



Published in final edited form as:

J Adolesc Health. 2024 January ; 74(1): 71–77. doi:10.1016/j.jadohealth.2023.08.026.

Mental Health During Early Adolescence and Later Cardiometabolic Risk: A Prospective Study of US Latinx Youth

Kathleen M. Roche, MSW, PhD¹, Katherine B. Ehrlich, PhD², Elizabeth Vaquera, PhD³, Todd D. Little, PhD⁴

¹Department of Prevention and Community Health, Milken Institute School of Public Health, George Washington University, 950 New Hampshire Avenue, Suite 300, Washington, DC 20052

²Department of Psychology, University of Georgia, Athens, GA 30602 USA.

³Department of Sociology and Trachtenberg School of Public Policy and Public Administration, George Washington University, 2114 G Street, NW, Washington, DC 20052 USA.

⁴Educational Psychology and Leadership, 1009 Canton Ave., Lubbock, TX 79409-1071 USA; East China Normal University; North-West University of South Africa.

Abstract

Purpose: Rising rates of cardiometabolic risk and mental health problems are serious public health concerns for US adolescents, particularly those of Latinx origin. This research examines how Latinx youth's internalizing symptoms during early adolescence are related to sleep problems, overweight/obesity, sedentary behavior, physical activity, healthy diet, and hypertension or diabetes risk during middle and late adolescence.

Methods: Participants included 547 adolescents listed as "Hispanic" on 2017–18 middle school enrollment lists in a suburban Atlanta, GA school district. Survey data collected at baseline (2018) and four years later (2022) were analyzed using Structural Equation Model. Path estimates from baseline internalizing symptoms to later health behaviors and physical health outcomes adjusted for demographics, the follow-up measure of internalizing symptoms, and correlations among outcome variables. Missing data were handled using Full Information Maximum Likelihood.

Results: At baseline, the 244 (44.6%) male and 303 (55.4%) female participants had a mean (SD) age in years of 13.31 (0.97). Early adolescent internalizing symptoms were associated positively with later sleep problems ($\beta=0.36$ [95% CI, 0.24–0.48]), overweight/obesity (AOR, 2.57; 95% CI, 1.29–5.15), sedentary behavior ($\beta=0.19$ [95% CI, 0.09–0.30]), and internalizing symptoms ($\beta=0.48$ [95% CI, 0.39–0.56]) and inversely with later physical activity ($\beta=-0.16$ [95% CI, -0.27– -0.05]) and a healthy diet ($\beta=-0.21$ [95% CI, -0.32– -0.09]).

Corresponding Author: Department of Prevention and Community Health, Milken Institute School of Public Health, George Washington University, 950 New Hampshire Avenue, Suite 300, Washington, DC 20052. Tel: 202-994-3858 USA. kroche@gwu.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Discussion: Latinx youth's internalizing symptoms during early adolescence not only track into later adolescence, but they also relate to health behaviors and outcomes underlying cardiometabolic risk during middle and late adolescence.

Keywords

cardiometabolic risk; Latinx adolescents; mental health; structural equation modeling

The rapid rise in adolescents' sedentary behavior, unhealthy diet, sleep problems, overweight/obesity, Type 2 diabetes, and hypertension raise serious concerns about cardiometabolic risk facing the next generation of US adults.^{1–3} The prevalence of obesity among 12- to 18-year-olds increased from 21.4% to 27.9% from the years 2011–12 through 2017–20.¹ Public health concerns regarding increased cardiometabolic risks are elevated for the large and growing Latinx population.² Latinx youth are almost twice as likely as White non-Latinx youth to have obesity (26% vs. 14%),⁴ and they have a much higher rate of pre-diabetes than do White non-Latinx youth (23% vs. 16%).⁵ Findings from the Study of Latino Youth (SOL; 2012–14) indicated that Latinx 8- to 16-year-olds spent an average of 10 hours per day engaged in sedentary behavior and 35 minutes per day engaged in physical activity – the latter of which is far below national guidelines of at least one hour per day.⁶ Although findings for racial/ethnic variations in sleep are not entirely consistent, Latinx youth have been shown to experience less sleep duration than White non-Latinx youth and to have more sleep disturbances than other racial/ethnic groups.^{7, 8} Attention to factors that compromise health behaviors and physical health outcomes during the adolescent years is critical for preventing adult cardiometabolic risk.

Irrefutable evidence identifies mental health as an important correlate of health behaviors and physical health outcomes underlying cardiometabolic risk.⁹ The mental health of children and adolescents often is assessed along a continuum of internalizing symptoms, the broad-band array of inward-directed outcomes, such as depression, low-self-esteem, anxiety, social withdrawal, and somatization (e.g., headaches, stomachaches).¹⁰ Among a UK population-based cohort of adolescents, females with a higher body mass index (BMI) at age 15 reported significant increases in depressive symptoms at age 18; however, age 15 depression was *not* related to BMI at age 18.¹¹ Other research also situated in the UK found that internalizing symptoms at age 11 were associated with increases in BMI from ages 11 to 15.¹² Further, among a sample of children in Germany assessed in grades 2, 6, and 10, boys with greater depression during childhood experienced greater insulin resistance and higher body fat during adolescence. In that same study, boys' increased depression was related to their increased insulin resistance over time.¹³ Although the Germany study found no significant mental health effects on girls' physical health outcomes, a study in the Southwestern US found that depressive symptoms among girls aged 11 to 15 were associated with more than a four-fold higher odds of obesity onset over the course of the subsequent four years.¹⁴

