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"Trajectory of Sleep Duration in College Students – A longitudinal analysis utilizing a multi-level modeling approach"

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“Trajectory of Sleep Duration in College Students – A longitudinal analysis utilizing a multi-level modeling approach”

By

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B.S, University of Missouri – Kansas City, 2019

An abstract of a thesis submitted to the
Department of Behavioral, Social, and Health Education Sciences
Rollins School of Public Health
in partial fulfillment of the requirements of the degree of
Master of Public Health

Abstract

"Trajectory of Sleep Duration in College Students – A longitudinal analysis utilizing a multi-level modeling approach"

By Robert Wright

Objective: This study aimed to understand the general trend of reported sleep duration over time in college students and how the trend was affected by gender, and social media usage, as well as. time-varying physical activity and depression. **Methods:** This is a secondary data analysis using a sample of 3418 college students who participated in 2-year longitudinal cohort study. Multi-level longitudinal modelling was conducted using participant data from 4 waves of data over the years of 2015 – 2016 of data collection. **Results:** Reported sleep duration decreased ($p < 0.001$) over time. Gender's effect on sleep was not significant but daily social media use showed higher sleep durations ($p=0.03$). Time-varying physical activity had no significant effect but, time-varying depression was significantly associated with lower sleep duration $p<0.001$).
Conclusions: Reported sleep duration reduction over time with noticeable differences between individuals who regularly use social media and with those reporting higher levels of depression.

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Behavioral, Social, and Health Education Sciences 2022

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Chapter 1

Introduction

Rationale

Sleep in general and more specifically sleep duration is an integral part of health and well-being. It is recognized that sleep deprivation is associated with adverse health implications (Centers for Disease Control and Prevention [CDC], 2017). In conjunction with other health risks, sleep deprivation often has drastic impacts on daily functioning and quality of life (Grandner, 2017). Unfortunately, the college student population consistently reports levels of sleep that are grossly insufficient for optimal health. Poor sleep within college students is linked to hypertension, insulin resistance, weight gain, stress, motor vehicle accidents and can impair cognitive functioning, thus affecting academic performance (Owens et al., 2017).

Knowledge of sleeping durations and factors associated with sleep can help health care providers and public health professionals understand what resources are needed to address the issue. In particular, there is a need to explore further biological, physical, and behavioral factors associated with sleep in college students to develop appropriate evidence-based recommendations regarding improving sleep duration in this population. This information is also needed to inform interventions.

Background

There is an urgent need to understand sleep durations and the factors that facilitate or limit sleep within the college student population. A plethora of cross-sectional studies has examined this, each with shortfalls that preclude causation, which limit the ability to address mechanisms leading to poor sleep (W.-L. Chen & Chen, 2019; Hershner & Chervin, 2014; Markwald et al., 2013; Pilcher et al., 2021; Touitou et al., 2016). Most rely on a single wave of data, which does

not allow for understanding changes over time. This can be problematic, as college students' experiences and behaviors change over time regarding sleep duration, mental health (depression), and physical activity frequency. Further, all of these factors could be affected by social media use, which is widely prevalent in today's college students (Alonzo et al., 2021; Shimoga et al., 2019). Failure to examine these factors can result in missing critical pieces that can help with building a deeper understanding of sleep patterns.

Studies examining whether there are sex differences in sleep outcomes among college students are mixed. Some studies have found female college student reporting more sleep problems than males (Cheng et al., 2012; Kenney et al., 2012), while other studies did not find differences (Choueiry et al., 2016; Gilbert & Weaver, 2010; Sing & Wong, 2010). This could be due to how the studies conceptualized and measured sleep problems such as some studies measuring different domains of sleep issues. Evidence has shown that females may have poorer sleep than males in the specific domains of sleep duration and sleep quality although findings differed from each other due to which sleep variables were of interest (Choueiry et al., 2016; Galambos et al., 2011; Kenney et al., 2012; Sing & Wong, 2010).

Numerous factors can affect the sleeping durations of college students. College students' behaviors, such as physical activity levels, could contribute to sleep inconsistencies. For instance, in a sample of college students from a mid-size university in Ontario measured sleep and moderate physical activity using the Borg Rating of Perceived Exertion scale and found moderate physical activity indirectly predicted higher sleep quality in college students through emotional regulation; while another study in adults from Boston found that sleep quality and duration were higher on days where the participants were more active by increasing the amount of steps they took that day (Semplonius & Willoughby, 2018; Sullivan Bisson et al., 2019).

However, other studies in college students found that physical activity levels did not significantly impact sleep duration, although it still affected other domains of sleep (Mead et al., 2019; Pilcher et al., 2021). Given the lack of broad consensus in findings, there is a need for further evidence to confirm or deny the association between physical activity and sleep in college students (Cahuas et al., 2020; Ghrouz et al., 2019; Semplonius & Willoughby, 2018).

Mental health factors such as depression contribute to lower quality sleep sessions (Alonzo et al., 2021; Beiter et al., 2015; Li et al., 2020). This is of concern because traditional college students tend to have a much higher prevalence of depression at around 30% when compared to the general adult population at 8.4% or young adults (ages 18-25) generally at 17% (Ibrahim et al., 2013; National Institute of Mental Health, 2021). Also, among students who report issues with depression, anywhere from 10%-50% tend to report problems with sleeping such as sleep duration, quality, and inconsistency (Beiter et al., 2015; Ghrouz et al., 2019; Nyer et al., 2013). Females report higher levels of depression in the general population and within college students, which is important to highlight since they now represent a majority of college students (Becker et al., 2018; Cahuas et al., 2020). The impact of depression on sleeping behaviors generally tends to show that higher levels of depression lead to reduced sleep durations and quality in college students. It is therefore critical to understand the role depression contribute to sleep in college students given its prevalence in this population.

In addition to physical activity and depression, the widespread use of social media and its potential impact on sleep quality is also worth exploring. Most young adults (96%) between the ages of 18-29 report owing media devices and also report their varying usage of social media, with nearly half reporting it to be “almost constant,” according to Pew Research (Perrin & Atske, 2021; Pew Research Center, 2021). The constant stimulation of social media combined with the

specific media devices used can disrupt biological processes involving light, leading to delayed time going to bed (S. Liu et al., 2019; Touitou et al., 2016). While a delay in bedtime might mean later wake-up times, most college students' schedules may require consistent wake up times or waking early regardless of their bedtime. This could consistently contribute to sleep deprivation since social media use is a daily routine for most young people, including college students. Social media is relatively new but its ubiquitous usage through media devices in college students has the potential to exacerbate sleep deprivation further in this population.

