37). Analyses were carried out using SUDAAN, version 11.0 (RTI International, Research Triangle Park, North Carolina), according to the guidelines specified for the analyses of Add Health Data (37).

Add Health used a school-based design in which the primary sampling units were schools, so we therefore accounted for clustering at the school level. The poststratification variable is the region of residence, and we thus stratified for region of residence as well. Sampling weights were calculated by the Add Health investigators to account for the unequal probability of selection of study participants. We used a longitudinal weight derived specifically for the sample of participants who responded in waves 1–4 of follow-up. These weights account for the inverse probability of retention in the sample. Analyses of the wave 4 sample indicated negligible bias from nonresponse between wave 1 and wave 4 (22). Formal tests for interaction were performed using a fully adjusted logistic regression interaction model that included variables for sex and depression symptoms and an interaction term that combined them. Depression symptoms were characterized as occurring only in adulthood, only in adolescence, or in both adolescence and adulthood. *F*-tests were used to determine statistical significance.

RESULTS

Table 1 shows the distribution of high levels of depressive symptoms, T2DM, and study covariates. The sample comprised mostly white (67%) men and women who were an average of 29 years of age at the time of the wave 4 follow-up in 2007–2008. The incidence of T2DM was 3.4% in men and 3.8% in women. The majority of participants (76%) with T2DM were not taking diabetes medications. A higher prevalence of depression symptoms was noted among women in both adolescence and adulthood. In adolescence, 25% of women and 15% men experienced high levels of depressive symptoms ($P < 0.05$); in adulthood, 19% of women and 13% of men experienced high levels of depressive symptoms ($P < 0.05$). Health behaviors in adulthood differed by sex in that men were more likely to smoke, be physically active, and sleep less than 6 hours per night in adulthood ($P < 0.05$) (Table 1).

BMI in either adolescence or adulthood was associated with the risk of T2DM among both men and women. No health behavior during adolescence or adulthood was associated with T2DM among men or women (data not shown). Short sleep duration and current smoking were associated with high levels of depressive symptoms in both men and women in adolescence and adulthood (Appendix Table 1). Alcohol consumption in adolescence was associated with high levels of depressive symptoms in both men and women in adolescence. Greater physical activity in adolescence was associated with lower odds of adolescent depression symptoms among men and women. Consumption of alcohol, as defined in Methods, and greater physical activity were associated with lower odds of depression symptoms among men in adulthood (Appendix Table 1).

The incidence of T2DM varied by the presence of depression symptoms (Table 2). Among women who did not

Table 1. Sociodemographic Factors, Health Behaviors, and High Levels of Depressive Symptoms in Adolescence and Adulthood by Sex ($n = 12,657$), National Longitudinal Study of Adolescent to Adult Health, 1994–2008

Demographic or Health Factor	Men ($n = 6,032$)			Women ($n = 6,625$)		
	Mean	%	SE	Mean	%	SE
Age at adolescent interview (wave 1)	16.0		0.03	15.9		0.03
Age at adult interview (wave 4)	29.0		0.03	28.9		0.03
Race/ethnicity						
White		67.4	0.80		66.2	0.78
Black		14.4	0.58		16.1	0.55
Hispanic		11.6	0.54		11.9	0.58
Asian		3.4	0.28		3.3	0.29
Other		3.2	0.33		2.5	0.25
Highest educational level						
Less than high school		10.1	0.56		7.6	0.49
High school graduate		25.0	0.78		17.2	0.64
Some college		38.6	0.85		42.5	0.83
College graduate or higher		26.3	0.78		32.7	0.78
Adult physical activity[a]		57.4	0.88		50.6	0.84
Adult current daily smoking[b]		27.8	0.80		23.1	0.72
Adult obesity[c]		36.3	0.85		38.3	0.83
Adult alcohol consumption[d]		54.5	0.88		57.6	0.83
Adult sleep <6 hours per night		16.1	0.68		10.4	0.51
Depression category and timing[e]						
Low[f]		76.1	0.75		64.11	0.81
High in adolescence only		10.7	0.54		16.5	0.62
High in adulthood only		8.7	0.50		10.8	0.56
High in adolescence and adulthood		4.5	0.38		8.5	0.45
Type 2 diabetes mellitus						
No diabetes		96.6	0.32		96.2	0.30
Diabetes		3.4	0.32		3.8	0.30
HbA_{1c} ≥6.5% and medication use		0.4	0.11		0.4	0.10
HbA_{1c} ≥6.5% and no medication use		2.9	0.30		2.5	0.23
HbA_{1c} <6.5% and medication use		0.1	0.05		0.8	0.16

