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Social Jetlag, Depressive Symptoms, and Longitudinal Outcomes in College Students

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University

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Abstract

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Social jetlag refers to the chronic shift in sleep timing between work and free days and has been associated with a variety of negative physical and psychological outcomes. Existing research on social jetlag has relied heavily on cross-sectional studies, preventing researchers and practitioners from assessing the effects of social jetlag over time. The current study used longitudinal data to explore the directionality of the association between social jetlag and depressive symptoms as well as the longitudinal associations between social jetlag, academic performance, and wellbeing in college students. Gender and race were also assessed as potential moderators of these associations. Cross-lagged panel analysis using Amos for SPSS revealed that social jetlag predicted depressive symptoms both concurrently adjusting for covariates and longitudinally in unadjusted models. This finding suggests that sleep disturbances may precede mood concerns, although causality cannot be proven due to the design of the current study. PROCESS moderation analyses indicated that social jetlag did not significantly predict academic performance or wellbeing over time, and neither gender nor race moderated these associations. Future research is needed to further assess the short- and long-term outcomes of social jetlag using prospective, well-controlled studies and objective measures of sleep timing.

Sleep is a multidimensional construct that includes sleep duration, efficiency, subjective quality, and timing (Buysse, 2014). For college students, variable schedules and biological characteristics of late adolescence make sleep timing an especially critical factor (Lund, Reider, Whiting, & Prichard, 2010). Bed and wake times on weekdays, which are often controlled by externally imposed schedules, can differ greatly from weekend bed and wake times, which are more subject to personal preferences. The chronic shift in sleep timing between work and free days has been termed *social jetlag* (Wittman, Dinich, Merrow, & Roenneberg, 2006). Social jetlag has been associated with depressed mood (Levandovski et al., 2011), poor academic and work performance (Haraszti, Ella, Gyongyosi, Roenneberg, & Kaldi, 2014; Yong et al., 2016), and lower general wellbeing (Moon, Yoo, & Cho, 2017). However, the current literature relies primarily on cross-sectional methodology (Beauvalet et al., 2017), making directional associations between social jetlag and various psychological and functional outcomes unclear.

Biological theories suggest that sleep disturbances precede depressive symptoms, while more socially based theories indicate that depressive symptoms lead to increased sleep concerns. By using longitudinal methods, the current study aimed to investigate the directionality of the association between social jetlag and depressive symptoms in a sample of college students. The study also aimed to use longitudinal methods to identify the negative academic and psychological outcomes that have been associated cross-sectionally with social jetlag (Moon et al., 2017). In order to better assess which students should be the primary targets of sleep interventions on college campuses, this study also explored whether students of particular gender or racial groups are more likely to experience these negative outcomes due to social jetlag. Through further exploring the interactions between mood disorder symptoms, social jetlag, and academic and psychological outcomes, this research aimed to contribute to the existing knowledge base on social jetlag to inform sleep recommendations and interventions for college students.

Literature Review

Components of Healthy Sleep

The importance of sleep has been consistently demonstrated. Sleep disturbance is associated with various negative health outcomes, including increased risk of obesity, diabetes, heart attack, stroke, and coronary artery disease (Grandner, 2014). Poor sleep is also associated with cognitive effects, such as impairments in working memory, abstract problem-solving, attentional set shifting, and concentration (Nebes, Buysse, Halligan, Houck, & Monk, 2009). Sleep is increasingly being recognized as one of three major factors that contribute to a healthy lifestyle, alongside exercise and diet, and national initiatives to improve public health by promoting sleep health are gaining traction (Matricciani et al., 2018).

However, in order to create interventions to improve sleep, healthy sleep must first be defined, a task that has caused some conflict in the current literature. To assess healthy sleep, some researchers analyze sleep architecture, or the amount of time an individual spends in each stage of sleep per night. Stages of sleep, including Non-Rapid Eye Movement Stages 1, 2, 3 (Slow Wave Sleep; SWS), and Rapid Eye Movement (REM), are electrophysiologically distinct and occur in cycles throughout the night. Although the exact function of each stage of sleep is still being established, individual differences have been noted in the amount of time spent in each stage, especially for individuals with mental illness (Smagula et al., 2014). In terms of healthy sleep, The National Sleep Foundation has identified proportions of the night that should be devoted to each stage of sleep for optimal outcomes (Ohayon, 2017).

Although time spent in each stage of sleep does seemingly contribute to overall sleep health, sleep is a multidimensional construct and several other factors need to be taken into consideration when determining healthy sleep, including sleep duration, efficiency, daytime alertness, and self-reported satisfaction (Buysse, 2014). Recent recommendations put forth by the National Sleep Foundation have defined healthy sleep for the young adult population as taking no more than 15 minutes to fall asleep, awakening no more than once per night, waking for less than or equal to 20 minutes per night, and having a sleep efficiency of 85% or greater (Ohayon, 2017). Still, these factors do not account for sleep's position as a component of daily time use (Matricciani et al., 2018). Sleep timing, or the placement of sleep within the 24-hour day, should also be addressed when deciding whether someone is experiencing sleep disturbance and is at risk for potential associated negative outcomes.

Sleep Timing. An individual's circadian rhythm contributes to the regulation of sleep timing. A circadian rhythm is a roughly 24-hour rhythm generated by the suprachiasmatic nucleus, located in the anterior hypothalamus. Although circadian rhythms are most often considered in terms of sleep, other bodily processes, such as hunger and body temperature, are also controlled by these rhythms (Baron & Reid, 2014). Certain genes may play a role in determining circadian rhythms, as the sleep times of both animals and humans who are "free running"- allowed to sleep based on their own body's needs without interference from environmental stimuli- tend to cluster around a species-specific mean, indicating that endogenous factors play a role in determining sleep timing. However, environmental stimuli also help to regulate circadian rhythms and further synchronize it to the 24-hour day, a process termed *entrainment*. The body relies on certain *zeitgebers*, or environmental stimuli, such as light, physical activity, endogenous melatonin (Baron & Reid, 2014), nutrients, and body temperature (Roenneberg & Merrow, 2017) for entrainment.

Individual differences have been noted, however, in the phase of entrainment, or the association between external time stimuli and internal timing. These differences have been referred to as an individual's chronotype (Roenneberg & Merrow, 2017). Chronotypes are normally distributed (Haraszti, Ella, Gyongyosi, Roenneberg, & Kaldi, 2014) with morning-types preferring diurnal activities, evening-types preferring nocturnal activities, and the majority of people somewhere in the middle (Hidalgo et al., 2009). Morning-types tend to have earlier rise times and to be more alert at earlier times of the day, whereas evening-types rise later and are often more productive in the evening hours (Zimmerman, 2011).

Chronotype is determined both by genetic and environmental factors. Polymorphisms of the *Period* and *Clock* genes have been associated with chronotype and are thought to account for approximately 50% of the variation in chronotype (Barclay et al., 2010; Ojeda et al., 2013). Light conditions due to geographical location and the photoperiod to which the individual was exposed prenatally may also contribute to the formation of chronotype (Adan, 2015). Age plays a key role in determining chronotype, as young children are more likely to be morning-types, shift towards eveningness in adolescence, and then return to morningness in adulthood (Roenneberg et al., 2007).

Sleep is more effective when it coincides with one's internal circadian clock, or chronotype (Roenneberg, Allebrandt, Merrow, & Vetter, 2012). However, modern lifestyles revolve around traditional business hours that may or may not align with an individual's chronotype (Beauvalet et al., 2017). For most full-time employees or students, weekday schedules are primarily dictated by external responsibilities. Although the circadian rhythm may dictate at what time and how quickly an individual falls asleep, the alarm clock, set for a socially mandated time, puts an abrupt end to the night's rest that may not correspond with the circadian clock. However, scheduling of weekend sleep is typically left up to the individual and her biological needs (Foster et al., 2013). The incongruence between weekday and weekend sleep schedules has been referred to in the literature as *social jetlag* (Beauvalet et al., 2017).

Social Jetlag. The term social jetlag was coined due to its similarity to the type of jetlag that one may experience from traveling across multiple time zones. The process of having to adjust to a new location's time schedule, and then readjusting to the original schedule upon return, causes circadian misalignment that has been linked to sleep disturbance, increased fatigue, and poor mental and physical performance (Inder, Crowe, & Porter, 2016). Similarly, social jetlag also refers to a circadian misalignment that leads to poor health outcomes. Rather than being caused by traveling across time zones, social jetlag is caused by the discrepancy between work and free day schedules (Roenneberg et al., 2012). Unlike travel jetlag, social jetlag is chronic, as most individuals never have time to readjust their circadian clock and must continue in the misaligned pattern (Wittman, Dinich, Merrow, & Roenneberg, 2006).

As stated previously, circadian rhythms contribute to when an individual is able to fall asleep on weeknights. However, the alarm clock puts an artificial end to the night's sleep, leaving many individuals to feel unrested and fatigued upon waking and accumulating what is commonly referred to as *sleep debt* (Foster et al., 2013). In order to compensate for this fatigue, many people may sleep much longer on free days than they do on weekdays (Roenneberg et al., 2012). It is important to emphasize, however, that social jetlag does not simply refer to a difference in sleep duration between work and free days. Rather, social jetlag refers to differences in the timing of sleep between scheduled and unscheduled days (Beauvalet et al.,

2017) and is often calculated by looking at the shift in time between the midpoint of sleep on free days and the midpoint of sleep on work days (Wittman et al., 2006). This irregularity in sleep schedules can lead to greater difficulty falling asleep and waking during the workweek (Lund et al., 2010). Furthermore, maintaining an irregular sleep pattern goes against common sleep hygiene recommendations, and “regularity” has been added as one of the main components of sleep health (Buysse, 2014).

More individuals may be at risk of experiencing social jetlag than ever before. Most modern workers and students do not spend a significant amount of time outdoors, and this lack of daylight may be pushing the majority of people towards even stronger evening chronotypes (Roenneberg et al., 2012). However, business hours remain stable. This incongruence indicates that even more people may be sleeping at times that do not align with their natural circadian rhythms. In fact, 69% of adults have been found to experience at least one hour of social jetlag per week on average, with only 13% indicating that they experience no social jetlag at all (Foster et al., 2013).

Social jetlag has been associated with numerous health outcomes. Individuals who experience higher levels of social jetlag are more likely to consume stimulants including cigarettes, alcohol, and caffeine (Wittman et al., 2006). Social jetlag has been associated with higher risk of obesity (Roenneberg et al., 2012), cardiovascular disease (Wong, Hasler, Kamarck, Muldoon, & Manuck, 2015), and metabolic syndrome (Rutters et al., 2016). Social jetlag predicted symptom severity and quality of life in patients with gastroesophageal reflux disease (Arora, Esteban, Fogg, Kashavarzian, & Abraham, 2015).