Longitudinal studies exploring how sleep duration and physical activity, sleep duration and depression, or sleep duration and social media all predict adverse sleep outcomes but either lack generalizable populations or weaker study methods (S. Liu et al., 2019; Rod et al., 2018; Semplonius & Willoughby, 2018). The immediate effects of lower quality sleep durations could impact academic performance, stress, and overall cognitive performance (Hershner & Chervin, 2014; W.-L. Chen & Chen, 2019; Touitou et al., 2016; Owens et al., 2017). Long-term sleep deprivation could increase the risk of hypertension, increased glucose and insulin resistance, and safety consequences such as delayed reaction times when driving (AlShareef, 2021; Centers for Disease Control and Prevention [CDC], 2017; Grandner, 2017; Hershner & Chervin, 2014). Undoubtedly, sleep and its impact on daily functioning and long-term health matters for this population.

Purpose/Research Question

The primary aim of this study is to examine the trajectory of sleep duration over time in college students. A secondary aim is to investigate how depression and moderate physical activity change over time along with sleep. A third aim is to understand whether gender and social media use potentially affect sleep duration outcomes. To explore these aims, a secondary

data analysis using data from 2-year longitudinal mixed-methods Project DECOY (Documenting Experiences with Cigarettes and Other Tobacco in Young Adults) was conducted to explore behavioral trends. Data collection was performed with self-report surveys at baseline and every four months. This secondary data analysis of Project DECOY data focused on the following research questions:

1. What is the trajectory of self-reported sleep duration over one year in college students?
2. Do college students' gender and social media usage impact their sleep duration?
3. How do changes in depression and self-reported moderate physical activity levels alter a college student's sleep duration trajectory?

Chapter 2

Literature Review

Sleep duration and why this is of interest

Sleep plays a vital role in sound health and well-being throughout life. Quality and duration of sleep can help protect one's mental health, physical health, quality of life, and safety (Centers for Disease Control and Prevention [CDC], 2017; Grandner, 2017; Hudson et al., 2020; Phillips & Sagberg, 2013). Conversely, a lack of sleep can produce the opposite effect for health. Obtaining less than the recommended amount of sleep over time leads to sleep deprivation which falls under the broader concept of sleep deficiency. Sleep deprivation is defined by the National Institutes of Health as not getting enough sleep per day/night (National Heart Lung and Blood Institute, 2021). Sleep deficiency could mean lack of sleep, sleeping during the wrong time of day, sleep disorders, and not getting enough of either deep or R.E.M sleep (National Heart Lung and Blood Institute, 2021). For health and well-being, it is recommended that adults aged 18 to 64 years old sleep at least seven to nine hours during a 24-hour period/day. In a national surveillance study conducted by the CDC in conjunction with local/state health departments and reported in the Behavioral Risk Factor Surveillance System (BRFSS), it was found that one-third of US adults, or 86 million, report regularly getting less than the recommended amount of sleep each day (Y. Liu, 2016). When examining by age group 26% of those 65 years and older report less than seven hours of sleep, 34% - 39% report less than seven hours of sleep for those ages 25-64, and 32% of those aged 18-24 report getting less than seven hours of sleep regularly (Centers for Disease Control and Prevention [CDC], 2017). When broken down by region the Southeastern United States and Appalachian Mountains regions were among the lowest quintile of respondents who reported getting at least 7 hours of sleep ranging from 56.1 % - 62.1% and

great plains states had the highest prevalence of healthy sleep durations by geographical clustering ranging from 68.8% to 71.6% (Y. Liu, 2016). There are disparities in healthy sleep durations in different groups and populations as well. Age-adjusted prevalence of healthy sleep duration was lower among non-Hispanic/Latinx blacks, multiracial non-Hispanics/Latinx, Native Hawaiians/Pacific Islanders, and American Indians/Alaska Natives with the groups ranging from 53.6% to 59.6% (Koinis-Mitchell et al., 2019; Y. Liu, 2016). That is compared to non-Hispanic/Latinx white, Hispanics/Latinx, and Asians who reported healthy sleep durations of 66.8%, 65.5% and 62.5% respectively (Koinis-Mitchell et al., 2019; Y. Liu, 2016). Individuals who reported being employed also reported higher levels of healthy sleep duration at 64.9% when compared to those reporting they are unemployed or unable to work with healthy sleep duration ranging from 51.0% to 60.2% highlighting the potential effects of employment on sleep duration (Y. Liu, 2016). When broken down by marital status, married couples had a 71% reporting prevalence of healthy sleep duration when compared to those that are divorced, widowed, or separated at 55% and never married at 62% (Y. Liu, 2016). Finally, those who reported that they possessed a college degree or higher had a high healthy sleep duration with 71.5%. Populations reporting lower levels of healthy sleep duration tend to have higher distributions of obesity, mental health issues such as depression and anxiety, and higher levels of other chronic illnesses (Grandner, 2017; Y. Liu, 2016). Sleep deficiency can also negatively affects attention and brain function, over-consumption of foods, circadian rhythm function, and safety across different groups from adolescents to older adults (Fatima et al., 2015; Hudson et al., 2020; Markwald et al., 2013). These findings highlight the impact of sleep deprivation on different groups, the scope of its reach, and consequences of sleep deprivation and the need to understand what factors may be attributable to lower reported levels of sleep in individuals.

