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Original Research

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Sleep Attitudes as an Indirect Predictor of Risk for Metabolic Syndrome in First-Year College Students

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Abstract

Background: Habit formation can be a challenge for first-year students. Research has suggested that regardless of sleep knowledge, favorable sleep attitudes predict better sleep.

Aim: Our aim was to investigate whether sleep attitudes directly or indirectly predicted risk for metabolic syndrome via sleep.

Method: Students completed self-report and physiological measures. Participants wore wristwatches to collect sleep data. Path analyses investigated the direct or indirect effect of sleep attitude on risk for metabolic syndrome via subjective sleep (sleep quality, duration, risk for apnea) and objective sleep (sleep efficiency, duration, subjective risk for apnea).

Results: In our subjective analysis that sleep attitudes predicted quality and duration (but not risk for apnea), the overall model yielded significance. Only risk for apnea was a significant predictor of risk for metabolic syndrome in the objective sleep analysis, as well as the total indirect effect.

Note: We have no conflicts of interest to disclose.

Limitations: Limitations include missing objective data, which lowered the sample size, and using Fitbit devices, which may not be as accurate as polysomnography.

Conclusion: Unfavorable sleep attitudes are related to risk for metabolic syndrome in college students via sleep.

Keywords: *freshman, college, metabolic syndrome, sleep, weight gain, transition*

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Introduction

Transitioning from high school to college involves overcoming numerous obstacles. New college students may deal with changes in sleep and work schedules, novel eating habits, routines, and new social expectations (Ruberman, 2014). Several of the potential changes, such as nutritional deficits and reduced physical activity (de Vos et al., 2015), may contribute to weight gain during the first year of college. Popularly referred to as the "Freshman 15," this weight-gain phenomenon may be the result of students eating in dining halls with limited foods available (Leischner et al., 2018), reduced physical activity (Miller & Hartman, 2020), and increased stress (Wilson et al., 2015).

Recent research suggests that the so-called Freshman 15 is a myth, yet weight gain during this period of transition is fairly common (Baum, 2017). For example, according to Vadeboncoeur et al. (2015), college students are likely to gain 2.2 to 13.2 pounds throughout their freshman year. And, according to Miller and Hartman (2020), weight changes in college can have serious health consequences, including a change in microbiota and negative psychological outcomes. For instance, Journey et al. (2020) found that even a small weight change of 6.5 pounds (on average) within the 9-month period of students' freshman year of college can change intestinal microbiota. One species, *Akkermansia muciniphila*, has been shown to promote metabolic health (Dao et al., 2016), but the species may be sensitive to small weight increases in college students (Journey et al., 2020).

Changes in body weight and fat mass have also been associated with a variety of psychological consequences. Tumin et al. (2020) reported that rapid weight changes and a higher body mass index (BMI) across early adult years were linked to higher perceived pain. Among Chinese college students, women with a normal to high BMI were more likely to experience significant depressive symptoms (Smith et al., 2015). Furthermore, weight gain in college-aged students is linked to physical and mental health issues later in life, such as symptoms of depression and even suicidality (Smith et al., 2015).

Sleep and Health Outcomes

College students often get too little sleep or experience poor quality sleep, which have been separately associated with a variety of unfavorable outcomes (Wolfson et al., 2018). For example, sleep deprivation in college students is associated with a lower grade-point average throughout their higher education (Chen & Chen, 2019). Sleep deprivation during the first year of college can also predict lower graduating grades (Chen & Chen, 2019). Wolfson and colleagues (2018) found, further, that students went to bed about 2 hours later in college than in high school, although their overall sleep duration did not change. In addition to a later bedtime, decrements of sleep quality (the restfulness and restorative nature of sleep) have been reported in an emerging adult population (Foulkes et al., 2019). Qualitative analyses by Foulkes and colleagues (2019) suggest that major themes associated with these sleep disturbances include noise pollution in on-campus dorms, peer pressure to socialize during later hours, and the lack of structure in freshman academic life. This is problematic, as worse sleep quality is associated with risk for depression, depressive symptoms, and a decrease in well-being (Çelik et al., 2019; Peach et al., 2016).

In addition to the cognitive and psychological associations of poor sleep, sleep has also been associated with physiological changes. Sa and colleagues (2020) investigated the relationship between sleep and obesity among college students. Results indicated that overweight college students sleep less than non-overweight students among both men and women. For men, identifying as Black posed an additional risk factor for short sleep duration. Sleep quality was found to be worse in women than men, obese and overweight individuals, and Asian and Black individuals who were overweight. Roane et al. (2015) found that among college-aged men, variability in sleep schedule (i.e., going to bed at different times across different nights) predicted weight gain in the first semester of university. Vargas et al. (2014) suggested that rather than sleep duration, sleep disturbances acted as a predictor for being overweight. In their study of individuals with an overweight BMI classification, 51% self-reported as bad sleepers, based on the Pittsburgh Sleep Quality Index (PSQI) cut-off score.

