

AGE-RELATED DIAGNOSTIC CONSIDERATIONS AND NEUROCOGNITIVE
IMPAIRMENT IMPLICATIONS FOR INSOMNIA DISORDER

By

Amy M. Gencarelli

December, 2023

Director of Dissertation: Daniel Erik Everhart, PhD

Major Department: Psychology

ABSTRACT

Insomnia affects 10-30% of the U.S. population and can be found across varying stages of life. While it has previously been shown that the addition of quantitative indices would be helpful for distinguishing between sleep disturbances and insomnia, it begs the question if quantity-derived thresholds vary throughout the lifespan. One of the major current diagnostic systems utilized in the U.S. (the DSM-5) acknowledges quantitative indices being useful in identifying cases of insomnia and that daytime impairment is necessary for a diagnosis of insomnia. This study aims to see how these two factors, may vary by age, sex, and/or race as well as if standardized objective neurocognitive measures can better assess for daytime impairment than self-report.

Age-Related Diagnostic Considerations and Neurocognitive Impairment Implications for
Insomnia Disorder

A Dissertation

Presented to the Faculty of the Department of Psychology
East Carolina University

In Partial Fulfillment of the Requirements for the Degree
PhD in Health Psychology

By

Amy M. Gencarelli

December, 2023

Director of Dissertation: Daniel Erik Everhart, PhD

Dissertation Committee Members:

Robert Carels, PhD

Jessica Ford, PhD

Alexander Schoemann, PhD

Samuel Sears, PhD

© Amy Gencarelli, 2023

Table of Contents

Title Page	<i>i</i>
Copyright Page	<i>ii</i>
List of Tables	<i>v</i>
List of Figures	<i>vi</i>
<i>Age-Related Diagnostic Considerations and Neurocognitive Impairment Implications for Insomnia Disorder</i>	<i>1</i>
Insomnia as a Health Issue	1
Sleep and Age	2
Sex Differences and Insomnia.....	5
Racial Disparities and Insomnia	6
Perceptions About Sleep	8
Current Diagnostic Criteria	9
Recent Advance of Quantitative Criteria to Supplement Diagnostic Criteria	10
Prevalence, Development, and Course.....	11
Common Associated Symptoms and Comorbidities.....	12
Daytime Functioning	12
Gaps in the Literature	15
Reason for the Current Study	15
The Current Study	16
Proposed Aims and Hypotheses	18
<i>Aim 1: To establish the presence and severity of sleep disturbance across age, sex, and race.</i>	<i>18</i>
<i>Aim 2: To establish the presence of daytime impairment in a population of individuals with significant insomnia symptomology.....</i>	<i>19</i>
<i>Aim 3 (exploratory): To determine the degree to which insomnia accounts for daytime impairment while controlling for mood</i>	<i>19</i>
<i>Aim 4 (exploratory): To determine the degree to which perceptions about sleep will account for sleep disturbance while controlling for age.....</i>	<i>19</i>
<i>Aim 5 (exploratory): To determine if the discordance between severity and complaint are primarily related to diminished ability to recall sleep (e.g., less complaints due to episodic memory decline in the presence of sleep disturbance), comorbidity context, and/or adjustment to chronicity.....</i>	<i>20</i>
Methods.....	21
Participants	21
Measures.....	21
Procedure.....	28

Aims, Hypotheses, and Data Analytic Strategy	30
<i>Aim 1: To establish the presence and severity of sleep disturbance across age, sex, and race.</i>	30
<i>Aim 2: To establish the presence of daytime impairment in a population of individuals with significant insomnia symptomology.....</i>	30
<i>Aim 3 (exploratory): To determine the degree to which insomnia accounts for daytime impairment while controlling for mood</i>	31
<i>Aim 4 (exploratory): To determine the degree to which perceptions about sleep will account for sleep disturbance while controlling for age.....</i>	32
<i>Aim 5 (exploratory): To determine if the discordance between severity and complaint are primarily related to diminished ability to recall sleep (e.g., less complaints due to episodic memory decline in the presence of sleep disturbance), is context sensitive, and/or due to adjustments of living with the disorder.....</i>	32
<i>Results</i>	34
<i>Sample Characteristics</i>	34
<i>Preliminary Analyses.....</i>	41
<i>Reliability</i>	41
<i>Bivariate Relationships.....</i>	41
<i>Normality</i>	41
<i>Discussion</i>	52
<i>Insomnia.....</i>	53
<i>References.....</i>	64
<i>Appendix A: Demographics Questionnaire</i>	106
<i>Appendix B: Retrospective Sleep Continuity Assessment Questionnaire</i>	118
<i>Appendix C: Insomnia Severity Index.....</i>	119
<i>Appendix D: Epworth Sleepiness Scale.....</i>	120
<i>Appendix E: Fatigue Severity Scale.....</i>	121
<i>Appendix F: Depression Anxiety Stress Scales-21</i>	122
<i>Appendix G: Sleep Disorder Symptom Checklist-25</i>	123
<i>Appendix H: Dysfunctional Beliefs and Attitudes about Sleep Brief Version</i>	124
<i>Appendix I: Functional Outcomes of Sleep Questionnaire: Reduced Version</i>	126
<i>Appendix J: Charlson Comorbidity Index.....</i>	127
<i>Appendix K: Institutional Review Board Approval Letter.....</i>	133

List of Tables

<i>Table 1. Self-Reported Demographic Characteristic</i>	<i>79</i>
<i>Table 2. Internal Consistency of Scale Measures</i>	<i>81</i>
<i>Table 3. Means of Sleep Continuity Variables of Total Sample.....</i>	<i>82</i>
<i>Table 4. Means of Sleep Continuity Variables by Age Decade.....</i>	<i>83</i>
<i>Table 5. Sleep Continuity Variables by Sex.....</i>	<i>85</i>
<i>Table 6. Sleep Continuity Variables by Race.....</i>	<i>86</i>
<i>Table 7. Correlation Matrix of Primary Variables of Interest.....</i>	<i>88</i>
<i>Table 8. Means and Standard Deviations of Sample and Normative Neurocognitive Assessment Outcomes.....</i>	<i>89</i>
<i>Table 9. Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Square Root Transformed Variable Of Sleep Latency</i>	<i>90</i>
<i>Table 10. Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Raw Variable Of Sleep Latency.....</i>	<i>91</i>
<i>Table 11. Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Log Transformed Variable Of Nightly Awakenings After Sleep Onset.....</i>	<i>92</i>
<i>Table 12. Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Raw Variable Of Nightly Awakenings After Sleep Onset.....</i>	<i>93</i>
<i>Table 13. Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Square Root Transformed Variable Of Minutes Spent Napping.....</i>	<i>94</i>
<i>Table 14. Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Raw Variable Of Minutes Spent Napping.....</i>	<i>95</i>
<i>Table 15. Descriptive Statistics Of The 2 X 7 MANOVA For Sex And Age Decade On The Square Root Transformed Variables Of Wake After Sleep Onset And Sleep Efficiency And Raw Variables Of Total Sleep Time And Sleep Quality Rating.....</i>	<i>96</i>
<i>Table 16. Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Continuous Performance Test Dprime Variable.....</i>	<i>99</i>
<i>Table 17. Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Fatigue Severity Scale.....</i>	<i>100</i>

List of Figures

Figure 1. <i>Line Graph of Means for Interaction Effect of Age and Sex on Minutes Spent Napping</i>	101
Figure 2. <i>Line Graph of Means for Main Effect of Sex on Sleep Efficiency</i>	1102
Figure 3. <i>Line Graph of Means for Main Effect of Age on Sleep Quality</i>	103
Figure 4. <i>Line Graph of Means for Main Effect of Age on Fatigue Level</i>	104
Figure 5. <i>Line Graph of Means for Main Effect of Age on Stress Level</i>	1055

Age-Related Diagnostic Considerations and Neurocognitive Impairment Implications for Insomnia Disorder

Insomnia as a Health Issue

In primary care settings, insomnia has been found to be one of the most common complaints and can be a disorder alone or comorbid with another medical or psychiatric condition (Morin & Benca, 2012; Morin et al., 2020). This is concerning given that individuals with chronic insomnia report impaired health-related quality of life that is comparable to people with clinical depression or congestive heart failure (Katz & McHorney, 2002). Chronic insomnia is associated with impaired mood, perceived deficits in functioning, elevated rates of absenteeism and workplace accidents, as well as increased healthcare costs and utilization (Daley et al, 2009; Walsh, 2004). Additionally, insomnia is highly comorbid across psychiatric disorders and a core identified symptom found in individuals with anxiety and depressive disorders (Nutt et al., 2008). Related, in older adults, research has suggested a link between anxiety, depression, pain, insomnia and health-related quality of life (Kennair et al., 2022). Furthermore, insomnia is associated with increased suicidal ideation (SI) and suicide attempts, independent of depressive severity (Peterson & Benca, 2006). Recent research found that COVID-19 pandemic-related fear was positively correlated with insomnia severity and SI but that the association could be completely accounted for by insomnia, suggesting that adequate sleep may have a direct impact on reducing SI (Killgore et al., 2020). Winkelman (2020) in a review of the epidemiology of insomnia in the British Medical Journal discussed how 10%-30% of the U.S. population reported symptoms of insomnia, leading to 5.5 million consultations annually. The review highlighted a higher prevalence of insomnia in patients with chronic medical conditions (e.g., diabetes, congestive heart failure, chronic respiratory disorders) than the general population. Lastly, the

strong correlations between pain disorders and insomnia were highlighted in that sleep difficulties appear to exacerbate pain symptomology and vice versa (Winkelman, 2020). This research highlights the bidirectional nature that insomnia and mental and physical health conditions share.

Research on the causes of insomnia often focus on predisposing, precipitating, and perpetuating factors (Morin & Benca, 2012), however, this may vary across the lifespan. A recent metanalysis of studies with over 100 participants in the Netherlands, UK, and US, from 2000 – 2017 revealed 13% of adults experienced poor sleep quality which was associated with spending less than 6 hours in bed and about 19% experienced insomnia symptoms which was associated with spending over 9 hours in bed (Kocevska et al., 2020). Additionally, individuals with insomnia endorse more dysfunctional beliefs and excessive worry about sleep than good sleepers (Edinger et al., 2000; Espie, 2002; Morin, Vallieres, & Ivers 2007), which can be prone to change with life stages and lifestyle alterations (e.g., careers, becoming a parent, etc.).

Sleep and Age

Insomnia complaints increase overall with advanced age, greater medical conditions, and increased anxiety and depression (Tutek et al., 2019). Similarly, sleep quantity and quality tend to decrease with age. This decrease has been hypothesized to be a result of reduced opportunity to learn and adapt to the environment as well as decreased exposure to novel experiences in combination with changes in health and neural circuitry as it relates to sleep regulation (Cirelli, 2012). Healthy aging typically results in an advancement of circadian rhythm (e.g., earlier bed and wake times; Dijk et al., 2000), with reductions in total sleep time (TST), sleep efficiency (SE), slow wave sleep (SWS), rapid eye movement (REM) sleep, and REM latency (Ohayon et al., 2004). Conversely, sleep latency, non-rapid eye movement (NREM) 1, NREM 2, and wake

after sleep onset (WASO) significantly increase with age (Ohayon et al., 2004). Insomnia symptomology has been found to be least frequent in individuals ages 20 - 40 and most frequent in individuals greater than 65 years of age and/or those spending greater than 9 hours in bed (Kocevska et al., 2020). Some researchers hypothesize that older adults need less sleep overall as they age (reduced sleep-need) whilst others suggest that aging reduces ability to obtain restorative sleep (reduced sleep-ability), but research utilizing behavior and polysomnography outcomes have found it difficult to disentangle the two views (Scullin, 2017). Overall, research favors the need for adequate sleep in older age and the issues in sleep quality and duration are thought to be due to cortical thinning and amyloid deposition, weakening the brain's ability to produce restorative sleep (Scullin 2017). An additional factor to consider with measuring sleep across the lifespan are the alterations of sleep spindles, which were the original features of sleep described in electroencephalography (EEG) recordings that reflected the waxing-and-waning nature of the 7-15 Hz spindle oscillation of about one second during NREM sleep (Loomis et al., 1935). With age, the density of K-complexes and sleep spindles decrease (Crowley et al., 2002). At older ages, spindle density decreases are most pronounced at both the frontal and occipital cortices, potentially relating to progressive neurodegenerative changes that preferentially affect these cortical areas with aging (Nelson et al., 2009; Martin et al., 2013). These spindle changes correlate with changes in sleep architecture and cognition although there is a large gap in the understanding of the neurophysiological changes that cause these declines in spindling as individuals age (Clawson et al., 2016). Researchers currently attempting to explain such changes discuss both decreases in cortical volume (i.e., the “shrinking brain phenomenon”) as well as decreases in gray and white matter among various regions of the brain (Resnick et al., 2003; Thambisetty et al., 2010).