Sleep in the college student population

Sleep deprivation and low sleep duration is an impediment for attaining optimal physical and mental health. Adolescents (11-17 years old) and especially young adults (18-24 years old) fail to get adequate amounts of sleep which stem from poor sleep hygiene and sleep behaviors (Becker et al., 2018; Owens et al., 2017). This is also true for traditional-aged college students who balance work, academic, and social responsibilities. In a large cross-sectional study of 7,626 college students in schools from different geographic regions of the U.S., 36% reported getting less than seven hours of sleep per night which is comparable to the one-third of U.S. adults that report not getting enough sleep daily (Becker et al., 2018; Centers for Disease Control and Prevention [CDC], 2017). There is also data showing the trend of reported sleep problems increasing in college students from 2010 through 2018 from 22% to 30% (Sivertsen et al., 2019). This could be recognized as traditional college students taking advantage of newfound independence that comes with attending college to forgo sleep to improve their work commitments and social engagements. Long-term health risk to college students include chronic diseases such as diabetes, heart disease, depression, and obesity, which have all been linked to sleep deficiency (W.-L. Chen & Chen, 2019; Grandner, 2017; Hershner & Chervin, 2014; Kang et al., 2012; Taylor & Bramoweth, 2010). Safety is of concern as fatal and non-fatal injuries in college students have strong links to sleep insufficiency. Of all traffic incidents caused by sleepiness, 55% were caused by those under the age of 25 with the majority being those around the age of 20 (Owens et al., 2017; Taylor & Bramoweth, 2010). Neurocognitive effects of sleep insufficiency are also well documented. When functioning in a sleep-deprived state working memory, processing speed, cognitive throughput, and executive functioning all decline which

makes paying attention, flexible thinking, and self-control difficult (J. Chen et al., 2017; W.-L. Chen & Chen, 2019; Grandner, 2017; Taylor & Bramoweth, 2010). College students who are getting enough sleep typically have fewer negative effects and have higher academic achievement. For example, a longitudinal study with 3549 college students using mixed effects models exploring sleep deprivation and GPA and college graduation shown that getting adequate sleep improves chances of getting/maintaining a higher GPA and improves chances of graduating on time (J. Chen et al., 2017). Similarly, a randomized control trial of 3755 participants found that improving sleep in college students improved multiple aspects of mental health including a decrease in depression scores and increases in well-being (Freeman et al., 2017).

Physical activity, sleep, and college students

Physical activity is shown to be inversely associated with many chronic health problems including the chronic health risk posed by sleep deficiency. Higher levels of physical activity are associated with lower levels of mental health problems such as depression, which have a high prevalence in college students (Bailey et al., 2018; Cahuas et al., 2020; Ghrouz et al., 2019). However, studies differ on the effect by gender with one study showing no effect in women (Cahuas et al., 2020; Ghrouz et al., 2019). A cross-sectional study with 386 college students exploring sleep and physical activity found longer sleep durations predicted lower BMI levels, which could aid in risk reduction of morbidities associated with sleep and weight (Pilcher et al., 2021). However, some studies found that there is no direct relationship between physical activity and sleep duration on the same day (Krietsch et al., 2019; Mead et al., 2019). Other studies point to there being a strong relationship between physical activity and sleep quality, but a weaker or

absent relationship for sleep duration (Brauer et al., 2019; Sullivan Bisson et al., 2019). A longitudinal study using cross-lagged modeling found indirect relationships for physical activity and sleep over time through emotional regulation only (Semplonius & Willoughby, 2018). While the literature is consistent that both adequate sleep and physical activity are important for health in college students, inconsistency in the findings and lack of longitudinal and experimental designs suggest that the relationship warrants further investigation.

Social Media use and sleep and college students

Social media use is ubiquitous in daily life among all populations but especially young adults. Eighty-four percent of young adults (18-29) report using some form of social media which is higher than the 72% for the total adult population (Pew Research Center, 2021). Also, around 60% of adults report using social media daily with 48% of young adults reporting they are online almost constantly (Perrin & Atske, 2021; Pew Research Center, 2021). As social media use frequency has risen, so have researchers' interest in the effects this could have on health and health behaviors. Of such concerns is the interplay and relationship between social media use and sleep health, particularly in college students as they are typically the demographic with the highest usage. Frequent social media use has been linked to behaviors that lead to shorter sleep duration and lower sleep quality (Alonzo et al., 2021; Carter et al., 2016; Touitou et al., 2016). Among studies done in the U.S., China, and across Europe, frequent social media use was consistently found to be significantly associated with poor sleep quality (Kang et al., 2012; Li et al., 2020; Touitou et al., 2016). For example, a cross-sectional study of 150 college students from a liberal arts college found that high smartphone use was found to contribute to poor sleep health and depression outcomes at statistically and clinically significant levels (Volungis et al., 2020).

Since most college students reported using social media almost constantly, their media device use throughout the day and especially at night leads to increased stimulation of the reticular activating system by light thus preventing normal biological functions from taking place and disrupting the mechanisms for inducing sleep (Alonzo et al., 2021; S. Liu et al., 2019; Touitou et al., 2016). This was also explored in a 4-week multi-wave study using objective smartphone tracking measures in a sample of 815 college students. That study showed that high frequency smart phone use leads to increased use at night correlated with increase sleep disturbances in 41% of participants causing reductions sleep duration (Rod et al., 2018). The previous study also found college students with disrupted sleep had 48 minutes shorter self-reported sleep duration and higher BMI; however, no differences in physical or mental health symptoms were found, which differs from than other studies finding relationships to mental health. Increases in media use alone have detrimental effects on mental health by showing increases in depression and anxiety which compound the effects of insufficient sleep with college students (Carter et al., 2016; Li et al., 2020; Touitou et al., 2016).

Depression, sleep, and college students

Poor sleep health outcomes have also been associated with depression status. Seven out of 10 adults in the U.S. report feeling moderate stress and anxiety daily (Beiter et al., 2015; Nyer et al., 2013). When it comes to depression, 17.3 million U.S. adults over the age of 18 experienced at least one major depressive episode within the year with women reporting experiencing depression and depressive symptoms more often (National Institute of Mental Health, 2021). These trends are observed at a slightly higher rate in college students. The prevalence of depression in college students in the U.S. is around 30% (Ibrahim et al., 2013). College students

that were depressed or reported psychological distress also reported sleeping problems (Becerra et al., 2020; Beiter et al., 2015). Studies show that for students reporting mental health issues such as depression, anxiety, and repetitive negative thinking, sleep problems ranged from 10% to 50% (Ghrouz et al., 2019; Nyer et al., 2013). Also, a cross-sectional study done in 374 college students examining correlates for mental health concerns including depression, found that students concerned with the ongoing quality of their sleep also reported higher levels of depression (Beiter et al., 2015). This illustrates that depression and depression symptoms contribute to sleep problems, which in turn leads to more stress and concern about sleep health in students, which further exacerbate problems with sleep ultimately ensuring a cycle of sleep deprivation. A systematic review synthesizing the literature on sleep, depression, self-harm/suicidal thoughts found that poor sleep in college students is associated with increased risk of suicide and self-harm (Russell et al., 2019). The rates of depression seem to differ by sex with women reporting higher levels of depression when compared to men in college students which mirrors depression reports from general population samples (Becker et al., 2018; Cahuas et al., 2020). This nuance is important to consider given that women tend to outnumber men in traditional college settings (National Center for Education Statistics, 2021). Overall depression is related to poor sleep outcomes such which hampers quality of life in college students. Determinants such as environment, living situation, and socioeconomic status may mediate associations between depression and sleep outcomes in college students. Findings such as these support the idea of discrimination acting as a stressor that can disrupt healthy sleep duration and quality. Shared living spaces while going to college and living on or off-campus can play a role in sleep (Beiter et al., 2015). A systematic review reported that students find some on campus and off-campus environmental unconducive to sleep in and had higher reports of sleep

disturbances (Owens et al., 2017). These factors all highlight the different social influences acting on college students which influence and potentially harm their sleep and overall health.