Circadian rhythm disruption, the ultimate outcome of social jetlag, has been associated with various mental illnesses including schizophrenia, bipolar disorder (Foster et al., 2013), and depression (Levandovski et al., 2011). Due to the lack of longitudinal research on these associations (Beauvalet et al., 2017), the directionality of and mechanisms underlying these associations are unclear. Psychiatric illness could activate the stress axis, which would then trigger disruption in the circadian rhythm (Wulff, 2010). There may also be a genetic explanation, as research has identified genes that have been linked to both mental illness and circadian rhythm generation and regulation (Foster et al., 2013). A genetic underpinning could imply that mental illness and circadian rhythm disruption occur concurrently, with certain individuals at greater risk for both psychopathology and circadian disruption. However, other studies have demonstrated that disturbed sleep presents prior to acute psychiatric symptoms (Sheaves et al., 2016). Prodromal sleep difficulties are found in patients with bipolar disorder (Tijssen et al., 2010) and schizophrenia (Mattai et al., 2006), indicating that sleep irregularities may actually lead to the development of psychological dysfunction. Accordingly, interpersonal social rhythm therapy (IPRST) has been used to effectively treat patients with mood disorders by regulating biological and social rhythms, further providing evidence that sleep difficulties could be prodromal (Frank, Swartz, & Kupfer, 2000).

It is imperative to understand the directionality of the association between social jetlag and mental illness in order to identify the most important targets for intervention. This paper will focus on the association between social jetlag and depression due to the increasing prevalence of depression in the college student population (American College Health Association [ACHA], 2008).

Social Jetlag and Depression

Research has strongly supported an association between mood and sleep. Mood variations throughout the day reflect endogenous circadian rhythms (Golder & Macy, 2011), with positive affect peaking around wake time and continuing to deteriorate throughout the day (Baron & Reid, 2014). Data gathered from Twitter messages revealed that the time of day when participants experienced their peak positive affect shifted from weekdays to weekends. This shift paralleled the changing sleep schedules from weekdays to free days, further implying the important association between sleep and mood (Golder & Macy, 2011).

The association between sleep disorders and mood disorders is complex. Sleep disturbance, in the form of either insomnia or hypersomnia, is one of the criterions for diagnosing major depressive disorder (MDD), although insomnia disorder may be diagnosed comorbidly with MDD if the insomnia is severe enough to require separate treatment (American Psychiatric Association, 2013). Research regarding the causal associations between depression and mood symptoms has been inconclusive. Some studies indicate that insomnia can increase the risk of developing depression. A meta-analysis of seven prospective studies indicated that both short and long sleep duration predicted risk of depression in adults (Zhai, Zhang, & Zhang, 2015). In older adults, sleep disturbance was the second strongest predictor of developing MDD, second only to bereavement (Cole & Dendukuri, 2003). Sleep concerns may also help to perpetuate depressive symptoms, as insomnia predicted the severity and chronic course of depression over two years (van Mill, Vogelzangs, van Someren, Hoogendijk, & Penninx, 2014).

Although these studies view sleep as the predictor of depressive outcomes, longitudinal studies have also supported the idea that depression may increase the risk of developing sleep disturbances, at least partially. One study indicated that depressive symptoms predicted sleep quality but not sleep quantity (Wallace, Boynton, & Lytle, 2017). In an effort to test the directionality of the association between mood and sleep, data were collected on 1,420 children over the course of seven years (Shanahan, Copeland, Angold, Bondy, & Costello, 2014). Sleep symptoms (difficulty falling asleep, waking in the middle of the night, hypersomnia, nightmares, etc.) predicted and also were predicted by depression as defined by *DSM-IV* criteria. Therefore, a bidirectional association might exist, with sleep and depression mutually influencing each other.

There also appears to exist an association between sleep timing and depression. Individuals with evening chronotypes are more likely to report depressive symptoms in both psychiatric and non-psychiatric populations (Baron & Reid, 2014). Eveningness was associated with a higher risk of reporting moderate and intense depressive symptoms in a sample that did not report any psychiatric diagnoses (Hidalgo et al., 2009). The researchers posit that eveningness may not be a characteristic of a depressed individual, but rather a premorbid trait that predisposes an individual to depression. However, this study was cross-sectional, so the directionality of the association is unclear. Trait endurance, or the ability to work adequately in demanding, long-lasting situations, was found to be a mediator in the relationship between eveningness and depressed mood, indicating that individual differences in temperament may impact how this association is expressed (Jankowski, 2014a).

In addition to a link between eveningness and depression, current research indicates that individuals with depression may be at higher risk of circadian misalignment (Baron & Reid, 2014), which was correlated with depression symptom severity in a pilot study of individuals diagnosed with MDD (Emens, Lewy, Kinzie, Arntz, & Rough, 2009). Older theories use a social perspective when explaining the association between circadian misalignment and mood. These perspectives suggest that individuals with depression may have irregularities in their social rhythms caused by the social withdrawal characteristic of depression. The lack of social cues may contribute to physiological irregularities in the circadian rhythm (Ehlers, Frank, & Kupfer, 1988). For example, individuals with depression may spend less time outdoors. Since natural light acts as a zeitgeber to regulate the circadian rhythm, the individual may not be exposed to adequate light and may therefore experience circadian misalignment. Newer theories, however, posit that biological mechanisms are at play. The two-process model of sleep regulation seeks to explain how circadian misalignment and depression may interact. The two processes put forth by this model are process C, which refers to the circadian pacemaker, and process S, which reflects the individual's drive to sleep and increases throughout the day in healthy patients (Wirz-Justice, Benedetti, & Terman, 2013). For patients with depression, process S is deficient or reduced. Healthy mood variation depends on the alignment between processes C and S, with the sleep-wake cycle coinciding with circadian rhythms. However, these cycles are not as closely aligned in individuals with depression, causing drops in mood throughout the day (Wirz-Justice et al., 2013).

The role of circadian misalignment in depressive symptoms and depression has implications for the study of social jetlag and these outcomes. Specifically, depressive symptoms were found to increase with social jetlag independent of chronotype in adults from a rural population (Levandovski et al., 2011). Therefore, the shift in sleep timing between work and free days may be related to depressive symptoms beyond the impact of one's level of eveningness. Social jetlag was also correlated with scores on the Beck Depression Inventory in a combined sample of high school students, workers, and unemployed adults (Polugrudov et al., 2016). A similar pattern was found in a sample of 501 adults (Wittman et al., 2006). However, a recent study indicated that individuals who were currently diagnosed with MDD were not more likely to experience social jetlag unless they were taking an antidepressant (Knapen et al., 2018). Taking an antidepressant in the evening may create an excitatory effect that causes the individual to go to bed later, increasing social jetlag. However, the timing of medication intake was not measured, so this hypothesis cannot be empirically tested (Knapen et al., 2018).

As stated previously, the two-process model of sleep regulation postulates that affective disorders occur when the circadian process (process C) and the sleep-wake cycle (process S) become misaligned, causing variations in mood. Social jetlag, which represents one manifestation of this misalignment, would thus likely precede and contribute to the development of depressive symptoms (Wirz-Justice, 2013). However, social theories indicate that the withdrawal characteristic of depressive symptoms causes a reduction in the number of social cues available to entrain the individual's circadian rhythms, suggesting that affective disorders precede and contribute to the development of social jetlag (Van den Hoofdakker, 1994). Each of the studies mentioned above (Levandovski et al., 2011; Polugrodov et al., 2016; Wittman et al., 2006; Knapen et al., 2018) employed a cross-sectional methodology, so the directionality of the association between social jetlag and depressive symptoms is still empirically unknown. However, clarifying the direction of this association is necessary in order to better understand the origins of circadian disruption, such as social jetlag, in relation to the symptoms of mental illness (Beauvalet et al., 2017). It is also essential to understand the populations that are most affected by this association between social jetlag and depressive symptoms. The following section will explore how college students are at particular risk of both sleep and mental health concerns.

College Students, Social Jetlag, and Mental Health

Sleep disturbances are especially prominent in the college student population. College students experience insomnia, short sleep duration (Taylor et al., 2011), and poor sleep quality (Nyer et al., 2013) at concerning rates, with 70.6% of students getting less than 8 hours of sleep per night and 60% being categorized as poor sleepers (Lund et al., 2010). These sleep concerns may be attributed to several factors. Upon entering college, many students are making decisions without adult supervision for the first time, including choices about their health behaviors. Unfortunately, college students may not yet recognize the importance of healthy sleep (Lund et al., 2011). Traditional-aged college students are in the developmental period termed *emerging adulthood*. Emerging adults are faced with many new tasks and transitions, including developing more intimate relationships, navigating academic and financial stressors (Mahmoud, Staten, Hall, & Lennie, 2012), choosing a career path, and taking greater responsibilities for one's actions (Arnett, 2016). These transitions may cause increased stress and changes in the enactment of health behaviors. When asked to report what factors they feel contribute the most to their poor sleep, college students identified academic stress, emotional stress, and external light/noise as most significant (Lund et al., 2011).

Social jetlag is an especially relevant topic for college students, particularly with regards to chronotype. Individuals with an evening chronotype are at higher risk of experiencing social jetlag (Moon, Yoo, & Cho, 2017), as modern life caters to those with morning chronotypes (Beauvalet et al., 2017). Evening-types must conform their weekday sleep schedules to conventional business hours, while typically adhering to their own sleep preferences on weekends (Baron & Reid, 2014). Age-related trends show that individuals are more likely to shift towards eveningness in adolescence and young adulthood, gradually returning to morningness in later adulthood (Diaz-Morales, 2016). Therefore, traditional-aged college students are more likely to be evening-types, and thus at greater risk of social jetlag, than individuals in other age groups.

It is possible that the flexibility of a college course schedule might put students at lesser risk of experiencing social jetlag (Diaz-Morales & Sanchez-Lopez, 2008). Since students may be able to choose their own schedule, they may be more likely to choose course times that align with their own biological preferences, making them less susceptible to social jetlag. However, differences in sleep timing do exist in college students. In one study, on weeknights, students went to bed at 11:40 PM and woke at 7:42 AM on average. On weekends, students went to bed at 1:17 AM and rose at 9:45 AM, indicating a mean social jetlag score of two hours (Buboltz, Brown, & Soper, 2001). Interestingly, students also perceived themselves as sleeping fewer hours during the week than they actually slept. The researchers hypothesize that this perception may function as a self-fulfilling prophecy, causing students to act tired throughout the week and sleep longer during the weekend (Buboltz et al., 2001). However, it is also possible that the discrepancy in perception and actual duration is caused by fatigue due to social jetlag rather than shorter weeknight duration. Inconsistent sleep-wake schedules also predicted insomnia severity in a sample of college students (Gellis, Stotsky, & Taylor, 2014).

The association between social jetlag and depressive symptoms in college students is also critical to examine given the high rates of depression in this population. In a sample of undergraduate students, 17% screened positively for depression (Hunt & Eisenberg, 2010), and results from the 2008 National College Health Assessment revealed that one in three undergraduates reported feeling levels of depression that impaired their functioning at least once in the previous year (ACHA, 2008). These rates appear to be on the rise, as the number of students diagnosed with depression increased by 5% between 2000 and 2006 (ACHA, 2008). Certain predictors place groups of students at greater risk for developing mental health concerns, including low socioeconomic status, low social support, and interpersonal stressors (Hunt & Eisenberg, 2010). Depression can impact various aspects of students' lives, including academic functioning (Bruffaerts et al., 2018), interpersonal relationships (Lowry, 2008), and alcohol consumption (Terlecki, Ecker, & Buckner, 2014).