Svetnik and colleagues (2017) found that individuals 65 or older with insomnia had decreased sleep latency compared to individuals with insomnia who were younger than ages 18-64. Additionally, females with insomnia who are older than 64 had nearly comparable WASO rates to males younger than 64, while males 65 or older had much higher WASO (Svetnik et al., 2017). Thus, factors for insomnia may vary with age and sex. In a study observing insomnia over a 5-year naturalistic period, females who were initially normal sleepers developed an insomnia syndrome at a rate of about 17% versus that of about 10% for males (Morin et al., 2020). Perhaps related to the reduced-sleep-need hypothesis, criteria for insomnia disorder may benefit from taking into account varying age group needs. Furthermore, EEG absolute power analysis via negative slopes revealed that power decreased with age for both individuals with and without insomnia, though only delta, theta, and sigma bands were statistically significant (Svetnik et al., 2017). Additional studies suggest that with advancing age, NREM sleep of middle-aged subjects become more vulnerable to disturbing environmental stimuli with concomitant elevated fast-frequency activity, which indicates cortical arousal, alluding to more difficulties in adapting to challenges to the sleep-wake cycle (Carrier et al., 2001; Perlis et al., 1997).

Vitiello and colleagues (2004) summarized his previous work as well as work by Foley et al., (1995, 1996) and Buysse et al., (1991) which suggest that sleep complaints in older adults appear secondary to increased health burden and although their sleep may be more disturbed, they may complain less as they adapt to their perception of what “acceptable” sleep is (Vitiello et al., 2004). As a result of an aging nervous system, healthy, noncomplaining older adults manifested significantly disturbed sleep relative to healthy adults as evidenced by a doubling of SL, 3-4x of total wake time, including WASO, a 13% reduction in SE, a 74% reduction in SWS and a 30% reduction in REM sleep (Vitiello et al., 2004). Overall, aging can result in significant

changes in sleep, but this does not necessarily result in complaints of disturbed sleep, potentially alluding to a change in cognitive appraisal of sleep needs in individuals of advanced ages.

Sex Differences and Insomnia

Women across age cohorts report more subjective sleep abnormalities than do men (Winkelman, 2020). This difference is seen at a young age and is especially prominent during times of reproductive hormonal changes for women (e.g., pregnancy, postpartum, perimenopausal, postmenopausal; Nowakowski & Meers, 2019). When looking at a restricted age range (20-60), Carrier and colleagues (2001) found that the aging process on sleep does not differentially influence men and women, though this contrasts with other historical studies that found a significant reduction in mean nighttime slow-wave activity for men in their 30s but not for women (Ehlers and Kupfer, 1997). Additional research suggests sleep may be affected by sex differentially beginning at an early age due to variations in hormones, physical and mental conditions, life/role transitions, aging and other factors (Meers et al., 2019). Meers and colleagues (2019) also highlight how women are vulnerable to insomnia during times of reproductive hormonal change, with menstrual cycle transition associated with alterations in circadian rhythms and sleep architecture. Researchers discuss sleep difficulties being present during the pregnancy period, postpartum exacerbation of difficulties due to newborn needs, and an increase of difficulties during the post-menopausal transitional period (Meers et al., 2019). Carrier et al., (2001) speculate the variance in findings could be due to the possibility that sex differences in the effect of age on sleep EEG power spectral differences are more prominent in REM as opposed to NREM sleep, which was not assessed in their study. Within NREM sleep, women in the study had higher power spectral densities in the delta, theta, low alpha (0.25-9.00 Hz) and the high sigma frequency range (14.25-16.00 Hz). In relation to the high sigma

frequency range, this varies with the level of reproductive hormones (e.g., reduction in power density within 14.25-15.00 Hz during pregnancy or large variations across the menstrual cycle, with a maximum in the luteal phase; Carrier et al., 2001). Corroborating this, a meta-analysis revealed subjective complaints are most prevalent in women (24/33 studies found a greater prevalence of sleep complaints in women) and insomnia rates increased with age (Lichstein et al., 2004). Within a sample of older men and women who did not complain of sleep difficulties, a significant number of women as compared to men endorsed elevated levels of sleep disturbance, though men with higher levels of sleep disturbance had a stronger subjective-objective correspondence than did women of higher levels of sleep disturbance (Vitiello et al., 2004). Increases in sleep difficulties in men have been associated with a decline in testosterone (Meers et al., 2019). This shows that studies across the previous two decades allude to sex differences from hormonal variance rather than age itself. Estimated prevalence rates of insomnia by sex utilizing a median difference between men and women was found to be 12.4% in men and 18.2% in women, with difficulty maintaining sleep as the most prevalent symptom, followed by difficulty initiating sleep and early morning awakenings (Lichstein et al., 2004).

Racial Disparities and Insomnia

Marginalized racial groups are more likely to report sleep disturbances as compared to White individuals (Grandner et al., 2013). Urban primary care patients who were Black reported sleep disturbance at triple the rate of White individuals (Pidgeon et al., 2011) and in general Black individuals exhibit chronic insomnia at double the rate of White individuals (Singareddy et al., 2012). In a military population, prevalence rates of moderate to severe insomnia symptoms were most common in pre-deployed soldiers who identified as Native American (Taylor et al., 2016). Cheng and colleagues (2020), reviewed potential mechanisms for disparities in insomnia

as the following: (1) racial discrimination as an accumulated chronic stressor, with stress directly linked to triggering and exacerbation of insomnia (2) increased vigilance against threat leading to ruminative cognitions associated with difficulties falling and staying asleep, and (3) comorbid health conditions that show disparities by race and are associated with sleep difficulties, such as obesity, cardiovascular disease, diabetes, and depression (Cheng et al., 2020). Racial discrimination was found to explain ~60% of differences in insomnia severity between White individuals and racial minority groups, even after accounting for covariates such as SES (Cheng et al., 2020). Other studies have not found race-related differences in insomnia rates between Black and White individuals, though Black individuals were more likely to report higher rates of short sleep (Kalmbach et al., 2016). Short sleep duration was also found to be more prevalent among Hispanic and Chinese individuals as compared with White individuals as well more pronounced in younger individuals (Chen et al., 2015). Furthermore, Chen and colleagues (2015) found that the shortest sleep duration was observed in Black men, who slept 75 minutes less than White women on average and Black women slept 43 minutes less on average than White women.

Insomnia severity was found to increase with age and the accumulation of health conditions with a more pronounced trend in Hispanic older adults than in non-Hispanic Whites (Kaufmann et al., 2016). One study assessed the interethnic heterogeneity in insomnia symptomology in a sample of urban American women and found that the prevalence of insomnia symptoms (defined as either difficulty initiating sleep, difficulty maintaining sleep, or early morning awakening) among African Americans was 71%, English-speaking Caribbeans 34%, Haitians 33%, Dominicans 73%, Eastern Europeans 77%, and European Americans 70%. Furthermore, researchers reported that ethnicity explained 20% of the variance in insomnia, SES explained 5%, risk markers 5%, medical factors 20%, and coping styles 1% (Jean-Louis et al.,

2008). Regarding reporting sleep complaints, survey data revealed Asian American report the least and Black and Hispanic individuals report fewer complaints than White individuals in general (Grandner et al., 2010).

Perceptions About Sleep

Individuals are classified into “poor” and “good” sleepers in the research that drives clinical application via their self-reported sleep quality on measures such as the Insomnia Severity Index and daily sleep diaries (Dzierzewski et al., 2021). However, research revealed inconsistent sleep characteristic reporting for older adults for wake after sleep onset, highlighting intraindividual variability where the mean values become less accurate (Shoji et al., 2015). Time estimation is a complex cognitive task that increases in difficulty when the time period includes sleep and estimation of sleep in the absence of time cues may depend on length of sleep *opportunity* and/or time of day (Bianchi et al., 2012).

Multiple classic insomnia studies report on the error between subjective reports and objective measurements of sleep using physiological criteria where individuals with insomnia may underestimate time to bed and overestimate wake times (Bonnet & Arand, 1997; Edinger & Fins, 1995; and Edinger & Krystal, 2003). Bianchi and colleagues (2012) reviewed some of the reasons for this difference, including how the subjective experience of wake may differ preceding sleep onset compared to mid-sleep awakenings, which may be associated with variable levels of alertness affecting perception. Authors also reviewed how the fragmentation of sleep and neurophysiological hyperarousal may affect time estimation (Bianchi et al., 2012).

A recent study found psychosocial factors of living with a spouse and economic satisfaction protected from sleep underestimation, defined as accelerometer-measured sleep time of greater than or equal to 6 hours and subjective reported sleep time less than 6 hours (Park et

al., 2020). Five percent of participants underestimated sleep time; 47% overestimated (i.e., objective sleep time less than 6 hours; subjective sleep time greater than or equal to 6 hours), meaning that over half the sample of 922 individuals misperceived the amount of time they actually slept for (Park et al., 2020). Additionally, higher levels of habitual pre-sleep arousal have been shown to be associated with a greater degree of sleep misperception (Sharman et al., 2022). Arousals can be cortical and represented by the presence of high EEG activity during sleep or cognitive and referring to pre-sleep worry, an inability to decrease thoughts while attempting to sleep, and an overactive mind (Perlis et al., 2001; Puzino et al., 2020).

Current Diagnostic Criteria

Insomnia, as outlined in *The Diagnostic and Statistical Manual of Mental Disorders (DSM), 5th Edition*, is a predominant complaint of dissatisfaction with sleep quality or quantity. It consists of problems of either initiating or maintaining sleep, with the latter characterized as frequent awakenings, problems returning back to sleep after awakenings, and/or waking up too early with the inability to return to sleep. The sleep disturbance associated with insomnia must cause clinically significant distress or impairment in social, occupational, educational, academic, behavioral, or other important areas of functioning. For sleep disturbance to be classified as insomnia, it must occur at least three nights per week for a period of at least three months and the sleep difficulty must occur despite having an adequate opportunity for sleep. The insomnia cannot be better explained by nor occur exclusively during the course of another sleep-wake disorder, such as circadian rhythm disorders or breathing-related sleep disorders. Lastly, the insomnia cannot be attributable to the physiological effects of a substance nor can coexisting mental or medical issues adequately explain the predominant sleep complaints. A diagnosis of insomnia should also specify any co-occurrences with a non-sleep disorder mental comorbidity,

other medical comorbidities, or another sleep disorder. Additionally, symptom specifiers provided within the DSM-5 are: episodic (occur between 1-3 months), persistent (3 months or longer) or recurrent (two or more episodes within a 1-year time span). Lastly, acute and short-term insomnia can be identified if an individual meets all criteria with regard to frequency, intensity, distress, or impairment for less than three months and should be coded as an other specified insomnia disorder (DSM-5; American Psychiatric Association, 2013).

Other commonly used nosologies for insomnia disorder are the *International Classification of Sleep Disorders – Third Edition* (ICSD-3) and the *International Classification of Diseases, 10th Revision* (ICD-10). Regarding the ICSD-3, chronic insomnia disorder similarly includes: (1) a report of sleep initiation or maintenance problems, (2) adequate opportunity and circumstances to sleep, and (3) daytime consequences (Sateia, 2014). The ICD-10 also includes difficulty of initiating or maintaining sleep, despite adequate opportunity and circumstances that result in general sleep dissatisfaction and some form of daytime impairment, including fatigue, depressed mood or irritability, general malaise, and cognitive impairment. Those who do not report daytime impairment are not regarded as having an insomnia disorder.

Recent Advance of Quantitative Criteria to Supplement Diagnostic Criteria

In an attempt to ameliorate diagnostic inconsistencies as well as enhance insomnia conducted research studies, Lichstein and colleagues (2003) reviewed two decades of clinical trials for insomnia to determine the most common practice regarding frequency, severity, and duration of sleep issues. Applying what they found, they used sensitivity-specificity analyses to identify the most valid criterion indicative of insomnia: severity of sleep onset latency (time it takes to fall asleep) or maintenance (wake time after sleep onset) of greater than or equal to thirty-one minutes, occurring three or more nights per week for a period of six months or more (Lichstein,

et al., 2003). Though these results were mainly for research studies with the potential for use in clinical settings, Edinger, 2016 supports adding quantitative indices into our current insomnia diagnostic criteria. The hope, from a public health perspective, is that with the monitoring of quantitative indicators of sleep disturbance, mere disease acquiescence rather than actual resolution or remission can be avoided (Edinger, 2016). Lineberger and colleagues (2006) suggest a more liberal time of 20 minutes or more of sleep onset latency or WASO to distinguish healthy sleepers from those who meet insomnia classification.

Prevalence, Development, and Course

Approximately one-third of adults report insomnia symptoms, with 10% experiencing chronic insomnia, and 6% of the adult population meeting diagnostic criteria for insomnia disorder (Ancoli-Israel & Roth, 1999; DSM-5; American Psychiatric Association, 2013). Twelve percent of the general population suffers from daytime sequelae of insomnia, with the disorder being a more prevalent complaint among females and consisting of a 40-50% comorbidity rate with other mental disorders (Ohayan, 2002; DSM-5; American Psychiatric Association, 2013).