Given the evidence explored in this review showing both short- and long-term consequences to college students quality of life and mental health there is a clear and present need to explore factors associated with poor sleep outcomes in college students. While a bevy of cross-sectional studies have examined the aforementioned factors and their impact on sleep, a longitudinal approach for understanding how these trends hold up over time would expand understanding of the impact on college students throughout their college careers. Improving on the design of previous longitudinal designs, the current study will use multiple college campuses including technical, public, and private colleges in Georgia, to explore sleep duration and the impact of different factors while strengthening representativeness and generalizability to the broader U.S college population (S. Liu et al., 2019; Semplonius & Willoughby, 2018). Finally, acknowledging the high prevalence of social media use, especially in the college student population, and the dearth of longitudinal literature on the topic, is essential to advancing our understanding of these factors. This study hypothesizes that the sleep deprivation or less than seven hours of sleep will be associated with various behaviors such as physical activity and social media use and the mental health factor of depression. In this study, I aim to explore and determine the trajectory of reported sleep durations in college students. The second aim is to determine the differences in trajectory by gender. Lastly, I aim to understand the effects of depression and physical activity on reported sleep duration.

Chapter 3

Student Contribution

The current study is a secondary analysis of data from Project DECOY which was approved by the Emory University and ICF International Institutional Review Boards as well as those of the participating colleges. Project DECOY was a longitudinal panel study consisting of 3418 college students between ages 18-25 from seven colleges in Georgia. A more detailed breakdown of Project DECOY was published in a previous paper (Berg et al., 2016). Data collected for Project DECOY began in the Fall of 2014 with follow-up surveys and assessments done every four months for two years totaling in 6 waves of data. The current study will examine data from the third through sixth waves.

Measures

The Project DECOY study collected a wide range of data on factors such as sociodemographics, tobacco and other substance use behaviors, psychosocial factors (e.g., depressive symptoms), weight related behaviors (e.g., physical activity), sleep and, social media use. This secondary analysis will focus on sleep duration as the key variable with depressive symptoms, physical activity, sex, and social media use. These variables are described in more detail below.

Sleep

Sleep was assessed at baseline and follow-up waves of the study by asking participants to report on average how much sleep they were getting within 24 hours. Participants only reported full hours of sleep. Long sleepers or sleep episodes lasting longer than 10 hours were excluded from the analysis. While it could be related to factors in the research question, different functions garner and facilitate longer sleep durations (Grandner & Drummond, 2007).

Depression

Depression was assessed using the PHQ-9 scale. The PHQ-9 is a 9-item self-report questionnaire which have participants rate how they felt over the previous two weeks. Each question was scored 0 to 3 (0 = not at all, 1 = several days, 2 = more than half the days and 3 = nearly every day) with a total results range of 0 to 27.

Physical Activity

Participants were asked about their physical activity during the past week at baseline and follow-up waves. Self-reported assessments of moderate physical activity were reported from questions “During the past seven days, on how many of those days did you do moderate-intensity cardio or aerobic exercise for at least 30 minutes?”, “During the past seven days, on how many of those days did you do, vigorous-intensity cardio or aerobic exercise for at least 20 minutes?”, and “During the past seven days, on how many of those days did you do 8-10 strength training exercises such as resistance training for 8-12 repetitions?”. The variable coding was the days of physical activity reported for the past week per each participant.

Social Media Use

Participants' were asked about their social media use frequency. Participants were asked the following, “How often do you use social media?”. The responses were recorded with a Likert scale with answers choices of “Never”, “Rarely, maybe once a week”, “Sometimes, maybe two or three times a week”, “Often, every day”, “More than once a day”, and “Almost hourly”. Social media use was dichotomized into daily users and non-daily users of social media.

Data Analysis

The data were analyzed using R version 4.0.5 statistical software. Univariate analyses examined descriptive statistics for frequencies, means, and standard deviations. Further, multi-

level growth curve modeling approach was used to analyze the longitudinal data in the form of longitudinal growth modeling (LGM). The LGM assessed trajectory in reported sleep duration as the outcome over time. Time-invariant predictors included gender and social media. Finally, time-varying predictors of depression and moderate physical activity were added. Growth changes were modeled by using multilevel statistical methods (Strenio et al., 1983) and R programming language package lme4. The shape of each linear growth curve was estimated by using 2-level models. The basic modeling started with an unconditional means model followed by a unconditional growth model with fixed and random parts. The fixed part of each model describes average growth for reported sleep duration; the random part partitions variation between subjects reported sleep durations. The models allow a unique growth curve to be derived for each subject based on his or her deviation from the average curve. Maximum likelihood estimation was used to estimate the model parameters.

Modeling

An unconditional means and growth model were ran initially as is the norm for modeling change over time. First, we added the time-invariant predictors gender and social media use. Next, we fitted models in which individual change is discontinuous. This means the linear trajectory has a shift in the elevation and/or slope. To fit a model with discontinuous change we need to "include one (or more) time-varying predictor(s) that specify whether and, if so, when each person experiences the hypothesized shift. This also in part justifies why time-varying covariates of depression and moderate physical activity were included. So, the final model included sleep duration as the outcome with wave, depression, and physical activity as time varying predictors at level 1 and gender and social media use as our time invariant predictors at

level 2. The model assumes at level 1 residuals normally distributed with a mean of zero and an unknown variance.