There are compelling reasons to consider how Latinx youth's mental health during early adolescence may shape the constellation of health behaviors and physical health outcomes that underlie cardiometabolic risk later in adolescence. First, across demographic

subgroups, the transition into adolescence tends to be accompanied by a significant uptick in internalizing symptoms.^{10, 15} Internalizing symptoms during the formative adolescent years may set in motion unhealthy behaviors and poor physical health outcomes with lasting consequences for health into adulthood. Second, Latinx adolescents are at elevated risk of experiencing internalizing symptoms. Among high school students in 2021, youth reports of persistently feeling sadness or hopelessness were significantly more prevalent among Latinx students (46%), compared to White non-Latinx (41%), Black, non-Latinx (39%), and Asian-Pacific Islander (35%) students.¹⁶ Finally, the large and growing US Latinx adolescent population also is mostly (93%) US born¹⁷ – a factor linked to greater cardiometabolic risk and worse mental health.^{18, 19} Although the diverse Latinx population experiences varying health risks, Latinx disparities in mental and physical health reflect adversity rooted in an anti-immigrant US political climate, experiences of neighborhood ethnic marginalization and ethnic discrimination, and socioeconomic disadvantage.¹⁹ Given these contextual challenges as well as the larger mental health crisis facing today's adolescents,²⁰ there is a pressing need to examine how mental health is affecting physical health for contemporary samples of Latinx youth.

Using prospective survey data collected from a school-based sample of Latinx adolescents, this study will examine how internalizing symptoms during early adolescence are associated with sleep problems, overweight/obesity, sedentary behavior, vigorous physical activity, healthy diet, and a diagnosis indicating diabetes or hypertension during middle and late adolescence. By examining myriad health behaviors and health outcomes, this research will advance knowledge about the range of interrelated, yet independent, factors tied to cardiometabolic risk. Data utilized in this study derive from surveys conducted in 2018 and 2022, a timeframe that facilitates studying a contemporary sample of Latinx youth. Finally, analytic models adjust for baseline measures of adolescent gender, age, nativity, and of maternal education, which are all important demographic correlates of adolescent mental and physical health.^{15, 21, 22}

Methods

Procedures and Sampling

Data derive from *Pathways to Health/Caminos al Bienestar* (“*Caminos*”), an ongoing, longitudinal study of Latinx adolescents and mothers. The *Caminos* project, which includes bilingual, bicultural research, is situated in suburban, Atlanta, GA, an emerging immigrant destination. The sampling frame was 1,105 students indicated as “Hispanic” on 2017–18 middle school enrollment lists from a single school district. Students were excluded if they had a severe emotional or learning disability indicated by an Individualized Education Plan; unable to read either English or Spanish; self-reported as not being Latino/a/x (or a related term); were a sibling of a previously selected participant; or had an age outside the typical range for the school grade. Online supplemental materials from prior research²³ provide extensive details on sample recruitment and retention. Among eligible adolescents whose parents were contacted and consented, the response rate was 65.2% (calculated as 547/839). Among the 574 consented adolescents, the response rate among was 95.3% (calculated

as 547/574). Since baseline, participants have completed eight follow-up surveys, spaced roughly six months apart, over four years. The four-year retention rate was 66.7% (n=365).

The gender inclusive ethnic label of Latinx is used in this study. Responses to the survey question: “In addition to Latino/a or Hispanic, what other race or ethnicity do you identify with?” indicated that many adolescents self-identified their race as *only* Latino/a or Hispanic (38.2%). Other groups included White, Caucasian, or European (24.7%); Black or African American (4.8%); Asian or Asian American (2.4%); American Indian or Indigenous (3.7%); and “other” (3.7%); 15.7% had missing data for this question.

Adolescents completed self-administered online surveys on a computer, tablet, or mobile phone using the *Qualtrics XM Research Core Survey Software* program. Investigators obtained Institutional Review Board (IRB) approval from The George Washington University. Parents provided oral or written consent; adolescents provided written assent. Study materials were provided in Spanish and English. For materials not already translated into Spanish, we translated using the double-translation and double back-translation method combined with a review team approach.³⁴

Measures

Baseline measures derive from adolescent surveys administered in 2018. Follow-up measures derive from surveys administered in 2022 (study time point nine), when health behaviors and physical health outcomes were first assessed in *Caminos*. See eMethod-Survey Items in the online supplement for measurement details.

Control variables.—Baseline demographics included continuous measures of adolescent age and maternal education and 0/1 measures for gender and US nativity.

Internalizing symptoms.—At baseline and at follow up, a 29-item measure of past six-month internalizing symptoms assessed anxious/depressive, withdrawn/depressed, and somatic syndromes from Youth Self Report²⁴ ($\alpha = .90-.93$). For the 11 (3%) 19-year-olds who completed Adult Self Report (ASR 18–adult),²⁵ Full Information Maximum Likelihood (FIML) was used to address missing data for YSR items.

Health behaviors and health problem outcomes.—Sedentary behavior indicated the total number of hours spent sitting on a weekday during the prior seven days. Vigorous physical activity measured the number of days during the prior seven days engaged in heavy physical activity. This was defined as activity that takes hard physical effort and makes one breathe much harder than normal (e.g., dancing, running, soccer, aerobic activity or heavy lifting).²⁶ Healthy diet was a summed score of no/yes responses to a 16-item version of the Food Habits Scale.²⁷ Higher scores indicated a healthier diet. From 13 items on the Pittsburgh Sleep Quality Index, sleep problems were assessed by a latent variable representing sleep quality, latency, duration, and disturbances. Higher scores indicate more sleep problems.²⁸ Overweight or obesity, a 0/1 indicator, was created using reports of weight and height converted into BMI. Following CDC guidelines, BMI scores of ≥ 25 indicated overweight or obesity.²⁹ (For sensitivity analyses conducted, age- and gender-adjusted BMI percentiles were developed following CDC guidelines for youth).³⁰ Finally, a 0/1 indicator

of hypertension or diabetes risk was measured by Behavior Risk Factor Surveillance Study items indicating that a health professional had diagnosed the adolescent with diabetes, pre-diabetes/borderline diabetes, high blood pressure, and/or borderline high blood pressure/pre-hypertension.³¹

Statistical Analysis

Missing data due to item non-response was minimal (2.0% to 3.3%), except for maternal education, which was missing for 16.1% of participants. Missing data due to survey non-response at Time 9 was 33.3%. Attrition mostly occurred at Time 2 and Time 9 due to changes in study procedures. Specifically, at Time 2, the project had shifted from surveys being completed during the school day to being completed outside of school on youth's own time. Later, at Time 9, the project involved a newly funded study with the existing cohort, thereby requiring re-consenting/assenting youth. Attrition analyses indicated that males were significantly less likely than females to complete follow-up surveys at Times 2 and 9.

