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John Mitchener Date

Associations of mood, stress, and social support with sleep health

By

John Mitchener

Degree to be Awarded: Master of Public Health

Epidemiology

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Dayna A. Johnson, PhD, MPH, MSW, MS

Committee Chair

Associations of mood, stress, and social support with sleep health

By

John Mitchener

Bachelor of Science
James Madison University
2020

Thesis Committee Chair: Dayna A. Johnson, PhD, MPH, MSW, MS

An Abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
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Abstract

By John Mitchener

Background: Depression, anxiety, stress, and sleep health problems are common among rural adolescents, and few studies have examined the relation and how it may vary by social support, a resilience factor. We investigated associations of mood and stress with self-reported sleep duration and daytime sleepiness and examined social support as an effect modifier of the prior association among adolescents in semi-rural Georgia.

Methods: We conducted a cross-sectional survey of adolescents living in semi-rural Georgia (N = 508) in November 2020. Participants self-reported depressive symptoms, anxiety severity, stress, sleep duration and daytime sleepiness. Linear and multinomial logistic regression models were fit to examine associations of mood or stress and sleep health outcomes adjusted for gender, race/ethnicity, socioeconomic status, physical activity, and caffeine use. Effect modification was tested by including an interaction term between mood or stress and social support on sleep health outcomes.

Results: Participants were 22%, 9%, and 6% Hispanic, Black, and Asian respectively, female (53%), and eligible for free or reduced lunch (66%). Mean sleep duration was 8.0 ± 1.36, with 42% of participants reporting short sleep duration (<8 hours), and mean daytime sleepiness was 5.17 ± 2.37. A unit increase in depressive symptoms, anxiety, and stress was associated with higher sleepiness scores, ($\beta = 0.16$, 95% CI 0.10, 0.22; $\beta = 0.44$, 95% CI 0.06, 0.83; $\beta = 2.26$, 95% CI 1.35, 3.17, respectively). Higher stress scores were associated with higher odds of short sleep (OR = 3.31, 95% CI 1.33, 8.27). Depression and anxiety were not associated with sleep duration. Evidence of effect modification by social support was not observed.

Conclusion: Mood and stress symptoms were associated with daytime sleepiness and stress was associated sleep duration in rural adolescents. While there was no evidence that social support buffered the associations between mood or stress with sleep duration or sleepiness, future studies should explore intervention strategies to reduce stress or enhance mood to improve sleep in adolescents.

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Introduction

Sleep is integral to health, and plays a fundamental role in mental and physical health (1). Sleep health is a multidimensional construct including but not limited to: sleep regularity, satisfaction, alertness, timing, efficiency, and sleep duration (2). Sleep consists of non-rapid eye-movement (NREM) and rapid-eye movement (REM) sleep, which are cyclical in nature (3). NREM precedes REM and consists of three stages. In NREM, the first two stages combined constitute approximately 47-60% of the sleep cycle, where brain activity begins to slow down during the transition from stage 1 to stage 2. Stages 3 of NREM sleep is referred to as "slow-wave sleep" which makes up approximately 13-23% of a sleep cycle (3). After NREM, REM takes place, where dreaming occurs, and memories are consolidated (3,4). During sleep, there are physiologic activities including changes in brain activity, heart rate, respiration, body temperature and muscle tone loss (3,4). An altered sleep-wake cycle is associated with a host of chronic conditions, including: heart and kidney disease, high blood pressure, diabetes, stroke, and obesity (5). A healthy sleep cycle includes optimal sleep duration. The National Sleep Foundation recommends adolescents aged 14-17 get 8-10 hours of sleep per night(6). According to Healthy People 2030, in 2017, the prevalence of adolescents who met this recommendation in the United States was only 25%, and the prevalence decreased to 22% of United States adolescents in 2019 (7). Research has shown that shorter sleep duration is associated with cognitive and affective deficits in adolescents, thus suggesting the urgent need to improve sleep among adolescents.

In order to reduce the adverse health consequences, it is important to identify modifiable determinants of insufficient sleep in the adolescent population. Depressive symptoms, anxiety, and stress are key indicators of mental health, and are important determinants of suboptimal sleep quality and short sleep duration (<8 hours). Depression occurs in approximately 13% of adolescents aged 12-17, and anxiety disorders occur in roughly 32% of adolescents aged 13-18 in the US (8). Previous studies have found that depression, anxiety, and perceived stress, are associated with sleep quality, through pathways involving

premature awakening and increased rumination (9). Therefore, mood and stress are likely important determinants of sleep health that warrant investigation among adolescents.

Depression, characterized by persistent negative affect, feelings of hopelessness or emptiness, is one of the leading causes of illness and disability in adolescents, and can alter daily activities such as the ability to work, eat, and/or sleep (10). Among a nationally representative sample of over 160,000 adolescents in the US, the prevalence of depression nearly doubled from 8.1% to 15.8% from 2009 to 2019 (11). Depressive symptoms have been identified as a risk factor for short sleep duration in the literature, however, studies have mostly been conducted in urban or lab-controlled settings. A randomized control trial study of Southern Australian high school students utilizing in-lab polysomnography and wrist actigraphy to control sleep duration, found that students who slept 5 hours a night were more irritable and depressed than those who slept 7.5 or more hours (12). There is a gap in the literature in regard to rural sleep health. Adolescents in rural settings may be at increased risk for adverse sleep health due to rural areas having less access to healthcare and mental health services (13). Other factors for adverse sleep health in rural populations include built environmental and other factors that contribute to comorbidities such as cardiovascular disease, diabetes, and obesity, which increases their risk for poor sleep (13,14). Compared to urban populations (5.2%), rural populations have higher prevalence of depression (6.1%) (15). This study will assess depression along with anxiety and stress symptoms on rural adolescent sleep and how social support potentially affects the associations.