Interestingly, sleep attitudes have also been associated with sleep and health outcomes (Humphries et al., 2022). Health-related attitudes can be identified as modifiable thoughts and beliefs surrounding the care of oneself (e.g., reducing ultraviolet [UV] exposure) that can predict health behaviors (e.g., wearing sun protection; Prentice-Dunn et al., 2009). Sleep attitudes can shape sleep hygiene, which includes behaviors and environments that have favorable sleep outcomes, which can lead to more—or better quality—sleep (Ruggiero et al., 2019; Yu et al., 2020). The present study defines sleep attitudes as the degree of positive or negative regard for sleep, expressed via thoughts and beliefs, affect, and behaviors (Peach & Gaultney, 2017). Ruggiero et al. (2019) reported that sleep attitudes vary widely across age, gender, and race, with individuals who identify as female, White, and older reporting more favorable attitudes towards sleep. Sleep attitudes have been found to predict both sleep duration and quality (Jin et al., 2018; Ruggiero et al., 2019). For instance, Jin and colleagues (2018) found that individuals who had favorable sleep attitudes were more likely to report longer and better quality of sleep and engage in self-relaxation and physical exercise.

Metabolic Syndrome and Sleep

Recent research has focused attention on the relationship between sleep and risk for metabolic syndrome (Lian et al., 2019). According to the American Heart Association (2021), *metabolic syndrome* is a cluster of five different symptoms associated with poor health outcomes like stroke, cardiovascular disease, and diabetes mellitus. These five symptoms include low high-density lipoprotein (HDL) or "good cholesterol," high blood sugar levels, high triglyceride levels, high blood pressure, and large body size.

The American Heart Association (2021) reports that 34% of adults in the United States have metabolic syndrome, and the rates are steadily increasing. Risk factors include obesity or being overweight, as well as developing or being predisposed to insulin resistance (Razzouk & Muntner, 2009). Further, Razzouck and Munter (2009) suggested that metabolic syndrome is more common in women than men and is more prevalent among Mexican American individuals than non-Hispanic White and Black individuals. Interestingly, among men, non-Hispanic Whites are more likely to have metabolic syndrome than non-Hispanic Blacks; however, among women, this relationship is reversed.

Nolan and colleagues (2017) conducted a pooled analysis investigating the prevalence of metabolic syndrome in young adults (18–30). Prevalence among these groups was about 5%–7%, with low HDL being the best predictor of diagnosing metabolic syndrome in young individuals. While it is unlikely to find clinical metabolic syndrome in college students, our aim was to assess each associated factor individually in order to identify whether sleep habits during young adulthood would be associated with known risk factors for later metabolic syndrome.

Given the association between weight and metabolic syndrome, as well as the connection between poor sleep with weight gain (Cooper et al., 2018), it is vital to study the association of sleep and metabolic syndrome. Smiley et al. (2019) recruited a sample of 2,737 adults to investigate whether sleep duration was associated with metabolic syndrome. Results indicated that sleep duration and risk for metabolic syndrome have a U-shaped association. Risk for metabolic syndrome was lowest when individuals slept 7 hours per night and highest for individuals who slept significantly less or more. Smiley and colleagues (2019) also reported significant differences between women and men, where women had a higher risk for metabolic syndrome if they reported short or long sleep durations, while for men, only shorter sleep duration was associated with risk for metabolic syndrome. In addition, a meta-analysis by Lian et al. (2019) found that poor sleep quality was associated with an increased likelihood of developing metabolic syndrome. Specifically, difficulty falling asleep, staying asleep, and not feeling rested after periods of sleep predicted higher rates of metabolic syndrome diagnoses.

Though the relationship between sleep and metabolic syndrome has been studied in adults broadly, this link is less clear in a college-aged population. A study of Korean university students used multiple logistic regression analyses and found that poor sleep quality and obesity in students were significantly associated with risk for metabolic syndrome (Shin et al., 2015). Yahia et al. (2017) investigated the prevalence of meeting the criteria for metabolic syndrome in U.S. college students and did not find any prevalence of metabolic syndrome in a large sample of students (0.0%–0.4%) but reported that 29.1% of students had at least one risk factor.

In contrast to data on adult populations, Yahia et al. (2017) did not find that sleep patterns differed between individuals with one or more metabolic syndrome risk factors and individuals without risk factors. Further, Quick et al. (2016) examined sleep duration and weight-related behaviors in college students. Their results indicated that students who slept less than 7 hours a night, compared to students who slept 8 or more hours a night, had more negative attitudes towards eating, poorer internal food regulation, and were more likely to engage in binge eating. Quick and colleagues (2016) suggested that negative attitudes toward one health behavior (eating/weight) may be associated with also having other negative/unfavorable attitudes toward other health behaviors, including sleep.