We were able to consider the data to be Missing at Random (MAR) for a few reasons. First, *Mplus* results for percent missing and fraction of missing data indicated that parameter estimates were recoverable through FIML. Second, in the structural equation model (SEM) analyses, missing data were handled using FIML estimation with auxiliary variables (as an exception, maternal education was estimated using grand mean estimates described in the online supplemental material). The Auxiliary Variable command in *Mplus* accounted for whether or not youth participated in a follow up survey at Times 2 through 9. Any differences in parameter estimates due to attrition at these time points provided information used to adjust parameter estimates in the SEM. These auxiliary variables represent patterns of missingness from all study variables that also contribute to ensuring a MAR process. Finally, to help ensure that data are missing at random, gender's influence is represented in the handling of the missing data using FIML and in correctly estimating the parameters.³² The eMethods-Missing Data and e-Table 2 in the online supplement provide additional information on missing data.³⁹

Confirmatory factor analysis was used to determine the construct validity and factorial invariance over time for latent measures of internalizing symptoms and sleep problems (see eMethod-Measurement Model Analytic Plan; eTables 1–3, online Supplement). Higher scores on these latent variables indicated more internalizing symptoms and more sleep problems. Bivariate associations between study variables were examined by examining parameter estimates representing bivariate (zero order) correlations from the measurement model of the SEM.

Multivariable, multivariate regression models within a SEM framework were run to examine prospective associations between internalizing symptoms during early adolescence (baseline) and health behaviors and outcomes during middle and late adolescence (follow up). The models adjusted for internalizing symptoms at follow up. This approach models the unique association between early adolescent internalizing symptoms and later physical health behaviors and outcomes not accounted for by across and within-time correlations for internalizing symptoms. Significant correlations among outcome variables were retained in the final model. In addition, analytic models adjusted for potential demographic confounders

(adolescent gender, age, and nativity, and maternal education), which may co-vary with internalizing symptoms and health behaviors and outcomes. The unstandardized coefficients are estimated as residual covariances; the standardized coefficients are estimated as residual correlations.

Due to gender differences in internalizing symptoms and some health behaviors and outcomes, we also tested the statistical significance of two-way interaction terms between gender and baseline internalizing symptoms in separate models. To confirm the validity of the final structural model results, sensitivity analyses were run subsequent to the final model. These analyses included models that omitted cases with missing data, removed all demographic variables, examined age- and gender-adjusted BMI percentile scores instead of a 0/1 indicator of overweight/obesity, and used a 0/1 indicator for a clinical level of internalizing symptoms at baseline, rather than a continuous score (See eTable 5, online supplement). Fit statistics included the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Chi-square model fit (see eMethod-Structural Model Analytic Plan, online supplement).

Results

As shown in Table 1, adolescents were mostly US born (89.6%) and there were more females (55.4%) than males (44.6%). At the time of the baseline survey (2018), adolescents were an average of 13.31 (SD=0.97) years of age. At the time of the follow-up survey, adolescents were an average of 17.47 years of age (SD=0.90). Among foreign-born adolescents, the mean (SD) number of years living in the US was 6.29 (4.12). On average, mothers had completed a little more than high school (M=3.18, SD=1.63). Approximately half (51.9%) of mothers were born in Mexico, 19.5% were born in the US, and the remaining were born in countries in Central America (11.9%), South America (12.3%), other countries (4.5%). Online supplemental materials from prior research²³ indicate how the sample compares to Latinx youth in metro Atlanta and in the US.

The average internalizing t-score at follow up (M=57.52, SD=13.24) was significantly higher than the average score at baseline (M=53.95, SD=11.96) for adolescents with complete data at both time points ($t=-5.18$, $df=350$, $p < .001$). Among adolescents who completed follow-up surveys, 39.1% had overweight or obesity and 14.5% had diabetes/pre-diabetes or hypertension/pre-hypertension risk. In addition, the average number of hours engaged in sedentary behavior on a typical day was 5.88 (SD=3.18), and the average number of days engaged in vigorous physical activity in the prior week was 2.80 (SD=2.53). Mean (SD) observed scores for sleep problems and healthy diet were 5.25 (3.13) and 6.67 (3.92), respectively.

Parameter estimates for bivariate correlations (derived from the measurement model) are shown in Table 2. Higher levels of internalizing symptoms at baseline were positively associated with internalizing symptoms, sedentary behavior and overweight/obesity at follow up. Higher baseline internalizing symptoms were inversely associated with physical activity and healthy diet at follow up. Concurrent bivariate associations *during* middle and late adolescence indicated that: (1) Internalizing symptoms were related to

more sleep problems, greater sedentary behavior, a less healthy diet, and fewer days engaged in vigorous physical activity; (2) Overweight/obesity was positively associated with diabetes/hypertension risk; (3) Healthy diet was associated with lower levels of sedentary behavior and with more sleep problems and vigorous physical activity; and (4) Sleep problems were positively associated with sedentary behavior and diabetes/hypertension risk. Several findings showed that mental and physical health outcomes varied by demographic characteristics. Specifically, adolescent age was positively associated with baseline internalizing symptoms and follow-up measures of obesity/overweight and inversely associated with vigorous physical activity. Male gender was associated with fewer internalizing symptoms at both time points, fewer sleep problems, and with more vigorous physical activity. Finally, maternal educational attainment was inversely associated with overweight/obesity but positively associated with adolescent sedentary behavior.