Abbreviations: HbA_{1c}, glycated hemoglobin; SE, standard error.
[a] Physical activity was defined as 5 or more bouts of moderate to vigorous physical activity per week.
[b] Current daily smoking was defined as smoking at least 1 cigarette per day in the previous 30 days.
[c] Body mass index (weight (kg)/height $(m)^2$) greater than 30 was categorized as obesity.
[d] Alcohol consumption was defined as consuming more than 2 drinks per drinking occasion for men and as consuming more than 1 drink per drinking occasion for women.
[e] High levels of depressive symptoms were defined as a score on the Center for Epidemiologic Studies Depression Scale of 16 or higher on the 20-item version (administered to the sample during adolescence) or 11 or higher on the 10-item version (used in the wave 4 follow-up interview in adulthood).
[f] In this group, there were few or no symptoms of depression at both time points.

experience high levels of depressive symptoms in either adolescence or adulthood, the incidence of T2DM was 3.0%; among women who experienced high levels of depressive symptoms in adolescence, adulthood, or both, it ranged from 4.1% to 7.5%. Among men who did not experience high levels of depressive symptoms, the incidence of T2DM was 3.3%. The incidence of T2DM among men who experienced high levels of depressive symptoms varied: Men with high levels of depressive symptoms in adolescence only had the highest incidence of T2DM, at 4.3%, and those who experienced high levels of depressive symptoms in both adolescence and adulthood had the lowest incidence of T2DM, at 2.0%.

As shown in Table 3, after adjustment for sociodemographic factors, women who experienced high levels of depressive symptoms in both adolescence and adulthood (compared with women without high levels of depressive symptoms in either period) had a higher risk of T2DM (odds ratio = 1.96,

Table 2. Incidence of Type 2 Diabetes Mellitus in Adulthood by Symptoms of Depression ($n = 12,657$), National Longitudinal Study of Adolescent to Adult Health, 1994–2008

Depression Category and Timing[a]	Incidence of Type 2 Diabetes Mellitus					
	Men ($n = 6,032$)			Women ($n = 6,625$)		
	No.[b]	%	SE	No.[b]	%	SE
Low	172	3.31	0.4	171	3.04	0.3
High in adolescence only	31	4.34	1.1	60	4.51	0.8
High in adulthood only	22	3.89	1.3	33	4.09	1.1
High in adolescence and adulthood	10	2.03	0.9	53	7.51	1.4

Abbreviation: SE, standard error.

[a] High levels of depressive symptoms were defined as a score on the Center for Epidemiologic Studies Depression Scale of 16 or higher on the 20-item version (administered to the sample during adolescence) or 11 or higher on the 10-item version (used in the wave 4 follow-up interview in adulthood).

[b] Sample size of study participants with type 2 diabetes mellitus, unweighted.

95% confidence interval: 1.23, 3.11). The odds ratios were not substantially different after adjustment for physical activity level, current smoking, BMI, alcohol consumption, and short sleep duration in adolescence and adulthood. Among men, no statistically significant associations between high levels of depressive symptoms and T2DM were noted after adjustment for sociodemographic factors. Upon adjustment for physical activity, current smoking, BMI, alcohol use, and short sleep duration, a lower odds ratio of T2DM was noted among men who experienced high depression symptoms in both adolescence and adulthood (odds ratio = 0.39, 95% confidence interval: 0.17, 0.91). There was a significant interaction between sex and chronic depression symptoms ($P = 0.01$) (Table 3).

DISCUSSION

In the present nationally representative longitudinal study, we noted that high levels of depressive symptoms in both adolescence and adulthood were associated with the onset of T2DM among women. However, the same association was not observed among men. These findings suggest that the onset of depression early in life might set up a trajectory of risk for T2DM among women.