Anxiety can be detrimental to not only one's mental health but also their sleep health (16). Symptoms such as excessive worry and fear are associated with short sleep duration, and research suggests the association is bidirectional (16).A study examining anxiety and sleep duration in Mexican American high schoolers reported that anxiety symptoms such as worrying were lowest in adolescents who slept 8.75-9 hours per school night (17). However, it was noted that as adolescents age and progress through school that their sleep duration became more restricted (17). Thus, it is important to identify and address anxiety

symptoms and issues earlier in life. Several studies have found that females had more difficulty initiating and maintaining sleep, and reported higher rates of insomnia(18,19). Ojio et al., determined the rate of anxiety in males was lowest between sleep duration of 8.5 and 9.5 hours and in females, was lowest between sleep duration of 7.5 and 8.5 hours (19). Another study found that adolescents who had short sleep duration were at twice the risk of developing anxiety disorders (20). This literature is limited in conducting studies in laboratory settings, which limit our understanding in the general population (18,20). We will address these gaps in the literature by understanding the effect of anxiety, depressive symptoms, and stress on sleep.

Stress is an emotional, physical, or mental response to an external source. Acute or chronic stress can affect one's wellbeing including cognition and behavior (21). Looking at sleep in the context of stress, a study of Hispanic and Black adolescent school-based health center patients found that 67% of the female participants experienced poor sleep quality, with 80% of patients reporting having experienced psychosocial stressors (22). Stress is especially pertinent to adolescents during the academic year. A study comparing stress during the academic year and vacation time found that students experienced higher levels of stress and shorter sleep duration during the school year(23). Some of the limitations in the literature include stress as the only exposure of interest, and, while some of the literature have studied stress in the school environment or in the context of the pandemic, other sleep aspects (ex. daytime sleepiness) were not measured.

Mood and stress are factors that impede adolescents from achieving healthy sleep. In order to mitigate the effects of mood and stress, it is important to understand potential modifying factors that may help to buffer this adverse association. According to the American Psychological Association, social support is the "provision of assistance or comfort to others, to help them cope with psychological and social stressors" (24). Studies have suggested social support has multiple beneficial effects, including reducing morbidity/mortality, and being protective against trauma, mental illness, and stress (25). In the context of sleep, social support may help to promote sleep health by providing an environment safe from enemies and threats, allowing adolescents to relax and sleep soundly (26). A study that looked at the association of family

on sleep duration suggested that social relationships and family dynamics are significant factors that influence adolescent sleep duration from day to day (27). Another study looking at the association between parental support on adolescent sleep with effect modification by family stress, found a null association between parental support and sleep when examined by itself (28). However, in the context of family stress, parental support was associated with longer sleep duration and less time spent awake at night, suggesting support helps create a stable and secure sleep environment for adolescents (28). The literature is limited in studies that include social support from the perspective of the parent as opposed to the student, and few studies have examined social support as a buffer for mood and stress on sleep.

Despite the increasing body of literature around mental health and sleep, there are a few limitations. The current literature features studies mainly conducted among homogeneous study populations where their results are limited in generalizability. Moreover, there are few studies that assess mental and sleep health in adolescents living in rural communities as compared to studies in urban or clinical settings. Social support has not been extensively examined as a potential modifier of the association between mood, stress, and sleep health in rural adolescents. It is important that we identify factors that can help to mitigate the harmful effects of mood and stress on sleep.

Among a racially-ethnically diverse sample of high schoolers in semi-rural Georgia, we 1) examined the association between mood (e.g., depression, anxiety) and stress, and sleep health outcomes including duration and daytime sleepiness; and 2) tested whether the prior associations varied by level of social support (Figure 1). We hypothesized that teenagers with lower vs. higher depressive symptoms, anxiety, or stress and higher vs. lower social support will have longer sleep duration and feel less sleepy during the daytime hours. Furthermore, we hypothesized that social support will modify the association between mood, stress, and sleep such that those with higher support will have reduced mood and stress symptoms, sleep the recommended duration, and be more awake during the daytime relative to those with less support. With the increasing public health focus on mental health of young people, it is crucial to investigate the association of

mood, stress, and social support on sleep as both are interrelated. It is critical to identify buffers of the effects of depression, anxiety, and stress on sleep to ensure that we can create proper intervention strategies to help reduce the impact of mood and stress on sleep.

Methods:

Data source:

This study uses data from the e*ffects of sleep on education and health outcomes among adolescents* study. The study was conducted in 2020 among two semi-rural high schools in Winder-Barrow County, Georgia. There were 1,133 10^{th} grade students were eligible to participate, of which 508 completed the survey. Exclusion criteria included students who had missing sleep health outcome information or were missing items from the mood and stress exposures due to differences in the amount of missing data by exposure (Figure 2). Due to the Covid-19 pandemic, study participants were recruited virtually and in-person for the survey in November 2020. IRB approval was obtained in 2019 for each study site, parental permission slips and student assent were utilized to acquire consent for all participants.

Exposure variables: Mood and stress

Depression, anxiety, and stress symptoms were measured by self-report. Depression was assessed from the Patient Health Questionnaire (PHQ-9) modified for adolescents (PHQ-A) depression assessment (29). Anxiety was assessed from the Generalized Anxiety Disorder – Child Age 11-17 (GAD-C) anxiety severity assessment (30). Stress was measured from the shortened version of the adolescent stress assessment, ASQ-S (31).

The PHQ-9 is a validated screening tool that utilizes DSM-IV criteria for major depressive disorder, and can be used to assess the severity of depressive symptoms among adolescents aged 11 to 17, with good internal reliability (Cronbach's $\alpha = 0.85$) (29,32). Participants were asked: "How often have you been bothered by each of the following symptoms during the past 7 days?", with items such as "feeling down,

depressed, irritable, or hopeless," and "little interest or pleasure in doing things,". The modified response scale included rating the symptoms on a scale of 0 to 4 [not at all (0), one day (1), several days (2), nearly every day or every day (3)]. The PHQ-A is a 9-item however, the item related to "thoughts that you would be better off dead, or of hurting yourself in some way," was omitted due to concerns from the schools participating in the study and removed at their request. Additionally, due to sleep being the outcome of the study, the item in the PHQ-9 related to sleep, "trouble falling or staying asleep, or sleeping too much," was removed before scoring the PHQ-9. Total depression scores were calculated as a sum of the seven remaining PHQ-9 items, with a final range of 0 to 21.