SEM results (Figure 1, eTable 4) indicated that, even after adjusting for covariates, internalizing symptoms during early adolescence were associated with more sedentary behavior, more sleep problems, a higher odds of overweight/obesity, less vigorous physical activity, and a less healthy diet during middle and late adolescence. As shown in the Figure, correlations among outcome variables indicated that, at follow up, (1) internalizing symptoms were related to more sleep problems and greater sedentary behavior, (2) overweight/obesity was associated with more diabetes/hypertension risk; and (3) healthy diet was associated with less sedentary behavior and more vigorous physical activity. Results from tests of two-way interactions between baseline internalizing symptoms and adolescent gender were not significant. Thus, these interaction terms were not included in the final model. Sensitivity analyses (eTable 5, online supplemental materials) indicated that estimates for paths from baseline internalizing symptoms to outcomes held across various analytic models. These models included the following changes to the the multivariate, multivariable model shown in Figure 1: (1) excluded adolescents who did not complete the follow-up (2022) survey, (2) omitted demographic variables; (3) utilized a 0/1 indicator of “borderline” or “clinical,” versus “normal,” internalizing symptoms for the baseline assessment, (4) measured BMI as an age- and gender-adjusted percentile score, and (5) included a measure of sleep problems assessed 12 months prior to the follow-up survey. In the latter model, baseline (2018) internalizing symptoms were associated with increases in sleep problems and increases in internalizing symptoms in 2022 directly and indirectly through elevated sleep problems reported in 2021.

Discussion

Latinx adolescents who experience poor mental health during early adolescence report worse sleep problems, greater overweight/obesity, more sedentary behavior, less physical activity, and a less healthy diet during middle and late adolescence. Importantly, the pathways linking early adolescent mental health to later health behaviors and physical health outcomes held even when adjusting for the co-occurrence of outcome variables and for internalizing symptoms during middle and late adolescence. These findings provide some of the first evidence for how mental health symptoms experienced by a contemporary sample of Latinx early adolescents may compromise a wide range of outcomes during middle and late adolescence in ways that elevate cardiometabolic risk into adulthood.

Our findings point to early adolescence as a critical developmental period for shaping later health behaviors and physical health outcomes. Discrepancies between the study's bivariate correlations (Table 2) and multivariate regressions (Figure 1, eTable4) suggest that focusing *only* on concurrent associations among internalizing symptoms and physical health may obscure meaningful patterns in the trajectory of adolescents' symptoms over time. Specifically, zero-order bivariate correlations indicated that internalizing symptoms during middle and late adolescence were associated with significantly more sleep problems and sedentary behavior and with less healthy diet and less vigorous physical activity during the same developmental period. However, internalizing symptoms during middle and late adolescence were *no longer* associated with either vigorous physical activity or healthy diet during that same developmental period after including path estimates from baseline internalizing symptoms to the outcome variables. As described in online supplementary material, the significance of correlations among outcome variables did not change when (1) only adjusting for baseline demographic covariates or (2) omitting correlations among physical health outcomes and behaviors and all demographic covariates. Thus, although unhealthy behaviors are expected to cluster at any particular age, those associations may, in fact, be due to worsening mental health over time rather than simply a coordinated pattern of interrelated health behaviors. By modeling the unique prediction of mental health to physical health over time, we were able to identify the potential impact of adolescents' declining mental health on later unhealthy behaviors.

The value of this study to research informative about impacts of Latinx youth's mental health during early adolescence on later cardiometabolic risk is strengthened by several study features. First, scientific rigor in the validity of findings is supported by results from several alternative models conducted as part of sensitivity analyses. Second, the study results are informative about a contemporary, school-based sample of Latinx youth. It is valuable to consider that assessments of mental health and cardiometabolic risk utilized in this study (during 2022) reflect the state of health among a population with elevated stress stemming from ethnic discrimination and anti-immigrant rhetoric³³ as well as a global pandemic. Almost 40% of adolescents in this study had overweight or obesity and 14.5% of them were at risk of diabetes or hypertension. Thus, the finding that Latinx early adolescents' mental health may compromise adolescents' later health behaviors and physical health outcomes is critically important from a public health perspective. Consistent with other studies,^{34–36} Latina adolescent females participating in the *Caminos* study experienced significant increases in internalizing symptoms after the onset of the COVID-19 pandemic.³⁷ As baseline estimates of mental health in the present study derived from data collected two years prior to the pandemic's onset, our findings may represent conservative estimates for mental health impacts on cardiometabolic risk among Latinx adolescents post-pandemic onset. Finally, the use of a random sampling approach for middle schools in a large and socioeconomically diverse suburban school district helps increase the generalizability of the findings to Latinx adolescents living in other new immigrant destinations in the United States.

Despite its unique contribution to the literature, some important study limitations indicate the need for further research on this topic. First, the absence of baseline measures for health behaviors and outcomes precluded our ability to examine how these predict later

mental health. Although some studies find no evidence for prospective associations between physical activity and later adolescent depressive symptoms,^{38–40} finding from a UK study showed that adolescents who engaged in moderate or high levels of sedentary behavior from ages 12 to 16 had 25% to 28% more depressive symptoms at age 18 than adolescents engaged in low levels of sedentary behavior. Moreover, adolescents with persistently high levels of moderate-to-vigorous physical activity from ages 12 to 16 had 31% fewer depressive symptoms at age 18 than did less physically active adolescents.²² Thus, future research examining paths from Latinx early adolescents' physical health to later mental health is warranted. A second limitation is that study variables derived from youth self-report. Although self-reports for outcomes such as diabetes have been shown to be valid,⁴¹ the present study does not include data for adolescent visits to health care providers. Thus, it is unclear whether findings would hold if we had used objective assessments for mental and physical health. Finally, the small sample sizes for diverse national origins limit our understanding of how national origin impacts pathways linking mental health to later health behaviors and outcomes. Investigating the nuanced changes in health behaviors and physical health outcomes in response to changes in mental health during adolescence can elucidate the developmental co-occurrence and directions of influence between mental and physical health. Studies that identify cultural and demographic variations in the links between mental health and physical health also are needed to help target intervention efforts for the large and growing US Latinx adolescent population.⁴²