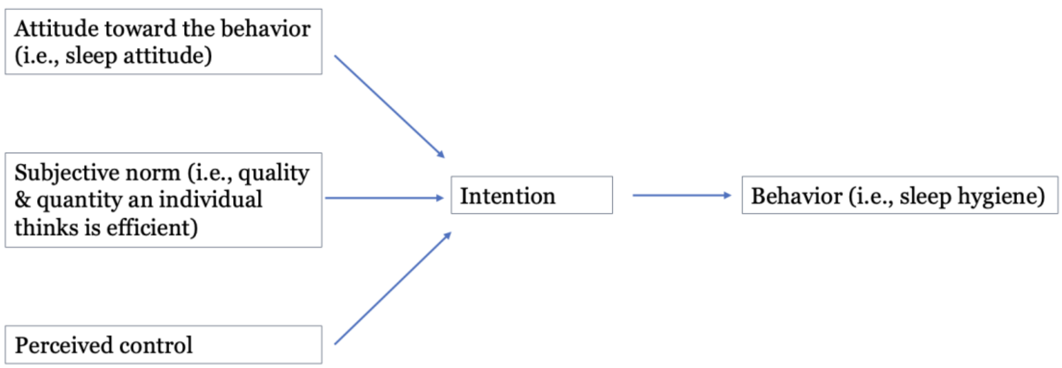
Although college students are less likely to have diagnosable metabolic syndrome than older adults, evidence points towards early development of risk factors. Hsu and Chang (2020) found that among college students, insomnia is associated with *hypertriglyceridemia*, an excess of glucose in the blood. Long-term consequences of hyperglycemia could include organ failure, as well as cancer progression and diabetes (Giri et al., 2018; Pecoits-Filho et al., 2016). In addition, Saylor et al. (2019) found that college students with fewer hours of weekday sleep had higher blood glucose levels. Finally, both poor sleep quality and short sleep duration were associated with larger waist circumference among young adults across low-, middle- and high-income countries (Peltzer & Pengpid, 2016), which could lead to health risks like diabetes, obstructive sleep apnea, and hyperuricemia (Darsini et al., 2020). Given these associations, it is possible that unfavorable sleep habits and patterns during the first year of college could be associated with early markers of metabolic syndrome.

It has not been established whether improved sleep would also improve the risk for metabolic syndrome. Sleep interventions have offered sleep education as a means to improve health and academic outcomes. Other work, however, suggests that one's knowledge of sleep may not predict whether one will engage in sleep promoting behaviors. Attitudes towards sleep appear to predict sleep outcomes independently of sleep knowledge (Peach & Gaultney, 2017). Given the association of sleep with risk factors for metabolic syndrome and the connection between sleep attitudes and sleep outcomes, the present study proposed to examine whether sleep attitudes directly or indirectly predicted early risk factors for metabolic syndrome via measures of sleep.

Theoretical Framework

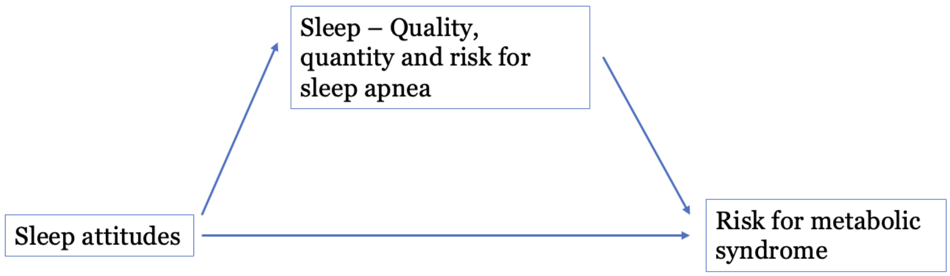
Our aim was to investigate whether early risk factors for metabolic syndrome were directly or indirectly predicted by sleep attitude. The Theory of Planned Behavior (Ajzen, 1991) links beliefs and attitudes towards a concept to a behavior. Ajzen (1991) suggested that attitudes, subjective norms (belief about the expectations of others), and perceived control of a behavior (including factors that make the behavior possible or obstruct the behavior) cannot only influence one another but also together influence a behavior through an intention. The Theory of Planned Behavior is able to explain the intention (25%) and follow-through (50%) of health behaviors (Ajzen, 1991). Therefore, favorable sleep attitudes are associated with better sleep behavior and, consequently, better sleep outcomes (Humphries et al., 2022; Ruggiero et al., 2018; Ruggiero et al., 2019). Figures 1 and 2 depict how sleep attitudes may influence sleep outcomes.