Given the high risk for college students to experience both social jetlag and depressive symptoms, and the known cross-sectional associations between these constructs, it is important to understand the association between these factors in this population over time. It is also crucial to investigate the longitudinal outcomes of social jetlag that are of particular interest to the college student population. Knowledge of these outcomes may help clinicians identify which factors to be especially attuned to when a student reports an inconsistent sleep/wake schedule. Two significant outcomes to focus on include academic performance and general wellbeing. Not only is undergraduate GPA associated with admission to and success in graduate programs (Hammond, Cook-Wallace, Moser, & Harrigan, 2015), but also perceived employability (Pinto & Ramalheira, 2017) and future income (Kittelsen Roberg & Helland, 2017). Therefore, it is important to prevent sleep disturbances that may impact GPA.

General wellbeing is also a critical outcome for college students. Early models of wellbeing focused on *hedonic*, or emotional, wellbeing, which emphasized happiness and positive affect. These factors may be directly linked to the absence of depression. However, current conceptions of wellbeing also include a *eudaimonic* component, which includes both social and psychological aspects of wellbeing (Ryff, 2014). Social wellbeing refers to whether one feels connected to and accepted by society and as if one is making a contribution to the betterment of society. Psychological wellbeing taps at deeper constructs than emotional wellbeing, referring to concepts such as autonomy and finding a purpose in one's life (Keyes, 2007). Social, psychological, and emotional wellbeing will be considered in this study to comprise a holistic view of wellbeing.

Wellbeing may be especially critical for the college population. Wellbeing has been found to be particularly relevant to identity formation, which is the stage of psychosocial development that traditional-aged college students are most likely experiencing (Hardy et al., 2013). Therefore, exploring variables that may impact one's sense of wellbeing is crucial to ensure that formation of identity and social connection is not stalled at a critical period in one's life. Although both GPA and wellbeing have been studied in relation to social jetlag (Moon, Yoo, & Cho, 2017), cross-sectional methodologies make it difficult to determine the longitudinal associations between social jetlag, academic performance, and wellbeing.

Social jetlag and academic performance. Sleep is known to influence cognitive performance. Poor sleep has been associated with negative cognitive outcomes, including decreases in working memory, abstract problem solving, attentional set shifting, and concentration (Nebes, Buysse, Halligan, Houck, & Monk, 2009). Sleep has been connected with memory consolidation, with results indicating that REM sleep is important for consolidation of procedural memory and the length of the NREM and REM cycles is implicated in declarative memory consolidation (Smith, 2001). Daytime sleepiness has been associated with decreased attention (Kamdar, Kaplan, Kerizian, & Dement, 2004) and impaired decision-making (Killgore, Williams, Lipizzi, Kamimori, & Balkin, 2007). Memory, attention, and decision-making may all contribute to a student's academic performance, and therefore performance may be hindered by sleep disturbances.

In a study of sleep disorders and academic performance in college students, students with at least one sleep disorder were more likely to have a grade point average (GPA) below 2.0 than were other students (Gaultney, 2010). Students who reported inconsistent weekend/weekday bedtimes also had lower GPA's on average, although social jetlag scores were not calculated in this study. Similarly, high school students who obtained less sleep, had later bedtimes, and had more irregular sleep/wake schedules throughout the week were more likely to report that they were struggling in or failing courses (Wolfson & Carskadon, 1998).

Research suggests that chronotype is predictive of academic performance, with greater levels of morningness associated with better grades (Genzel et al., 2013). Social jetlag was demonstrated to be an even stronger predictor of grades than chronotype in a sample of medical and dental students. Students were assessed during the lecture terms, when their schedules are heavily regulated, and the exam term, when students have greater flexibility in scheduling (Haraszti et al., 2014). Grades were negatively impacted during the scheduled lecture term but not during the flexible exam term. It was presumed that students were sleeping in accordance to their own circadian preferences during the exam term, and therefore not experiencing social jetlag. Thus, grades were only negatively impacted when students were adhering to a schedule that did not align with their circadian rhythms. Social jetlag similarly predicted academic performance in a sample of Korean medical students (Moon et al., 2017). In a sample of 12-16 year olds, social jetlag more strongly predicted GPA, *g*, or general intelligence, and scores on numerical, spatial, and reasoning tasks than either sleep duration or sleep quality (Diaz-Morales & Escribano, 2015). The associations between social jetlag and academic performance are thought to relate to the overall quantity and quality of sleep that students with higher social jetlag may be experiencing (Diaz-Morales & Escribano, 2015). If students are not sleeping in alignment with their natural circadian rhythms, their sleep may not be of adequate duration or self-reported quality, causing daytime sleepiness that impacts the students' ability to concentrate and perform effectively at school (Haraszti et al., 2014).

Although these studies provide valuable data supporting the association between social jetlag and academic performance, they employed a cross-sectional methodology that makes it difficult to assess for directionality (Haraszti et al., 2014; Moon et al., 2017; Diaz-Morales & Escribano, 2015). In a longitudinal analysis on a sample of junior high and high school students, social jetlag predicted future academic performance, defined by self-report, class ranking, and number of courses failed. This poor academic performance also led to later conduct problems (Lin & Yi, 2015). Therefore, there is evidence that social jetlag may contribute to the development of academic concerns in adolescents. More research is needed to confirm this result with the college student population.

Social jetlag and wellbeing. As stated previously, general wellbeing is an important outcome variable in the college student population. Although wellbeing is associated with mental health concerns such as depression and anxiety (Fergusson et al., 2015), this construct, along with psychological wellbeing, is often viewed in a broader sense. High levels of wellbeing indicate that the individual finds meaning in life, has healthy relationships, creates and sustains positive environments, and continues to develop and grow (Sayler, 2009). Wellbeing in college students is predicted by a number of constructs including self-esteem, emotional intelligence, social support (Kong, Zhao, & You, 2012), and stress (Holinka, 2015).

Sleep may also predict wellbeing. In one study, individuals who habitually obtained less sleep were more likely to report lower life satisfaction, a construct closely related to wellbeing (Kelly, 2004). In a rural adult sample, later midpoint of sleep as well as short sleep duration predicted lower wellbeing (de Souza & Hidalgo, 2015). A recent study explored the association between sleep disturbance and quality of life, a concept that refers to an individual's perceived life satisfaction in the context of their culture and value systems (Marques, Meia-Via, da Silva, &

Gomes, 2017). Sleep disturbance, including duration, subjective quality, sleep-onset latency, sleep efficiency, and daytime dysfunction, predicted quality of life when controlling for psychological symptomatology. Therefore, it seems likely that sleep impacts wellbeing beyond its association with mental health concerns.

Researchers have hypothesized an association between social jetlag and wellbeing due to the impact of social jetlag on mood, as previously described (Jankowski, 2014b). Lower daily mood associated with social jetlag may accumulate over time, causing a lower overall sense of wellbeing. Empirical findings, however, have been mixed. In a cross-sectional sample of Korean medical students, social jetlag predicted mental wellbeing as measured by the Warwick-Edinburgh Mental Well-Being Scale (Moon et al., 2017). This scale measures positive emotionality (ex. “I’ve been feeling relaxed”) as well as positive functioning (ex. “I’ve had energy to spare”; Tennant et al., 2007). On the other hand, social jetlag did not predict general wellbeing as measured by the Satisfaction with Life Scale in a sample of Polish university students (Jankowski, 2014b). The researcher posited that life satisfaction and wellbeing might be more strongly linked to an individual’s underlying chronotype than to social jetlag. However, the small body of research and use of differing scales and terms leaves the association between social jetlag and wellbeing still unclear. The long-term association of social jetlag with wellbeing, while controlling for the effect of psychological symptomatology, should be examined more thoroughly in order to better understand the associations between these variables.

Gender and Race as Moderators

Beyond the overall associations between social jetlag, depressive symptoms, and associated academic and wellbeing outcomes, it is important to understand if demographic factors may exacerbate the effects of social jetlag in the college student population. In particular, gender and race may place certain students at higher risk of social jetlag along with its associated outcomes.

Gender. Gender differences in sleep have been widely studied (Krishnan & Collop, 2006; Lee & Kryger, 2008; Mong et al., 2011). Hormonal changes have been linked to insomnia during both menses (National Sleep Foundation, 2007) and menopause (Krishnan & Collop, 2006). Depression and shift work, factors that impact sleep quantity and quality in both genders, have been found to impact women much more than men (Johnson, Roth, Schultz, & Breslau, 2006; Chung, Wolf, & Shapiro, 2009). In a sample of college students, female students were more likely to have sleep problems (subjective sleep quality, sleep latency, duration, efficiency, disturbances, use of sleeping medications, and daytime dysfunction) than were male students, and this association was mediated by both co-rumination with a best friend and depressive symptoms (Chow, Homa, & Amersdorfer, 2017).

Although fewer studies have examined gender differences in social jetlag, a related body of research on chronotype suggests that gender does impact circadian alignment. Gender differences have been found regarding sleep and chronotype, with age playing a key role. Adult women are more likely to have earlier chronotypes compared to men (Baron & Reid, 2014). However, girls and young women have been demonstrated to have greater levels of eveningness, potentially due to sex differences in developmental timing (Diaz-Morales & Escribano, 2015). Females hit their peak level of eveningness at 19.5 years, whereas men do not reach this peak until 21 years and tend to maintain an evening chronotype for most of adulthood (Roenneberg & Merrow, 2007).

Based on this research, female students may be reaching their peak eveningness, and thus more likely to experience social jetlag, towards the middle of their college experience, although little research has focused on this trend. In a sample of adolescents, Diaz-Morales (2016) found that female high school students experienced greater levels of social jetlag. Female adolescents had earlier wake times on weekdays than their male counterparts but slept later on weekends. The author posits that the earlier weekday wake times may be associated with the grooming rituals that many female students undertake prior to school, whereas male students may wake earlier on weekends due to athletic obligations.

Both chronotype and social jetlag have also been associated with worse psychological, academic, and wellbeing outcomes for females. Eveningness was more closely related to anxiety for females than males in a sample of rural adults (Diaz-Morales & Sanchez-Lopez, 2008), while a later midpoint of sleep has been associated with lower wellbeing for females (de Souza & Hidalgo, 2015). In a cross-sectional study of 12-16 year olds, social jetlag was more closely linked with a decline in mental abilities for female students (Diaz-Morales & Escribano, 2015), indicating a possible greater impact on academic performance. Women have also been shown to be more susceptible to further sleep difficulties as predicted by social jetlag, including shorter sleep duration and poorer sleep quality (Polugrudov et al., 2016).

Race. Much less research has been conducted exploring racial differences in social jetlag. However, social jetlag has been demonstrated in various racial groups across studies, including in medical students in Korea (Moon et al., 2017), adolescents in Spain (Diaz-Morales, 2016), and adults living in rural Brazil (de Souza & Hidalgo, 2015). This diversity across studies indicates that members of various racial groups experience social jetlag; however, it is unclear whether racial differences in social jetlag exist and if social jetlag's associations with depressive symptoms, academic performance, and wellbeing differ among racial groups in a diverse sample.