The GAD-C is a 10-item measure that assesses anxiety symptoms in adolescents using DSM-V criteria for generalized anxiety disorder. On the survey, participants were asked "During the past 7 days, I have…" with items such as "felt moments of sudden terror, fear, or fright," "felt anxious, worried, or nervous," "felt a racing heart, sweaty, trouble breathing, faint, or shaky," and rated their individual symptoms on a scale of 0 to 4 from [never (0), occasionally (1), half the time (2), most times (3), all times (4)] for each question. Responses were scored from 0 (never) to 4 (all times) and summed for a total range of 0 to 40. The sum of the 10 items of the anxiety scale for each participant were averaged and analyzed on a categorical 5-point scale according to GAD-C thresholds 0 (none) to 4 (extreme). Due to the distribution of participant scores, 'moderate' to 'extreme' categories were combined into one, and the categories were 0 to 2 [none (ref), mild, moderate to extreme].

The ASQ-S is a comprehensive 27-item assessment that measures how stressful adolescents feel in certain situations or experiences with a good internal reliability (Cronbach's $\alpha = 0.93$) (33). The assessment asks participants to "Please indicate how stressful you have found each of the following experiences or situations during the past 6 months," on a 5-point Likert scale ranging from 1 to 5 (not stressful, a little stressful, moderately stressful, quite stressful, very stressful). (33). The ASQ-S was modified to remove 2 items regarding disagreements between the adolescent and each parent (mother, father), resulting in 25 items,

and an N/A option was also added to the survey. Scores were coded 0 to 5, with ‘not stressful’ and ‘N/A’ grouped together, with a range of 25 to 125.

Effect measure modifier: social support

To measure social support participants completed the 4-item Social Support Scale, SSS. Social support was assessed by a response to the following question: “If you were having a serious problem at school, how much help do you think you would get from each of the following people?” with teachers, friends, classmates, and parents comprising the four items on the scale (34). The responses ranged on a scale of 1 (no help) to 5, (a lot of help). The total range of scores for social support was 4 to 20 and was dichotomized as ‘low’ or ‘high’ social support at the median score of 13, with those scoring less than or equal to 13 as ‘low’ and those scoring higher than 13 having ‘high’ social support.

Outcomes variables: Sleep health

Participants self-reported sleep duration in hours per day by reporting times as hours and minutes in intervals of 0, 15, 30, and 45 intervals, accompanied by am/pm for wake up and sleep time. Students were asked in separate questions for both weekdays and weekends “what time do you usually fall asleep,” and “what time do you usually wake up.” Sleep duration was averaged as a weighted variable by weekdays and weekends, in hours, and was then converted to total sleep time in minutes for analysis as a continuous outcome. Sleep duration was further grouped by hours according to existing sleep recommendations for adolescents: ‘short,’ (<8 hours), ‘recommended,’ (8-10 hours), and ‘long,’ (>10 hours).

Daytime sleepiness was assessed by a single question asking, “Please measure your sleepiness on a typical school day,” with scores ranging 0 to 10 from ‘never sleepy,’ to ‘extremely sleepy,’. Sleepiness was analyzed as a continuous variable.

Covariates

Sociodemographic characteristics were self-reported. Participants reported school, gender (male/female/nonbinary), race/ethnicity (Asian, Black, Hispanics, multiracial, White), eligibility for free or reduced lunch (yes/no), and regularly scheduled physical activity or organized sports (yes/no). Caffeine use per week was assessed by a question asking "During the past 7 days, how many times did you drink a cup, can, bottle, or glass of coffee, soda, energy drink, or any kind of caffeinated drink?" and was rated on a 0 (did not drink) to 6 (4 or more times per day) dose response scale. Dose response options ranged from: 0 'did not drink,' 1 '1-3 times per week,' 2 '3-6 times per week,' 3 '1 time per day,' 4 '2 times per day,' 5 '3 times per day,' 6 '4 or more times per day,'.

Statistical analysis

Data analysis was conducted using SAS 9.4 programming. For descriptive statistics of the sample, mean and standard deviations for continuous variables and percentages for categorical variables were reported in Table 1. T-tests and chi-square tests were conducted to test for differences in demographic characteristics by gender. To assess whether the exposure variables were correlated with each other, a Pearson correlation matrix was reported in Table 2. To examine the associations between mood, stress, social support, and sleep health outcomes, multiple linear and multinomial logistic models were fit. After assessment for normality, anxiety and stress were found to be right skewed, and were log-transformed for analysis. For linear and logistic regression, three models were used to test for associations: Model 1 was unadjusted; and Model 2 was adjusted for school, gender, race/ethnicity, free or reduced lunch, physical activity, and caffeine use. Table 3 are the crude and adjusted multiple linear regression models of mood, stress, or social support with continuous sleep outcomes. Table 4 displays the crude and adjusted odds of short and long sleep duration. To assess for effect modification, a product term between each mood or stress variable and dichotomous social support was in included in the fully adjusted model. Stratified associations were shown for significant p-interaction <0.10 associations.

Results:

Participants (n=254) with missing data for depressive, anxiety, stress, or sleep duration were excluded, yielding a final sample size of 254 (Figure 2). Selected participant characteristics are presented in Table 1. The study participants were racially/ethnically diverse: (55% White; 22% Hispanic; 9% Black; 8% Multiracial; 6% Asian respectively), majority female (53%), were eligible for free or reduced lunch (66%), did not engage in organized sports or regularly scheduled physical activity (59%), and drank caffeinated beverages less than 4 times a week (57%) (Table 1). Female participants engaged less in organized sports or regularly scheduled physical, and reported more depressive symptoms, anxiety, and stress compared to males (Table 1). Sleep duration and daytime sleepiness on average was 8 hours (SD 1.36) and 5.17 (SD 2.37), respectively. Short sleep duration was common, 42%. There was no difference in sleep duration or daytime sleepiness between males and females, [sleep duration (8.1 vs 8.0 hours) and daytime sleepiness (5.32 vs 5.0), respectively], (Table 1). Depressive, anxiety, and stress symptoms were moderately to highly correlated: depressive and anxiety 0.68; depressive and stress 0.77; anxiety and stress 0.67 (Table 2).