Figure 1. *Theory of Planned Behavior (Ajzen, 1991) Where Sleep Attitudes Predict Sleep Outcomes*



Although findings linking sleep and early risk for metabolic syndrome in college students have been sparse, there is a good indication of such a relationship in middle-aged and older adults (Lian et al., 2019; Smiley et al., 2019). Investigating college students' sleep attitudes and the long-term effect on health is vital for understanding the biopsychosocial transitions first-year college students face when starting their higher education journey. Given the theoretical background of sleep attitudes on sleep outcomes and the relationship between sleep quality and quantity on health outcomes that may contribute to metabolic syndrome, we investigated whether sleep attitudes directly or indirectly predicted risk for metabolic syndrome via sleep factors. We hypothesized that (H1) sleep (attitudes, quality, subjective and objective duration, and efficiency) would correlate with early risk for metabolic syndrome, where more favorable sleep is associated with lower risk for metabolic syndrome. In addition, we hypothesized (H2) that sleep attitudes would be a significant direct and indirect predictor of early risk factors for metabolic syndrome. Finally, we predicted (H3) that the indirect relationship would be moderated by (a) age and (b) gender.

Figure 2. *Model of Direct (H1) and Indirect (H2) Effects via Subjective and Objective Sleep on Risk for Metabolic Syndrome*



Methods

Participants

Participants were 165 first-year college students taking Introductory Psychology in the fall semesters of 2016 through 2019 at a large university in the Southeastern United States. Recruitment was completed via a participant pool; student participants received course credit as compensation for their participation. An alternative assignment was available for those who did not want to take part in a study. Participants were excluded from the sample if they were under the age of 18, were non-English speakers, pregnant, or were individuals diagnosed with and/or treated for any type of eating disorder. The study was approved by the university's Institutional Review Board.

Table 1. *Sociodemographic Characteristics of Participants*

		n	Valid %
Gender			
	Female	104	63
	Male	61	37
Race			
	White	33	55.9
	Black	13	22
	Asian	6	10.2
	Latinx	2	3.4
	Multiracial	5	8.5
Roommate			
	Yes	117	70.9
	No	48	29.1

Note. *N* = 165 for gender and roommates. *N* = 59 for Race. Participants were on average 18.66 years old (*SD* = 3.33).

Materials

Sleep Attitudes

Sleep attitudes were assessed using the 10-item Charlotte Attitudes Towards Sleep Scale (CATS; Peach & Gaultney, 2017). According to Peach and Gaultney (2017), CATS has promising psychometrics in college students. A higher score indicated more favorable sleep attitudes. The Cronbach's alpha for college students in this study was .69.

Subjective Sleep Quality and Quantity

Subjective sleep quality and quantity were measured using the Pittsburg Sleep Quality Index (Buysse et al., 1989), which assesses sleep variables over the past month. We used the sleep quantity subscale as a measure of subjective sleep quantity and followed calculation procedures to calculate a global sleep quality score. A score of 5 or higher indicated poor sleep quality (Buysse et al., 1989). This index has been widely accepted and shown to be a reliable measure of subjective sleep in college-aged individuals (Dietch et al., 2016). Reliability analysis revealed a Cronbach's alpha of .62.

Objective Sleep Quality and Quantity

The Fitbit Flex actigraph records data in *1-minute* intervals, including total hours of sleep and sleep efficiency (time asleep/(total time in bed—time to fall asleep)). Sleep efficiency is one component of sleep quality (Buysse et al., 1989) and was used in this project as an objective indicator of sleep quality. These data can be downloaded to the user website. Montgomery-Downs et al. (2012) suggest that it is an affordable sleep measure for use on a normative population in obtaining accurate objective sleep measures. The Fitbits were worn for 7 consecutive days, and sleep duration and efficiency were averaged over the amount of time that sleep data were collected.

Risk for Sleep Apnea

The Apnea Eight-Item Subscale of the SLEEP-50 (Spoormaker et al., 2005) assessed risk for apnea as defined by the *Diagnositc and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2013). The items were scored on a 4-point Likert scale ranging from *1 not at all* to *4 very much*. Items included "I am told that I snore" and "I was told that I hold my breath when sleeping." A higher summed score indicated more risk for sleep apnea (Cronbach's alpha = .50).

Known Factors Associated With Metabolic Syndrome

Overall, we included six risk factors: BMI, triglyceride, cholesterol, glucose level, body weight, and systolic and diastolic blood pressure. Body weight and height were obtained through mechanical balance with a stadiometer and scale and was rounded to the nearest .1cm and .1kg. Then, BMI was calculated using the following formula: BMI = kg/m^2. To measure blood pressure, participants sat still with their non-dominant arm flexed 90° and their elbow on a table. Blood pressure was taken with an automated blood pressure monitor. Triglyceride, cholesterol, and glucose levels were obtained by trained research assistants using the CardioChek Portable Blood Test System.