Model building

Model 1: Means model

Level 1: $Y_{ij} = B_{0i} + e_{ij}$

Level 2: $B_{0i} = \gamma_{00} + u_{0i}$

Composite: $Y_{ij} = \gamma_{00} + (e_{ij} + u_{0i})$

Model 2: Growth model

Level 1: $Y_{ij} = B_{0i} + B_{1i}Wave_{ij} + e_{ij}$

Level 2: $B_{0i} = \gamma_{00} + u_{0i}$

$B_{1i} = \gamma_{10} + u_{1i}$

Composite: $[Y_{ij} = \gamma_{00} + \gamma_{10}Wave_{ij}] + [(e_{ij} + u_{0i} + u_{1i}Wave_{ij})]$

Final model: Time invariant gender and social media use predictors with time varying depression and physical activity

Level 1: $Y_{ij} = B_{0i} + B_{1i}Wave_{ij} + B_{2i}DeprScore_{ij} + B_{3i}PA_{ij} + e_{ij}$

Level 2: $B_{0i} = \gamma_{00} + \gamma_{01}Gen_i + \gamma_{02}SMRoften_i + U_{0i}$

$B_{1i} = \gamma_{10} + u_{1i}$

$B_{2i} = \gamma_{20}$

Level 2: $B_{3i} = \gamma_{30}$

Composite: $[Y_{ij} = \gamma_{00} + \gamma_{01}Gen_i + \gamma_{02}SMRoften_i + \gamma_{10}Wave_{ij} + \gamma_{20}DeprScore_{ij} + \gamma_{30}PA_{ij}] + [(e_{ij} + u_{0i} + u_{1i}Wave_{ij})]$

Intended journal

The journal intended for first submission is the Journal of American College Health.

Chapter 4

Exploring factors associated with the trajectory of reported sleep duration in college students

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Exploring factors associated with the trajectory of reported sleep duration in college students

Abstract of 150 words. Objective, Participants, Methods, Results, and Conclusions.

Objective: This study aimed to understand the general trend of reported sleep duration over time in college students and how the trend was affected by gender, and social media usage, as well as. time-varying physical activity and depression. **Methods:** This is a secondary data analysis using a sample of 3418 college students who participated in 2-year longitudinal cohort study. Multi-level longitudinal modelling was conducted using participant data from 4 waves of data over the years of 2015 – 2016 of data collection. **Results:** Reported sleep duration decreased ($p < 0.001$) over time. Gender's effect on sleep was not significant but daily social media use showed higher sleep durations ($p=0.03$). Time-varying physical activity had no significant effect but, time-varying depression was significantly associated with lower sleep duration $p<0.001$). **Conclusions:** Reported sleep duration reduction over time with noticeable differences between individuals who regularly use social media and with those reporting higher levels of depression.

Keywords: sleep duration; social media; physical activity; depression; college students

Introduction

Sleep plays a vital role in sound health and well-being throughout life. Quality and duration of sleep can help protect one's mental health, physical health and quality of life. [1] Conversely, a lack of sleep can produce the opposite effect for health. Lack of sleep or sleep deprivation is associated with higher prevalence of obesity, mental health issues such as depression and anxiety, and higher levels of other chronic illnesses. [2,3] Sleep deficiency can also negatively affect attention and brain function, over-consumption of foods, circadian rhythm function, and safety across different groups from adolescents to older adults. [4–6]

For younger age groups, sleep deprivation and low sleep duration has been extensively documented. Due to a multitude of innate and environmental factors, older adolescents (11-19 years old) and young adults (18-24 years old) are particularly vulnerable to sleep deprivation, and as a consequence, have reduced sleep quality and sleep duration. [7,8] This is also true for traditional-aged college students who balance work, academic, and social responsibilities. In a large cross-sectional study of 7,626 college students across the U.S., 36% report getting less than seven hours of sleep per night which is comparable to the one-third of U.S. adults who report not getting enough sleep daily. [1,8] Further, reported sleep problems have been trending upward in college students, increasing from 22% to 30% during 2010 through 2018. [9] This could be recognized as traditional college students taking advantage of newfound independence that comes with attending college to forgo sleep to for work commitments and social or academic engagements. Long-term health risk to college students includes chronic diseases such as diabetes, heart disease, depression, and obesity, which have all been linked to sleep deficiency. [3,10–13] Multiple factors have been examined that may affect sleep outcomes which include physical activity, social media use, depression, and sociodemographic factors. [1,10,14–17]

The literature shows mixed results for the relationship between physical activity and sleep. For instance a 6-day study conducted in college students found that over the period that their levels of physical activity did not significantly predict sleep duration for that night. [18] In a randomized crossover study observing the effects of physical activity before bed and sleep found that in young healthy adults there was practically no real difference in sleep duration but some difference in sleep efficiency.[19] Other studies have also found no direct relationship between physical activity in a day and sleep duration the same day. [18,20] Other studies point to there being a strong relationship between physical activity and sleep quality, but a weaker or absent

relationship for sleep duration. [16,21] A longitudinal study using cross-lagged modeling found indirect relationships for physical activity and sleep over time through emotional regulation only. [22] Meta-analysis show most studies point to physical activity having a positive effect on sleep outcomes along with most individuals reporting they have better sleep quality and duration on days when they exercised. [23,24] While the literature is consistent that both adequate sleep and physical activity are important for health in college students, inconsistency in the findings and relationship warrants further investigation.

Social media use is ubiquitous in daily life among college students. Eight-four percent of young adults (18-29) report using some form of social media which is higher than the 72% for the total adult population. [25] Also, around 60% of adults report using social media daily with 48% of young adults reporting they are online almost constantly. [25,26] As social media use frequency has risen in daily life, so too has its impact on health. The relationship between frequent social media use and sleep health, particularly in college students has been linked to behaviors that lead to shorter sleep duration and lower sleep quality. [14,27,28] Among studies done in the U.S., China, and across Europe, frequent social media use was consistently found significantly associated with poor sleep quality. [13,28,29] For example a cross-sectional study of 150 college students from a liberal arts college found that high smartphone use was found to contribute to poor sleep health and depression outcomes at statistical and clinically significant levels. [30] Since most college students reported using social media almost constantly, their media device use throughout the day and especially at night may lead to increased stimulation of the reticular activating system by light thus preventing normal biological functions from taking place disrupting the mechanisms for inducing sleep. [14,28,31] This was also explored in a 4 week multi-wave study using objective smartphone tracking measures in a sample of 815 college students

showing that high frequency smart phone use leading to increase use at night correlated with increase sleep disturbances in 41% of participants causing reductions sleep duration. [32] Increases in media use alone have detrimental effects on mental health by showing increases in depression and anxiety which compound the effects of insufficient sleep with college students. [27–29]

Poor sleep health outcomes have also been associated with depression status in college students. The prevalence of depression in college students in the U.S. is around 30%. [33] College students that were depressed or reported psychological distress also reported sleeping problems. [15,34] Studies show that for students reporting mental health issues such as depression, their problems with sleeping ranged from 10% to 50%. [35,36] Also, a cross-sectional study done in 374 college students examining correlates for mental health concerns including depression, found that student concerned with the ongoing quality of their sleep also reported higher levels of depression. [34] This could be illustrating that depression and depression symptoms contribute to sleep problems, which in turn causes more stress and concern about sleep health in students, which further exacerbate problems with sleep. A systematic review synthesizing the literature on sleep, depression, self-harm/suicidal thoughts found that poor sleep in college students is associated with increase suicide and self-harm. [37] Overall depression is related to poor sleep outcomes such which hampers quality of life in college students.