According to the DSM-5 (2013), the onset of insomnia can occur at any point during an individual's lifetime with the first episode being more common in young adulthood. Late-life onset is typically associated with the conjunction of other health-related conditions. Situational or acute insomnia is defined as lasting only a few days to a few weeks, is often associated with life events or rapid changes in sleep schedules or the environment, and typically resolves once the event subsides. Episodic insomnia contains recurrent episodes of sleep difficulties associated with stressful events and persistent insomnia occurs when conditioned arousal persists through perpetuating factors even when the precipitating event is resolved (DSM-5; American Psychiatric Association, 2013).

While insomnia can have three main presentations (initial, middle, late), nocturnal awakenings (NWAK) and the subsequent WASO is associated with subjective shorter sleep duration, poorer sleep quality, greater daytime impairment, and increased likelihood of seeking treatment and receiving a sleep medication (Ohayon et al., 2010).

Common Associated Symptoms and Comorbidities

Sleep and health share a bidirectional relationship, where sleep disturbances contribute to the development and severity of medical and psychiatric disorders, and these disorders result in poor sleep quality (Zee & Turek, 2006). Daytime sequelae of insomnia include fatigue, daytime sleepiness and impaired cognitive performance, such as attention, concentration, and memory difficulties (DSM-5; American Psychiatric Association, 2013). Biological mechanisms are likely responsible, though the etiology of poor sleep quality is often multifactorial and may shift over time (Zee & Turek, 2006). The harmful effects of insomnia were tested in a study of acute sleep deprivation and revealed deficits in waking neurobehavioral functioning including increased cognitive, emotional, and somatic complaints as well as mood lability, mental exhaustion, and stress (Dinges et al., 1997).

Daytime Functioning

Previously, daytime impairment and sleep have been described as “clouded” due to the ambiguity of directionality in causation, the lack of objective evidence in lieu of well documented subjective complaints, and unknown factors that may be contributing to impaired daytime functioning (Kierlin et al., 2012, Lichstein et al., 2004; Shekelton et al., 2010). It has been found that impairment in daytime functioning is significantly associated with younger age as well as WASO when controlling for health functioning and minority status (Kierlin et al., 2012). The authors speculate that relative youth could: (1) potentiate a greater impact of

insomnia on a comparatively higher level of functionality, (2) that older subjects may have greater chronicity and adapted their functioning with the adverse daytime consequences experienced, and/or (3) that younger individuals were more likely to be working and needed to perform at a higher level (though employment status was not related to daytime functioning). Research has also shown that global sleep dissatisfaction considerably increased the proportion of individuals who experienced daytime consequences in those who had insomnia symptoms, with nonrestorative sleep and difficulty resuming or initiating sleep as subsequent predictors (Ohatyon et al., 2012). This study, however, was limited to individuals living in the states of California, New York, and Texas and daytime repercussions were assessed through 15 questions answered on a 5-point scale ranging from “no impact” to “severe impact”. Items covered cognitive functioning (e.g., memory and concentration), affective tone (e.g., anxiety and depression), sensory irritability, fatigue, and excessive sleepiness.

Shekelton and colleagues (2010) attempted to review the literature that examined neurobehavioral impairments of insomnia to identify which cognitive domains appear to be impaired and found that increasing the complexity or demands of the task appear to increase its sensitivity to detect impairments associated with insomnia. When summarizing data specific to attention, it was found that simple attention tasks (e.g., a participant responds to a particular stimulus while ignoring a distractor) show no performance differences in the reaction time of insomnia patients and controls. When accuracy over speed is assessed, there are some studies that report performance deficits in insomnia patients while others report no differences and in one study, insomnia patients outperformed controls. Similar variability was found in the summarization of sustained attention or vigilance tasks (e.g., ability to maintain alertness over a period of time with increased demand on anticipatory readiness than simple attention tasks) with

some studies showing insomnia patients as having slower response times while others do not. Lastly, shift attention (e.g., the ability to flexibly and adaptively alter the focus of one's attention, requiring higher levels of cognitive involvement) more consistently highlights differences between insomnia patients and controls, with those who experience insomnia having a reduced accuracy response (Shekelton et al., 2010). The authors also reviewed data on psychomotor and processing speed, with a majority of studies showing no significant differences between insomnia and control groups. Continuing with their review, working memory (e.g., tasks requiring reverse repeating, tracking or addition of numbers) was assessed and three studies reported impaired working memory in patients with insomnia compared to controls while two reported no differences. When reviewing work on new learning and memory, utilizing tests of new verbal or visual learning followed by immediate or delayed recall, it was revealed that most studies found no differences between those with insomnia and the control group. However, memory consolidation (e.g., performing a particular task [motor, adaptation, texture discrimination] several times and post a usual night of sleep, performing the task the following day) is affected by poor sleep. Lastly, when reviewing executive functioning (e.g., higher level cognitive processes like planning, reasoning, mental flexibility, and multitasking) has not been well studied within the insomnia literature and those that were, reported no significant group differences other than one study with a verbal reasoning task (Shekelton et al., 2010). It has also been proposed that deficits occurring in patients with insomnia are not substantial enough to be elicited from a single testing episode and may need repeated administration, though are then at risk for training and adaptation effects (Scheider et al., 2004).

Gaps in the Literature

As Lichstein and colleagues (2004) discussed in their book *Epidemiology of Sleep: Age, Gender, and Ethnicity*, most epidemiological studies have focused on determining the *prevalence* of sleep rather than quantitatively describing sleep (e.g., SL, NWAK, WASO, and TST), whereby subjective views of sleep difficulties may vary without quantifiable measures. The authors proceed to explain that the sleep differences found across sex groups could be attributed to differences in subjective definitions of sleep disturbance rather than actual quantitative differences. Additionally, most studies employ single-sampling point retrospective assessments that are prone to recall errors, overestimation of symptoms, and unduly influenced by situational factors such as current mood or the most recent experience with the prior night's sleep (Lichstein et al., 2004).

Limitations in studies that have attempted to quantify daytime impairment, include unequal sex group sizes, underrepresentation of the general older adult population, and difficulties in objective assessment of dysfunction (Kierlin et al., 2012).

Reason for the Current Study

Given cognitive behavioral therapy for insomnia, the number one recommended line of treatment (Edinger et al., 2021), takes into account sleep *ability*, and it is hypothesized that this varies across the lifespan, further research and clarification would be beneficial. Particularly relevant is the decrease in sleep ability with the advancement of age and as such it is proposed that perhaps individuals are unaware of sleep ability shifts and are associating insomnia-like symptoms when rather their ability and need has decreased. The novelty of this study was to assess if presenting complaint (e.g., initial, middle, late insomnia) and quantitative values for what is considered insomnogenic varies with age and how daytime dysfunction maps onto age by

severity (e.g., are age cohorts equally impacted by daytime dysfunction as a result of sleep disturbance or are older adults protected/more at risk). This study assessed a community sample, with the option to report sleep difficulties, if they identify these difficulties as a problem, and what retroactive sleep continuity variables look like on average over the past one-month period. Understanding severity is of utmost importance as the diagnosis of insomnia requires evidence of significant distress or impairment in daytime functioning, which could be categorized as symptoms of fatigue, sleepiness, attentional/memory complaints, or mood disturbance. Quantifying the extent to which this occurs with more sensitive neurocognitive measures in tandem with the traditional subjective measures (e.g., sleepiness or fatigue scales), is important to understand what may look “normal” for a given age group. As important, is the understanding of what other factors may be contributing to impairment in daytime functioning (e.g., sedative medication usage, depressed mood, alcohol use, etc.). Characterizing daytime impairment associated with insomnia may enhance the efficacy of treatments to remedy the wake-time consequences of the disorder.

Overall, the main gaps that this study attempted to address was to capture an up-to-date sample of individuals across age groups who may identify as having insomnia and to create more sensitive quantitative delineations as well as testing (e.g., beyond subjective self-report) for daytime dysfunction.

The Current Study

Although polysomnography is the “gold standard” of sleep research followed by actigraphy, in an effort to decrease participant burden and increase recruitment given the limited availability of more objective assessment instrumentation and the limited financial abilities of the present study, subjective self-report measures were chosen as the primary sleep outcomes. Some

benefits to utilizing self-report measures in addition to its convenience and inexpensive nature, are that it does not alter participants' normal sleep settings or routines, making it an appropriate and available measure of subjective sleep perception. The disadvantages include exclusion of sleep stage information, the presence of occult sleep disorders (e.g., apnea or periodic limb movement disorders), and validity is reliant on the participants' abilities to recall and estimate sleep variable information, introducing measurement error. However, for the diagnosis of insomnia, only subjective report is utilized, and one may argue that objective measures are therefore not necessary for the main questions this study aims to address.

While several nosologies have outlined insomnia phenotypes, for the purposes of research, the American Academy of Sleep Medicine commissioned a work group to review the literature and standardize operational research diagnostic criteria for the definition of insomnia that was used for the present study. Part of this universal definition of insomnia is nocturnal sleep disturbance and associated daytime impairment and for insomnia disorder, the individual must report: (1) one or more of the following sleep related complaints: [a] difficulty initiating sleep, [b] difficulty maintaining sleep, [c] waking up too early or [d] sleep that is chronically nonrestorative or poor in quality, (2) the sleep difficulties occur despite adequate opportunity and circumstances for sleep, (3) at least one of the following forms of daytime impairment related to the nighttime sleep difficulty is reported by the individual: [a] fatigue/malaise, [b] attention, concentration, or memory impairment, [c] social/vocational dysfunction or poor school performance, [d] mood disturbance/irritability, [e] daytime sleepiness, [f] motivation/energy/initiative reduction, [g] proneness for errors/accidents at work or while driving, [h] tension headaches and/or GI symptoms in response to sleep loss, and [i] concerns or worries about sleep (Edinger et al., 2004).

The Retrospective Sleep Continuity Assessment Questionnaire (described below) was utilized to capture multifaceted aspects of participant's sleep patterns and issues. Additionally, a major factor in diagnosing dysfunctional sleep is daytime impairment. Given sleep's close relationship with daytime functioning, it should be looked at in a full diurnal (i.e., 24-hour) experience rather than an isolated event. Questionnaires assessing daytime functioning include the Epworth Sleepiness Scale and Fatigue Severity Scale. Additional neurocognitive measures were used to increase the sensitivity of daytime impairment. In tandem, a demographic questionnaire was used to capture physical and mental health conditions that participants may be experiencing.

In an attempt to balance sex and age stratification across age decades beginning with 20-29 and ending with 80 – no upper limit, recruitment efforts aimed to obtain at least 20 males and 20 females from each decade grouping. PI analyzed recruitment numbers every 24-48 hours in an attempt to balance the number of participants in each decade (e.g., sample without restriction until n per group per decade was filled and closed this group to further sampling until all groups were represented). While efforts to do so were put forth, it still proved difficult to attain older adults at the upper age bands as well as males in general, even with targeted advertisements for these demographics in specific.

Proposed Aims and Hypotheses

Aim 1: To establish the presence and severity of sleep disturbance across age, sex, and race.

- Hypothesis 1a: Sleep difficulties will be present across all age, sex, and race stratifications

- Hypothesis 1b: As individuals age, sleep will worsen as measured by sleep efficiency and supplemental sleep measures (e.g., age will be negatively correlated with SE and supplemental sleep measures)
- Hypothesis 1c: Insomnia symptomology will be positively correlated with age and perceptions about sleep

Aim 2: To establish the presence of daytime impairment in a population of individuals with significant insomnia symptomology

- Hypothesis 2a: Insomnia will be present in the sample collected
- Hypothesis 2b: Females will experience significantly more insomnia than males
- Hypothesis 2c: Daytime impairment will be positively correlated with age
- Hypothesis 2d: Age will be positively correlated with daytime impairment as measured by sleepiness scales and neurocognitive measures

Aim 3 (exploratory): To determine the degree to which insomnia accounts for daytime impairment while controlling for mood

- Hypothesis 3a: Insomnia will significantly account for daytime impairment while controlling for anxiety and depression

Aim 4 (exploratory): To determine the degree to which perceptions about sleep will account for sleep disturbance while controlling for age

- Hypothesis 4a: Perceptions of sleep will account for sleep disturbance while controlling for age

Aim 5 (exploratory): To determine if the discordance between severity and complaint are primarily related to diminished ability to recall sleep (e.g., less complaints due to episodic memory decline in the presence of sleep disturbance), comorbidity context, and/or adjustment to chronicity

- Hypothesis 5a: The decrease in sleep disturbance severity and complaint will largely be a function of diminished episodic memory, severity of medical comorbidities, and chronicity of insomnia symptomology

Methods

Participants

Participants of this study were comprised of individuals ages 20 – no upper limit. Fifty-six participants were needed for ANOVAs and 48 for regression analyses to achieve 0.80 power to detect a difference using a two-sided hypothesis test with a significant criterion of 0.05 and an effect size of .71 and 1, respectively (Faul, Erdfelder, Lang, & Buchner, 2007; Faul, Erdfelder, Buchner, & Lang, 2009). The study was adequately powered with 176 eligible participants who completed all measures. Five hundred thirteen prospective participants clicked the link to access the study. Three hundred seventeen exited out, did not provide initial consent, and/or did not complete sleep or neurocognitive data measures. Twenty individuals did not meet the age criteria.