To calculate the metabolic syndrome risk score, metabolic components were binomially coded into 0 (below risk threshold) or 1 (at or above risk threshold) for each of the five measures that contribute to MS. For BMI, participants received a score of 1 if they were classified as being overweight or obese, indicated by a BMI score of >25 (World Health Organization, 2021). Blood pressure was scored as 1 if systolic blood pressure was >130, and/or diastolic blood pressure was >85 (John Hopkins Medicine, 2023; Moore et al., 2017). Triglyceride concentrations of >150 were coded 1, and HDL levels <40 for men and <50 for women as 1 (John Hopkins Medicine, 2023). Finally, glucose was coded as 1 if glucose levels were <100 (Grundy et al., 2004). Risk factors were summed producing a risk score. Thus, the range for early risk of metabolic syndrome ranged from 0 to 6, with 0 indicating the lowest risk and 6 indicating the highest risk.

Procedure

Survey data were collected via Qualtrics prior to the first in-person meeting. Participants attended a scheduled session where they were greeted by the researcher and provided informed consent. Body weight and height, blood pressure, and blood samples were obtained. Participants received instructions on the use of the Fitbit Flex wristwatch and signed an agreement that they would return the device in good condition. Participants also received a charging cable. Participants wore the wristwatch for 7 consecutive days and were instructed to remove the device only if they went swimming or to charge it. Charging was required on the 4th day of the week. Before participants went to sleep, they were asked to activate the sleep mode on their watch. After awakening, participants tapped their watch rapidly to activity awake mode. In addition, participants recorded their sleep and wake time to confirm the Fitbit readings. After 7 days, Fitbits and charging cables were returned and participants received proof of return.

Plan of Analyses

We used *IBM SPSS Statistics 28* for all analyses (IBM Corporation, Armonk, NY, USA). After examination of preliminary descriptive and correlational data, two path model analyses were conducted to test hypotheses. Considering the potential association of age and gender with risk for metabolic syndrome (Razzouk & Muntner, 2009), these variables were included in analyses as covariates. First, we examined whether there were potential direct or indirect routes (via subjective sleep quality, duration, and risk for sleep apnea) from sleep attitude to risk for metabolic syndrome. For the second analysis, we replaced subjective quality and duration with objective sleep efficiency (as an indicator of sleep quality) and duration, respectively. Because an objective measure of apnea was not available, the subjective estimate of risk for apnea was included because of the strong association between apnea and metabolic syndrome among adults (Gaines et al., 2018); therefore, we wanted to keep the construct in the overall model. Moderated mediation tested the third hypothesis via the index score generated by the PROCESS macro for SPSS (Model 8; Hayes, 2018) to determine whether any direct or indirect pathways were moderated by age or gender. Indirect effects used bootstrapped coefficients and confidence intervals. Figures and tables report unstandardized coefficients.

Since analyses revealed noteworthy amounts of missing sleep data, we (1) conducted a Little's Test to determine whether data was missing completely at random; and (2) conducted a series of *t*-tests for each sleep measure to see whether there were significant differences in those that had data missing versus those with complete data. Incomplete data was coded as 0 and complete data was coded as 1, and all relevant variables (sleep apnea, average objective and subjective sleep duration, sleep efficiency, sleep quality, sleep attitudes, and risk for metabolic syndrome) were compared with each relevant missing data group.

Results

Demographic Information

The sample (N = 165) consisted mostly of women and most participants were 18 years of age (M = 18.65, SD = 3.33, range = 18–55). About half of the participants reported their race as White, followed by Black and Asian. The majority of our sample had at least one roommate. Descriptive data for the present sample can be seen in Table 1.

Correlational Analyses

Preliminary correlational analyses are presented in Table 2. Primary variables correlated significantly in the expected directions. The Pittsburgh Sleep Quality Index (PSQI) quality scores were significantly negatively associated with subjective sleep duration, objective sleep duration, sleep efficiency, sleep attitude, and metabolic risk. PSQI duration was positively associated with objective duration and sleep attitudes. Fitbit sleep efficiency was significantly negatively correlated with risk for metabolic syndrome. Fitbit sleep duration was positively associated with sleep attitude and negatively associated with risk for metabolic syndrome.