Given the evidence there is a clear need to explore factors associated with poor sleep outcomes in college students. While a bevy of cross-sectional studies have examined the aforementioned factors and their impact on sleep, a longitudinal approach for understanding how these trends hold up over time would expand understanding within the college student population. Improving on the design of previous longitudinal designs this study will use multiple college campuses including technical, public, private colleges in Georgia, to explore sleep

duration and the impact of different factors while strengthening representativeness and generalizability to broader U.S college population. [22,31] Finally, acknowledging the high prevalence of social media use, especially in the college student population, and the dearth of longitudinal literature on the topic, this study plans to incorporate it. This study hypothesized that sleep deprivation or less than seven hours of sleep will be associated with various behaviors such as physical activity and social media use and the mental health factor of depression. Therefore, the purposes of this study were to: 1) explore the trajectory of reported sleep duration in college students; 2) examine differences in sleep trajectory by gender and social media use; and 3) examine effects of depression and physical activity on reported sleep duration over time.

Methods

Design

This is a secondary analysis of data from Project DECOY. Project DECOY was a longitudinal panel study consisting of 3418 college students between ages 18-25 from seven colleges in Georgia. A more detailed breakdown of Project DECOY has been published elsewhere. [38] Data collected for Project DECOY began in the Fall of 2014 with follow-up surveys and assessments done every four months for two years totaling in 6 waves of data. The current study will examine the third through sixth waves.

Measures

Sociodemographic

A wide range of sociodemographic data during baseline was collected. The sociodemographic variables used in this study include gender.

Sleep

Sleep was assessed at baseline and follow-up waves of the study by asking participants to report on average how much sleep they were getting within 24 hours. Participants only reported full

hours of sleep. Long sleepers or sleep episodes lasting longer than 10 hours were excluded from the analysis because different functions garner and facilitate longer sleep durations.[39]

Depression

Depression was assessed using all nine items from the PHQ-9 scale. The PHQ-9 is a 9-item self-report questionnaire in which participants' rate how they felt over the previous two weeks to screen for depression severity. Each question is scored 0 to 3 (0 = not at all, 1 = several days, 2 = more than half the days and 3 = nearly every day) with a total results range of 0 to 27.

Physical Activity

Participants were asked about their physical activity during the past week at baseline and follow-up waves. Self-reported assessments of moderate physical activity were reported from questions "During the past seven days, on how many of those days did you do moderate-intensity cardio or aerobic exercise for at least 30 minutes?". The variable was coded as the days of physical activity reported for the past week per each participant.

Social Media Use

Participants were asked the following, "How often do you use social media?". The responses were recorded with a Likert scale with answers choices of "Never", "Rarely, maybe once a week", "Sometimes, maybe two or three times a week", "Often, every day", "More than once a day", and "Almost hourly". Social media use was dichotomized into daily users and non-daily users of social media.

Data Analysis

The data were analyzed using R version 4.0.5 statistical software. Univariate analyses examined descriptive statistics for frequencies, means, and standard deviations. Missing data and patterns in missing data were assessed using weighting and imputation methods accordingly. Further,

multi-level growth curve modeling approach was used to analyze the longitudinal data in the form of longitudinal growth modeling (LGM). The LGM assessed trajectory in reported sleep duration as the outcome over time. Time-invariant predictors including gender and social media. Finally, time-varying predictors of depression and moderate physical activity will be added. Growth changes were modeled by using multilevel statistical methods [40] and R programming language package lme4. The shape of each growth curve was estimated by using 2-level models. The basic modeling started with an unconditional means model followed by a unconditional growth model with fixed and random parts. The fixed part of each model describes average growth for reported sleep duration; the random part partitions variation between subjects reported sleep durations. The models allow a unique growth curve to be derived for each subject based on his or her deviation from the average curve. Maximum likelihood estimation was used to estimate the model parameters. Final model equation is shown below.

Composite: $[Y_{ij} = \gamma_{00} + \gamma_{01}Gen_i + \gamma_{02}SMRoften_i + \gamma_{10}Wave_{ij} + \gamma_{20}DeprScore_{ij} + \gamma_{30}PA_{ij}]$
$+ [(e_{ij} + u_{0i} + u_{1i}Wave_{ij})]$

Results

Sociodemographic characteristics of the study sample are shown in Table 1. Table 2. shows daily social media usage with 79.5% (N=2259) reporting they use social media daily. Table 3, Table 4, and Table 5 show average sleep duration per wave, average depression score per wave, and average days spent during the last week engage in moderate physical activity per wave, respectively. Average reported sleep duration for waves 3 through wave 6 were 7.26 (SD=1.32), 7.14 (SD=1.29), 7.00 (SD=1.29), and 7.23 (SD=1.26). Average depression score for waves 3 through 6 were 4.53 (SD=4.99), 5.28 (SD=5.39), 5.36 (SD=5.64), and 4.14 (SD=4.99). Average

moderate physical activity per waves 3 through 6 were 2.61 (SD=2.20), 2.08 (SD=2.00), 2.58 (SD=2.08), and 2.48 (SD=2.06).

[Table 1 goes here]

Growth curve modeling

Unconditional and conditional models

Based on the intraclass correlation coefficient, 42% of the total variation in reported sleep durations is attributable to differences among college students rather than changes over time within college students. The unconditional growth model has an intercept of 7.21 with a change over time of -0.03 (-0.05 - -0.02) over time with the slope being significant. The estimated within-person variance decreased by about 5% from the unconditional means model, implying that 5% of within-individual variability in reported sleep duration can be explained by a linear increase over time. Table 2 shows the results and significance of the unconditional and conditional models.