Existing research is mixed regarding the association between sleep disturbances and race. Although several studies have found that members of minority groups have poorer sleep quality (Boss et al., 2011; Moore et al., 2011), others have found sleep quality to be equal across majority and minority groups (Grandner et al., 2010; Hale & Rivero-Fuentes, 2011). Black/African American participants are more likely to have longer sleep-onset latency than non-Hispanic white participants. However, they are less likely to report difficulty maintaining sleep, daytime sleepiness, early morning awakenings, and non-restorative sleep (Grandner et al., 2013). Individuals who experience higher levels of perceived discrimination are more likely to have poorer sleep quality, potentially suggesting a mechanism explaining sleep disturbances among racial/ethnic minority groups (Johnson-Lawrence & Hunte, 2015).

Despite inconsistent findings regarding racial/ethnic differences in general sleep disturbances, Black/African American college students may be at particular risk of sleep disturbance. In a sample of 158 Black/African American college students, 63% reported poor sleep quality, and 62% reported obtaining 6.5 or fewer hours of sleep per night (Billings & Berg-Cross, 2014). Moreover, students in this sample reported delaying weekend bedtimes by over an hour more than White students in previous studies, suggesting the potential impact of social jetlag in this population. Sleep disturbances reported by Black/African American students are disproportionate to those reported by White students and emerge by age 24 (Walsemann, Ailshire, Fisk, & Brown, 2017), providing evidence for the existence of racial/ethnic sleep disparities in emerging adulthood. Research with diverse samples should be conducted in order to explore the specific associations of social jetlag with relevant outcomes for members of racial/ethnic minority groups.

Summary and Study Aims:

Risk factors and outcomes of social jetlag should continue to be studied in order to better understand precursors and implications of this phenomenon. Social jetlag, or the misalignment in sleep timing between work and free days, has been associated with numerous negative health outcomes, including higher risk of obesity (Roenneberg et al., 2012), cardiovascular disease (Wong, Hasler, Kamarck, Muldoon, & Manuck, 2015), and metabolic syndrome (Rutters et al., 2016). Therefore, it is important to understand the role of social jetlag in the emerging adult population before these negative health risks develop. It is necessary to identify which groups of students are at heightened risk of social jetlag, as well as whether academic performance and overall wellbeing are currently being impacted by this jetlag. This study aimed to shed light on these questions.

College students in general may be at particular risk of experiencing social jetlag due to their greater likelihood of having an evening chronotype (Diaz-Morales, 2016), and, in fact, one study found that college students do experience significant shifts in their sleep pattern on weeknights versus weekends (Buboltz et al., 2001). At the same time, concern about mental health in this population is growing, and the number of college students who are experiencing depressive symptoms is increasing (ACHA, 2008). Social jetlag is associated with depressive symptoms (Levandovski, 2011), although cross-sectional methodology has made the directionality of this relationship challenging to untangle (Beauvalet et al., 2017). Social jetlag may also predict academic performance and general wellbeing (Moon et al., 2017), two critical outcomes for college students. Again, more longitudinal research is needed to support the temporal associations of these variables. Lastly, diverse samples are needed to explore how race and gender may impact the experience of social jetlag, as research has been mixed regarding the roles that race and gender may play in these associations (Diaz-Morales & Escribano, 2015; Gardner et al., 2010; Boss et al., 2011).

Following are the aims of the current study:

Aim 1: To examine the directionality of the association between social jetlag and depressive symptoms. Social jetlag and depressive symptoms are shown to be concurrently correlated (Levandovski et al., 2011); however, it is unclear whether depressive symptoms predispose an individual to experiencing social jetlag, whether social jetlag places an individual at greater risk of depression, or whether both mechanisms are at play. Shanahan et al. (2014) suggest that sleep disturbances both predict and are predicted by depressive symptoms. Based on these findings, the following were hypothesized:

Hypothesis 1.1. Greater depressive symptoms will predict greater future social jetlag.

Hypothesis 1.2. Greater social jetlag will predict greater future depressive symptoms.

Hypothesis 1.3. Greater social jetlag will be concurrently associated with greater depressive symptoms.

Aim 2: To examine the longitudinal associations of social jetlag with future GPA. Social jetlag has shown potential to predict academic performance, both cross-sectionally (Moon et al., 2017) and longitudinally in an adolescent population (Lin & Yi, 2015). Based on these findings, the following was hypothesized:

Hypothesis 2. Greater social jetlag will predict lower future GPA.

Aim 3: To examine the longitudinal associations of social jetlag with future wellbeing. There have been conflicting results regarding the relationship between social jetlag and life satisfaction/general wellbeing (Moon et al., 2017; Jankowski, 2014). However, general sleep disturbance has been found to predict wellbeing (de Souza & Hidalgo, 2015). Therefore, the following was hypothesized:

Hypothesis 3. Greater social jetlag will predict lower future wellbeing.

Aim 4: To examine the role of gender as a moderator of the associations between social jetlag and depressive symptoms, GPA, and wellbeing. Given that women experience greater susceptibility to the risks of social jetlag (Diaz-Morales & Escribano, 2015; Polugrudov et al., 2016). Therefore, the following were hypothesized:

Hypothesis 4.1. Gender will moderate the association between social jetlag and depressive symptoms, with the association exacerbated for female participants such that greater social jetlag will be associated with higher depressive symptoms for females than for males.

Hypothesis 4.2. Gender will moderate the association between social jetlag and GPA, with the association exacerbated for female participants such that greater social jetlag will be associated with worse GPA outcomes for females than for males.

Hypothesis 4.3. Gender will moderate the association between social jetlag and wellbeing, with the association exacerbated for female participants such that greater social jetlag will be associated with lower wellbeing outcomes for females than for males.

Aim 5: To examine the role of race as a moderator of the associations between social jetlag and depressive symptoms, GPA, and wellbeing. There is a lack of research on the association between race and social jetlag. However, evidence suggests that Black/African American college students are at increased risk of sleep disturbances including short duration, poor sleep quality, and daytime sleepiness (Billings & Berg-Cross, 2014). Therefore, the following were hypothesized:

Hypothesis 5.1. Race will moderate the association between social jetlag and depressive symptoms, with the association exacerbated for participants of color such that greater social jetlag will be associated with greater depressive symptoms for participants of color than for White participants.

Hypothesis 5.2. Race will moderate the association between social jetlag and GPA, with the association exacerbated for participants of color such that greater social jetlag will be associated with worse GPA outcomes for participants of color than for White participants.

Hypothesis 5.3. Race will moderate the association between social jetlag and wellbeing, with the association exacerbated for participants of color such that greater social jetlag will be associated with lower wellbeing outcomes for participants of color than for White participants.

Method

Participants

An archival analysis of the Spit for Science project was conducted. Spit for Science is an ongoing longitudinal study at Virginia Commonwealth University, a large, urban public university, that studies behavioral and genetic variables in college students (Appendix A; Dick et al., 2014). Students must be 18 years and older to participate. Both full- and part-time students were eligible for participation. Participants completed one survey per academic year for five consecutive years, including post-graduation. Data from this survey was retrieved from years 1, 2, 3, and 4 of study participation. Analyses for the current study used data from Cohort 2. Members of Cohort 2 began participating in the study during the 2012-2013 academic year, with 2,040 students completing the initial survey.

Sociodemographics were obtained for students included in the final sample (Table 1). Students were on average 18.46 years old (*SD* = .36) at the start of the study and primarily female (73.0%). When race was coded dichotomously into White students and students of color, 58.2% of participants were students of color. All students endorsed engaging in paid weekly employment, with 42.1% of students working 10-19 hours per week. Students obtained an average of 472.68 minutes of sleep per night (approximately 7 hours and 52 minutes; *SD* = 80.17). Students rated their sleep quality at 2.93 on average (*SD* = .58) on a four-point scale.

Procedure

All incoming freshmen, along with their parents, were mailed information about the Spit for Science study approximately 2 weeks before the students arrived on campus. One week prior to arriving on campus, freshmen who were 18 years or older received an email inviting them to participate in the Spit for Science project. Reminders were emailed weekly for the first four weeks and then intermittently for the following six weeks. Participants received a link to an online survey using REDCap (Research Eletronic Data Capture; Harris et al., 2009), a secure, web-based application designed to support data capture for research studies. Upon clicking on this link, participants were informed about the purpose of the study and then gave consent. Participants then completed a series of behavioral and psychological measures. Participants were able to go to a central location at the university, where they could collect a $10 payment and free t-shirt. Participants could then give a saliva DNA sample for an additional $10, although participants could agree to participate only in the survey and forgo the DNA sample. Students were asked to participate in a follow-up survey via email each subsequent spring and were also compensated for participation with $10.

Table 1
Participant Sociodemograhic Variables (M, SD)

Variable	N	Percentage (%)
Age (18.46, .36)		
18	279	62.0
19	163	36.2
20	7	1.6
21	1	0.2
Gender		
Female	386	73.0
Male	143	27.0
Race/Ethnicity		
White	218	41.8
Asian	126	24.1
Black/African American	114	21.8
Hispanic/Latino	28	5.4
More than one race	28	5.4
Native Hawaiian/Other Pacific Islander	6	1.2
American Indian/Native Alaskan	1	.2
Hours of Weekly Employment		
1-9 hours/week	55	19.3
10-19 hours/week	120	42.1
20-29 hours/week	88	30.9
30-39 hours/week	19	6.7
40-49 hours/week	1	.4
50-59 hours/week	2	.7
Sleep Duration (472.43, 80.43)		
Less than 360	18	3.4
361-420	56	10.6
421-480	173	32.8
481-540	161	30.5
541-600	101	19.1
More than 600	19	3.6
Sleep Quality (2.94, .58)		
Very bad	6	1.1
Fairly bad	89	16.7
Fairly good	371	69.7
Very good	66	12.4

Note: Sleep Duration was measured in average minutes of sleep per night. Sleep Quality was measured on a 4-point scale ranging from *1 = very bad* to *4 = very good*

Measures

A subset of the behavioral and psychological measures included in the Spit for Science dataset was selected for analysis in the current study. The following sections detail the measures used in the current study.

Demographic Factors. Gender and race were used as moderator variables in the current study. Both variables were assessed in year 1. Participants were asked to select their sex from the following options: *female*, *male,* or *I choose not to answer.* Participants were also asked to identify their race/ethnicity with the question, “Which of these groups best describes you?” Response options included *African American/Black, American Indian/Alaska Native, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Other Asian group, Hispanic/Latino, Native Hawaiian/Other Pacific Islander, White, Other, Unknown,* and *I choose not to answer.* For the purposes of this study, race/ethnicity was coded dichotomously, with students who selected *White* coded as one group and all other categories (with the exception of *I choose not to answer* and *unknown*) coded as another group representing “students of color.” Age was also entered into the model as a covariate. Age was assessed at each year of the study, and participants were allowed to enter their numeric age into the electronic survey.

Social Jetlag. In years 3 and 4 of the study, participants were asked the following questions: (1) “When do you usually go to bed on weekdays?”, (2) “When do you usually go to bed on weekends and holidays when you don’t have to get up at a particular time to go to school/work or another appointment?”, (3) “When do you usually wake up on weekdays?”, and (4) “When do you usually wake up on weekends and holidays when you don’t have to get up at a particular time to go to school/work or another appointment?” For the questions referring to bedtimes, participants responded on a 17-point scale from *“before 8:30 PM”* with increments of

30 minutes (*8:30 PM, 9:00 PM, etc.)* to "*after 3:30 AM*." For the questions regarding wake times, participants responded on a 22-point scale from *"before 6:00 AM"* with increments of 30 minutes (*6:00 AM, 6:30 AM, etc.)* to *"after 3:30 PM*."