Table 2. *Correlations.*

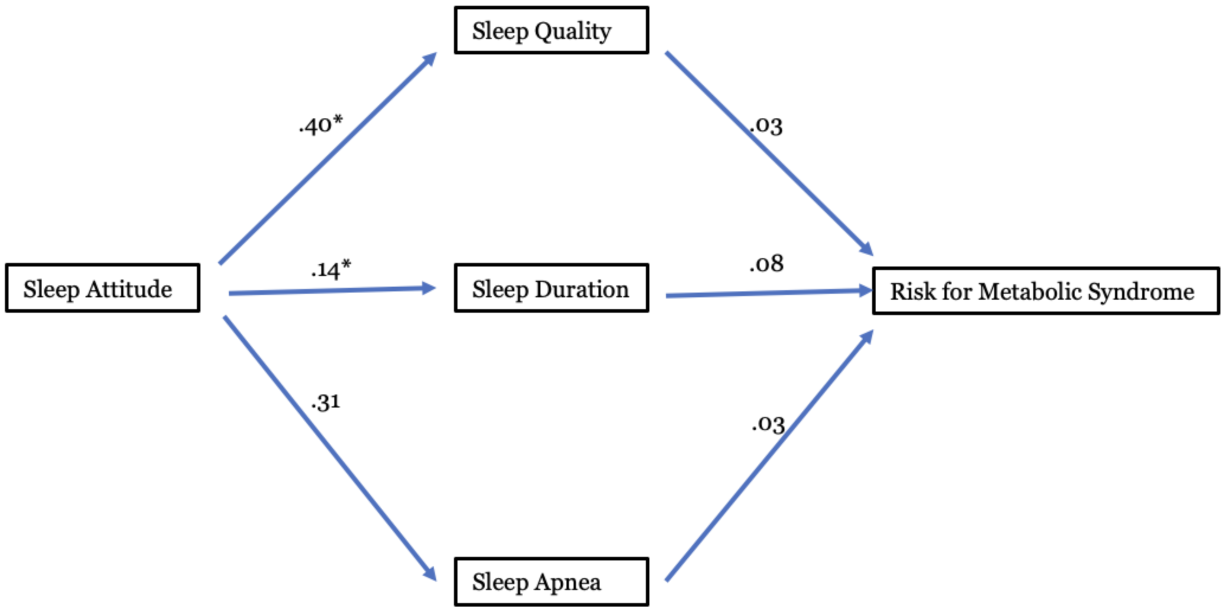
Variable	*n*	*M*	*SD*	% missing	1	2	3	4	5	6
1. PSQI	165	6.44	3.12	0%	-					
2. Subjective duration	165	6.98	1.15	0%	-.636**	-				
3. Objective duration	55	7.18	1.54	66.6%	-.404**	.555**	-			
4. Sleep efficiency	41	90.03	13.03	75.2%	-.385*	.205	.732	-		
5. Sleep attitude	73	4.62	.69	55.5%	-.291*	.378**	.334*	.128	-	
6. BMI	149	24.67	5.57	9.7%	.194	-.087	-.088	-.116	.033	-
7. Metabolic risk	112	.77	.81	32.1%	.219*	-.173	-.271*	-.311*	.035	.483**

Note. PSQI = Pittsburgh Sleep Quality Index. Subjective sleep data was collected via PSQI and objective sleep data was collected via Fitbit.
* p < .05. **p < .01.

Sleep Attitudes Predicting Risk for Metabolic Syndrome

We examined whether sleep attitudes would directly (H1) or indirectly (H2) predict risk for metabolic syndrome (Figure 3). Sleep attitudes predicted PSQI sleep quality ($p = .01$) and PSQI duration ($p < .001$), but not risk for sleep apnea. Neither PSQI sleep quality, PSQI duration, nor sleep apnea directly predicted risk for metabolic syndrome. Although significant direct paths from sleep attitudes to risk for metabolic syndrome were not found in either subjective or objective analyses, bootstrapped results indicated a significant indirect route from sleep attitude to risk for metabolic syndrome, via PSQI global sleep quality. Both the age and gender covariates accounted for significant variability in metabolic syndrome scores (*p*s <.01).

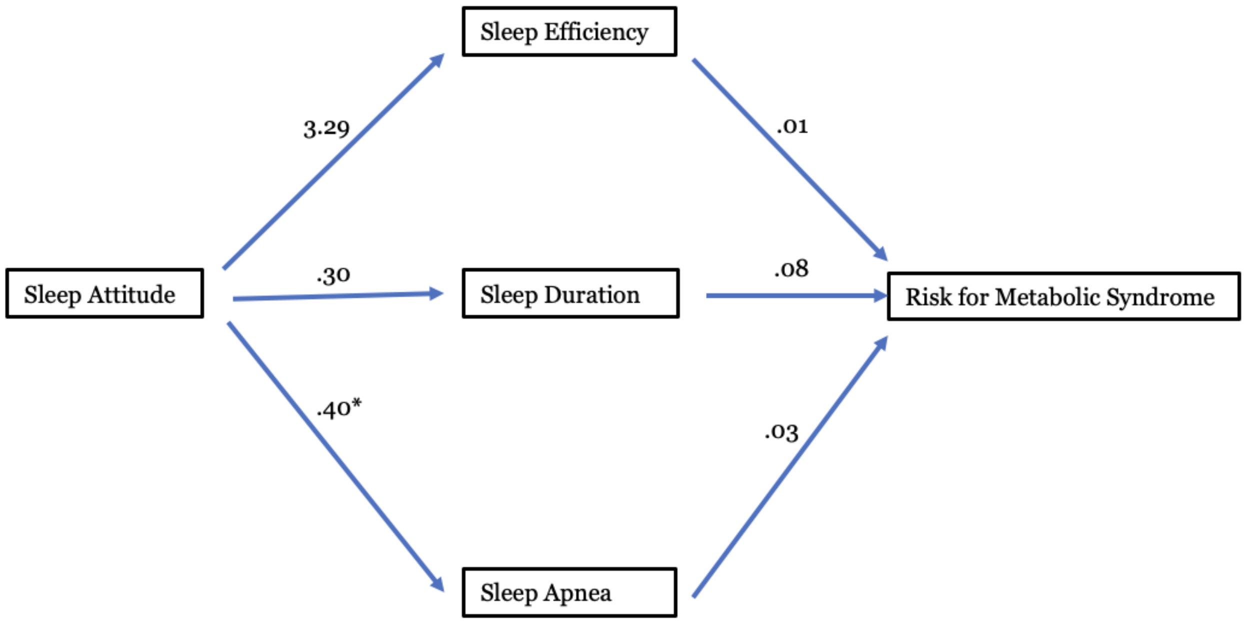
Figure 3. *Sleep Attitudes on Risk for Metabolic Syndrome via Subjective Sleep.*