Associations between mood, stress, and social support with sleep health outcomes are reported in Table 3. There were no associations found between mood, stress, or social support with self-reported sleep duration in minutes. Depressive symptoms were associated with a higher daytime sleepiness score after adjusting for school, gender, race/ethnicity, free or reduced lunch, physical activity, and caffeine use (β = 0.16, 95% CI 0.10, 0.22) (Table 3). Anxiety was associated with a higher daytime sleepiness score after adjusting for covariates (β = 0.44, 95% CI 0.06, 0.83) (Table 3). Mild and moderate to extreme anxiety compared to no anxiety were associated with a 1.31-unit and 1.29-unit increase in daytime sleepiness after adjusting for covariates, β = 1.31, 95% CI 0.38, 2.24 and β = 1.29, 95% CI 0.31, 2.27, respectively. For a unit increase in social support, daytime sleepiness decreased by 0.17 units after adjusting for covariates (β = -

0.17, 95% CI -0.30, -0.05) (Table 3). When comparing low versus high support, those who had low social support were sleepier than those with high support (β = 1.03, 95% CI 0.27, 1.78) (Table 3).

Associations between mood, stress, and social support with short or long sleep duration are reported in Table 4. There was no association between anxiety or social support with short or long sleep compared to recommended. Higher reports of depressive symptoms were associated with a 6% and 9% higher odds of short sleep duration (OR = 1.06, 95% CI 1.02, 1.11) and long sleep duration (OR = 1.09, 95% CI 1.01, 1.17), respectively (Table 4). These associations did not persist with adjustment for sociodemographic and health behaviors. Adolescents who reported moderate to extreme anxiety symptoms compared to none, had a higher odds of long sleep duration (OR = 3.58, 95% CI 1.10, 11.64) (Table 4). The association did not remain significant after adjusting for covariates. As stress symptoms increased, there was a higher odds of short sleep duration (OR = 3.45, 95% CI 1.75, 6.79) (Table 4). This association persisted after adjusting for sociodemographic and health behaviors (OR = 3.31, 95% CI 1.33, 8.27) (Table 4). In addition, higher reports of stress symptoms were associated with almost 4 times higher odds of long sleep duration (OR 3.99, 95% CI 1.11, 14.26) (Table 4).

There was no evidence that social support modified the associations between depressive symptoms, stress, or anxiety and self-reported sleep health outcomes.

Supplementary analysis

In supplemental analyses, the dataset was restricted to participants with no missing data for social support data (n = 191). Gender differences for demographics, exposures, and outcomes were mostly consistent with Table 1, however, more female participants significantly reported yes for eligibility for free and reduced lunch compared to males (Supplemental Table 1). Overall, associations between mood, stress, and social support with daytime sleepiness scores were consistent with Table 3 (Supplemental Table 2). When assessing the odds of exposures on short or long versus recommended sleep, there were some notable differences. Associations between log-transformed stress on short sleep compared to recommended were

consistent with Table 4 (Supplemental Table 3). However, associations between depressive symptoms on odds of short sleep persisted after adjusting for covariates, unlike in Table 4. Additionally, the association of moderate to extreme anxiety on long compared to recommended sleep did not remain significant after restricting to only those with complete social support (Supplemental Table 3).

Discussion:

This study examined associations between mood, stress, and social support with self-reported sleep duration and daytime sleepiness in rural adolescents. Depressive, anxiety, and stress symptoms were associated with more sleepiness, and social support was associated with less sleepiness. Stress was associated with higher odds of short sleep duration after adjusting for covariates, but the confidence limits were larger and may be inflated due to the small sample size, so we must interpret with caution. Depressive, moderate to extreme anxiety, and stress symptoms were not associated with long sleep duration after adjustment for covariates. There was no evidence of effect modification by social support on the association between mood and stress with sleep health outcomes. These findings are important because adolescence is a dynamic phase of transition and growth as adolescents transition to adulthood. Biological changes during puberty affect adolescent sleep, such as the delay in circadian rhythm resulting in adolescents sleeping later at night (9). As adolescents navigate their changing sleep patterns, while trying to stay on top of the academic and social challenges that high school presents (e.g. homework, extracurriculars, late-night electronic device use), a consequence may be poorer sleep health (9). Daytime sleepiness and short sleep duration are associated with reduced academic performance and health outcomes. Therefore, targeting the determinants of poor sleep, such as reducing mood and stress symptoms, could improve quality of life of adolescents as they transition towards adulthood.

The findings between mood or stress and daytime sleepiness were consistent with the literature. For example, a cross-sectional study of adolescents found that adolescents with depression or anxiety reported more daytime sleepiness, 19% and 10% respectively compared to those with no depression or anxiety (35).

A three-wave study of adolescents in China utilizing cross-sectional surveys over two years found that depression at baseline predicted daytime sleepiness a year later (36). While we cannot assume temporality, our findings indicate an inverse association between depression and daytime sleepiness. There are plausible pathways connecting stress with daytime sleepiness. For example, a longitudinal study of Chinese adolescents suggested that an underlying mechanism for excessive daytime sleepiness is that psychosocial changes and stressors during adolescence result in increased daytime sleepiness (37). Future studies should explore the associations of mood or stress and daytime sleepiness using objective measures of sleepiness and include a larger sample size and a longitudinal data collection method.

Studies on social support have indicated that support may be beneficial for sleep health, which our study found mixed results. Social support was only associated with daytime sleepiness but not sleep duration. Potential reasons for why this may have been the case is perhaps due to factors that we did not collect or consider for our analysis. For example, the scale we utilized for social support asked about troubles in school, and where adolescents were likely to look for help. Due to the vague nature of the question, it is unclear what this may refer to. Another possibility may be that teenagers who had support were likely reporting time in bed and not actual sleep, which could result in sleepiness if they are not actually sleeping.