For the purpose of this study, time options were converted to a 24-hour clock. Social jetlag was calculated by subtracting the midpoint of sleep on weeknights from the midpoint of sleep on weekend/holiday nights. This formula for calculating social jetlag is supported by previous research (Wittman et al., 2006). The midpoints of sleep on weeknights and weekend/holiday nights were found by subtracting the reported bedtime from the reported wake time and dividing by two. Due to the categorical nature of the response options, social jetlag was calculated in 100-increment units, where a social jetlag score of 100 represents one hour of jetlag, and a score of 150 represents an hour and a half of jetlag. The absolute value of social jetlag was used, as a shift in midpoint is presumed to be equally impactful regardless of the direction (Wittman et al., 2006). For the current study, social jetlag data collected in Years 3 and 4 were used.

Depressive Symptoms. In years 1-5 of the study, depressive symptoms were assessed using a subset of four items from the Symptoms Checklist-90 (Derogatis, Lipman, & Covi, 1973), a measure used in both clinical and research settings to assess symptoms of psychopathology. Participants were asked to choose how often they experienced depressive symptoms ("feeling blue," "worrying too much about things," "feeling no interest in things," and "feeling hopeless about the future") over the past 30 days. There were five response options ranging from *not at all* to *extremely*. A total depressive score was derived from summing the scores on these four items. Total depressive scores could range from 4-20. The scale had strong internal reliability for the current sample (α = .86). These symptoms correspond to three of the

DSM-5 criteria for major depressive disorder (American Psychiatric Association, 2013), suggesting construct validity. In the current study, data on depressive symptoms was collected from years 2, 3, and 4.

Academic Performance. Each year after the initial survey, participants were asked to self-report their Grade Point Average (GPA) for the preceding term on a scale from 0.0 to 4.0. For the current study, GPA data was collected in the spring of Year 4; therefore, participants reported the GPA that corresponded with the fall semester of their fourth year in college.

Wellbeing. In year 4 of the study, wellbeing was measured by the 14-item Mental Health Continuum-Short Form (MHC-SF; Keyes, 2006; Appendix B). Participants were asked how often they felt indicators of emotional wellbeing (e.g. "interested in life"), social wellbeing (e.g. "that people are basically good"), and psychological wellbeing (e.g. "good at managing the responsibilities of your daily life") during the past month. There were six response options ranging from *never* to *every day*. Although Keyes (2007) provided cutoff scores for categorizing individuals as having flourishing, languishing, or moderate mental health, the current study derived a total wellbeing score from summing the scores on all items of the MHC-SF in order to capture greater variability among participants. Scores ranged from 14 to 84. The scale demonstrated strong reliability for the current sample ($\alpha = .94$). Convergent validity has been demonstrated with measures of emotional and psychological wellbeing. The social wellbeing subscale also demonstrated convergent validity with items assessing level of social engagement, political participation, and political efficacy (Lamers, Westerhof, Bohlmeijer, ten Klooster, & Keyes, 2011).

In order to assess divergent validity and support the notion that wellbeing represents a distinct construct rather than the absence of mental illness, Lamers et al. (2011) conducted a confirmatory factor analysis to test whether a one-factor or two-factor model best fit items from the Brief Symptom Inventory as well as the Mental Health Continuum-Short Form. A two-factor model was demonstrated to better fit the data. The factors were moderately negatively correlated (Lamers et al., 2011), suggesting that, although wellbeing and mental illness do share some variance, they are indeed separate constructs. In the current study, wellbeing data from year 4 was used.

Covariates

Employment. Employment was considered as a potential covariate in the model, as a student's time spent in employment may impact their sleep and activity timing. Participants were asked to report how many hours per week they usually work at all jobs combined. There were eight response options ranging from *0 hours per week* to *60 or more hours per week*, with response options divided into nine-hour increments (e.g. *0 to 9 hours per week*). Employment was assessed in years 2, 3, and 4. Year 3 employment data was used in the current study in order to assess how employment impacts concurrent sleep and social jetlag.

Sleep duration. Sleep duration was assessed in years 3 and 4 with the question, "How many hours of sleep do you typically get per night?" Response options ranged from *0* to *24* hours per night in one-hour increments. Sleep duration data from year 3 was used in this study.

Sleep quality. Sleep quality was assessed in years 3 and 4 with the item, "Rate your sleep quality." Response options were on a 4-point scale ranging from *very bad* to *very good*. Sleep quality data from year 3 was used in this study.

Statistical Analyses

Descriptive statistics and covariate evaluation. Age, employment, sleep duration, and sleep quality were considered as covariates due to their known associations with social jetlag, depressive symptoms, academic performance, and general wellbeing (Diaz-Morales, 2016; Johnson et al., 2006; Wittman et al., 2006). In order to increase power for analyses, Pearson correlational analyses were conducted, and only those covariates that correlated significantly ($p < .05$) with variables of interest were entered into final analyses. Sleep duration and sleep quality were included as covariates in the analyses for Aims 1 and 2 due to their significant correlations with the variables of interest in these analyses. Age, sleep duration, and sleep quality were entered into the model for Aim 3, due to the associations with wellbeing. Employment was not included in statistical models for any analysis, as it was not significantly correlated with any variables of interest (Table 2).

Table 2
Pearson Correlation Coefficients among Social Jetlag, Depressive Symptoms, Wellbeing, GPA, and Covariate Variables

	Social Jetlag	Depressive Symptoms	GPA	Wellbeing
Social Jetlag	-			
Depressive Symptoms	.164**	-		
GPA	.018	-.020	-	
Wellbeing	-.071	-.453**	.019	-
C_1 Age	.016	.046	.074	-.108*
C_2 Employment	-.072	-.039	.111	-.066
C_3 Sleep Duration	-.103*	-.154**	-.042	.132**
C_4 Sleep Quality	-.129**	-.289**	.027	.248**

Note. C_1-C_4 indicates covariates.

- $p < .05$. ** $p < .001$.

Cross-Lagged Panel Analysis. In order to assess Aim 1, a cross-lagged panel analysis was conducted using Amos Version 24 for SPSS (Arbuckle, 2014). A cross-lagged panel models the associations between two or more variables measured at two or more time-points. Cross-lagged analysis is advantageous over running several linear regressions or correlations because it allows for examination of the unique effects of cross-paths, while controlling for the effects of other variables in the model. Stronger effects of cross paths demonstrate that one variable is causally dominant (Kearney, in press).

Moderation Analyses. In order to assess Aims 2-5, moderation analyses were conducted using Hayes' (2013) SPSS PROCESS macro. PROCESS is a computational tool for SPSS that allows for the calculation of coefficients of a model using OLS regression in addition to providing the conditional effects of a moderation model. Because all moderators used in this paper were dichotomous, PROCESS generated the conditional effect of the independent variable in each analysis at each of the two values of the moderators. PROCESS uses a bootstrapping procedure of 5,000 resamples from the data set in order to estimate the sampling distribution of the conditional effects and regression coefficients.

Results

Data Preparation

Descriptive statistics (means, standard deviations, skewness, kurtosis) of all variables of interest were calculated to verify that data met the assumptions of all analyses. Skewness and kurtosis values for depressive symptoms (at all time points), GPA, and wellbeing were below a value of 1, indicating that the data for these variables approximated a normal distribution. Although the skewness and kurtosis values for Year 3 social jetlag were also below 1, social jetlag in Year 4 was both positively skewed and mesokurtotic. Outliers were examined, and values for two extreme cases were altered to four standard deviations above the mean. The modification of these cases brought the skewness and kurtosis values of this variable to below 1.0, and normality was assumed.

Descriptive Results

Frequencies and descriptive statistics were calculated for sleep timing variables (Table 3). In Year 3, many students (46.8%) endorsed going to bed between 12:00 and 1:00 AM on weekdays. Weekend bedtimes were more variable, with bedtimes between 1:30 and 2:30 AM as the most popularly endorsed options (38.7%). On weekdays, 38.3% of students endorsed waking between 7:00 and 8:00 AM, whereas 68.2% did not endorse waking before 10:00 AM on free days. Year 4 sleep timing patterns were similar, although average bedtimes and wake times were earlier in Year 4 than in Year 3 for both weekdays and free days. As stated previously, a social jetlag score of 100 represents a difference of one hour between weekday and weekend midpoints. Students had an average social jetlag score of 178.38 (*SD* = 87.87) at Year 3 and an average score of 115.09 (*SD* = 64.48) at Year 4. Fewer students had more than two hours of social jetlag in Year 4 (8.5%) than in Year 3 (34.4%).

Frequencies and descriptive statistics were also calculated for other variables of interest (Table 4). Scores on the depressive symptoms scale could range from 4 - 20. In the current study, there was an average of 9.60 (*SD* = 3.86) at Year 2, 9.45 (*SD* = 4.01) at Year 3, and 9.38 (*SD* = 4.04) at Year 4. Average GPA was 2.96 (*SD* = 1.02). Scores on the wellbeing scale had a possible range of 14 - 84. Students in this sample had an average score of 49.86 (*SD* = 11.49), with a maximum value of 70.

Table 3
Descriptive Statistics of Sleep Timing Variables (M, SD)

Variable	N	Percentage (%)	N	Percentage %
	Year 3		Year 4	
Weekday Bedtime				
Before 10:30PM	11	2.1	18	3.4
10:30-11:30PM	95	17.9	86	16.2
12:00-1:00AM	249	46.8	256	48.1
1:30-2:30AM	147	27.6	117	22.0
After 2:30AM	30	5.6	28	5.3
Free Day Bedtime				
Before 10:30PM	3	0.6	9	1.7
10:30-11:30PM	23	4.3	34	6.4
12:00-1:00AM	152	28.6	164	30.8
1:30-2:30AM	206	38.7	210	39.5
After 2:30AM	148	27.8	115	21.6
Weekday Wake				
Before 7:00AM	47	8.8	68	12.8
7:00-8:00AM	204	38.3	215	40.4
8:30-9:30AM	177	33.3	165	31.0
10:00-11:00AM	86	16.2	72	13.5
11:30AM-12:30PM	15	2.8	11	2.1
After 12:30PM	3	0.6	1	0.2
Free Day Wake				
Before 7:00AM	2	0.4	6	1.1
7:00-8:00AM	21	3.9	39	7.3
8:30-9:30AM	92	17.3	112	21.1
10:00-11:00AM	209	39.3	227	42.7
11:30AM-12:30PM	154	28.9	112	21.1
After 12:30PM	54	10.2	36	6.8
Social Jetlag Score	(178.38, 87.87)		(115.09, 64.48)	
≤ 100	135	25.4	307	57.7
101-200	214	40.2	180	33.8
201-300	151	28.4	42	7.9
301-400	25	4.7	3	0.6
401-500	7	1.3	0	0.0

Note: A social jetlag score of 100 represents one-hour difference between midpoint of sleep times on weekdays versus free days.