Indirect effects		Bootstrapped 95% CI	
Total	*b* = -.09	-.19.	-.02
Quality	*b* = -.04	-.16.	-.00
Duration	*b* = -.04	-.13	.04
Apnea	*b* = -.00	-.05	.04

A separate path model examined direct and indirect effects using objective sleep data (Figure 4). In this analysis, Fitbit sleep efficiency, Fitbit sleep duration, and risk for sleep apnea served as potential simultaneous indirect pathways. Sleep attitudes predicted risk for sleep apnea but not Fitbit-measured sleep efficiency or duration. Although no single indirect path produced a significant indirect effect, the overall model did ($p < .01$), suggesting that the larger construct of sleep may be an indirect predictor of risk for metabolic syndrome. Gender, but not age, explained significant variability in the model.

Figure 4. *Sleep Attitudes on Risk or Metabolic Syndrome via Objective Sleep*



Indirect effects		Bootstrapped 95% CI	
Total	*b* = -.11	-.23	-.01
Efficiency	*b* = -.01	-.04	.11
Duration	*b* = -.07	-.25	.03
Apnea	*b* = -.05	-.13	.02

Given that the path models using objective Fitbit data included fewer participants due to missing data, the lack of significance could be attributed to lower statistical power. To examine this possibility, missing data (see Table 2) were replaced using multiple imputation. The results produced the same pattern of results as before, suggesting the pattern was not an artifact of differences in sample size. The data reported in the text and tables are the original data only.

Finally, we investigated whether gender or age moderated the indirect path from sleep attitudes to metabolic syndrome risk via subjective sleep measures (moderated mediation using PROCESS, Model 8; Hayes, 2018). Neither variable produced a significant index of moderated mediation, suggesting the indirect path via subject sleep quality did not differ as a function of gender or age.

Missing Sleep Data

As shown in Figure 2, our analyses revealed that a large proportion of objective sleep data (as measured by Fitbits) were missing. Some participants reported that their Fitbits malfunctioned or did not charge, while others stated that they forgot to wear the device. Variables of interest included sleep apnea, average objective and subjective sleep duration, sleep efficiency, and sleep quality. To assess whether these missing data would impact our overall findings, we (1) conducted a Little's Test to test whether data was missing completely at random; and (2) conducted a series of *t*-tests separately for each sleep measure to assess group differences.

Little's Test

Assuming a standard cut-off of $p < .05$, the Little's Test did not produce any significance ($x^2 = 14.26$, DF = 9, $p = .113$). Given that *p* was not significant, this would indicate that data were missing completely at random.

Sleep Outcomes

There were no significant differences between individuals who had no missing data and those who had missing data for sleep quality (*M* = 5.21, *SD* = 2.29 vs *M* = 6.52, *SD* = 2.97, respectively), subjective (*M* = 7.45, *SD* = 1.05 vs *M* = 6.82, *SD* = 1.06, respectively), sleep attitudes (*M* = 4.56, *SD* = .52 vs *M* = 4.63, *SD* = .73, respectively), and risk for metabolic syndrome (*M* = .87, *SD* = 75 vs *M* = .68, *SD* = .86, respectively; All *p*s > .60). Independent samples *t*-tests for objective sleep duration and sleep efficiency were not computed, as missing sleep apnea data was also missing in the objective sleep variables.

When assessing for differences in missing data for sleep quality, subjective and objective duration, and sleep efficiency, only group differences in risk for metabolic syndrome were computed, as in the other variables sleep data was missing in both groups. There was no significant difference between participants who had no sleep quality or subjective sleep duration data (*M* = .88, *SD* = .72) and those who had sleep quality and subjective sleep duration data (*M* = .71, *SD* = .85), *p* = .288.

Discussion

Integration Into the Current Literature

Overall, these findings suggest that sleep attitudes may be an easily measured construct associated with risk for metabolic syndrome among college students. We found that sleep attitudes can indirectly predict risk for metabolic syndrome through subjective sleep quality. In contrast, when we investigated objective measures obtained via the Fitbit information, no significant indirect pathways were found; however, significant total indirect effect suggested that objective measures of sleep should continue to be considered in future research.