Measures

Demographics Questionnaire (Appendix A)

The demographics questionnaire enabled the collection of variables such as sex, race, age and education level as well as information pertaining to physical health (e.g., list current illnesses, medications, and vitamins), mental health, and caffeine, alcohol, and nicotine consumption.

Retrospective Sleep Continuity Assessment Questionnaire (RSCAQ; Appendix B)

The RSCAQ is a brief questionnaire that asked respondents to estimate their sleep experience on most nights over the past month. The RSCAQ yielded the following sleep measures: (1) sleep latency (SL) or the time it takes to fall asleep from the moment of sleep intent; (2) nightly awakenings (NWAK) or the number of times an individual wake up during the night; (3) wake after sleep onset (WASO) in minutes or wake time during the night where SL

and wake time in bed prior to final arising in the morning do not contribute to this measure; (4) total sleep time (TST) in minutes or actual time slept (computed utilizing time in bed (TIB) by subtracting wake time in the morning from time to bed. The sum wake time during the sleep period was derived by adding SL, WASO, and TIB). TST is the product of TIB – sum of wake time; (5) sleep efficiency (SE) percent is the ratio of TIB/(TST X 100); (6) summary quality rating (SQR) of the night's experience (0 being "poor" and 5 being "excellent"); and (7) napping time in minutes spent the previous day. There is no reliability information on the RSCAQ, but it was built upon items from existing, validated sleep measures such as the Consensus Sleep Diary (CSD). The CSD has a sensitivity of 73% and a specificity of 81% in differentiating between good sleepers and individuals with insomnia disorder based on the Duke Structured Interview for Sleep Disorders (Maich et al., 2018). The CSD TST is highly correlated with EEG, actigraphy, and retrospective questionnaires ($r = .63 - .75$), a medium correlation for SE between the CSD and retrospective questionnaire-derived SE ($r = .42$; Dietch & Taylor, 2021). The RSCAQ is based on a single time point asking participants to reflect on average sleep patterns over a one-month time period. The RSCAQ was utilized in an attempt to capture more representative sleep as opposed to sleep that could be influenced by a temporally proximal event.

Insomnia Severity Index (ISI; Morin, 1993; Appendix C)

The ISI is a 7-item measure designed to assess the nature, severity, and impact of insomnia symptoms within the past two weeks based upon a 5-point Likert scale (0=no problem; 4=very severe). The ISI is a reliable (Cronbach's alpha = .74) and valid ($p < .05$, comparing to self-reports of sleep) measure that is commonly used among sleep researchers. The total score ranges from 0-28 with higher scores suggestive of more severe insomnia symptoms. A score of 7 or below is indicative of clinically non-significant insomnia, 8-14 has been suggested to indicate

a clinical level of insomnia symptoms (sub-threshold insomnia), 15-21 evidences moderate symptom severity and 22-28 signifies severe clinical insomnia symptoms (Bastien et al., 2001).

Epworth Sleepiness Scale (ESS; Johns, 1991; Appendix D)

The ESS is an 8-item measure designed to assess the usual chances of dozing or falling asleep while engaged in 8 different activities in the past few weeks based on a 4-point Likert Scale (0 = would never doze - 3 = high chance of dozing). For example, “Watching TV” and “As a passenger in a car for an hour without a break” are two of the items. The ESS score (sum of the 8 item scores 0-3) can range from 0-24 with the higher the score, the higher the average sleep propensity in daily life (ASP)/level of daytime sleepiness. The reference range of ‘normal’ ESS scores is 0-10 with ESS scores of 11-24 representing increased levels of ‘excessive daytime sleepiness’ (EDS). Generally, the ESS scores are interpreted as: (0-5) Lower Normal Daytime Sleepiness, (6-10) Higher Normal Daytime Sleepiness, (11-12) Mild Excessive Daytime Sleepiness, (13-15) Moderate Excessive Daytime Sleepiness, and (16-24) Severe Excessive Daytime Sleepiness. The internal consistency of the eight items has a Cronbach’s alpha between 0.73-0.90 over ten separate investigations (Johns, 1992; Hagell et al., 2007). The test-retest reliability of ESS scores has an intraclass correlation coefficient between 0.81 and 0.93 in five separate investigations (Gibson et al. 2006; Izci et al. 2007; Cho et al 2011; van der Heide et al. 2015).

Fatigue Severity Scale (FSS; Krupp et al., 1989; Appendix E)

The FSS is a 9-item questionnaire used to measure subjective severity of fatigue. respondents are asked to indicate agreement with questionnaire items on a 7-point scale (1 = strongly disagree to 7 = strongly agree). Responses are averaged across the nine items, yielding a possible score range of 1 to 7 or placed on a continuum with higher scores equating to greater

fatigue severity. Sample items include “Exercise brings on my fatigue” and “Fatigue interferes with my work, family, or social life.” Normative data from a healthy population revealed a mean (SD) of 2.3 (0.7) for healthy individuals (Grace et al., 2007). The questionnaire was validated on multiple populations, including healthy adults and it showed high internal consistency with a Cronbach’s alpha of .88 and clearly differentiated patient populations from healthy individuals with a score ratio exceeding 2:1 and adequate test-retest reliability (Krupp et al., 1989). Additionally, FSS appears to measure fatigue separate from daytime sleepiness (Lichstein et al., 1997).

The Short-Form Version of the Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995; Appendix F)

The DASS-21 is a 21-item measure of depression (e.g., “I was unable to become enthusiastic about anything”), anxiety (e.g., “I felt scared without any good reason”), and stress symptoms (e.g., “I tended to over-react to situations”) divided into three subscales of seven items each). Items are rated on a 4-point scale ranging from 0 (*did not apply at all*) to 3 (*applied to me very much or most of the time*). Item scores of 14, 10, and 19 indicate moderate levels of depression, anxiety, and stress, respectively. Item scores are summed then each subscale is multiplied by two on the DASS-21 to yield a maximum score of 42, in an effort to be compatible with the long version of the DASS-42. The DASS-21 total scale score has excellent internal consistency (.93; Henry & Crawford, 2005), and its score interpretations have sound construct validity (Henry & Crawford, 2005; Page et al., 2007). The construct validity of the short-form was tested in a non-clinical sample of the general adult United Kingdom (UK) population (Henry & Crawford, 2005). There is no evidence of differences between the mean severities or the factor structure of DASS-21 scores collected in Western countries such as the UK and the United States

(Ronk et al., 2013). Reliability of the DASS-21 Anxiety, Depression, and Stress total scale scores were good with internal consistencies of .88, .82, and .9, respectively and good convergent and discriminant validity when compared to the Hospital Anxiety and Depression Scale and the Personal Disturbance Scale (Henry & Crawford, 2005).

Sleep Disorders Symptom Checklist-25 (SDS-CL-25; Klingman et al., 2016; Appendix G)

The SDS-CL-25 is used as a comprehensive screener for sleep disorders within primary care and research settings. The SDS-CL-25 screens for six sleep disorders (insomnia, obstructive sleep apnea, restless legs syndrome/periodic limb movement disorder, circadian rhythm sleep-wake disorders, narcolepsy, and parasomnias). Sensitivities/specificities for the diagnosed sleep disorders ranged from 0.64-0.88 with interviewees endorsing the instrument as user friendly and recommendation for clinical use for assessing a large number of sleep disorders (Klingman et al., 2017). While validation is still in progress, this tool may serve as a useful screener to assess what other sleep disorders may be present in the proposed sample of individuals with insomnia.

Dysfunctional Beliefs and Attitudes about Sleep Brief Version (DBAS-16; Morin, 1993; Appendix H)

The DBAS is a 16 item self-report measure designed to evaluate a subset of sleep related cognitions (e.g., faulty beliefs and appraisals, unrealistic expectations, perceptual and attention bias). Respondents rate on a 0-10 Likert-type scale how much they agree with each sleep related cognition. Items consist of statements such as “I am worried that I may lose control over my abilities to sleep” or “When I sleep poorly on one night, I know it will disturb my sleep schedule for the whole week”. An average is computed from the 16 items with a higher score reflecting greater dysfunctional beliefs about sleep and target beliefs expressed in items with scores greater than 5. The DBAS-16 is reliable with adequate internal consistencies in both clinical and

research samples (Cronbach alphas of 0.77 and 0.79, respectively). DBAS total scores were significantly correlated with insomnia severity, anxiety, and depression (Morin et al., 2007).

Functional Outcomes of Sleep Questionnaire: Reduced Version (FOSQ-10; Chasens et al., 2009; Appendix I)

The FOSQ has been used in research and clinical practice to assess the impact of daytime sleepiness on activities of daily living. The reduced version of the FOSQ asks how difficult participants find it to complete 10 tasks (e.g., concentrating on things) because they are sleepy or tired on a 1 (extremely) to 4 (none) Likert-type Scale. The 10-item version has good internal consistency ($\alpha = 0.87$) and was able to detect a large, clinically meaningful change in Total scores post CPAP treatment ($p < 0.0001$) as well as discriminate between normal individuals who do not experience sleepiness-related impairment from those suffering limitations in daily activities related to excessive daytime sleepiness (Chasens et al., 2009).

Charlson Comorbidity Index (CCI; Charlson et al., 1987; Appendix J)

The CCI has been used to categorize comorbidity categories based on the International Classification of Diseases with an associated weight from 1-6 based on the adjusted risk of mortality and/or resource use (e.g., gastric or peptic ulcer and pulmonary disease/asthma have an associated weight of 1 and HIV or AID and metastatic solid tumor have an associated weight of 6). The sum of all the weights results in a single comorbidity score for a patient (e.g., a score of 0 indicates no comorbidities were found); the higher the score, the more likely the outcome will result in mortality and/or higher resource use.

TestMyBrain (TMB) Digital Neuropsychology Toolkit

In an effort to measure visual and episodic memory, TMB Visual Paired Associates Memory will be utilized. This test requires that participants learn and recognize a set of picture

pairs (scene images). It is mobile device compatible, has a normative sample consisting of 10,371 individuals and an acceptable reliability ($\rho = 0.79$). As outlined above, more complex tasks appear to be more sensitive for individuals with insomnia and thus TMB Gradual Onset Continuous Performance Test was chosen to measure sustained attention, response inhibition, and cognitive control in an attempt to capture features of potential daytime impairment. This test demands that participants press a key when a city image appears and to *not press* anything when a mountain image appears. Images rapidly transition from one to the next, with mountains appearing only 10-20% of the time. The average completion time is 6 minutes, the test is mobile device compatible, and the reliability is acceptable $\rho = 0.77$ (discrimination), $p = 0.78$ (criterion). The normative sample for this test is 23,757 individuals.

TMB is contained on a digital research platform that has been in operation since 2008 with data from over 2.5 million participants. The tools are funded by the US National Institutes of Health and have been disseminated to over 220 sites. Due to the COVID-19 pandemic, remote assessment was made widely available for administration of cognitive assessments with free access to age (12-90), sex, education, and device (laptop, iPad, smartphone) normative data. Tests administered via remote versions show good correlations with traditional testing (Chaytor et al., 2020; Germaine et al., 2012; Fortenbaugh et al., 2015). The minimum browser requirements in order to run remote testing were as follows: Android 4.4.2, Chrome 30, Edge 12, Firefox 31.3.0 ESR, IE 11, Opera 17, Safari 5. This was communicated to participants in a prompt prior to initiating testing. The TMB Digital Neuropsychology Toolkit is in accordance with US HIPPA regulations and does not store personal identifiable data or demographic data. The normative samples vary across tests from 4,000 to 60,000 participants with an age range of 12 to 90+ (average of 29 years, SD of 14). Participants tended to include an over

overrepresentation of women (58%), sexual and gender minorities (13%), participants of Asian descent (9.2%), and individuals from rural areas (28%). Within the US, Hispanic Americans (9%), Black individuals (4%), and individuals with a native or primary language other than English (6%) are underrepresented. Sixty-eight percent of TMB research participants have never participated in a research study before and are not represented by current research initiatives. The primary reasons for participation are interest in the mind and brain (24%), self-knowledge (28%), and recreation (25%). Research looking at age-related differences, sociodemographic differences, and differences related to mental health characteristics replicated findings from traditional research studies (Hartshorne & Germine, 2015; Dodell-Feder et al., 2020; Germine et al., 2012).

Procedure

Participants were recruited via social media (i.e., Facebook and Instagram). The estimated time for the initial survey was 45 minutes, including reading the consent. For completing the entirety of the study, each participant was entered into a lottery system with 16 prizes of \$250 which were distributed through Greenphire cards.

For this study, target recruitment consisted of 280 adults with insomnia ($n = 160$ of the total as older adults [i.e., age ≥ 65]). Via utilization of a secure and HIPPA compliant data collection site (i.e., Research Electronic Data Capture [REDCap]), sleep, medical, and neurocognitive measures were completed. REDCap is a secure, web-based software platform designed to support data capture for research studies, providing: 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for data downloads to common statistical packages; and 4)

procedures for data integration and interoperability with external sources (Harris et al., 2009; Harris et al., 2019).