[Table 6 goes here]

Conditional growth model

After the unconditional growth model, the final model was estimated. The estimated initial reported sleep duration was 7.19 ($p<0.001$) for male college students who reported non-daily use of social media, controlling for depression and moderate physical activity. Average change in reported sleep duration over time is -0.04 ($p<0.001$) for male college students after controlling for social media use, depression, and moderate physical activity. College students reporting daily social media use is associated with a 0.11 ($p<0.05$) increase in estimated reported sleep duration score after controlling for gender, depression, and moderate physical activity. Depression levels

for college students is associated with a -0.03 ($p<0.001$) decrease in estimated reported sleep duration, after controlling for gender, social media use, and moderate physical activity. College students reporting higher levels of moderate physical activity saw no difference in their estimated reported sleep duration when controlling for gender, social media use, and symptomatic depression.

[Table 7 goes here]

Discussion

This study was an examination of how sleep duration changes over time in college students and how factors may alter that sleep time in general and over time. Our findings demonstrate that insufficient sleep duration and factors affecting it documented in cross-sectional studies are also present in a longitudinal design for college students. Mean reported sleep duration times in college students was approximately 7 hours which is adequate for the sample but there was a lot of variation for time.

Changes in sleep over time in this sample were found to be statistically significant with the trend showing some loss in sleep over time. Sleep duration between the genders was not found to be statistically significant. Surprisingly, those reporting daily usage of social media use had a higher sleep duration. When looking at time-varying predictors, depression had a significant impact in reducing reported sleep duration. Physical activity, which was assessed at each wave and thus modelled as time-varying, was not shown to have a significant impact on sleep duration.

When looking at college students we found in the sample that 28%, 32%, 34% and 27% for waves 1-4 respectively, reported getting less than 7 hours of sleep. This is somewhat higher

at some waves than other research showing anywhere from 22%-30% of college students getting less than adequate sleep. [9] This provides more evidence that lack of sleep is a consistent issue in college students. This potentially puts this group at risk of short-term impacts of sleep deprivation. Everyday activities such as driving and focusing can be affected by lack of sleep. For example, up to 30% of motor-vehicle-related incidents can be attributed to sleepiness with a 33% increase in the risk of a car accident for those getting 6 hours of sleep compared to 7-8 hours of sleep. [41–43] Also, when controlling for other factors, it was found that being young, male, and reporting 5-6 hours of sleep or having a sleep-related disorder was the most likely group to be in an accident. [42,43] Of all traffic incidents caused by sleepiness, 55% were caused by those under the age of 25 with the majority being those around the age of 20. [7,12] There are also consequences that have a more direct impact on college students' academic success. When functioning in a sleep-deprived state, working memory, processing speed, cognitive throughput, and executive functioning all decline which makes paying attention, flexible thinking, and self-control difficult. [3,11,12,44] Maintaining normal levels of sleep can affect academic performance for college students. For example, a longitudinal study with 3549 college students using mixed and random effects models exploring sleep deprivation and GPA and college graduation showed that adequate sleep improves chances of getting/maintaining a higher GPA and improves chances of graduating on time. [44] Similarly, a randomized control trial of 3755 college students found that improving sleep enhanced multiple aspects of mental health including a decrease in depression scores and increases in well-being. [45]

Physical activity's role in reported sleep duration was shown to have no significant impact on sleep duration outcomes. This is also consistent with the literature reporting that physical activity has little to no impact on sleep outcomes in cross-sectional studies. [18,20] This

could be due in part to the average amount of days a participant does physical activity per week or month. For this study, college students reported an average of about 2-3 days of physical activity in the past week over each wave of the study. Also, it could speak to the role that physical activity plays along with sleep. While reported sleep durations are weakly effected, sleep quality is usually reported to be significantly associated with physical activity that day, with deeper sleep typically being reported. [16,21] The extended deep sleep phase which is hypothesize to be when the body repairs tissue make help one feel more rested without significantly changing the overall sleep duration. [46]

Seventy-four percent of males and 84% of females within the sample reported daily usage of social media. This is consistent with percentages seen in other studies, including Pew Research data on the matter. [25,47] For college students reporting they used social media daily also had higher initial status of reported sleep durations when controlling for other factors. While this finding was surprising, it was not unfounded. Most of the literature shown that social media tends to effect sleep quality in college students, which could result in latter onsets of sleep and latter waking times, without effecting overall duration. [29] The results estimated about a 10-minute increase in starting sleep duration over the 4 waves for those with daily social media usage. This could possibly be explained by the mechanisms for falling asleep being disturbed during the onset of sleep leading disruptions in sleep quality that college students try to make up for by increasing their overall sleep duration. Also, looking at the specific timing of social media use is also important as college using social media at night was associated with worst sleep quality while evening used was associated with better sleep quality. [48] Along with timing, duration of usage and what device college students are using could play a role with greater variety of media device usage being associated with longer sleep durations. [49] College student

probably used many different devices for social media as well for school and work which could have contributed to the longer sleep durations reported in this study.

The effects of time-varying depression were significant in terms of initial sleep status. Of the sample used for this analysis, between 34% to 43% reported symptomatic depression at a 5-point cut-off based on their PHQ-9 score. This is slightly to moderately higher than the average for depression prevalence in U.S. college students.[33] As depression score increased so to did the impact on sleep duration as higher PHQ-9 scores correlated with worst initial status in reported sleep duration. This is practically significant as this put with higher depression below the threshold of seven hours for getting adequate sleep duration. Multiple other studies have also shown there to be associations with depression and differing domains of sleep including sleep duration. [8,17,33,36]

Limitations

There were several limitations to the study. These data were collected in a sample of college students with the state of Georgia and can affect generalizability outside the state. Social media use was time-invariant and thus no inferences could be made on its effects as college student potentially change their social media usage over time. Multi-level modelling is adequate for understanding relationship in hierarchical forms but is limited in its ability to make inferences on cross-lagged relationships, for instance, with the relationship between time-varying depression, physical activity and, reported sleep duration. Reported sleep duration over the month is subjective and thus could be affected by recall biases. Lastly, social media usage in college students looks different now compared to when the data were collected.

Conclusion

Overall, there appears to be support for reported sleep duration changing overtime in colleges

students with it trending down over time. Most of the college students reported normal sleep durations but a sizable portion still reported less than the recommended amounts of sleep. There appeared to be no difference in initial starting point or change over time for reported sleep between males and females. Also, depression and social media usage appear to significantly affect where college students start in terms of their reported sleep duration. Future studies could examine social media usage over time and see how as it changes if reported sleep duration is also changed. In terms of implications for health practitioners working with college students, there could be a focus on assessing depression and sleep along with question about media device usage with an emphasis on the timing and amount usage.