Other work has reported subjective sleep to be more predictive of mood and other health outcomes than objective sleep (Bei et al., 2010; Gadie et al., 2017). This suggests that perceived restorativeness of sleep, or feeling more rested at awakening, may be more of a health indicator than actual sleep. Subjective and objective sleep appear to be related but not necessarily identical constructs, both of which may inform health assessments (Van Den Berg et al., 2008). Subjective sleep may be more related to perceived level of control as described in the theory of planned behavior. Feeling less sleepy and more rested may encourage engagement in more active behaviors, and thus contribute to a less sedentary lifestyle and lower risk of developing metabolic syndrome (Mbugua et al., 2017). However, it is still important to explore the larger construct of sleep and sleep health, including objective sleep, in order to understand health implications.

Sleep is a multi-faceted construct, and as such the PSQI may capture a more comprehensive operationalization of sleep quality, incorporating other elements like sleep disruptions and sleep difficulties. In contrast, the sleep efficiency estimate generated by the Fitbit indicated only time in bed asleep, which is related to sleep quality, but a narrower parameter.

Subjective sleep quantity did not play a significant role in the present analyses. Multiple studies have also indicated that sleep quality is more important than sleep quantity for health outcomes, as the lack of sleep restoration under conditions of deprivation may lead to higher inflammation and general worse health (Irwin, 2014; Kohyama, 2021). An advantage of using both quantity and quality as simultaneous potential indirect pathways allows consideration of unique variability explained by each construct.

Though sleep apnea has been a predictor for metabolic syndrome in other instances, this study failed to replicate those findings. It is likely that this is a result of low rates of obstructive sleep apnea occurring in college students, with a prevalence of around 5.4% (Khassawneh et al., 2018). Risk for sleep apnea commonly increases with age. Additionally, apnea and older age are commonly associated with heavier weight; 70% of cases of sleep apnea are in patients comorbidly diagnosed with obesity (Tuomilehto et al., 2013). The college participants reported here had an average BMI of 24.62, slightly below the overweight threshold of 25.

Our moderated mediation did not produce a significant effect for age. It is likely that this is the result of having a limited age range for our first-year college sample. However, future research may address age as a risk factor in all college students, rather than just freshmen. In addition, gender also did not act as a moderator. Currently, research on sex differences in the risk of metabolic syndrome has produced mixed findings (Beigh & Jain, 2012; Das et al., 2017; Huang et al., 2007). A study by Huang et al. (2007) found that in college samples, men tend to have a higher risk for metabolic syndrome and that males were more likely to be obese and have hypertension and hyperglycemia.

Limitations

Our study did include noteworthy strengths and limitations. For instance, our study suggests preliminary connections between sleep and metabolic syndrome that could be evident even among young adults. Thus, sleep attitudes are a potentially modifiable risk factor that may be a route for early intervention. One noteworthy strength was the inclusion of objective measures of health, as well as the inclusion of both objective and subjective measures of sleep.

Limitations due to sampling are noted. For instance, we were missing objective data that lowered sample size and, thus, power. However, data were re-examined using imputed data, which produced the same pattern of results as the original data. The problem remains that the missing data may have reflected some unidentified characteristic of the subsample that could relate to the outcome (i.e., not missing at random). It is important to note that the sample used had very little variability, and calculated risk scores were relatively low. Nevertheless, given that our sample reflects a college population, and that we aimed to examine individual risk factors rather than diagnose metabolic syndrome as a whole, these low scores still appear to be representative. Along those lines, we did not assess for family history of metabolic syndrome or risk factors of metabolic syndrome. Including family history may have been a way to assess whether these findings were related to genetic predisposition to risk factors, or to the recent transition to college. Further, these data collected were cross-sectional. Because of this, we cannot determine causality or direction, but rather must limit our findings to associated factors. We also cannot make longitudinal predictions from the present data, such as whether students with risk factors for metabolic syndrome will develop the disorder later in life.

Finally, using Fitbits to capture sleep is not as accurate as using more extensive polysomnography data, as Fitbits are not able to capture some arousals or sleep disorders. More longitudinal research is needed in the future to explore the specific implications for health. If the findings reported here are robust, future research could focus on preventative measures, such as improving sleep attitudes to reduce the risk for developing metabolic syndrome. Screenings across campuses may be helpful to detect students at risk for metabolic syndrome and may encourage students who are affected to act early to prevent the development of metabolic syndrome.

Conclusion

Favorable sleep attitudes may be related to risk for metabolic syndrome in college freshmen through some measures of sleep. These findings suggest that students should be informed about the importance of sleep and taught behaviors that enable better sleep. Attitudes are potentially modifiable (Ruggiero et al., 2020); thus, promoting positive attitudes towards sleep may influence a broader scope of health outcomes for students.

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