Although sex-specific risks among adults have been suggested in other studies, to our knowledge there has been no other study in which sex differences in depression and diabetes among younger populations have been examined (38). Among adolescents, there is evidence of a sex-differentiated association between depression and obesity. Similar to our findings, in a study conducted among adolescents in New Zealand, Richardson et al. (9) noted that depression in adolescence was associated with obesity in adulthood among girls only. Different coping mechanisms among men and women have been proposed as explanations for sex differences in the development of metabolic disorders. However, our analyses in which we examined behavioral factors in adolescence and adulthood suggest a relationship between weight status, health behaviors (sleep duration, physical activity level, smoking status, and alcohol consumption), and depression that is similar across sexes and therefore not likely to account for the observed differences. Physiological sex differences in the response to depression are plausible (e.g., hypothalamic-pituitary-adrenal axis dysregulation). In future studies, investigators should explore whether sex-differentiated responses to depression in relation to diabetes are explained by hypothalamic-pituitary-adrenal axis dysregulation or other physiological pathways.

An association between symptoms of depression and T2DM might be attributable to obesity and behavioral factors such as lack of physical activity, smoking, alcohol consumption, and short sleep duration. In our analyses, adjustment for

Table 3. Sex-Specific Associations of Symptoms of Depression in Adolescence and Adulthood With Type 2 Diabetes Mellitus ($n = 12,657$), National Longitudinal Study of Adolescent to Adult Health, 1994–2008

Depression Category and Timing[a]	Model 1[b]				Model 2[c]				Model 3[d]			
	Men ($n = 6,032$)		Women ($n = 6,625$)		Men ($n = 6,032$)		Women ($n = 6,625$)		Men ($n = 6,032$)		Women ($n = 6,625$)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Low	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
High in adolescence only	1.04	0.57, 1.92	1.20	0.78, 1.85	0.88	0.45, 1.75	1.08	0.68, 1.70	0.87	0.43, 1.77	1.10	0.70, 3.15
High in adulthood only	0.87	0.44, 1.71	1.13	0.62, 2.07	0.79	0.38, 1.62	1.16	0.63, 2.15	0.81	0.40, 1.67	1.15	0.63, 2.10
High in adolescence and adulthood	0.46	0.20, 1.05	1.96	1.23, 3.11	0.40	0.18, 0.91	1.91	1.19, 3.07	0.39	0.17, 0.91	1.94	1.20, 3.15

Abbreviations: CI, confidence interval; OR, odds ratio.

[a] High levels of depressive symptoms were defined as a score on the Center for Epidemiologic Studies Depression Scale of 16 or higher on the 20-item version (administered to the sample during adolescence) or 11 or higher on the 10-item version (used in the wave 4 follow-up interview in adulthood).

[b] Adjusted for age, educational level, and race/ethnicity.

[c] Adjusted for the variables in model 1 and behavioral risk factors (smoking, body mass index, alcohol consumption, physical activity level, and short sleep duration) at wave 4 (adulthood).

[d] Adjusted for variables in models 1 and 2 and behavioral risk factors (smoking, body mass index, alcohol consumption, physical activity level, and short sleep duration) at wave 1 (adolescence).

these factors did attenuate the association. A relationship between depressive symptomatology and higher BMI, as well as lower dietary quality, has been reported previously (39). Therefore, behavioral factors and obesity might account for the association, and the potential relationship should be explored further.