In an effort to capture episodic memory correlated with subjective responses on the sleep diary and daytime dysfunction, the Visual Paired Associates TMB Digital Neuropsychology test was completed by participants. The reasoning for capturing episodic memory was to represent the type of memory used for reporting sleep. Subjective sleep disruption with age tends to decrease, which may be a result of a decreased ability to recall particulars from the night prior, resulting in an increased likelihood that one would report a neutral or good night. In other words, it was of interest to see if memory performance mitigated the effects of complaint (e.g., ISI) and severity (e.g., SE). Given the importance of sleep and neurocognitive measures in analyses, listwise deletion will be utilized as opposed to pairwise and/or substitution of missing data.

Funding support for recruitment, remuneration, neurocognitive site building, and advertisement were provided by the National Institute on Aging (NIA) K24 award from Dr. Michael Perlis at the University of Pennsylvania. Participant remuneration consisted of a lottery-based system for all individuals who completed the entirety of the study (e.g., one week of prospective sleep diary data and associated measures). The lottery was comprised of 16 prizes of \$250. If the study filled to maximum occupancy ($n = 280$), then each participant was expected to have ~6% chance to win one of the 16 prizes. The total number of participants at study completion however was 176, which increased the odds of winning to about 9%. While research data are mixed regarding the influence of completion rates as well as preference of remuneration in reference to fixed incentives compared to the chance of winning a higher prize lottery payment, there is pilot support to show that lotteries increase incentive to study adherence and completion (Husain et al., 2019; Lee & Chung, 2022).

Aims, Hypotheses, and Data Analytic Strategy

Aim 1: To establish the presence and severity of sleep disturbance across age, sex, and race.

- Hypothesis 1a: Sleep difficulties will be present across all age, sex, and race stratifications.

Analytic Strategy: Descriptive statistics were used to create tables with means and standard deviations for each of the sleep variables within an age decade starting with decade 20 (ages 20-29) and ending with decade 80 (80+). These means and standard deviations were considered elevated and were compared to prior research operationalization standards of >30 minutes. Sleep difficulty means and standard deviations were further categorized into sex and race stratifications.

- Hypothesis 1b: As individuals age, sleep will worsen as measured by sleep efficiency and supplemental sleep measures.

Analytic Strategy: A 2x7 ANOVA was conducted (2 sex and 7 age decades) for each of the seven sleep measures: SL, NWAK, WASO, TST, SE percent, SQR, and time spent napping.

- Hypothesis 1c: Insomnia symptomology will be positively correlated with age and perceptions about sleep

Analytic Strategy: A bivariate correlation was used between the total insomnia score as measured by the ISI with age and perceptions about sleep as measured by the DBAS.

Aim 2: To establish the presence of daytime impairment in a population of individuals with significant insomnia symptomology

- Hypothesis 2a: Insomnia will be significantly present in the sample collected

Analytic Strategy: Descriptive statistics of the ISI total raw scores were summarized to convey the level of insomnia in the overall sample as compared to a normal population. In particular, the mean total raw score will be compared to the cutoff score of seven. Per ISI guidelines for scoring/interpretation, a score greater than 7 is indicative of sub-threshold insomnia and a score of 15 or greater is indicative of clinical insomnia of at least moderate severity.

- Hypothesis 2b: Females will experience significantly more insomnia than males

Analytic Strategy: An independent *t*-test was conducted in order to compare insomnia severity in females and males. The total raw scores of the ISI subscale were used in the analysis as the dependent variable.

- Hypothesis 2c: Daytime impairment will be positively correlated with age

Analytic Strategy: A bivariate correlation was ran between the total raw neurocognitive measures (TMB Gradual Onset Continuous Performance Test and TMB Visual Paired Associates Memory) with age.

- Hypothesis 2d: Daytime impairment will worsen with age as measured by sleepiness scales and neurocognitive measures

Analytic Strategy: A two-factor ANOVA consisting of 7 age decades (20-29, 30-39, 40-49...) by 2 sex category identification (male and female) for 2 daytime impairment measures: TMB Gradual Onset Continuous Performance and FSS was conducted.

Aim 3 (exploratory): To determine the degree to which insomnia accounts for daytime impairment while controlling for mood

- Hypothesis 3a: Insomnia will significantly account for daytime impairment while controlling for anxiety and depression

Analytic Strategy: A hierarchical analysis was run using the ISI total score as the independent variable and the TMB Gradual Onset Continuous Performance daytime neurocognitive measure as the dependent variable. The depression and anxiety total scores on the DASS-21 were loaded into Block 1, while the ISI total score was loaded into Block 2.

Aim 4 (exploratory): To determine the degree to which perceptions about sleep will account for sleep disturbance while controlling for age

- Hypothesis 4a: Perceptions of sleep will account for sleep disturbance while controlling for age

Analytic Strategy: A hierarchical analysis was run using the DBAS total score as the independent variable and SE percentage as the dependent variable. Age was loaded into Block 1, while the DBAS total score assessing perceptions and beliefs about sleep was subsequently loaded into Block 2.

Aim 5 (exploratory): To determine if the discordance between severity and complaint are primarily related to diminished ability to recall sleep (e.g., less complaints due to episodic memory decline in the presence of sleep disturbance), is context sensitive, and/or due to adjustments of living with the disorder

- Hypothesis 5a: The decrease in sleep disturbance severity and complaint will largely be a function of diminished episodic memory, medical comorbidities, and chronicity

Analytic Strategy: A multiple regression analysis was conducted using the TMB Visual Paired Associates Memory scores, the severity of comorbidities CCI total score, and the number of

insomnia symptomology experienced and as the independent variables. SQR was input as the dependent variable.

Results

Sample Characteristics

One hundred and seventy-six individuals (ages 20-85; $M = 47.31$; $SD = 20$) comprised the final sample. In total, 513 prospective participants clicked the link to take the survey and either exited out, did not provide consent and/or answered “no” to taking the survey, had partially completed data but did not answer sleep continuity questions, completed the study, or were under the age of 20 and did not meet the inclusion criteria. Participants in the final sample had completed sleep data and/or neurocognitive measures. Fifty-six individuals identified as male (~32%) and 120 identified as female (~68%). The majority of the sample identified as non-Hispanic White (70.5%) followed by Asian (9.1%), Black (African-American; 8%), multi-racial (2.3%), Black (African; 2.3%), Hispanic/Latino (Mexican; 1.7%), Hispanic/Latino (Cuban, other South American, other; 1.1% each), Hispanic/Latino (other Caribbean/Central American), Black (Afro-Caribbean), and an individual who preferred not to answer at .6% each. Data from the 176 individuals was collected over a period of 86 days.

A community sample was collected, and frequencies were ran regarding age decades, retrospective sleep parameters by decade, sex, and race, BMI categories, education level, relationship status, employment status, work hours, shift worker status, and annual household income.

Almost a quarter of the sample reported an age within the decade of 20-29 ($N = 41$; 23.3%), followed by an age within the decade of 60-69 ($N = 30$; 17.0%), 40-49 ($N = 28$; 15.9%), 30-39 ($N = 27$; 15.3%), 50-59 ($N = 26$; 14.8%), 70-79 ($N = 19$; 10.8%), and 80-89 ($N = 5$; 2.8%). The most common reported times to bed for individuals in the 20-29 age group was 10:00pm ($N = 7$; 17.1%), 11:00pm ($N = 5$; 12.2%), and 1:00am ($N = 4$; 9.8%) while the most

common time to sleep was 11:00pm and 12:00am (N = 5; 12.2% for each time). Twenty-two individuals (57%) and 23 individuals (56.1%) within this age decade consider their sleep latency and wake after sleep onset, respectively, to be a problem. The most common reported wake times were 3:00am (N = 5; 12.2%), 5:00am, 7:00am, 7:30am, and 9:00am (N = 4; 9.8% for each time), while the most common time out of bed was 7:00am, 8:30am, and 9:00am (N = 4; 9.8% for each time). About half of the individuals within this age group reported waking up too early as a problem (N = 20; 48.8%).

The most common reported times to bed for individuals in the 30-39 age group was 10:00pm (N = 8; 30.8%) and 11:00pm (N = 6; 23.1%), while the most common time to sleep was 11:00pm (N = 5; 19.2%). Fourteen individuals (53.8%) and 19 individuals (73.1%) consider their sleep latency and wake after sleep onset, respectively, to be a problem. The most common wake times reported were 6:00am (N = 4; 15.4%), 5:00am and 7:00am (N = 3; 11.5% for each time) and the most common reported times out of bed were 7:00am (N = 5; 19.2%), 6:00am and 6:30am (N = 3; 11.5% for each time). About three quarters of the individuals within this age group reported waking up too early as a problem (N = 20; 76.9%).

Within the age decade of 40-49, the most common reported times to bed for individuals were 10:00pm, 11:00pm (N = 7; 25.9% for each time) and 9:00pm (N = 4; 14.8%), while the most common time to sleep was 10:30pm and 11:30pm (N = 4; 14.8% for each time). Seventeen individuals (63.0%) and 22 individuals (81.5%) consider their sleep latency and wake after sleep onset, respectively, to be a problem. The most common wake times reported were 5:00am (N = 4; 14.8%) and 6:00am (N = 3; 11.1%) and the most common time out of bed was 5:00am and 5:30am (N = 4; 14.8% for each time). About half of the individuals within this age group reported waking up too early as a problem (N = 14; 51.9%).

Individuals within the age range of 50-59 reported their most common bed times as 10:00pm (N = 6; 23.1%), 9:00pm (N = 5; 19.2%), and 11:00pm (N = 4; 15.4%), while the most common time to sleep was 9:00pm, 10:30pm, and 11:00pm (N = 4; 15.4% for each time). Less than half of the individuals in this age group considered their sleep latency to be a problem (N = 11; 42.3%) but a large majority considered their wake after sleep onset to be a problem (N = 23; 88.5%). The most common wake times reported were the most spread at a rate of 2 (7.7%) for each of the following times: 3:30am, 4:00am, 4:30am, 5:30am, 5:45am, 6:00am, 7:00am, 7:15am, and 8:30am. The most common reported times individuals got out of bed were 9:00am (N = 3; 11.5%), 7:00am, 6:00am, and 4:30am (N = 2; 7.7% for each time). Fourteen individuals within this age group reported waking up too early as a problem (N = 14; 53.8%).

The most common times to bed and time to sleep reported within the age range of 60-69 were 10:00pm (N = 9; 31%; and N = 6; 20.7%, respectively) and 11:00pm (N = 6; 20.7% and N = 3; 10.3%, respectively). Ten individuals considered their sleep latency to be a problem (34.5%) while 16 considered their wake after sleep onset to be a problem (55.2%). The most common reported times to wake were 7:30am and 8:00am (N = 4; 13.8% for each time). The most common reported time out of bed was 7:00am (N = 7; 24.1%). About half of the individuals in this group reported waking up too early as a problem (N = 16; 55.2%).

Within the age range of 70-79, the most common reported times to bed were 9:00pm (N = 4; 21.1%), 10:00pm and 11:00pm (N = 3; 15.8% for each time) while the most common time to sleep was 9:30pm, 10:00pm and 12:00am (N = 2; 10.5% for each time). Nine individuals considered their sleep latency and wake after sleep onset to be a problem (47.4%). The most common reported wake times were 6:00am (N = 4; 21.1%) and 7:00am (N = 3; 15.8%), while

the most common reported times out of bed were 9:00am (N = 4; 21.1%) and 7:00am (N = 3; 15.8%).

For the 5 individuals within the 80-89 age range, descriptive information of all responses will be provided given the small n size. Bedtimes varied between individuals, with reported times to bed as follows: 9:00pm, 10:00pm, 10:30pm, 11:00pm, and 1:00am (N = 1; 20% for each time). One individual failed to report time to sleep, while the others reported 10:00pm, 10:30pm, 10:45pm, and 1:00am. Only one individual reported their sleep latency to be a problem (20%), while three reported wake after sleep onset and early morning awakening to be a problem (60%). The most common wake time was 7:00am (N = 2; 40%), while others reported 6:00am, 6:15am, and 9:00am (N = 1; 20% for each time). Reported times out of bed varied by individual with the following reported times: 6:30am, 7:00am, 7:45am, and 9:00am (20% each; one individual failed to report). Formal analyses could not be run given the small number of participants within this age group.

The most commonly reported time to bed across all age decades for individuals who identified themselves as male was 10:00pm (N = 11; 19.6%) followed by 11:00pm (N = 7; 12.5%). The most commonly reported time to sleep was 11:00pm (N = 8; 14.3%), followed by 10:30pm (N = 6; 10.7%). Twenty-five males considered their sleep latency to be a problem (44.6%), 30 considered their wake after sleep onset to be a problem (53.6%), and 26 considered early morning awakenings to be a problem (46.4%). The most commonly reported wake times were 6:00am (N = 8; 14.3%) and 5:00am (N = 5; 8.9%) and the most commonly reported times out of bed were 5:00am, 7:00am, and 10:00am (N = 5; 8.9% for each time).