Conclusion

Explanations for the onset and progression of chronic diseases of aging are multifactorial and complex. Yet, efforts to reduce early onset Type 2 diabetes, hypertension, and other indicators of cardiometabolic dysregulation overwhelmingly focus on improving lifestyle behaviors such as diet and physical activity.⁴³ Some researchers speculate that internalizing symptoms may increase BMI via reduced physical activity, dieting, physiological changes and/or medication.⁴⁴ Despite the potentially strong role that behavior plays in linking mental health to physical health, controlled trials to target these behaviors often fall short of goals to improve individuals' cardiometabolic health.⁴⁵ Our results suggest the potential value of public health interventions that move beyond lifestyle behaviors and directly address mental health during the early adolescent years.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

This work was funded by research grants R01 HD090232 and R01 HD106650 from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, National Institutes of Health.

The authors are grateful to Roushanac Partovi, MPH at The George Washington University for her careful and difficult work on recruitment, the calculation of response and retention rates, data cleaning, data collection, and data management, and for her contributions to the preparation of the final manuscript. We are especially grateful to the Pathways to Health/Caminos al Bienestar study families who participate in the surveys. Everyone who contributed significantly to the work has been listed in Acknowledgments. There are no potential conflicts of interest, real or perceived, for all authors.

Abbreviations:

US	United States
SEM	structural equation modeling
BMI	body mass index
FIML	Full information maximum likelihood
CFI	Comparative Fit Index
RMSEA	Root Mean Square Error of Approximation

References

1. Hu K, Staiano AE. Trends in obesity prevalence among children and adolescents aged 2 to 19 years in the US from 2011 to 2020. *JAMA Pediatr.* Oct 1 2022;176(10):1037–1039. doi:10.1001/jamapediatrics.2022.2052 [PubMed: 35877133]
2. Liu J, Ma J, Orekoya O, Vangeepuram N, Liu J. Trends in metabolic syndrome among US youth, from 1999 to 2018. *JAMA Pediatrics.* 2022;176(10):1043–1045. doi:10.1001/jamapediatrics.2022.1850 [PubMed: 35816325]
3. Centers for Disease Control and Prevention. Trends in the prevalence of physical activity and sedentary behaviors National YRBS: 1991–2019. Accessed November 17, 2022. https://www.cdc.gov/healthyyouth/data/yrbs/factsheets/2019_physical_trend_yrbs.htm
4. Katz SF, Rodriguez F, Knowles JW. Health disparities in cardiometabolic risk among Black and Hispanic youth in the United States. *American Journal of Preventive Cardiology.* Jun 2021;6:100175. doi:10.1016/j.ajpc.2021.100175 [PubMed: 34327498]
5. Andes LJ, Cheng YJ, Rolka DB, Gregg EW, Imperatore G. Prevalence of prediabetes among adolescents and young adults in the United States, 2005–2016. *JAMA Pediatrics.* 2020;174(2):e194498–e194498. doi:10.1001/jamapediatrics.2019.4498 [PubMed: 31790544]
6. Evenson KR, Arredondo EM, Carnethon MR, et al. Physical activity and sedentary behavior among US Hispanic/Latino youth: The SOL Youth Study. *Med Sci Sports Exerc.* May 2019;51(5):891–899. doi:10.1249/mss.0000000000001871 [PubMed: 30570586]
7. Marczyk Organek KD, Taylor DJ, Petrie T, et al. Adolescent sleep disparities: Sex and racial/ethnic differences. *Sleep Health.* Mar 2015;1(1):36–39. doi:10.1016/j.sleh.2014.12.003 [PubMed: 29073411]
8. Guglielmo D, Gazmararian JA, Chung J, Rogers AE, Hale L. Racial/ethnic sleep disparities in US school-aged children and adolescents: A review of the literature. *Sleep Health.* Feb 2018;4(1):68–80. doi:10.1016/j.sleh.2017.09.005 [PubMed: 29332684]
9. Gage SH, Patalay P. Associations between adolescent mental health and health-related behaviors in 2005 and 2015: A population cross-cohort study. *J Adolesc Health.* Oct 2021;69(4):588–596. doi:10.1016/j.jadohealth.2021.03.002 [PubMed: 33867232]
10. Costello EJ, Copeland W, Angold A. Trends in psychopathology across the adolescent years: What changes when children become adolescents, and when adolescents become adults? 10.1111/j.1469-7610.2011.02446.x. *Journal of Child Psychology and Psychiatry.* 2011/10/01 2011;52(10):1015–1025. doi:10.1111/j.1469-7610.2011.02446.x [PubMed: 21815892]
11. Chaplin AB, Smith N, Jones PB, Khandaker GM. Direction of association between Cardiovascular risk and depressive symptoms during the first 18 years of life: A prospective birth cohort study. *J Affect Disord.* Sep 1 2021;292:508–516. doi:10.1016/j.jad.2021.05.094 [PubMed: 34146903]
12. Patalay P, Hardman CA. Comorbidity, codevelopment, and temporal associations between body mass index and internalizing symptoms from early childhood to adolescence. *JAMA Psychiatry.* Jul 1 2019;76(7):721–729. doi:10.1001/jamapsychiatry.2019.0169 [PubMed: 30892586]