The present study has some limitations. First, a screening test rather than a diagnostic measure was used to identify depression. However, the CES-D is a widely used test with well-documented reliability and validity (29–32). Second, although we adjusted for potential confounding factors such as physical activity level, smoking, alcohol consumption, and sleep duration, we have no information on dietary habits, which were not assessed in the present study. Third, we did not have information on laboratory-measured HbA_{1c} concentrations in adolescence, and we relied on self-reported diabetes status before the adult assessment. However, because of the low overall prevalence of T2DM among adolescents—less than 1% (27, 40)—it is unlikely that the associations we noted could be due to reverse causality. Fourth, although we were able to assess a longitudinal relationship between depressive symptoms in adolescence and T2DM in adulthood, depressive symptoms and T2DM in adulthood were assessed simultaneously; because of the cross-sectional nature of the assessment, we cannot establish temporality. Finally, we relied on measured HbA_{1c} concentrations and on the use of insulin alone in adulthood to determine the type of diabetes in the sample, as was done in other studies (27). We therefore might have excluded persons with T2DM who were treated solely with insulin and included persons with type 1 diabetes mellitus who were treated with both metformin and insulin. However, we expect this potential for misclassification of T2DM to be small and not to be associated with high levels of depressive symptoms. We were also unable to distinguish cases of T2DM from maturity-onset diabetes of the young or latent autoimmune diabetes in adults. However, maturity-onset diabetes of the young is rare (41), and latent autoimmune diabetes in adults is typically not diagnosed until after the age of 35 years (older than all of the participants in the present study were at follow-up) (41, 42); therefore, the potential for misclassification is small.

The present study also has a number of strengths. We used a nationally representative sample of US adolescents in high school. The ethnic and geographic diversity of the present sample increased its relevance and translatability to contemporary US adolescents. In addition, T2DM in adulthood was assessed using objectively measured HbA_{1c} concentrations to minimize possible measurement bias. Finally, we took a life-course approach, examining the long-term impact of high levels of depressive symptoms from adolescence into adulthood.

The rise in the rate of obesity during the past 2 decades has led to a dramatic increase in the number of adolescents and adults with T2DM, particularly among minority populations (43). Our finding of a 3%–4% incidence of T2DM in a nationally representative sample of 29-year-old persons, which is higher than in previous samples (27, 44), warrants a focus on the identification and prevention of risk factors early in the life course. Because adolescents who are depressed are more likely to be depressed as adults, it is prudent to begin prevention efforts early.

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(Appendix follows)

Appendix Table 1. Cross-Sectional Associations Between Health Factors and High Levels of Depressive Symptoms in Adolescence and Adulthood by Sex ($n = 12,657$), National Longitudinal Study of Adolescent to Adult Health, 1994–2008

Health Factor	Significant Symptoms of Depression in Adolescence[a]				Significant Symptoms of Depression in Adulthood[a]			
	Men ($n = 6,032$)		Women ($n = 6,625$)		Men ($n = 6,032$)		Women ($n = 6,625$)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Physical activity[b]	0.77	0.60, 0.99	0.81	0.66, 1.00	0.79	0.65, 0.97	0.89	0.75, 1.05
BMI[c]	1.00	0.99, 1.00	1.00	1.00, 1.01	1.00	0.98, 1.01	1.01	1.00, 1.02
Alcohol consumption[d]	1.32	1.04, 1.68	1.84	1.54, 2.20	0.75	0.61, 0.93	0.87	0.74, 1.03
Smoking[e]	1.82	1.41, 2.36	1.75	1.42, 2.15	1.56	1.21, 2.01	1.26	1.02, 1.56
Short sleep duration[f]	1.64	1.31, 2.05	1.56	1.30, 1.87	1.51	1.19, 1.90	1.47	1.13, 1.91

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a] High levels of depressive symptoms were defined as a score on the Center for Epidemiologic Studies Depression Scale of 16 or higher on the 20-item version (administered to the sample during adolescence) or 11 or higher on the 10-item version (used in the wave 4 follow-up interview in adulthood).

[b] Physical activity was defined by the number of bouts of moderate to vigorous physical activity per week.

[c] BMI was calculated as weight (kg)/height $(m)^2$ for adults, and the Center for Disease Control and Prevention 2000 BMI growth references (36) were used to determine BMI percentiles for adolescents.

[d] Alcohol consumption was defined in adolescence as any episode of binge drinking in the previous year. In adulthood, alcohol consumption was defined for men as consuming more than 2 drinks per drinking occasion and for women as consuming more than 1 drink per drinking occasion.

[e] Smoking was defined as current daily smoking of at least 1 cigarette per day in the previous 30 days.

[f] Short sleep duration was defined in adolescence as less than 8 hours of sleep per night and in adulthood as less than 6 hours per night.