Individuals who identified as female reported the most common times to bed as 10:00pm (N = 30; 25.6%), 11:00pm (N = 25; 21.4%), and 9:00pm (N = 13; 11.1%), while the most

commonly reported times to sleep were 10:00pm and 11:00pm (N = 14; 12.0% for each time). Half of the females in the sample considered sleep latency to be a problem (N = 59; 50.4%), 85 females felt wake after sleep onset was a problem (72.6%), and 72 felt early morning awakenings were a problem (61.5%). The most commonly reported wake time was 7:00am (N = 14; 12.0%) followed by 6:00am (N = 12; 10.3%). The most commonly reported time out of bed was 7:00am (N = 19; 16.2%) followed by 6:00am and 9:00am (N = 10; 8.5% for each time).

Participants who reported their race as non-Hispanic White reported the most common times to bed as 10:00pm (N = 30; 24.6%) and 11:00pm (N = 24; 19.7%) and the most common times to sleep as 11:00pm (N = 16; 13.1%), 10:30pm and 1:00am (N = 11; 9% for each time). Less than half considered sleep latency to be a problem (N = 53; 43.4%) but more than half reported wake after sleep onset to be a problem (N = 77; 63.1%), and half found early morning awakenings to be a problem (N = 62; 50.8%). The most commonly reported wake times were 8:00am (N = 16; 13.1%) and 6:00am (N = 13; 10.7%) while the most commonly reported times out of bed were 7:00am (N = 14; 11.5%) and 9:00am (N = 12; 9.8%).

Participants who reported their race as Asian reported the most common times to bed as 11:00pm (N = 4; 25%), 10:00pm, and 11:30pm (N = 2; 12.5% for each time). The most common reported times to sleep were 11:00pm and 12:00am (N = 2; 12.5% for each time). Seven individuals felt their sleep latency was a problem (43.8%), 13 felt their wake after sleep onset was a problem (81.3%), and 14 felt early morning awakenings were a problem (87.5%). The most common reported wake times were 3:00am, 4:00am, and 6:00am (N = 3; 18.8% for each time) and the most common times to get out of bed were 7:00am (N = 5; 31.3%) and 6:00am (N = 3; 18.8%).

Participants who reported their race as Black (African-American) reported the most common time to bed as 10:00pm (N = 2; 15.4%). All other times to bed varied at the individual level. The most common times to sleep were 11:00pm and 11:30pm (N = 2; 15.4% for each time). All other sleep times varied at the individual level. Ten individuals found their sleep latency to be a problem (76.9%), 12 found wake after sleep onset to be a problem (92.3%), and 11 found early morning awakenings to be a problem (84.6%). Wake time varied at the individual level, ranging from 3:00am – 12:00pm. The most commonly reported time out of bed was 7:00am (N = 3; 23.1%).

Due to n<5 of reporting for each category, Black (Afro-Caribbean) and Black (African) frequencies were ran together for a total n of 5. The most commonly reported time to bed was 11:00pm (N = 2; 40%) and time to sleep was 10:00pm (N = 3; 60%). Four individuals reported sleep latency and wake after sleep onset to be a problem (80%), while three individuals reported early morning awakenings to be a problem (60%). Time to wake varied at the individual level from 2:00am – 7:15am and the most common time out of bed was 7:15am.

Similarly, due to n<5 of reporting for each category, Hispanic/Latino: Mexican, Cuban, other South American, and other Caribbean/Central American were aggregated and frequencies were ran together for a total n of 10. The most commonly reported time to bed was 10:00pm (N = 3; 30%) and the most commonly reported times to sleep were 10:00pm and 2:00am (N = 2; 20% for each time). Half of the individuals felt their sleep latency and wake after sleep onset was a problem (N = 5; 50%) and 4 individuals felt early morning awakenings were a problem (N = 4; 40%). The most commonly reported wake time and time out of bed was 5:00am (N = 3; 30% for both).

Individuals who identified as multiracial reported times to bed at an individual level of 9:00pm, 10:00pm, 12:30am, and 3:00am as well as times to sleep of 11:00pm, 11:59pm, 1:00am, and 1:30am. All four individuals reported sleep latency and early morning awakenings to be a problem. Three individuals (75%) reported wake after sleep onset to be a problem. Wake times varied at the individual level and ranged from 2:00am, 3:00am, 5:00am, and 5:15am. Times out of bed also varied at the individual level and ranged from 5:00am, 6:50am, 8:00am, and 10:00am.

Full sample means and standard deviations of sleep continuity variables can be found in Table 3. Table 4 displays sleep continuity means and standard deviations by age decade. Table 5 portrays sleep continuity means and standard deviations by sex. Table 6 describes sleep continuity means and standard deviations by race.

About a quarter of the sample reported a height and weight resultant in a calculated BMI in the overweight range (N = 51; 29.0%). The remaining participants fell into a BMI category of underweight (N = 11; 6.3%), healthy weight (N = 56; 31.8%), overweight (N = 51; 29.0%), obese (N = 4; 2.3%), or morbidly obese (N = 15; 8.5%). About 30% of the sample reported obtaining a bachelor's degree as their highest level of education as well as having a full-time job (N = 55; 31.3% and N = 56; 30.7%, respectively). More than half of the sample worked hours primarily during the day (i.e., 9:00am – 5:00pm; N = 94; 53.4%) and the majority did not report shift working (N = 127; 72.2%). Of the 31 individuals who did shift work (17.6%), they mainly worked standard shifts (N = 20; 11.4% of total sample and 64.52% of shift working sample) versus rotating shifts (N = 11; 6.3% of total sample and 35.48% of shift working sample). The most common annual household income reported in this sample before taxes was within the range of \$20,000 - \$29,999 (N = 19; 10.8%), followed by \$30,000 - \$39,000 and \$50,000 -

\$59,000 (N = 17; 9.7% for each group). A portion of the sample reported an annual household income of less than \$10,000 (N = 14; 8.0%) and more than \$150,000 (N = 12; 6.8%). Further demographic information is presented in Table 1.

Preliminary Analyses

Reliability. The internal reliability of the ISI, DBAS, FSS, DASS-Anxiety Subscale (DASS-A), and DASS-Depression Subscale (DASS-D) were measured using Cronbach's Alpha. Analyses indicated good internal consistency for the ISI ($\alpha = .91$), DBAS ($\alpha = .90$), FSS ($\alpha = .86$), DASS-A ($\alpha = .87$), and DASS-D ($\alpha = .94$). All internal consistency statistics, means and standard deviations are reported in Table 2.

Bivariate Relationships. Bivariate relationships between all primary variables of interest are presented in Table 7. Pearson's r was used for all measures with normal distributions. Spearman's rho was used for all other measures in which the distribution was skewed.

Normality. The Gradual Onset Performance DPrime, Visual Paired Associates Accuracy Outcome measures, ISI DBAS, and FSS totals as well as TST and SQR were normally distributed. Table XX shows the sample means and normative means for both neurocognitive measures. Of note, the TMB Visual Paired Associates table has the descriptive statistics for the total score as opposed to accuracy given what was provided by the researchers in the development and reporting of psychometric characteristics (Singh et al., 2021). Sleep latency, number of nighttime awakenings, wake after sleep onset, violated assumptions of normality by producing skewness and kurtosis values that were greater than twice their standard errors. Sleep efficiency violated assumptions of normality by producing a skewness value that was greater

than twice its standard error. Beyond the descriptive statistics used to discuss the sample collected, an attempt to rectify the abnormal scales utilizing outlier identification, removal, and data transformations were completed. Regarding SL, values equal to or greater than 120 minutes were removed as outliers ($n = 10$). Regarding NWAK, values equal to or greater than 9 were removed as outliers ($n = 30$). Values greater than or equal to 100 were removed as outliers for WASO ($n = 16$). Regarding SE, percentages less than 50 were removed as outliers ($n = 18$). Values of 0 minutes and those greater than 240 minutes spent napping were removed as outliers ($n = 59$). Transformations of square root, log10, and inverse were completed; final transformation was chosen for variables that brought them most toward normality. In an attempt to rectify violations of normality, SL, WASO, SE, time spent napping, DASS depression total scale, anxiety total scale, and stress total scale scores were transformed using the square root technique. NWAK was transformed using the log technique.

Primary Analyses

Aim 1. Hypothesis 1a: sleep difficulties will be present across all age, sex, and race stratifications. Within each age decade, both SL and WASO were found to be elevated (>30 minutes as compared to established cutoffs) on average, with the exception of the age decade of 80-89 where the mean SL was found to be 19 minutes ($SD = 14.75$). The age decade of 30-39 reported the highest SL ($M = 47.77$; $SD = 47.1$) and the decade of 20-29 reported the highest WASO ($M = 44.29$; $SD = 56.97$). The lowest reported WASO was found to be within the age decade of 70-79 ($M = 36.11$; $SD = 39.45$). The age decade with the longest time spent in bed was found to be within ages 20-29 ($M = 9.21$ hours; $SD = 1.59$) and the least time spent in bed was within the decade of 60-69 ($M = 8.19$ hours; $SD = 0.96$). The longest average reported total sleep

time was found to be within the decade of 80-89 ($M = 7.36$; $SD = 2.26$) and the shortest was found to be within the decade of 30-39 ($M = 6.00$; $SD = 1.24$). Lastly, the highest calculated sleep efficiency percentage utilizing the equation: $SE = (TST/TIB) \times 100$ was found to be within the decade of 80-89 ($M = 81.69$; $SD = 22.67$) and the lowest was found to be within the decade of 30-39 ($M = 71.02$; $SD = 18.19$). See Table 4 for all sleep continuity variables by age decade.

Sleep latency for both males ($M = 42$; $SD = 54.45$) and females ($M = 36.91$, $SD = 30.58$) were found to be elevated (>30 minutes as compared to established cutoffs). Wake after sleep onset was also found to be elevated (>30 minutes as compared to established cutoffs) for both males ($M = 36.16$; $SD = 49.41$) and females ($M = 41.55$; $SD = 43.10$). See Table 5 for all sleep continuity variables by sex.

Sleep latency for individuals who identified as non-Hispanic White ($M = 36.36$; $SD = 35.12$), Black (African-American; $M = 66.54$; $SD = 73.84$), Hispanic/Latino (Mexican, Cuban, other South American, other Caribbean/Central American, and other; $M = 35.5$; $SD = 34.84$), and Multi-racial ($M = 88.75$; $SD = 67.5$) was found to be elevated (>30 minutes as compared to established cutoffs). Sleep latency for individuals who identified as Asian ($M = 25.63$; $SD = 18.96$) and Black (Afro-Caribbean or African; $M = 29.6$; $SD = 23.92$) were not found to be elevated. Wake after sleep onset was found to be elevated (>30 minutes as compared to established cutoffs) across all races: non-Hispanic White ($M = 39.37$; $SD = 43.17$), Asian ($M = 35.19$; $SD = 47.29$), Black (African-American; $M = 62.77$; $SD = 77.6$), Black (Afro-Caribbean and African; $M = 34.0$; $SD = 26.07$), Hispanic/Latino (Mexican, Cuban, other South American, other Caribbean/Central American, and other; $M = 39.82$ $SD = 45.15$), and Multi-racial ($M = 41.25$; $SD = 22.5$). See Table 6 for all sleep continuity variables by race.

Hypothesis 1b₁: as individuals age, sleep will worsen as measured by SL. A 2x7 factorial ANOVA was conducted to compare the main effects of sex and age decade as well as their interaction effects on SL. Levene's test showed that the variances of the groups were equal $F(13,147) = 1.59, p = .09$, however normality was violated and thus the square root transformed variable of SL was utilized. There was no significant difference between males and females on SL ($F(1,147) = 2.43, p = .12; P\eta^2 = .02$). There was no significant difference between age decade on SL ($F(6,147) = 1.23, p = .29; P\eta^2 = .05$). There was no significant interaction between age decade and sex on SL ($F(6,147) = 1.00, p = .43; P\eta^2 = .04$). Tables 9 and 10 reflect the descriptive characteristics, including means and standard deviations of both the transformed and raw variable of sleep latency, respectively, by age decade and sex.

Hypothesis 1b₂: as individuals age, sleep will worsen as measured by NWAK. A 2x7 factorial ANOVA was conducted to compare the main effects of sex and age decade as well as their interaction effects on NWAK. Levene's test showed that the variances of the groups were equal $F(12,132) = .82, p = .63$, however normality was violated and thus the log10 transformed variable of NWAK was utilized. There was no significant difference between males and females on NWAK ($F(1,132) = .63, p = .43; P\eta^2 = .01$). There was no significant difference between age decade on NWAK ($F(6,132) = 1.03, p = .41; P\eta^2 = .05$). There was no significant interaction between age decade and sex on NWAK ($F(6,132) = 1.08, p = .38; P\eta^2 = .05$). Tables 11 and 12 reflect the descriptive characteristics, including means and standard deviations of both the transformed and raw variable of nighttime awakenings after sleep onset, respectively, by age decade and sex.