13. Olive LS, Telford RM, Byrne DG, Abhayaratna WP, Telford RD. Symptoms of stress and depression effect percentage of body fat and insulin resistance in healthy youth: LOOK longitudinal study. *Health Psychol.* Aug 2017;36(8):749–759. doi:10.1037/hea0000496 [PubMed: 28541073]
14. Stice E, Presnell K, Shaw H, Rohde P. Psychological and behavioral risk factors for obesity onset in adolescent girls: A prospective study. *Journal of Consulting and Clinical Psychology.* 2005;73(2):195–202. doi:10.1037/0022-006X.73.2.195 [PubMed: 15796626]
15. Hankin BL, Young JF, Abela JRZ, et al. Depression from childhood into late adolescence: Influence of gender, development, genetic susceptibility, and peer stress. *Journal of Abnormal Psychology.* 2015;124:803–816. doi:10.1037/abn0000089 [PubMed: 26595469]
16. Centers for Disease Control and Prevention. High School YRBS 2019 Results. Accessed January 17, 2023, 2023. <https://nccd.cdc.gov/Youthonline/App/Default.aspx>
17. National Research Center on Hispanic Children and Families. November 29, 2022. <https://www.hispanicresearchcenter.org/hisp-family-facts/over-90-percent-of-all-u-s-latino-children-were-born-in-the-united-states/#:~:text=Over%2090%20Percent%20of%20all,United%20States%20%2D%20Hispanic%20Research%20Center>
18. Alegria M, Canino G, Shrout PE, et al. Prevalence of mental illness in immigrant and non-immigrant U.S. Latino groups. *Am J Psychiatry.* Mar 2008;165(3):359–69. doi:10.1176/appi.ajp.2007.07040704 [PubMed: 18245178]
19. Perreira KM, Allen CD. The health of Hispanic children from birth to emerging adulthood. *The ANNALS of the American Academy of Political and Social Science.* 2021/07/01 2021;696(1):200–222. doi:10.1177/00027162211048805 [PubMed: 37123537]
20. Office of the Surgeon G. Publications and Reports of the Surgeon General. Protecting Youth Mental Health: The US Surgeon General's Advisory. US Department of Health and Human Services; 2021.
21. Jamnik MR, DiLalla LF. Health outcomes associated with internalizing problems in early childhood and adolescence. *Front Psychol.* 2019;10:60. doi:10.3389/fpsyg.2019.00060 [PubMed: 30761037]
22. Kandola A, Lewis G, Osborn DPJ, Stubbs B, Hayes JF. Depressive symptoms and objectively measured physical activity and sedentary behaviour throughout adolescence: a prospective cohort study. *Lancet Psychiatry.* Mar 2020;7(3):262–271. doi:10.1016/s2215-0366(20)30034-1 [PubMed: 32059797]
23. Roche KM, White RMB, Lambert SF, et al. Association of family member detention or deportation with Latino or Latina adolescents' later risks of suicidal ideation, alcohol use, and externalizing problems. *JAMA Pediatrics.* 2020;174(5):478–486. doi:10.1001/jamapediatrics.2020.0014 [PubMed: 32176245]
24. Achenbach TM. Manual for the Child Behavior Checklist 4–18 and 1991 profile. Burlington, VT: University of Vermont, Department of Psychiatry; 1991.
25. Achenbach TM, Rescorla LA. Manual for the ASEBA adult forms & profiles. University of Vermont, Research Center for Children, Youth, & Families; 2003.
26. Fernald DH, Froshaug DB, Dickinson LM, et al. Common measures, better outcomes (COMBO): A field test of brief health behavior measures in primary care. *Am J Prev Med.* Nov 2008;35(5 Suppl):S414–22. doi:10.1016/j.amepre.2008.08.006 [PubMed: 18929989]
27. Johnson F, Wardle J, Griffith J. The Adolescent Food Habits Checklist: Reliability and validity of a measure of healthy eating behaviour in adolescents. *Eur J Clin Nutr.* Jul 2002;56(7):644–9. doi:10.1038/sj.ejcn.1601371 [PubMed: 12080404]
28. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Res.* May 1989;28(2):193–213. doi:10.1016/0165-1781(89)90047-4 [PubMed: 2748771]
29. Kuczmarski RJ, Carroll MD, Flegal KM, Troiano RP. Varying body mass index cutoff points to describe overweight prevalence among U.S. adults: NHANES III (1988 to 1994). *Obes Res.* Nov 1997;5(6):542–8. doi:10.1002/j.1550-8528.1997.tb00575.x [PubMed: 9449138]