Some of the observed findings in the current study were inconsistent with the literature. For example, a study in North Carolina using 7 hours as the cutoff for short vs recommended sleep duration found 40% of rural high schoolers had short sleep duration, and short sleep duration was associated with higher depressive symptoms compared to recommended (38). When compared to our study which uses 8 hours as the cutoff for recommended sleep, there was no association between depression and self-reported short sleep duration in our study after adjusting for covariates. Thus, very short sleep duration may be more relevant than short sleep as used in the present study. Additionally, the North Carolina study assessed suicidal ideation, a depressive symptom we omitted from our study. Another study that had inconsistent findings with the present study assessed sleep duration and depression in rural communities. The prior study participants had

overall elevated levels of depressive symptoms, 17%, and higher depressive scores were more prevalent among those with short (26%) or long sleep (24%) compared to recommended sleep (12%) (39). Our study found elevated mean depressive symptoms in our sample but did not find associations between depression and short or long sleep. The prior study differed from our study due to being conducted among rural adults compared to the current study among adolescents, and utilized an older version of the Patient Health Questionnaire, the PHQ-2, which only assessed two depressive symptoms.

Our study deviates from the literature in regard to mood, stress and social support being associated with sleep duration. A study of adolescents from urban Singaporeon and international high schools (N = 2346) found that the prevalence of depressive symptoms was over 2-fold higher in adolescents with short sleep duration (40). This study differed from our study findings likely due to differences in how short sleep was defined, (<7 hours) the prevalence of short sleep (62%), and potential cultural differences that may contribute to depression (40). Data from the Fragile Families Study (N = 517) suggested social support and positive experiences such as adolescents getting along with their parents or siblings resulted in increased sleep duration between 26 and 45 minutes longer on average when compared to adolescents with no such experiences (41). The prior study used objective sleep duration, whereas our study included self-reported sleep, which is weakly correlated with objective sleep and can yield different results.

This study contributes to the existing sleep literature by examining rural adolescents' mood and stress symptoms on self-reported sleep duration and daytime sleepiness and whether social support modifies the association between mood or stress with sleep health outcomes. It is important to consider various aspects of mood and stress because psychological health contributes to sleep health through different pathways. For example, the ASQ-S assesses different dimensions of stress, such as home life, stress of teacher interaction or school performance, that may affect sleep health differently than depression or anxiety (33). Our findings suggest that depressive, anxiety, and stress symptoms were highly correlated with each other. However, these exposures represent different domains of psychological health; mood from stress, and our findings

indicate that depressive, anxiety, and stress are relevant to sleep health. Therefore, mood and stress are likely targets for interventions in future studies.

Our study did not find that the association between mood and stress variables on short or long sleep duration varied by level of social support. This null finding of interaction by social support may be due to several potential underlying reasons: only 192 of our study participants had complete social support, reducing study power to detect an association; or perhaps only specific aspects of social support such as parental support or friendship modify the association and that association may be masked due to using an aggregated measure. Future studies should examine social support or other resilient factors that may modify the effects of mood and stress on sleep by incorporating larger sample sizes, objective sleep measures, and unaltered validated mood and stress surveys.

Strengths:

Our study has several notable strengths. We recruited a racially/ethnically diverse sample of adolescents in the southern United States, a region of the country well-known for excluding certain racial/ethnic groups in research. This study focused on rural adolescents' health; an area of research generally understudied. Our study utilized validated scales for assessing depressive, anxiety, and stress symptoms, which increases validity. Additionally, some studies on mood, stress, and sleep duration have been conducted in lab settings, whereas our study was conducted in the real world. Our study utilizes adolescent-reported perceptions of social support, whereas the existing literature has utilized parental-reported social support. Our study includes not just sleep duration but also daytime sleepiness, which allows us to assess more than just one dimension of sleep health.

Limitations:

There are some important limitations in our study. As a cross-sectional study design, we cannot infer causality or temporality. We cannot assess whether the associations between exposures and sleep health

outcomes are bidirectional or not. Additionally, as our study investigated associations among rural adolescents in Georgia, which is not generalizable to other parts of the country. This analysis was restricted to self-reported sleep. Due to the subjective nature of using self-reported sleep data, there is potential bias of under or overestimating sleep duration and daytime sleepiness. Additionally, alterations were made to the depression and stress surveys, which may reduce the reliability of these instruments. The relatively small analytic sample size limits our study power and may lead to inaccurate associations. Other potential confounding factors, such as student grade point average (GPA), having a medical diagnosis for mental health conditions, sleep hygiene, or factors such as neighborhood noise and safety that relate to the built environment, that we did not adjust for in our analysis may affect whether our associations are true and valid. Residual confounding is also another limitation for our study.

Conclusion:

Mood and stress symptoms were associated with increased daytime sleepiness scores, and social support was associated with a decrease in sleepiness. Stress symptoms were associated with higher odds of short sleep duration after adjusting for covariates. Future studies should address our limitations by utilizing a prospective study design to assess for temporality, as well as utilize objective sleep measure instruments such as watch actigraphy as opposed to self-reported sleep. Rural adolescent health is an area in research that warrants further investigation, and our study findings indicate that mood, stress, and social support may be targets for reducing sleepiness, which may help to improve subsequent health outcomes. It is important to investigate and work towards implementing viable interventions among rural adolescents.

References: Tables and Figures

Figure 1. Basic conceptual framework for the association of mood and stress, with sleep outcomes.

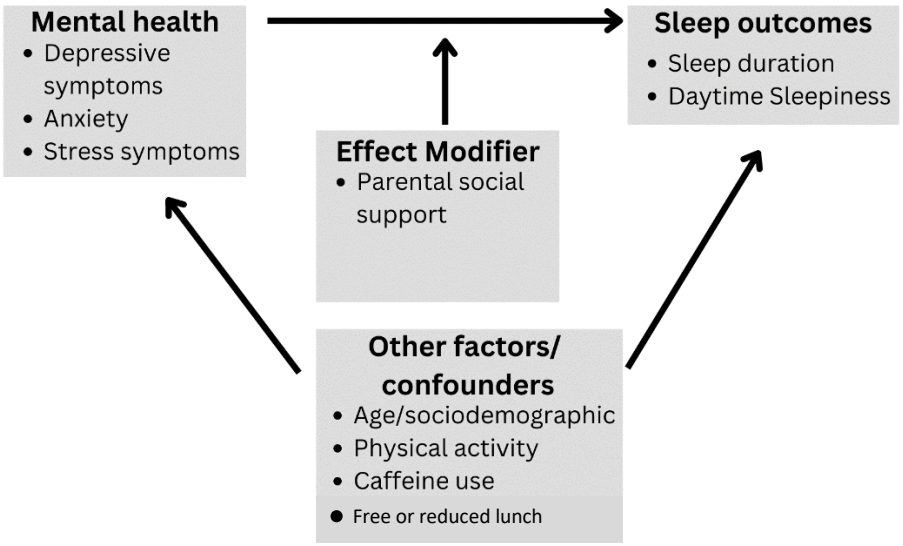

Figure 2. Participation and exclusion criteria to identify analytic sample.