Table 4

Descriptive Statistics of Variables of Interest (M, SD)

Year Collected	Variable	N	Percentage (%)
2	Depressive Symptoms (9.60, 3.86)		
	0-5	72	15.6
	6-10	218	47.1
	11-15	129	27.9
	16-20	44	9.5
3	Depressive Symptoms (9.45, 4.01)		
	0-5	87	16.5
	6-10	256	48.7
	11-15	137	26.0
	16-20	46	8.7
4	Depressive Symptoms (9.38, 4.04)		
	0-5	94	17.9
	6-10	257	48.9
	11-15	120	22.8
	16-20	55	10.5
4	GPA (2.96, 1.02)		
	0.0-1.0	28	6.9
	1.1-2.0	36	8.9
	2.1-3.0	106	26.2
	3.1-4.0	234	57.9
4	Wellbeing (49.86, 11.49)		
	0-20	1	.2
	21-40	105	20.4
	41-60	310	60.3
	61-84	98	19.1

Cross-Lagged Panel Analysis

Due to the longitudinal nature of the study, there were many missing data points. Missing data may cause bias in longitudinal data of an unknown direction and magnitude (Biering, Hjollund, & Frydenburg, 2015). In order to more accurately assess Aim 1, only participants who provided data for social jetlag at both time points and depressive symptoms at a minimum of two time points were included. The deletion of participants with missing data yielded a sample size of 532. Recommendations for sample size in path analysis vary; however, common guidelines indicate that the current sample size (<500) is considered good, with adequate power to detect cross-lagged panel effects (Meyers, Gamst, & Guarino, 2016).

A cross-lagged panel analysis was conducted controlling for sleep quality and sleep duration. Error terms were correlated. Results indicated that social jetlag and depressive symptoms were only significantly associated concurrently at Year 3 (Table 5). The strongest pathways for this model were between sleep quality and depressive symptoms. Therefore, a second model (Figure 1) was run without covariates to assess the associations that may have been masked due to the presence of these correlated variables. In this model, the pathway between concurrent social jetlag and depressive symptoms measured at Year 3 was significant, B = .006, $p < .001$ (Table 6). The concurrent pathway between social jetlag and depressive symptoms measured at Year 4 was not significant. Year 3 social jetlag did significantly predict Year 4 depressive symptoms, B = .004, $p = .034$. Depressive symptoms did not predict social jetlag at any time points.

Longitudinal Outcomes and Moderation Analyses

The association between social jetlag and GPA was examined with sleep duration and sleep quality entered as covariates. Social jetlag did not predict GPA, $p = .16$, 95% CI [-.00, .01]. Further, neither gender nor race moderated this association.

The association between social jetlag and wellbeing was examined while controlling for age, sleep duration, and quality. Both sleep quality, $p < .001$, 95% CI [2.82, 6.54] and age, $p = .02$, 95% CI [-6.50, -.50] predicted wellbeing. However, social jetlag did not predict wellbeing, $p = .71$, 95% CI [-.04, .06]. Neither race nor gender moderated this association.

Table 5

Cross-Lagged Panel Pathway Estimates with Covariates

Pathway	Estimates	Standard Error	*p*-value
SQ→Y2Dep	-1.143	.297	**
SQ→Y3Dep	-1.773	.288	**
SQ→Y4Dep	-1.690	.295	**
SQ→Y3SJL	-16.116	6.645	.015*
SQ→Y4SJL	-8.347	5.026	.097
Duration→Y2Dep	-.002	.002	.250
Duration→Y3Dep	-.004	.002	.074
Duration→Y4Dep	-.003	.002	.232
Duration→Y3SJL	-.079	.047	.095
Duration→Y4SJL	-.031	.035	.379
Y3SJL→Y3Dep	.005	.002	.002*
Y3SJL→Y4Dep	.002	.002	.190
Y2Dep→Y3SJL	.564	1.047	.590
Y2Dep→Y4SJL	.843	.962	.381
Y3Dep→Y4SJL	.633	.932	.497
Y4Dep→Y4SJL	-1.272	.913	.163

Note: SQ refers to Sleep Quality. “Y2” refers to Year 2. “Dep” refers to Depressive Symptoms. “SJL” refers to Social Jetlag.

* $p < .05$ ** $p < .001$

Table 6

Cross-Lagged Panel Pathway Estimates without Covariates

Pathway	Estimates	Standard Error	*p*-value
Y3SJL→Y3Dep	.006	.002	**
Y3SJL→Y4Dep	.004	.002	.034*
Y2Dep→Y3SJL	1.171	1.036	.259
Y2Dep→Y4SJL	.626	.914	.494
Y3Dep→Y4SJL	.245	.826	.767
Y4Dep → Y4SJL	-.003	.002	.202

Note: “Y3” refers to Year 3. “Dep” refers to Depressive Symptoms. “SJL” refers to Social Jetlag.

* $p < .05$ ** $p < .001$

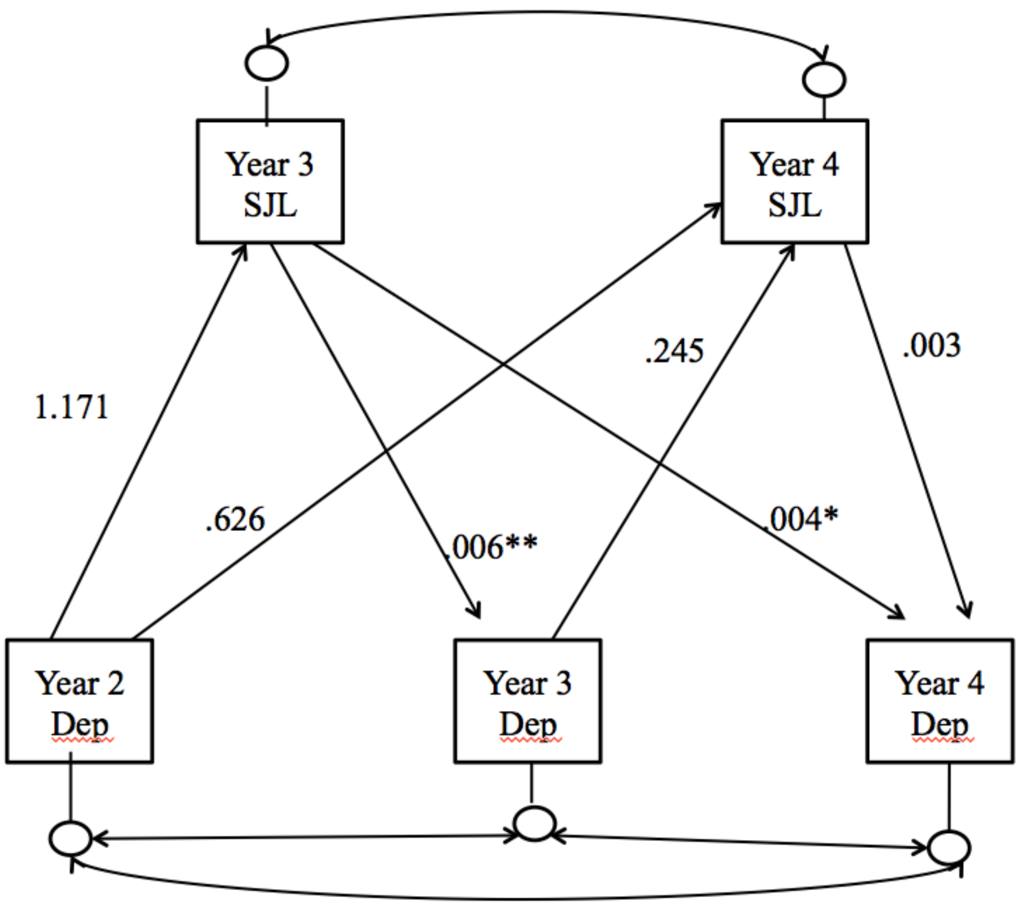

Figure 1. Cross-lagged panel analysis of social jetlag and depressive symptoms

Moderation analyses were conducted to assess how gender and race interact with the association between Year 3 social jetlag and Year 3 depressive symptoms, the pathway of strongest significance in the cross-lagged panel analysis. Neither race nor gender moderated this association. Moderation analyses were also conducted to assess how gender and race interact with the significant association between Year 3 social jetlag and Year 4 depressive symptoms. Neither race nor gender served as moderating variables in this analysis.

In order to more completely assess aims 4 and 5, gender- and race-based differences were analyzed for each main variable of interest. Female students had greater Social Jetlag at both time points; however, these differences were not significant (Table 7). Female students had significantly higher rates of depressive symptoms at all time points; however, there were no gender differences in GPA or wellbeing. There were no differences between white students and students of color in social jetlag, GPA, or wellbeing. White students were more likely to have depressive symptoms at every time point than students of color.

Table 7

Gender and Race Differences in Variables of Interest

Variable	Gender *M* (*SD)*		Race *M* (*SD*)	
	Females	Males	White Students	Students of Color
Year 3 Social Jetlag	180.38 (88.43)	173.43 (85.59)	178.44 (79.64)	178.87 (92.99)
Year 4 Social Jetlag	117.62 (66.40)	108.92 (58.10)	110.67 (68.36)	117.93 (61.57)
Year 2 Depressive Symptoms	9.98 (3.91)**	8.54 (3.53)	10.02 (3.79)*	9.30 (3.91)
Year 3 Depressive Symptoms	9.68 (4.01)*	8.75 (3.90)	10.03 (4.01)*	9.00 (3.93)
Year 4 Depressive Symptoms	9.77 (4.05)**	8.34 (3.88)	10.12 (4.06)**	8.81 (3.94)
Year 4 GPA	3.00 (0.96)	2.86 (1.15)	2.85 (1.07)	3.04 (.96)
Year 4 Wellbeing	49.67 (11.29)	50.42 (12.13)	50.29 (11.33)	49.62 (11.72)

Note: * $p < .05$. ** $p < .001$

Discussion

The current study had the following aims: 1) examine the directionality of the association between social jetlag and depressive symptoms, 2) examine the longitudinal association between social jetlag and GPA, 3) examine the longitudinal association between social jetlag and wellbeing, 4) assess gender as a moderating variable in these associations, and 5) assess race as a moderating variable in these associations. Results provided support for some of the current hypotheses, while failing to yield significant findings for others.

The current results yielded a concurrent positive association between social jetlag and depressive symptoms even when controlling for sleep duration and quality, reflecting the existent cross-sectional literature (Levandovski et al., 2011; Polugrudov et al., 2016; Wittman et al., 2006) that links an irregular sleep pattern with greater depressive symptoms. The previously cited studies were conducted with samples of working adults and high school students; therefore, the current findings add to the literature by suggesting that similar associations between social jetlag and mood exist within the college student population. This finding provides a counterargument to previous claims that the flexibility of a college course schedule may prevent students from experiencing social jetlag and its negative effects (Diaz-Morales & Sanchez-Lopez, 2008).