30. Center for Disease Control and Prevention. Healthy Weight, Nutrition, and Physical Activity. Accessed April 10, 2023. https://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html#interpreted
31. Center for Disease Control and Prevention. Behavioral risk factor surveillance system survey data. Accessed November 28, 2022. <https://www.cdc.gov/brfss/questionnaires/index.htm>
32. Enders C Applied Missing Data Analysis. Second ed. Guilford Press; 2022.
33. Roche KM, White RMB, Rivera MI, Safa MD, Newman D, Falusi O. Recent immigration actions and news and the adjustment of U.S. Latino/a adolescents. *Cultur Divers Ethnic Minor Psychol*. Jul 2021;27(3):447–459. doi:10.1037/cdp0000330 [PubMed: 32757570]
34. De France K, Hancock GR, Stack DM, Serbin LA, Hollenstein T. The mental health implications of COVID-19 for adolescents: Follow-up of a four-wave longitudinal study during the pandemic. *Am Psychol*. Jan 2022;77(1):85–99. doi:10.1037/amp0000838 [PubMed: 34110880]
35. Alt P, Reim J, Walper S. Fall From Grace: Increased Loneliness and Depressiveness Among Extraverted Youth During the German COVID-19 Lockdown. *J Res Adolesc*. Sep 2021;31(3):678–691. doi:10.1111/jora.12648 [PubMed: 34448311]
36. Romm KF, Park YW, Hughes JL, Gentzler AL. Risk and protective factors for changes in adolescent psychosocial adjustment during COVID-19. 10.1111/jora.12667. *Journal of Research on Adolescence*. 2021/09/01 2021;31(3):546–559. doi:10.1111/jora.12667 [PubMed: 34448304]
37. Roche KM, Huebner DM, Lambert SF, Little TD. COVID-19 stressors and Latinx adolescents' mental health symptomology and school performance: A prospective study. *J Youth Adolesc*. Jun 2022;51(6):1031–1047. doi:10.1007/s10964-022-01603-7 [PubMed: 35381907]
38. Rothon C, Edwards P, Bhui K, Viner RM, Taylor S, Stansfeld SA. Physical activity and depressive symptoms in adolescents: A prospective study. *BMC Med*. May 28 2010;8:32. doi:10.1186/1741-7015-8-32 [PubMed: 20509868]
39. Stavrakakis N, Roest AM, Verhulst F, Ormel J, de Jonge P, Oldehinkel AJ. Physical activity and onset of depression in adolescents: A prospective study in the general population cohort TRAILS. *Journal of Psychiatric Research*. 2013/10/01/ 2013;47(10):1304–1308. doi:10.1016/j.jpsychires.2013.06.005 [PubMed: 23820109]
40. Toseeb U, Brage S, Corder K, et al. Exercise and depressive symptoms in adolescents: A longitudinal cohort study. *JAMA Pediatr*. Dec 2014;168(12):1093–100. doi:10.1001/jamapediatrics.2014.1794 [PubMed: 25317674]
41. Schneider AL, Pankow JS, Heiss G, Selvin E. Validity and reliability of self-reported diabetes in the Atherosclerosis Risk in Communities Study. *Am J Epidemiol*. Oct 15 2012;176(8):738–43. doi:10.1093/aje/kws156 [PubMed: 23013620]
42. Castañeda SF, Buelna C, Giacinto RE, et al. Cardiovascular disease risk factors and psychological distress among Hispanics/Latinos: The Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *Prev Med*. Jun 2016;87:144–150. doi:10.1016/j.ypmed.2016.02.032 [PubMed: 26921653]
43. Sigal RJ, Kenny GP, Wasserman DH, Castaneda-Sceppa C, White RD. Physical Activity/Exercise and Type 2 Diabetes: A consensus statement from the American Diabetes Association. *Diabetes Care*. 2006;29(6):1433–1438. doi:10.2337/dc06-9910 [PubMed: 16732040]
44. Zhou N, Liang Y, Cao H, Chen Y, Lin X, Zhang J. Body mass index and internalizing symptoms from early childhood through early adolescence: Trend of codevelopment and directionality. *J Child Psychol Psychiatry*. Mar 2022;63(3):324–332. doi:10.1111/jcpp.13474 [PubMed: 34196400]
45. Andrews RC, Cooper AR, Montgomery AA, et al. Diet or diet plus physical activity versus usual care in patients with newly diagnosed type 2 diabetes: The Early ACTID randomised controlled trial. *The Lancet*. 2011/07/09/ 2011;378(9786):129–139. doi:10.1016/S0140-6736(11)60442-X

Implications and Contribution

Explanations for the onset and progression of chronic diseases of aging are multifactorial and complex. Results from this study suggest the potential value of public health interventions that move beyond lifestyle behaviors and directly address mental health during the early adolescent years.

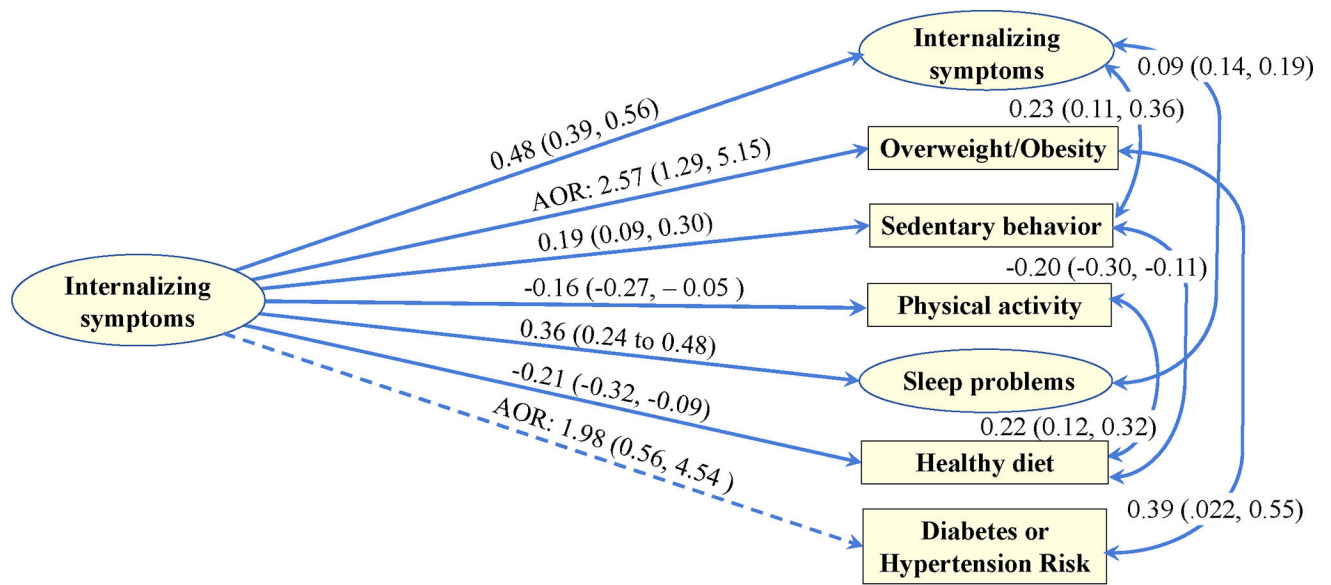


Figure 1. Associations between internalizing symptoms at ages 11–14 and health at ages 15–18

Notes: Standardized coefficients for continuous variables are β 's (95% CI) and for 0/1 variables are AOR's (95% CI).

Associations among variables at ages 15–18 represent within-time residual correlations. The model adjusts for adolescent gender, age, and nativity and for maternal education. Pathways for non-significant correlations among outcome variables are not retained in the final model. Table e4 includes model fit statistics and all unstandardized and standardized estimates for regression paths.