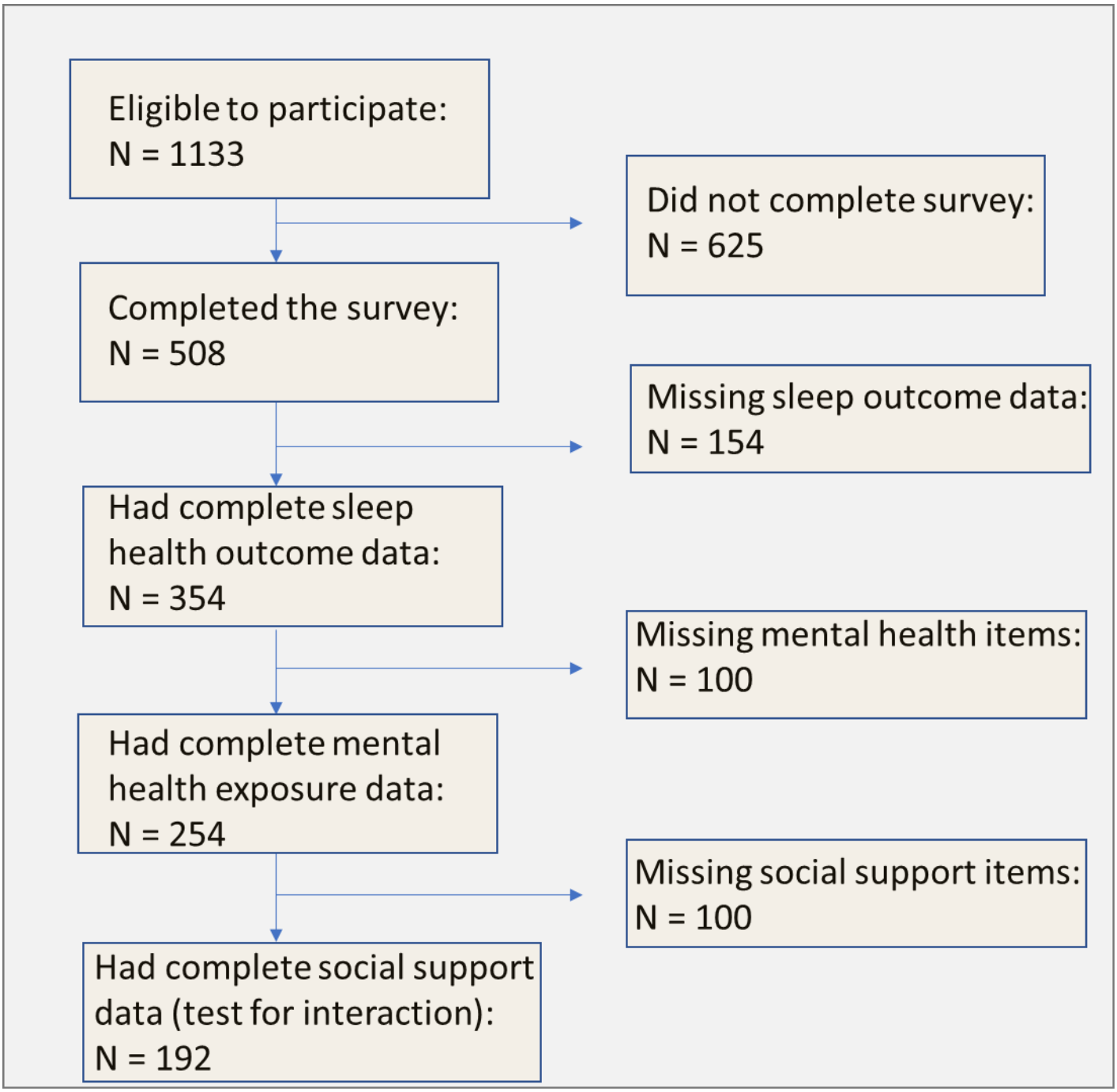

Table 1. Selected participant sleep characteristics and prevalence of depressive, anxiety, and stress symptoms by gender among 10th grade students (N = 254).

	Total sample	**Female**	**Male**	**Non-Binary**	**P value**
Proportion % (N)	**100%**	**53%**	**45%**	**2%**	
Characteristics					
School (%)					**0.79**
School A	67%	67%	66%	75%	
School B	33%	33%	34%	25%	
Race/Ethnicity (%)					**0.51**
Asian	6%	6%	6%	-	
Black	9%	11%	5%	25%	
Hispanic	22%	24%	20%	-	
Multiracial	8%	8%	9%	-	
White	55%	50%	60%	75%	
Free or reduced lunch (%)*					**0.06**
Yes	66%	73%	59%	33%	
No	34%	27%	41%	67%	
Engage in organized sports or regularly scheduled physical activity, (%)					**<0.01**
Yes	41%	33%	51%	50%	
No	59%	67%	49%	50%	
Number of caffeinated drinks per week, (%)					**0.05**
Never	16%	18%	14%	25%	
1-3 times per week	41%	46%	34%	50%	
4 to 6 times per week	15%	14%	18%	-	
1 time per day	8%	7%	9%	-	
2 times per day	12%	7%	18%	-	
3 times per day	6%	5%	5%	25%	
4 or more times per day	3%	3%	3%	-	
Depressive symptoms (PHQ-A), mean ± SD	**8.70 ± 6.52**	**10.65 ± 6.45**	**6.01 ± 5.48**	**18.5 ± 2.89**	**<0.01**
Anxiety symptoms (GAD), mean ± SD	**9.20 ± 9.44**	**11.86 ± 9.76**	**5.48 ± 7.28**	**25.00 ± 9.49**	**<0.01**
Anxiety symptoms (GAD), (%)					**< 0.01**
None	58%	45%	75%	-	