Hypothesis 1b₃: as individuals age, sleep will worsen as measured by minutes spent napping during the day. A 2x7 factorial ANOVA was conducted to compare the main effects

of sex and age decade as well as their interaction effects on minutes spent napping during the day. Levene's test showed that the variances of the groups were equal $F(12,84) = 1.76, p = .07$, however normality was violated and thus the square root transformed variable of minutes spent napping during the day was utilized. There was no significant difference between males and females on minutes spent napping during the day $F(1,84) = .09, p = .77; P\eta^2 = .001$. There was a significant difference between age decades on minutes spent napping during the day $F(6,84) = 3.14, p = .008; P\eta^2 = .18$. The interaction effect is significant $F(6,84) = 2.75, p = .017; P\eta^2 = .16$, indicating that there was a combined effect for sex and age decade on minutes spent napping during the day. An unplanned comparison using the Scheffe test showed a significant simple main effect for females and males at both age decades of 30-39 ($M_D = 2.57, SE = 1.28$); $F(1,84) = 4.01, p = .049; P\eta^2 = .05$ and 40-49 ($M_D = 3.53, SE = 1.42$); $F(1,84) = 6.13, p = .015; P\eta^2 = .07$. See Figure 1 for a line graph of the means for the interaction effect of age decade and sex. Tables 13 and 14 reflect the descriptive characteristics, including means and standard deviations of both the transformed and raw variable of minutes spent napping during the day, respectively, by age decade and sex.

Hypothesis 1b4: as individuals age, sleep will worsen as measured by WASO, TST, SE, and SQR. Given conceptually the variables represent a theoretical composite and to assist in reduction of the risk of type I error, a combined analysis of WASO, TST, SE, and SQR was completed to see how these DVs together were related to sex and age decade. Bivariate correlations were completed and each of the DVs were related to each other within the r range of .3-.6. Regarding multivariate normality, the square root transformation of WASO and SE was utilized. TST and SQR were normally distributed. Box's test of equality of covariance matrices showed the groups were equal $F(100,3609) = 1.20, p = .09$. Additionally, individual levels of

Levene's test of all 4 dependent variables, homogeneity of variance were met ($p > .05$). Pillai's Trace revealed there was no significant difference between males and females on the combined DVs of WASO, TST, SE, and SQR ($F(4,122) = 2.17, p = .08$). Pillai's Trace revealed there was a significant difference between age decade on the combined DVs of WASO, TST, SE, and SQR that accounts for 8% of the variability $F(24,500) = 1.71, p = .019$. There was no significant interaction between age decade and sex on the combined DVs $F(24,500) = 1.24, p = .20, \text{P}\eta^2 = .06$. There was a significant difference between males and females on sleep efficiency $F(1,125) = 3.86, p = .052; \text{P}\eta^2 = .03$ (see figure 2). There was a significant difference between age decade on sleep quality $F(6,125) = 4.33, p < .001; \text{P}\eta^2 = .17$ (see figure 3). There was a significant multivariate simple main effect for males and females age 70-79 on sleep efficiency ($M_D = .93, SE = .44; F(1,125) = 4.48, p = .036; \text{P}\eta^2 = .035$). There was a significant multivariate simple main effect for females and males age 30-39 on sleep quality ($M_D = 1.14, SE = .54; F(1,125) = 4.45, p = .037; \text{P}\eta^2 = .034$). Unplanned comparisons using Scheffe's Test displayed a significant difference between age decade 50-59 ($M = 1.77, SD = 1.07$) and 70-79 ($M = 3.33, SD = 1.45, p = .019$) on sleep quality.

Hypothesis 1c: insomnia symptomology will be positively correlated with age and perceptions about sleep. There was a significant negative correlation between insomnia and age $r(146) = -.215, p = .009$ and a significant positive correlation between insomnia and dysfunctional beliefs about sleep $r(146) = .675, p < .001$.

Aim 2: Hypothesis 2a: insomnia symptomology will be significantly present in the sample collected. Descriptive statistics of the ISI total raw scores of which 148 participants completed yielded elevated sleep disturbance ($ISI > 7; M = 12.26; SD = 6.88$) among this sample. Forty participants obtained a total ISI score of 7 or less, indicative of clinically non-

significant insomnia, 57 obtained a score between 8-14, indicative of a clinical level of insomnia symptoms of sub-threshold insomnia, 40 individuals obtained a score of 15-21, evidence of moderate insomnia symptom severity, and 11 individuals obtained a score of 22-28, signifying severe clinical insomnia symptoms. Although 108 individuals reported sub-threshold to severe clinical insomnia symptoms, only 61 individuals identified themselves as suffering from a sleep disturbance that they identify as insomnia. Of these 61 individuals, 31 have previously been treated for sleep problems, with the majority reporting sleep apnea/Cpap followed by insomnia and a form of sleep medication, and one individual reporting REM behavior disorder.

Hypothesis 2b: females will experience significantly more insomnia than men.

Females ($M_F = 12.28$; $SD = 6.72$) did not experience significantly more insomnia than Males ($M_M = 12.20$; $SD = 7.31$; $t(146) = -.06$, $p > .05$).

Hypothesis 2c: daytime impairment will be positively correlated with age. There was no significant correlation between age and sustained attention as measured by the Continuous Performance Test's DPrime measure of psychophysical performance, computed as the difference between the standard scores for the false-alarm rate and the hit-rate $r(113) = .003$, $p = .97$. One outlier of the CPT DPrime variable was removed due to being more than 2 SD from the mean. There is a significant negative correlation between age and visual and episodic memory as measured by Visual Paired Associate's accuracy measure computed by the proportion of number correct out of total trials $r(113) = -.20$, $p = .03$.

Hypothesis 2d1: daytime impairment will worsen with age as measured by the neurocognitive measure of CPT DPrime. A 2x7 factorial ANOVA was conducted to compare the main effects of sex and age decade as well as their interaction effects on CPT DPrime as a measure of daytime impairment. Levene's test showed that the variances of the groups were not

equal $F(12,99) = 2.89$, $p = .002$. CPT DPrime is normally distributed. There was no significant difference between males and females on CPT DPrime ($F(1,99) = 0.11$, $p = .74$; $P\eta^2 = .001$). There was no significant difference between age decade on CPT DPrime ($F(6,99) = 0.26$, $p = .95$; $P\eta^2 = .02$). There was no significant interaction between age decade and sex on CPT DPrime ($F(6,99) = 0.81$, $p = .44$; $P\eta^2 = .06$). See Table 16 for the descriptive characteristics, including means and standard deviations of CPT DPrime measure by age decade and sex.

Hypothesis 2d2: daytime impairment will worsen with age as measured by the FSS.

A 2x7 factorial ANOVA was conducted to compare the main effects of sex and age decade as well as their interaction effects on FFS as a measure of daytime impairment. Levene's test showed that the variances of the groups were equal $F(12,131) = 0.58$, $p = .85$ and the fatigue scale was normally distributed. There was no significant difference between males and females on fatigue level $F(1,131) = 0.35$, $p = .56$; $P\eta^2 = .003$. There was a significant difference between age decades on fatigue level $F(6,131) = 2.27$, $p = .04$; $P\eta^2 = .09$. There was no significant interaction between age decade and sex on fatigue level $F(6,131) = .91$, $p = .49$; $P\eta^2 = .04$. LSD post hoc test revealed that the age decade of 20-29 ($M = 46.59$, $SD = 10.98$) had significantly higher fatigue levels than the age decade of 60-69 ($M = 38.50$, $SD = 11.28$; $p = .013$) as well as 70-79 ($M = 37.87$, $SD = 15.50$; $p = .021$). LSD post hoc test revealed the age decade of 30-39 ($M = 48.48$, $SD = 13.87$) had significantly higher fatigue than 60-69 ($M = 38.50$, $SD = 11.28$; $p = .006$) as well as 70-79 ($M = 37.87$, $SD = 15.50$; $p = .01$). LSD post hoc test revealed the age decade of 40-49 ($M = 46.95$; $SD = 12.54$) had significantly higher fatigue than 60-69 ($M = 38.50$, $SD = 11.28$; $p = .022$) as well as 70-79 ($M = 37.87$, $SD = 15.50$; $p = .03$). See figure 4 for a line graph of the means of fatigue level across the age decades. See Table 17 for the descriptive characteristics, including means and standard deviations of FSS measure by age decade and sex.

Exploratory Aim 3: Hypothesis 3a: insomnia will significantly account for daytime impairment while controlling for anxiety and depression. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity, and homoscedasticity. After the square root transformations of the depression and anxiety totals, all regression assumptions were met. Results of the hierarchical multiple regression analysis showed that the model with only covariates included did not significantly predict daytime impairment as measured by the gradual onset performance DPrime variable, r^2 change = .03, $F(2, 110) = 1.45$, $p > .05$. When the predictor variable of insomnia severity was added to the model in block 2, it did not significantly account for variance in daytime impairment r^2 change = .03, $F(1, 109) = 2.91$, $p > .05$.

Exploratory Aim 4: Hypothesis 4a: perceptions of sleep will account for sleep disturbance while controlling for age. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity, and homoscedasticity. After the square root transformation of the sleep efficiency variable, all regression assumptions were met. Results of the hierarchical multiple regression analysis showed that the model with only covariate age included did not significantly predict sleep efficiency, r^2 change = .01, $F(1, 137) = 1.03$, $p > .05$. When the predictor variable of dysfunctional beliefs about sleep was added to the model in block 2, it did significantly account for 7.8% of the variance in sleep efficiency r^2 change = .06, $F_{\text{change}}(1, 136) = 9.44$, $p = .003$. ($b = -.12$, $SE = .04$, $Beta = -.26$, $t(136) = -3.07$, $p = .003$).

Exploratory Aim 5: Hypothesis 5a: the decrease in sleep disturbance severity and complaint will largely be a function of diminished episodic memory, severity of medical comorbidities, and chronicity of insomnia symptomology. A multiple regression analysis was

conducted to predict sleep quality from measures of memory, severity of comorbidities, and insomnia symptomology. Assessment of Cook's Distance and SD residual revealed one case with significantly high influence. To correct for this violation of the assumption, this outlier was removed and regression analysis was rerun excluding this case. After removal there were no further violations of assumptions of normality, linearity, multicollinearity, and homoscedasticity. Combined, memory, comorbidities, and insomnia symptomology significantly predicted sleep quality $r^2 = .45$, $F(3,108) = 29.16$, $p < .001$. Insomnia symptom severity significantly predicted sleep quality, $b = -0.13$, $SE = .014$, $t(108) = -9.29$, $p < .001$. Memory and comorbidity severity did not significantly contribute to the prediction of sleep quality.

Post-hoc 1. In order to gain a full and more comprehensive perspective on the current sample, additional variables were analyzed to see if there were any group differences on those who completed the neurocognitive measures and those who did not. Independent t-tests revealed no significant differences between individuals who completed neurocognitive measures ($N = 113$; $M = 12.72$; $SD = 6.71$) and those who did not ($N = 32$; $M = 10.31$; $SD = 7.37$) on the measure of insomnia severity level $t(143) = -1.75$, $p = .08$. Similarly, there were no significant differences between individuals who completed neurocognitive measures ($N = 113$; $M = 44.96$; $SD = 12.30$) and those who did not ($N = 32$; $M = 40.88$; $SD = 13.27$) on fatigue severity level $t(143) = -1.63$, $p = .11$. Lastly, there were no significant differences between individuals who completed neurocognitive measures ($N = 113$; $M = 5.26$; $SD = 1.79$) and those who did not ($N = 39$; $M = 5.15$; $SD = 1.97$) on the measures of dysfunctional beliefs about sleep $t(150) = -0.30$, $p = .76$.

Post-hoc 2. A 2x7 factorial ANOVA was conducted to compare the main effects of sex and age decade as well as their interaction effects on level of stress. Given the violation of

normality, the square root transformed version of the DASS Stress subscale was utilized in this analysis. Levene's test showed that the variances of the groups were equal $F(12,134) = .60, p = .85$. There was no significant difference between males and females on stress level ($F(1,134) = 1.87, p = .17, \eta^2 = .01$). There was a significant difference between age decades on stress level $F(6,134) = 4.35, p < .001; \eta^2 = .16$. There was no significant interaction between age decade and sex on stress level $F(6,134) = .51, p = .80; \eta^2 = .02$. Scheffe post hoc test revealed that the age decade of 20-29 ($M = 3.90, SD = 1.63$) had significantly higher stress levels than the age decade of 60-69 ($M = 2.13, SD = 1.58; p = .009$). Scheffe post hoc test revealed the age decade of 30-39 ($M = 48.48; SD = 13.87$) had significantly higher fatigue than 60-69 ($M = 2.13, SD = 1.58; p = .046$). See figure 5 for a line graph of the means of stress level across the age decades.

Discussion

This is the first study to have examined the relationship between sleep and daytime impairment via standardized measures of neurocognitive testing above and beyond self-reported impairment via questionnaires. Furthermore, the study strove to provide an overview of sleep continuity across the lifespan. In sum, data from the study sample showed participants experienced an elevated level of SL and WASO, with the exception of the age decade of 80-89. This may perhaps be due to the small number of individuals representing this later age decade, and conceivably if a larger sample were collected, there would also reveal elevated levels of SL and WASO. Additionally, memory capabilities and/or a lack of remembrance of how one sleeps during the night via neurocognitive testing may not be adequately representing this later age group in aggregate analyses.