Interestingly, the concurrent association was not significant at Year 4. One potential explanation for this finding is the fact that students' social jetlag scores appeared to improve in Year 4. In Year 3, the mean social jetlag score was 178.38, representing over an hour and a half of lag between midpoint of sleep on work days and free days. In Year 4, the mean social jetlag score was only 115.08, or just over one hour of lag. Results from a post-hoc dependent samples *t*-test indicated that the difference in social jetlag in Year 3 and Year 4 was significant, $t(531) = 15.71$, $p < .001$. Thus, students' sleep patterns may have become more regular over time, lessening the association of social jetlag with mood. There were no significant differences in depressive symptoms over time, however. This finding indicates that other variables besides social jetlag were perpetuating students' depressive symptoms.

Because students' schedules vary widely across semesters, it is unclear whether the improvement in social jetlag over time is due to increased awareness of sleep health and efforts to improve sleep regularity, or due to a simple change in schedule demands. Little research has examined how sleep changes over the course of a student's time in college. One study showed that both sleep duration and quality fluctuated over the first three years of college; however, this trend was not linear, as duration and quality decreased in the second year but improved in the third year (Tavernier & Willoughby, 2014). Therefore, although evidence indicates that sleep may change throughout the student's years at the university, it is unclear in which direction this change takes place and how it may impact factors such as mood.

Given established and strong links between sleep quality and duration and mood outcomes, the researcher investigated whether social jetlag was longitudinally associated with depressive symptoms when the effects of quality and duration were removed. Results indicated that social jetlag did predict depressive symptoms after a one-year period once sleep quality and duration were removed from the model. This finding supports the two-process model of sleep regulation, which posits that misalignment between the circadian process (process C) and the sleep-wake cycle (process S), such as that which causes social jetlag, leads to depressed affect (Wirz-Justice et al., 2013). Following process C, or natural circadian rhythms, mood is lowest in the early morning, increases throughout the day, and declines again during the night. Regarding process S, mood is best when there is low sleep pressure, or need to sleep, in the mornings, and declines throughout the day. Therefore, when these two processes are aligned, mood is stable and balanced. However, misalignment may cause sudden drops in mood, which may help explain the diurnal mood swings in patients with depression (Wirz Justice et al., 2013). Few studies have examined this process in individuals with non-seasonal depression over an extended period. Instead, evidence that the two-process model interacts with mood has come primarily from the success of treatments for depression that focus on regulating the circadian pacemaker, including sleep deprivation and light therapy (Borbely, Dean, Wirz-Justice, & Deboer, 2016). Therefore, this study provides evidence that social jetlag, perhaps a manifestation of the misalignment of these processes, may have longer-term impacts on depressive symptoms, rather than just diurnal variations.

The hypothesis that depressive symptoms would predict future social jetlag was not supported. This hypothesis was based on social models of the association between depression and sleep, which posit that individuals who have depressive symptoms are more likely to withdraw socially (Jorgsensen & Nelson, 2018). This withdrawal may mean that students with depression have less exposure to social cues and natural zeitgebers, such as sunlight, that regulate the circadian rhythm (Ehlers et al., 1988). Therefore, sleep may be more erratic on free days in which these students are relying on their own natural rhythms rather than the alarm clock, causing a more significant lag than those of their peers.

One potential explanation for this nonsignificant finding is the unique social atmosphere of college. Previous research on this model has been conducted with adult patients with severe clinical depression (Ehlers et al., 1988). College students with moderate depressive symptoms may be less likely to socially withdraw to an extent that impacts the circadian rhythm. Many college students live with roommates who provide social stimulation. Moreover, many students may rely on dining halls and other campus facilities for their basic needs, requiring them to interact and be exposed to natural zeitgebers to a greater extent than clinical patients.

The social rhythms of college also vary from other populations. A great deal of social interaction occurs in the evenings and at night for all students. Therefore, all college students may receive fewer social cues during the day than the general population, making this difference in diurnal social cues less drastic for college students with depressive symptoms than for clinically depressed adults.

Using cross-lagged panel analysis, the researcher is able to conclude that one variable is causally dominant (i.e., demonstrating elements for determining causation) over others by comparing the strength of the effects of its cross-paths (Kearney, in press). Therefore, given the fact that social jetlag predicted depressive symptoms longitudinally but that depressive symptoms did not significantly predict future social jetlag, social jetlag appears to be causally dominant over depressive symptoms. In other words, it is more likely that sleep concerns precede mood disturbances rather than the converse. Importantly, given the observational research design, causation cannot be ascertained by these findings. However, the results shed light on potential temporal associations between social jetlag and depressive symptoms.

It is important to address the role of sleep quality and duration in the cross-lagged panel analysis used to examine Aim 1. When these covariates were entered into the path model, only the concurrent association between social jetlag and depressive symptoms was significant. Sleep quality was correlated with depressive symptoms at all time points (r_{mean} = -0.24) while sleep duration was correlated with depressive symptoms at two of the three time points (r_{mean} = -0.14). This finding supports previous research that emphasizes the importance of sleep duration (Zhai et al., 2015) and quality (Wallace et al., 2017) in the link between sleep concerns and depressive symptoms. Sleep concerns that are more salient to the individual, such as duration and quality, have been found to more strongly impact anxiety than less salient factors such as sleep timing (Wong et al., 2013). Duration and quality are more easily calculated and observed by individuals than discrepancy in timing; therefore, individuals may notice that their sleep is short and of poor quality and may ruminate on this topic, creating affective changes.

The hypothesis that social jetlag would predict future academic performance was also not supported. This result contradicts previous findings, in which greater social jetlag predicted poorer academic performance in both medical students (Moon et al., 2017) and adolescents (Diaz-Morales & Escribano, 2015). These differing findings may be due to factors unique to the undergraduate student population. Individuals reach their peak levels of eveningness between the ages of 19-21, which indicates that they experience the highest levels of social jetlag compared to other age groups due to their natural circadian rhythms being the most poorly aligned with traditional business hours. However, many college students may also have a level of flexibility in scheduling that adolescents and medical students do not. Students who know that they can attend and concentrate more effectively in the evening may be more likely to opt for afternoon or evening classes, decreasing the impact that social jetlag would have on their academic performance.

Another potential explanation for this finding relates to the one-year interval between time points. Previous research linking social jetlag and academic performance have been cross-sectional (Moon et al., 2017; Diaz-Morales & Escribano, 2015), suggesting that there is a concurrent association between these two factors. However, because average social jetlag had significantly improved by Year 4, the link with academic performance may have decreased. It is unclear, however, when the improvement in social jetlag occurred, as students were asked to report their GPA from the Fall semester of Year 4, whereas social jetlag information was collected in the Spring semester. Therefore, it is unknown whether the improvement in social jetlag had occurred prior to or after the semester in which GPA was calculated.

Despite known links between sleep and academic performance, less attention has been paid to the longitudinal associations between sleep and academic performance in college students. One study of Chinese undergraduates found that sleep disturbances (waking throughout the night) and daytime dysfunction predicted future GPA three semesters later, but discrepancy in duration of sleep from weekdays to weekends did not (Wong et al., 2013). Moreover, the association between sleep factors and GPA was mediated by anxiety-disturbed sleep and daytime sleepiness. These easily recognizable sleep disturbances led to students feeling anxious, which then led to poor academic performance. Social jetlag may not induce the same level of anxiety as more overt aspects of sleep, causing it to have less of an effect on students' cognitive abilities and study habits over time. The impact of sleep timing on academic performance should be investigated across shorter time intervals, such as one month, to clarify the duration of these effects.

Additionally, social jetlag did not predict wellbeing over a one-year time interval. Previous studies have been mixed regarding the cross-sectional association between these variables (Moon et al., 2017; Jankowski, 2014b). Although one study did find a significant negative association between these variables, wellbeing was tested using a scale of mental wellbeing and positive emotionality (Moon et al., 2017). When measures are used that consider social wellbeing, including connection to others, this association has not been found (Jankowski, 2014b).

The current study used the Mental Health Continuum-Short Form, which assesses emotional, psychological, and social wellbeing. In college students, social jetlag may not negatively impact social wellbeing. As stated previously, much social activity in college takes place later in the evening and at night on weekends. Therefore, participating in this social activity, which would presumably increase an individual's social jetlag score, may actually improve their sense of connectedness to others. In this way, individuals may experience a tradeoff between their sleep health and their social wellbeing.

As with academic performance, the association between social jetlag and wellbeing may have been nonsignificant due to the one-year time interval. Previous research that has found an association between these variables has been cross-sectional (Moon et al., 2017). Research in the domain of work has identified employee wellbeing as a construct that includes job satisfaction, involvement, engagement, and positive emotions, similar aspects to general wellbeing. This construct is thought to represent more of a "state" variable than a "trait" variable, meaning that it fluctuates often in response to environmental circumstances (Xanthopoulou, Bakker, & Illies, 2012). General wellbeing may similarly fluctuate, causing it to be less impacted by social jetlag trends over time. More research is needed to examine the stability of emotional, psychological, and social wellbeing over time.

The hypothesis that gender would moderate these associations, with female students having higher levels of social jetlag and worse outcomes of social jetlag, was not supported. Females did have higher levels of social jetlag at both time points; however, these differences were not significant. Previous research has suggested that female students may have higher social jetlag due to reaching their peak levels of eveningness earlier and more towards the middle of their college experience (19.5 years old versus 21 years old; Roenneberg & Merrow, 2007).

Because the present study did not include a measure of chronotype, the impact of levels of eveningness on this sample cannot be examined.

Post-hoc *t*-tests revealed that females were significantly likely to go to bed earlier and rise earlier than were their male counterparts on both work and free days. This finding suggests that female students in this sample may have actually had greater levels of morningness than expected and would thus experience a smaller jetlag and fewer negative effects. Previous research suggests that adolescent females were more likely to rise earlier than males on schooldays in order to complete grooming rituals, but rose later on weekends than males due to their lack of participation in organized sports (Diaz-Morales, 2016). College students are less likely to participate in organized sports, causing less of a gendered difference in weekend wake times.

Hormonal changes during menses (National Sleep Foundation, 2007) have been suggested as one explanation for gender differences in sleep. Because this study asked students to self-report their typical sleep patterns, female students may have not reported their sleep during times of menstruation. Further research should address whether gender differences in sleep change throughout college women's menstruation cycles. Shift work has also been suggested as an explanation for gender differences in sleep (Chung et al., 2009). Although the timing of work was not measured in this study, there was not a significant gender difference in the number of hours students worked per week. Therefore, college females may not be more likely to have differing work patterns than college males, thus lessening the impact of work on sleep.

Race was also posited as a potential moderator of the association between social jetlag and longitudinal outcomes. Although few studies have examined racial differences specifically regarding social jetlag, research does suggest that students of color are more at risk of sleep disturbances than White students, including poor sleep quality and short duration (Billings & Berg-Cross, 2014). In the current study, students of color were more likely to have shorter sleep duration than White students. However, there were no differences in sleep quality or social jetlag.

On average, students of color went to bed later than White students on both work and free days. They also woke significantly later on weekends. However, there were no differences in wake times on weekdays. Because social jetlag is calculated using the midpoints of sleep, it can be inadvertently affected by differences in duration. Due to the fact that students of color had significantly shorter sleep than White students, the midpoints of sleep may not have been as late as they would have been if students of color had gone to bed later but slept just as long. In this case, the similar midpoints may reflect the fact that students of color did not sleep as long as White students.