Mild	25%	32%	18%	25%	
Moderate to Extreme	17%	23%	7%	75%	
Stress symptoms (ASQ), Mean ± SD	**50.00 ± 20.43**	**55.53 ± 20.48**	**42.41 ± 16.83**	**80.50 ± 31.33**	**<0.01**
Social support (SSS), mean ± SD*	**13.27 ± 3.44**	**13.13 ± 3.40**	**13.50 ± 3.43**	**10.67 ± 5.51**	**0.46**
Low	63%	64%	61%	75%	
High	37%	36%	39%	25%	
Self-reported sleep duration (hours), mean ± SD	**8.04 ± 1.36**	**8.10 ± 1.35**	**8.00 ± 1.39**	**7.70 ± 1.49**	**0.57**
Self-reported sleep duration (hours), (%)					**0.28**
Short (<8 hours)	42%	41%	43%	50%	
Recommended (8-10 hours)	51%	50%	53%	50%	
Long (>10 hours)	7%	10%	4%	-	
Sleepiness on a typical school day, mean ± SD	**5.17 ± 2.37**	**5.32 ± 2.11**	**5.00 ± 2.60**	**4.50 ± 3.87**	**0.30**

***missing data**

Note: 1 person did not report gender

SD = standard deviation; PHQ-A = Patient health questionnaire for adolescents; GAD = Generalized anxiety disorder scale; ASQ = Adolescent stress questionnaire; SSS = Social support scale

Table 2. Pearson correlation matrix for depression, anxiety, and stress exposures (N = 254).

	1	2	3
1. Depression	1.00		
2. Stress	0.77*	1.00	
3. Anxiety	0.68*	0.67*	1.00

* results indicate statistical significance $p < 0.01$

Table 3. Unadjusted and adjusted multiple linear regression models examining mood, stress, and social support with self-reported sleep duration and sleepiness (N = 254).

	Sleep duration (min)				Daytime sleepiness			
	Model 1		Model 2		Model 1		Model 2	
Exposures	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Depression	-1.09	(-2.65, 0.46)	-0.27	(-2.47, 1.93)	0.12*	(0.08, 0.17)	0.16*	(0.10, 0.22)
Anxiety								
Continuous	0.51	(-10.67, 11.68)	8.08	(-6.71, 22.86)	0.44*	(0.14, 0.73)	0.44*	(0.06, 0.83)
Mild	-4.69	(-28.82, 19.43)	-2.16	(-35.29, 30.98)	1.00*	(0.31, 1.68)	1.31*	(0.38, 2.24)
Moderate to Extreme	-1.21	(-29.54, 27.12)	20.67	(-14.16, 55.51)	1.04*	(0.24, 1.85)	1.29*	(0.31, 2.27)
None	Ref		Ref		Ref		Ref	
Stress	-21.88	(-47.06, 3.30)	-20.46	(-53.98, 13.07)	1.83*	(1.13, 2.53)	2.26*	(1.35, 3.17)
Social support (continuous)	-1.11	(-4.33, 2.11)	0.63	(-3.52, 4.79)	-0.15*	(-0.24, -0.05)	-0.17*	(-0.30, -0.05)
Social support (low compared to high)	-8.48	(-29.42, 12.46)	-20.62	(-47.14, 5.90)	0.30*	(0.28, 1.47)	1.03*	(0.27, 1.78)

Model 1: Unadjusted

Model 2: Adjusted for school, gender, race/ethnicity, free or reduced lunch, physical activity, caffeine use

* results indicate statistical significance $p < 0.01$

Table 4. Odds of short or long sleep duration and mood, stress, and social support (N = 254).

	Short vs recommended sleep duration				Long vs recommended sleep duration			
	Model 1		Model 2		Model 1		Model 2	
Exposures	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Depression	1.06**	(1.02, 1.11)	1.05	(0.99, 1.11)	1.09*	(1.01, 1.17)	1.10	(0.99, 1.22)
Anxiety								
Continuous	1.13	(0.86, 1.49)	0.93	(0.65, 1.33)	1.45	(0.83, 2.54)	1.60	(0.76, 3.34)
None	Ref		Ref		Ref		Ref	
Mild	1.35	(0.74, 2.47)	1.66	(0.69, 3.95)	1.31	(0.37, 4.65)	4.07	(0.83, 19.95)
Moderate to Extreme	1.56	(0.75, 3.26)	1.03	(0.40, 2.62)	3.58*	(1.10, 11.64)	3.78	(0.83, 17.25)
Stress	3.45**	(1.75, 6.79)	3.31**	(1.33, 8.27)	3.99*	(1.11, 14.26)	5.43	(0.99, 29.68)
Social support (continuous)	0.96	(0.88, 1.05)	0.92	(0.82, 1.04)	0.9	(0.77, 1.06)	0.94	(0.78, 1.14)
Social support (low compared to high)	1.29	(0.76, 2.20)	1.79	(0.87, 3.68)	0.82	(0.30, 2.21)	0.43	(0.12, 1.58)

Model 1: Unadjusted

Model 2: Adjusted for school, gender, race/ethnicity, free or reduced lunch, physical activity, caffeine use

* results indicate statistical significance $p < 0.05$

** results indicate statistical significance $p < 0.01$

Sleep duration compared with recommended sleep defined as 8-10 hours (ref). Short sleep was defined as < 8 hours, long sleep was defined as > 10 hours.

Supplemental Table 1. Selected participant sleep characteristics and prevalence of depressive, anxiety, and stress symptoms by gender among 10th grade students for only those with complete social support (N = 191).