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Table 1. Demographics

	Overall (N=2840)
Age	
Mean (SD)	20.5 (1.93)
Median [Min, Max]	20.0 [18.0, 25.0]
Gender	
Male	1011 (35.6%)
Female	1829 (64.4%)
Race	
African Amerian or Black	634 (22.3%)
American Indian or Alaskan Native	9 (0.3%)
Asian	188 (6.6%)
Native Hawaiian or Pacific Islander	1 (0.0%)
White	1815 (63.9%)
More than one race	110 (3.9%)
Other	46 (1.6%)
Missing	37 (1.3%)
Ethnicity	
No	2603 (91.7%)
Yes	218 (7.7%)
Missing	19 (0.7%)

Table 2. Social Media use

	Overall (N=2840)
Daily social media use	
0	581 (20.5%)
1	2259 (79.5%)

Table 3. Reported sleep durations by wave

	Overall (N=2840)
Sleep at wave 3	
Mean (SD)	7.26 (1.32)
Median [Min, Max]	7.00 [3.00, 10.0]
Missing	123 (4.3%)
Sleep at wave 4	
Mean (SD)	7.14 (1.29)
Median [Min, Max]	7.00 [3.00, 10.0]
Missing	255 (9.0%)
Sleep at wave 5	
Mean (SD)	7.00 (1.29)
Median [Min, Max]	7.00 [3.00, 10.0]
Missing	385 (13.6%)
Sleep at wave 6	
Mean (SD)	7.23 (1.26)
Median [Min, Max]	7.00 [3.00, 10.0]
Missing	600 (21.1%)

Table 4. Depression scores by wave

	Overall (N=2840)
Depression at wave 3	
Mean (SD)	4.53 (4.99)
Median [Min, Max]	3.00 [0, 27.0]
Missing	123 (4.3%)
Depression at wave 4	
Mean (SD)	5.28 (5.39)
Median [Min, Max]	4.00 [0, 27.0]
Missing	255 (9.0%)
Depression at wave 5	
Mean (SD)	5.36 (5.64)
Median [Min, Max]	4.00 [0, 27.0]
Missing	385 (13.6%)
Depression at wave 6	
Mean (SD)	4.14 (4.99)
Median [Min, Max]	2.00 [0, 27.0]
Missing	600 (21.1%)

Table 5. Moderate physical activity per week by wave

	Overall (N=2840)
Moderate PA at wave 3	
Mean (SD)	2.61 (2.20)
Median [Min, Max]	2.00 [0, 7.00]
Missing	123 (4.3%)
Moderate PA at wave 4	
Mean (SD)	2.08 (2.00)
Median [Min, Max]	2.00 [0, 7.00]
Missing	255 (9.0%)
Moderate PA at wave 5	
Mean (SD)	2.58 (2.08)
Median [Min, Max]	2.00 [0, 7.00]
Missing	385 (13.6%)
Moderate PA at wave 6	
Mean (SD)	2.48 (2.06)
Median [Min, Max]	2.00 [0, 7.00]
Missing	600 (21.1%)

Table 6. Unconditional means and growth models

	Unconditional Means			**Unconditional Growth**		
Predictors	Estimates	CI	p	Estimates	CI	p
(Intercept)	7.16	7.12 – 7.20	**<0.001**	7.21	7.16 – 7.25	**<0.001**
Wave				-0.03	-0.05 – -0.02	**<0.001**
Random Effects						
σ^2	0.98			0.93		
τ_{00}	0.71 $_{id}$			0.81 $_{id}$		
τ_{11}				0.03 $_{id.Wave}$		
ρ_{01}				-0.34 $_{id}$		
ICC	0.42			0.45		
N	2840 $_{id}$			2840 $_{id}$		
Observations	9997			9997		
Marginal R^2 / Conditional R^2	0.000 / 0.420			0.001 / 0.449		

Table 7. Full model

	Final Model		
Predictors	Estimates	CI	p
(Intercept)	7.19	7.04 – 7.34	**<0.001**
Wave	-0.04	-0.05 – -0.02	**<0.001**
Depr Score	-0.03	-0.03 – -0.02	**<0.001**
Mod PA	-0.00	-0.02 – 0.01	0.629
Gender	0.05	-0.03 – 0.12	0.232
Social Media Use	0.11	0.01 – 0.20	**0.024**
Random Effects			
σ^2	0.93		
$\tau_{00\ id}$	0.78		
$\tau_{11\ id.Wave}$	0.03		
$\rho_{01\ id}$	-0.34		
N_{id}	2840		
Marginal R^2 / Conditional R^2	0.015 / 0.450		

Chapter 5

Public Health Implications

The purpose of this research was to gain a broader and deeper understanding of associations among sleep, physical activity, depression, and social media use through conducting a secondary data analysis of longitudinal trends. Findings indicate college students were strongly affected by factors such as the passage of time, social media use, and depression. In general, the modelling showed that college students were trending downward in terms of their reported sleep duration. With respect to depression, the findings from this study shows that college students varied in where they started for sleep duration. This essentially means that those with lower depressions scores had higher starting points for sleep and the opposite was true for higher depression scores. It could be of benefit to college/universities and specifically those working in student health to screen for both sleep problems and depression to protect students' overall health. When finding students that are struggling with sleep issues, psychological interventions might prove to be useful. Psychological interventions such as those involving cognitive behavioral therapy have been shown to not only be efficacious but improve sleep outcomes in college students (Freeman et al., 2017; Saruhanjan et al., 2021).

Further, given there was variability in sleep from wave to wave, it might be useful to set up protocols for screening during certain time periods for students checking into student health clinics. For instance, there was a pattern of sleep changing per wave which could align with beginning of semesters or change of seasons.

Another implication is for future research and continuing to build on the multi-level modeling framework to investigate if other higher-level factors could play a role in reported sleep durations. While useful, findings here were limited to a two-level modeling only assessing

time nested within students. Future research should explore whether specific school or type of school attended affects reported sleep durations. It would also be useful to scrutinize the relationship longitudinally of sleep durations and depression with cross-lagged modeling to understand if depression and time affect each other, so those working with college students can better focus resources to reduce unnecessary burden and increase well-being in the college student population.

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