Moreover, research on this topic has mainly focused on Black and White students (Billings & Berg-Cross, 2014; Walsemann et al., 2017). The current sample was much more diverse; however, due to small numbers in several racial categories, it was necessary to dichotomize race into White students and students of color. Further research is needed to explore differences between more specific racial categories.

Previous studies have suggested that racial differences in sleep may be attributable to experiences of discrimination. Chronic stress caused by experiences of discrimination may consistently activate the hypothalamic-pituitary-adrenal axis, causing chemical changes that disrupt normal circadian activity (Buckley & Schatzberg, 2005). Moreover, worry about the strains that come along with discriminatory experiences may also disrupt sleep (Beatty et al., 2011). Because discrimination is one potential cause of poorer sleep for racial minorities, it is essential to examine the campus climate and racial diversity at which students are enrolled. The current study was conducted at a racially diverse university located in a city; therefore, students at this university may have different discriminatory experiences than students on other campuses, which has differential impacts on sleep.

Strengths and Limitations of the Current Study

The design of the current study had several strengths that allow for unique contributions to the existing literature. The study also had several limitations on which future research can build.

Strengths. Most research on social jetlag and its associated psychological and functional outcomes relies on cross-sectional methodology (Moon et al., 2017; Levandovski et al., 2011). Evidence of a temporal association is one aspect of determining causality, so the current research base lacks conclusions regarding the impact of social jetlag due to common study designs (Beauvalet et al., 2017). Although the current design cannot prove causality, its longitudinal nature did allow for evidence of a temporal association. Social jetlag did predict depressive symptoms after one year, suggesting that social jetlag might have longer-term ramifications on mood than previously demonstrated. However, social jetlag did not predict either GPA or wellbeing one year later. Future research should attempt to replicate this finding in order to assess whether social jetlag has long-term effects on these variables.

The ways in which various constructs were measured were also strengths unique to the study. Although social jetlag is thought to be a discrepancy in sleep timing between workdays and free days, it is often measured instead by assessing sleep on weekdays and weekends (Zhai et al., 2015). This method of assessment assumes that individuals are free to sleep to their natural preferences on weekends, despite the possibility of having work or other obligations. The present study specified that students should report their sleep on "weekends and holidays when you don't have to get up at a particular time to go to school/work or another appointment?" The specificity of this question allowed the researcher to ensure that free days were indeed free of other obligations that might dictate sleep.

In addition, some studies have measured depression in a categorical fashion; for example, studies have divided participants into "minimal or nondepressive symptoms," "mild depressive symptoms," "moderate depressive symptoms," and "severe depressive symptoms" groups for certain analyses (Levandovski et al., 2011) or required a previous diagnosis of Major Depressive Disorder for inclusion in the study (Emens et al., 2009). The current study measured depressive symptoms as a continuous variable that may be more appropriately suited to the college population. Although mental health concerns are on the rise on college campuses (ACHA, 2008), college students are likely to be more psychologically healthy than their non-college peers (Arnett, 2016). Gaining admission into a university requires one to have successfully completed both primary and secondary education, which is less likely for individuals who struggle with severe mental health concerns. Therefore, it may be more fruitful to assess symptomatology in a continuous rather than dichotomous manner so as to include students who may not meet criteria for a formal diagnosis (or may not have sought help to receive a diagnosis in the past) but are still struggling with symptoms that may impact their functioning.

The statistical analysis used in this study was also a unique strength of its design. Cross-lagged panel analysis allows for the analysis of the unique effects of cross-paths within a model while controlling for the effects of other variables in the model. Therefore, the researcher is able to conclude that one variable is causally dominant over others due to stronger effects of its cross-paths (Kearney, in press). In this case, social jetlag appears to be causally dominant over depressive symptoms. In other words, it is more likely that sleep concerns precede mood disturbances rather than the converse. Studies that have previously examined social jetlag and mood disorders have been unable to address which of these variables is causally dominant (Beauvalet et al., 2017).

Lastly, the diversity of the current sample serves as a strength. Previous research has been conducted in racially homogenous samples, albeit in various locations such as Brazil (de Souza & Hidalgo, 2015), Korea (Moon et al., 2017) and Spain (Diaz-Morales, 2016). The current sample included students from varied racial backgrounds and allowed for the comparison between White students and students of color. In this case, it was found that there were no significant differences in these two groups with regard to social jetlag, although White students were more likely than students of color to report depressive students at all time points. All students in the current sample reported engaging in paid work at some point during an average week. Thus, this sample represented students who may have other factors beyond academic and social obligations that may impact their sleep. Thus, although these findings can only be generalized to the college population, these findings may be more applicable to non-college emerging adults than studies conducted at more traditional universities in which students do not engage in paid work.

Limitations. It is also important to acknowledge the limitations of the current study. Perhaps the most significant limitation is the method by which sleep data was collected. Students self-reported their “usual” bed- and wake-times on week and free days. However, it is unclear what method students may have used to assess these “usual” times; for example, some students may have averaged their sleep times from the previous week, while others may have simply taken their sleep times from the night before. It has been demonstrated that retrospective self-reported sleep data are often inaccurate, with participants in one study consistently overestimating the duration of their sleep (Lauderdale, Knutson, Yan, Liu & Rathouz, 2008). Future research should use techniques such as actigraphy in order to gain more objective measures of sleep, as well as to assess sleep over several days rather than measuring an estimate of "usual" sleep times.

Although the measurement of depressive symptoms as a continuous variable was appropriate for the college population, participants responded to only four items per year regarding depressive symptomatology. Moreover, one of these items, "worrying too much about things," may have tapped into anxiety symptoms more strongly than symptoms typically regarded as indicative of depression. A thorough measurement of depression that addresses all of the DSM-5 criteria for Major Depressive Disorder may more accurately capture students with depressive symptomatology.

The interval between time points may also have limited the study's findings. Data were collected once per year during the spring semester. Although it was found that average social jetlag improved between Year 3 and Year 4, the researcher was unable to assess whether that change was gradual or related more to a shift in the students' schedules or obligations. Moreover, it is unclear whether the nonsignificant associations, specifically between social jetlag, academic performance, and general wellbeing, would have yielded significance within a shorter time span. Because general wellbeing is thought to fluctuate over time (Xanthopoulou et al., 2012), it may be necessary to measure the association between this construct and social jetlag over a shorter time span. Future research should include varied time intervals (e.g., one week, one month, one year) to assess both short- and long-term effects of social jetlag.

The study suffered from attrition (69.9%) due to its longitudinal nature. In order to adequately measure the association between social jetlag and depressive symptoms, only students who provided data for social jetlag at Years 3 and 4 and depressive symptoms at a minimum of two time points were eligible for inclusion in the study. Individuals who dropped out of the study may have done so due to greater mental health concerns than their counterparts. Therefore, the study may have missed out on valuable data regarding the sleep patterns of students with more severe depressive symptoms.

A last limitation regards the use of race as a moderating variable in the study. Although the sample was racially diverse, small numbers of participants in certain racial categories caused the researcher to dichotomize race into two groups: White students and students of color. It is unclear whether diversity between racial categories was masked by this dichotomization. Furthermore, one major theory regarding race-based sleep disparities is that individuals of racial minority groups experience greater discrimination, which in turn increases stress levels and causes sleep disturbances (Beatty et al., 2011). Future studies should investigate the diversity in social jetlag among more specific racial categories as well as explore the impact of discrimination and other social experiences on jetlag.

Implications and Future Directions

The current study's findings have multiple implications for both researchers and practitioners. Previous researchers have questioned whether social jetlag is problematic in the college student population, and posited that the flexibility of a college schedule, including self-selection of courses and other obligations, may lessen the existence and impact of jetlag for students (Diaz-Morales & Sanchez-Lopez, 2008). However, the current study found that students experienced over 1.5 hours of jetlag on average in one year. Thus, this study suggests that social jetlag is an important factor in college student sleep, and further research should be conducted on jetlag and its ramifications within this population.

The study also found that social jetlag predicts depressive symptoms, both concurrently and longitudinally. Practitioners at college counseling centers should assess sleep regularity during intake, as this factor may be influencing students' mood symptoms. Furthermore, sleep regularity should be emphasized as a component of healthy sleep (Matricciani et al., 2018), and sleep education programs on college campuses should include regularity and social jetlag. Researchers should investigate the antecedents of social jetlag, or factors that may cause certain college students to have a greater lag than others. Structural factors, such as the meeting times of various campus organizations, should be examined to assess whether they impact social jetlag. Research should also address the impact of social jetlag on mood disturbances across shorter time spans in order to clarify the association and its potential mediators.

It is important to note that the longitudinal association between social jetlag and depressive symptoms was only significant once sleep quality and duration were removed as covariates from the model. Future research should examine the associations between social jetlag and other sleep variables. Social jetlag may impact the quality and duration of one's sleep, indicating that other sleep variables may serve as explanatory mechanisms for the associations between social jetlag and negative psychological and behavioral outcomes.

The study did not find that social jetlag predicted future GPA or wellbeing. However, future research should address these associations within shorter time spans in order to capture potential fluctuations in these variables. Research should also explore the potential social benefits of jetlag. Students may have greater social jetlag due to higher rates of participation in social activities. The interaction between social participation and jetlag should be explored, along with potential interventions to allow for social participation without negative ramifications for sleep health.

Although the study did not find significant gender differences in social jetlag, female students had higher average social jetlag scores at both time points than their male counterparts. Factors that place female students at greater risk of jetlag should be explored. Practitioners should take special care to assess for jetlag in female clients and to inform female clients about the potential effects of irregular sleep. Similarly, the study did not find significant racial differences in social jetlag. Future research should assess social jetlag within more specific racial categories, as well as examine factors that may place certain racial groups at greater risk of irregular sleep.

Conclusion

The current study examined the directional association between social jetlag and depressive symptoms; the longitudinal associations between social jetlag, academic performance, and wellbeing; and the role of gender and race as moderating variables in these associations. It was found that social jetlag predicts depressive symptoms both concurrently and longitudinally. Social jetlag was found to be causally dominant over depressive symptoms, suggesting that sleep concerns may precede mood disturbances in college students. Social jetlag was not found to longitudinally predict academic performance or wellbeing, and neither gender nor race moderated these associations. These findings have implications for both researchers and practitioners who wish to understand and assess for the warning signs of future psychopathology. Future research should continue to explore social jetlag and its associated short- and long-term outcomes in college students.

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Appendix A

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Appendix B

Mental Health Continuum-Short Form

During the past month, how often did you feel the following ways:

1 – Never
2 – Once or twice
3 – 2 or 3 times a week
4 – Almost every day
5 – Every day

1. Happy
2. Interested in life
3. Satisfied with life
4. That you had something important to contribute to society
5. That you belonged to a community (like a social group, school, neighborhood, etc.)
6. That our society is a good place, or is becoming a better place, for all people
7. That people are basically good
8. That the way our society works made sense to you
9. That you like most parts of your personality
10. Good at managing the responsibilities of your daily life
11. That you had warm and trusting relationships with others
12. That you had experiences that challenged you to grow and become a better person
13. Confident to think or express your own ideas and opinions
14. That your life has a sense of direction or meaning to it

Vita

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