Table 1.Study Variables at baseline and follow up, N = 547^a

	Total
Baseline variables	
Male gender, No. (%)	244 (44.6)
US born, No. (%)	490 (89.6)
Age, mean (SD)	13.31 (0.97)
Maternal education, mean (SD)	3.18 (1.63)
Internalizing symptoms, mean (SD)	12.91 (10.92)
Follow-up variables ^a	
Internalizing symptoms, mean (SD)	17.85 (9.77)
Overweight or obesity, No. (%)	136 (39.7)
Hours for sedentary behavior, mean (SD)	5.88 (3.18)
Sleep problems, mean (SD)	5.25 (3.13)
Days of vigorous physical activity, mean (SD)	2.80 (2.53)
Healthy diet, mean (SD)	6.67 (3.92)
Diagnosis indicating hypertension or diabetes, No. (%)	53 (14.5)

^a. Descriptive statistics for follow-up variables derive from the subset of participants (n = 365) who participated at Time 9. FIML is used to address missing data in multivariate SEM.

Table 2.
Correlation Matrix of Study Variables, N = 547 (Bolded font indicates significant correlation)

	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	--											
2. Male gender ^a	-0.01	--										
3. US born ^b	-0.09 ^e	0.01	--									
4. Maternal education	-0.31 ^g	0.04	-0.01	--								
5. Baseline internalizing symptoms	0.13 ^f	-0.26 ^g	0.02	-0.7	--							
6. Follow-up internalizing symptoms	0.09	-0.31 ^g	-0.02	-0.04	0.53 ^g	--						
7. Overweight/obesity ^c	0.22 ^f	-0.06	0.03	-0.25 ^g	0.25 ^g	0.09	--					
8. Healthy diet	-0.07	-0.06	-0.02	0.05	-0.19 ^g	-0.14 ^e	-0.06	--				
9. Sleep problems	0.06	-0.19 ^f	0.03	-0.01	0.39 ^g	0.63 ^g	0.05	-0.15 ^f	--			
10. Sedentary behavior	0.01	-0.08	0.08	0.14 ^f	0.19 ^f	0.28 ^g	0.04	-0.22 ^g	0.07	--		
11. Physical activity	-0.14 ^f	0.21 ^g	-0.01	-0.03	-0.21 ^g	-0.21 ^g	-0.18 ^f	0.23 ^g	-0.05	-0.06	--	
12. Diabetes/hypertension risk ^d	0.05	0.07	0.11	-0.07	0.13	0.15	0.44 ^g	-0.07	0.18 ^e	-0.01	-0.04	--

Note: Bivariate correlations derive from parameter estimates in the measurement model of SEM.

^aReference group: female

^bReference group: foreign born

^cReference group: no overweight or obesity

^dReference group: no diabetes or hypertension risk

^ep < .05

^fp < .01

^gp < .001

Table 3.

Multivariate, Multivariable Structural Model Parameter Estimates: Adolescent Outcomes by Internalizing Symptoms at Baseline, N = 547^{abc}

Baseline variable	Adolescent Outcomes at Time of Follow-Up Survey																				
	Internal. symptoms ^d			Overweight/Obese			Sedentary beh. ^d			Physical activity			Sleep problems			Healthy diet			Diab./Hyp. risk ^d		
	B (SE)	β	95% CI	B (SE)	AOR	95% CI	B (SE)	β	95% CI	B (SE)	β	95% CI	B (SE)	β	95% CI	B (SE)	β	95% CI	B (SE)	AOR	95% CI
Internal. symptoms ^d	0.55 (0.07)	0.48	0.40, 0.57	0.61 (0.19)	2.73	1.44, 5.18	1.76 (0.49)	0.20	0.10, 0.31	-1.08 (0.43)	-0.16	-0.27, -0.04	0.84 (0.18)	0.40	0.29, 0.51	-2.38 (0.66)	-0.22	-0.34, -0.11	0.31 (0.24)	1.83	0.85, 3.94
Male gender ^e	-0.15 (0.04)	-0.18	-0.27, -0.08	--	--	--	--	--	--	0.80 (0.28)	0.16	0.06, 0.26	--	--	--	-0.95 (0.42)	-0.12	-0.22, -0.02	--	--	--
Age	--	--	--	0.17 (0.07)	1.30	1.02, 1.66	--	--	--	-0.30 (0.14)	-0.11	-0.21, -0.01	--	--	--	--	--	--	--	--	--
Mother $\geq$ high school ^f	--	--	--	-0.13 (0.04)	0.80	0.69, 0.92	0.27 (0.10)	0.14	0.04, 0.24	--	--	--	--	--	--	--	--	--	--	--	--

^aPath estimates for demographic variables only included if statistically significant. Although not shown in the Table, there were significant paths to baseline internalizing symptoms by (1) male gender: B(SE) = -0.21 (0.04), β =-0.28, 95% CI: -0.37, -0.19) and (2) adolescent age in years: B(SE) = 0.06(0.02), β =0.14, 95% CI: 0.05, 0.24).

^bB is the unstandardized estimate; SE is the β is the standardized beta coefficient. CI for B. and corresponding 95% CI provided for the five continuous outcome variables (internalizing symptoms, sedentary behavior; physical activity; sleep problems; healthy diet). AOR (adjusted odds ratios) and corresponding 95% CI provided for the two binary outcome variables (Overweight/Obese; Diabetes/Hypertension risk).

^cFit Statistics: CFI = 0.98; RMSEA = 0.018 (90% CI: .000, .031); chi-square = 1126.45, df = 136, p < .001.

^dAbbreviations: Internal. symptoms = Internalizing symptoms; Sedentary beh. = Sedentary behavior; Diab./Hyp. risk = Diabetes / Hypertension risk

^eReference group: Female

^fReference group: Mother < high school education