	Total sample	**Female**	**Male**	**Non-Binary**
Proportion % (N)	**100%**	**53%**	**45%**	**2%**
Characteristics				
School (%)				
School A	66%	68%	64%	67%
School B	34%	32%	36%	33%
Race/Ethnicity (%)				
Asian	6%	7%	6%	-
Black	7%	9%	5%	33%
Hispanic	21%	25%	17%	-
Multiracial	7%	7%	8%	-
White	58%	53%	64%	67%
Free or reduced lunch (%)*				
Yes	66%	76%	56%	50%
No	34%	24%	44%	50%
Engage in organized sports or regularly scheduled physical activity, (%)				
Yes	41%	33%	49%	67%
No	59%	67%	51%	33%
Number of caffeinated drinks per week, (%)				
Never	16%	18%	14%	-
1-3 times per week	41%	47%	33%	67%

4 to 6 times per week	17%	15%	20%	-
1 time per day	8%	6%	10%	-
2 times per day	12%	8%	17%	-
3 times per day	4%	4%	2%	33%
4 or more times per day	3%	3%	3%	-
Depressive symptoms (PHQ-A), mean ± SD	**8.60 ± 6.35**	**10.52 ± 6.46**	**5.95 ± 5.10**	**17.67 ± 2.89**
Anxiety symptoms (GAD), mean ± SD	**9.25 ± 9.50**	**12.09 ± 10.02**	**5.38 ± 7.03**	**23.00 ± 10.54**
Anxiety symptoms (GAD), (%)				
None	58%	44%	76%	-
Mild	27%	32%	20%	33%
Moderate to Extreme	16%	24%	5%	67%
Stress symptoms (ASQ), Mean ± SD	49.11 ± 20.14	55.40 ± 20.21	40.84 ± 16.12	**73.67 ± 34.53**
Social support (SSS), mean ± SD	**13.27 ± 3.44**	**13.13 ± 3.40**	**13.50 ± 3.43**	**10.67 ± 5.51**
Low	51%	53%	48%	67%
High	49%	47%	52%	33%
Self-reported sleep duration (hours), mean ± SD	**8.13 ± 1.29**	**8.21 ± 1.29**	**8.09 ± 1.29**	**7.26 ± 1.48**
Self-reported sleep duration (hours), (%)				
Short (<8 hours)	39%	35%	43%	67%
Recommended (8-10 hours)	53%	55%	51%	33%
Long (>10 hours)	8%	10%	6%	-
Sleepiness on a typical school day, mean ± SD	**5.13 ± 2.35**	**5.30 ± 2.07**	**4.91 ± 2.58**	**5.00 ± 4.58**

***missing data**

Note: 1 person did not report gender

SD = standard deviation; PHQ-A = Patient health questionnaire for adolescents; GAD = Generalized anxiety disorder scale; ASQ = Adolescent stress questionnaire; SSS = Social support scale

Supplemental Table 2. Unadjusted and adjusted multiple linear regression models examining mood, stress, and social support with self-reported sleep duration and sleepiness after restriction to those with social support (N = 191).

	Sleep duration (min)				Daytime sleepiness			
	Model 1		Model 2		Model 1		Model 2	
Exposures	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Depression	-1.38	(-3.11, 0.36)	-1.38	(-3.85, 1.10)	0.14*	(0.09, 0.18)	0.20*	(0.13, 0.27)
Anxiety								
Continuous	0.74	(-11.49, 12.98)	8.39	(-9.16, 25.93)	0.55*	(0.22, 0.88)	0.64*	(0.15, 1.12)
Mild	-6.49	(-32.33, 19.35)	4.71	(-33.02, 42.43)	1.16*	(0.40, 1.92)	1.54*	(0.41, 2.68)
Moderate to Extreme	-13.62	(-45.25, 18.01)	2.94	(-37.91, 43.79)	1.09*	(0.16, 2.02)	1.42*	(0.19, 2.65)
None	Ref		Ref		Ref		Ref	
Stress	-24.61	(-52.29, 3.07)	-24.72	(-61.58, 12.14)	1.57*	(0.76, 2.39)	2.26*	(1.17, 3.35)
Social support (continuous)	-1.11	(-4.33, 2.11)	0.63	(-3.52, 4.79)	-0.15*	(-0.24, -0.05)	-0.17*	(-0.30, -0.05)
Social support (low compared to high)	-0.39	-22.54, 21.77	-8.68	(-37.62, 20.26)	1.01*	0.35, 1.66	1.22*	(0.33, 2.10)

Model 1: Unadjusted

Model 2: Adjusted for school, gender, race/ethnicity, free or reduced lunch, physical activity, caffeine use

* results indicate statistical significance $p < 0.01$

Supplemental Table 3. Odds of short or long sleep duration and mood, stress, and social support after restriction to those with social support (N = 191).

	Short vs recommended sleep duration				Long vs recommended sleep duration			
	Model 1		Model 2		Model 1		Model 2	
Exposures	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Depression	1.07**	(1.02, 1.13)	1.10**	(1.02, 1.18)	1.09*	(1.00, 1.19)	1.13	(1.00, 1.27)
Anxiety								
Continuous	1.09	(0.80, 1.49)	0.86	(0.55, 1.36)	1.28	(0.71, 2.31)	1.37	(0.62, 3.02)
None	Ref		Ref		Ref		Ref	
Mild	1.5	(0.76, 3.02)	2.02	(0.69, 5.92)	1.46	(0.39, 5.44)	5.05	(0.93, 27.43)
Moderate to Extreme	1.9	(0.80, 4.56)	1.59	(0.48, 5.26)	3.05	(0.77, 12.05)	3.84	(0.69, 21.23)
Stress	3.55**	(1.61, 7.86)	3.90**	(1.28, 11.87)	3.43	(0.85, 13.91)	4.15	(0.69, 25.02)
Social support (continuous)	0.96	(0.88, 1.05)	0.93	(0.82, 1.04)	0.9	(0.77, 1.06)	0.94	(0.78, 1.14)
Social support (low compared to high)	1.13	(0.63, 2.06)	1.52	(0.67, 3.47)	0.89	(0.30, 2.65)	0.62	(0.15, 2.53)

Model 1: Unadjusted

Model 2: Adjusted for school, gender, race/ethnicity, free or reduced lunch, physical activity, caffeine use

* results indicate statistical significance $p < 0.05$

** results indicate statistical significance $p < 0.01$

Sleep duration compared with recommended sleep defined as 8-10 hours (ref). Short sleep was defined as < 8 hours, long sleep was defined as > 10 hours.

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