Individuals within the age range of 30-39 reported the highest average SL and 20-29 reported the highest average WASO. Future studies should assess for daytime demands within these age groups as compared to others as a possible factor for why the SL and WASO were exacerbated within these age groups. SL and WASO were also elevated across males and females as well as all races with the exception of individuals who identified as Asian and Black (Afro-Caribbean or African). There were no significant differences between males and females or age decade on their levels of SL or NWAK. While there was no significant difference between sex and minutes spent napping during the day, results showed there was a significant difference between age decades and the interaction of age decade and sex. Females ages 30-39 and 40-49 spent more time napping than males, which could be attributed to hormonal and/or lifestyle changes around the time of pregnancy, postpartum, perimenopausal, and postmenopausal events (Nowakowski & Meers, 2019). In combination, WASO, TST, SE, and sleep quality rating did

not differ between males and females, but age decade did account for 8% of this combined variance. In isolation, there was a significant difference between males and females on sleep efficiency and a difference in age decade on sleep quality. Regarding the interaction of age and sex, there was a significant difference for males and females within the age range of 70-79 on SE, with males reporting higher SE as well as males and females ages 30-39 on sleep quality, with females reporting higher sleep quality. Lastly, regarding sleep continuity, there was a significant difference between the age decade of 50-59 and 70-79 on sleep quality, with an increased level of quality in the latter decade. This finding is in contrast to previous research that reported that sleep quantity and quality tend to decrease with age (Cirelli, 2012).

Insomnia

Further analyses revealed a significant negative association between insomnia and age, implicating that as age increases, insomnia symptomology decreases. This is in line with previous research that suggests subjectively, insomnia decreases with age. Additionally, a significant positive association was found between insomnia symptomology and dysfunctional beliefs about sleep, indicating increased levels of insomnia with an increased amount of dysfunctional beliefs regarding sleep. Beliefs about sleep may account in part for why subjectively individuals feel they experience less insomnia as they age, with the insinuation that individuals hold less rigid dysfunctional beliefs and/or their beliefs surrounding sleep need decreases with age.

In 2016, the American College of Physicians strongly recommended CBT-I as a first-line treatment for adults experiencing insomnia thus creating a shift away from the initial use of pharmacological treatment (Brasure et al., 2016; Qaseem et al., 2016; Wilt et al., 2016). Given a decrease in dysfunctional beliefs may be a protective factor for decreasing the impact of

insomnia, it may prove beneficial to focus on the “C” aspect of CBT-I. Riemann and Perlis (2009) identified interventional strategies in this category to include cognitive reappraisal, planned time to worry, and paradoxical intention. Cognitive reappraisal consists of strategies aimed at reducing dysfunctional beliefs, attitudes, concerns, and false beliefs about the inability to sleep/causes of insomnia. Worry time consists of writing down a list of worries and/or plans for the next day in an attempt to process and decrease emotionally loaded intrusive thoughts prior to bed. Paradoxical intention’s goal is to reduce anticipatory anxiety when trying to fall asleep by instructing individuals to remain still in bed with eyes closed, trying to stay awake as long as they can. Subsequently, sleep effort is reduced, leading to a shorter sleep latency (Riemann & Perlis, 2009). Baglioni and colleagues (2019) discuss how over 14 metaanalyses, CBT-I efficacy was demonstrated for daytime and comorbid symptoms, was just as effective as a sedative hypnotic during acute treatment, was more effective in the long term, and promoted stable changes for SL, WASO, and TST. They also highlight, however, that CBT-I’s applicability to specific populations, such as pregnant women and women going through menopause have less evidence available than those of the general adult population (Baglioni et al., 2019). Considering the correlations between dysfunctional beliefs about sleep and insomnia symptomology, one may speculate that during key hormonal and lifestyle changes, such as pregnancy, postpartum, and menopause, increasing dedicated time to analyzing and processing beliefs and worries may increase treatment response.

The Transdiagnostic Sleep and Circadian Intervention (TranS-C), is utilized as a treatment approach for sleep with comorbid conditions, addressing the similarities in the maintenance of varying disorders (Harvey, 2022). It promotes a health perspective optimized to foster well-being, has cognitively driven components, including a core module of correcting

unhelpful sleep-related beliefs and an optional module of reducing sleep-related worry as well as vigilance (Harvey & Buysse, 2017). Current findings support utilization of this optional module in the hopes that it increases treatment effectiveness for individuals who may otherwise be treatment resistant. As highlighted by the TranS-C treatment of sleep problems manual, this is in line with previous research that showed a reduction in unhelpful beliefs about sleep after treating insomnia was associated with persistent and enduring improvements in sleep (Edinger et al., 2001, Harvey & Buysse, 2017, Morin et al., 2002). Reduction techniques include time spent on learning skills such as evaluating negative thoughts, setting a worry time, problem solving, journaling, and pleasant imagery (Harvey & Buysse, 2017). This is related to the current findings of increased dysfunctional beliefs and cognitions about sleep and their relation to insomnia symptomology, highlighting support for the importance of this optional module.

Within the study sample, insomnia symptomology was found to be significantly elevated, with 73% of the sample meeting sub-threshold to severe clinical symptoms of insomnia, although only 41% of the sample identified themselves as suffering from a sleep disturbance they identified as insomnia. This could indicate that individuals experience sub-threshold or clinical insomnia symptomology and may not recognize it as such and/or may perhaps have a misperception about what insomnia must look like. They may potentially not be identifying issues with sleep either because they feel there is no daytime impairment or because they do not match a more severe clinical profile of what insomnia looks like. Females did not experience significantly more insomnia than males overall, which is in contrast with the majority of recent research (Lichstein et al., 2004; Nowakowski & Meers, 2019; Winkelman, 2020), but in line with more historical studies (Carrier et al., 2001), which may be attributed to a threat of internal validity (e.g., COVID-19 and leveling the effects of insomnia for both sexes equally) or external

validity (e.g., sampling bias and those individuals who chose to take the study may differ substantially from the general population).

The rate of 73% of the current sample meeting sub-threshold to severe clinical symptoms of insomnia is much higher than the general population historically, as well as the recent rise of symptomology during the COVID-19 pandemic with the pooled estimated prevalence of insomnia symptoms, subthreshold to severe, being 52.57% (AlRasheed et al., 2022). This data was derived from a systematic review of 48 studies from 25 countries and consisted of about 133,000 participants. There was a significant difference found between countries and within the U.S. pooled results from 1,716 studies revealed about 68% experienced subthreshold to severe insomnia symptoms (AlRasheed et al., 2022), which is more comparable to the current findings. This may be due to the increased rate of COVID-19 as compared to other countries. The World Health Organization (WHO) Coronavirus Dashboard revealed total confirmed cases by country and the United States had the highest number of cases compared with China, India, France, Germany, Brazil, Republic of Korea, Japan, Italy, the United Kingdom, the Russian Federation, and Türkiye based on WHO case definitions (Public Health Surveillance; World Health Organization (WHO), 2022). The WHO Coronavirus Dashboard also reported current cumulative cases by region; the Americas was reported to be third, with Europe and Western Pacific as first and second, respectively. According to one study estimating the global, regional, and national incidences and mortality from 2019-2022 of the coronavirus disease, in the year 2022, Europe had the highest cumulative incidence of COVID-19, followed by the Americas (Kim & Yeniova, 2022). It would also be of interest to analyze which countries continued the most work during this time as well as transitioned to in-person employment post remote work to see if these numbers potentially impact the perception of insomnia symptoms in light of daytime

demands during and post a period of high stress. In an international, multi-center survey of 22,330 adults in the general population in 13 countries and 4 continents, clinical insomnia symptoms were reported by 36.7% with rates of insomnia being significantly higher in certain countries, including the USA, those who reported greater financial burden, were in confinement for a period of four to five weeks, and lived alone or with more than five people (Morin et al., 2021). Morin and colleagues (2021) reviewed the potential causes for this increase in insomnia symptomology which included the confinement element leading to increased stress, burden, and sleep disturbances, the need to care for children, and the frustration of not being able to accomplish one's work due to an overcrowded dwelling during quarantine. Environmental factors such as noise, light, and electronic media, shift in sleep schedules, increased time in bed, and an increased demand to care for others who were sick may have increased stress and sleep difficulties (Morin et al., 2021). The long-term effects for the high rate of individuals experiencing insomnia symptoms in the current study, should the course be persistent and chronic, may lead to adverse health outcomes such as increased risk of depression, hypertension, and prolonged absences from work (Baglioni et al., 2011, Morin et al., 2020, Sivertsen et al., 2006, & Suka et al., 2003).

Exploratory analyses analyzing sleep efficiency showed that age did not significantly predict SE, however, dysfunctional beliefs about sleep, significantly accounted for 7.8% of the variance in sleep efficiency. This is in line with previous research highlighting that individuals with insomnia endorse an increased and more severe level of dysfunctional beliefs and excessive worry about sleep (Edinger et al., 2000; Espie, 20002; Morin, Vallieres, & Ivers, 2007). Data suggests that beliefs about *how* one should be sleeping, above and beyond the actual sleep they are obtaining, may be most affecting time spent in bed (e.g., increasing the accommodation of

the bed and wakefulness because perhaps they believe they need to sleep more). Given this possibility, future research may benefit from analyzing dysfunctional beliefs more specifically to increase treatment efficacy and further address a potential barrier in the treatment of insomnia above and beyond sleep restriction. Combined, episodic memory, insomnia symptomology, and severity of comorbidities significantly predicted sleep quality, with insomnia symptomology having the only independent significant contribution.

Daytime Impairment

Neurocognitive test constructs of sustained attention, cognitive control, and response inhibition were measured with a continuous performance test that combines sustained attention with a response inhibition component similar to the standard Go-No-Go test. This test was chosen as it manipulates stimulus presentation to rapidly exhaust attentional resources, making it sensitive to individual differences in vigilance where participants respond to images that rapidly transition from one to the next, pressing a button when they see a city scene and not pressing a button when they see a mountain scene. While it is meant to exhaust attentional resources, this test may not have accurately captured individuals' attentional resources that would correlate to what they perceived as daytime impairment relative to sleep difficulties. DPrime, computed as the difference between standard scores for the false-alarm rate and the hit rate was utilized in study analyses. There was no significant correlation between age and sustained attention found in the study sample. Additional analyses revealed no significant difference between sex, age, or the combination of the two on measures of sustained attention, cognitive control, or response inhibition. This is in line with previous research that showed no performance differences in attention tasks in individuals with insomnia and normal controls, though results have been mixed with some studies showing insomnia patients as having a slower response time in these tasks

(Shekelton et al., 2010). There may not yet be neurocognitive tasks sensitive enough to varying levels of sleep difficulty, outside of those captured post sleep deprivation, that may make objective daytime impairment from sleep disturbance challenging to capture.

The neurocognitive visual paired associates test was utilized to measure visual and episodic memory. The main outcome for this test is accuracy, measuring the proportion of correct responses out of all 24 trials. Within the study sample, a significant negative correlation between age and visual episodic memory was found, implying a relationship between an increase in age and a decrease in visual/episodic memory. This finding is in contrast to previous research on new learning and memory via the utilization of tests of visual immediate and delayed recall, though is in line with poorer sleep affecting performance on tasks (Shekelton et al., 2010). This finding may help to explain that if individuals are not recalling their sleep patterns as accurately as they age, they may not be remembering how well or poorly they slept. This may result in reporting, a more neutral mode of sleeping instead, which may assist in the explanation for a decrease in subjectively poor sleep quality within older age bands.

Assessment of fatigue as a measure of daytime impairment revealed significant differences between age decades, but not between males and females nor via the interaction of sex and age decade. Specifically, ages 20-29 had significantly higher fatigue than individuals within the age decades of 60-69 and 70-79. Similarly, individuals within the age decade of 30-39 revealed significantly higher levels of fatigue than individuals within the age decade of 60-69 and 70-79. Finally, individuals within the age decade of 40-49 also reported significantly higher levels of fatigue than individuals within the age decades of 60-69 and 70-79. This may be due to higher daytime demands (e.g., school, work), higher performance expectations, or that older subject may have greater chronicity and adapted to their functioning and adverse daytime

consequences as proposed by Kierlin and colleagues (2012). It is also worth considering the resilience level of differing age groups, the mentality of severity level when assessing what is considered to be a problem within the different eras (e.g., someone in their 70s versus their 20s), which may lead to individuals in latter decades being less prone to report.

When analyzing what may be contributing the daytime impairment (i.e., constructs of sustained attention, cognitive control, and response inhibition; continual performance test d'), depression, anxiety, and insomnia did not significantly predict this. This was unexpected given previous research highlighting perceived deficits in functioning and the relationship of insomnia, anxiety, and depressive disorders (Daley et al, 2009; Nutt et al., 2008; Walsh, 2004). This relationship was identified in chronic, rather than acute insomnia, and thus one explanation could be that this study sample had relatively acute insomnia symptomology compared to the general population.

Limitations

This sample was not fully representative due to confining our study to the United States and also obtaining a sample with a majority of participants who reported their ethnic background as White. This limits other cultural reactions and sleep difficulties, daytime impairment, and psychological sequelae that other countries may be experiencing. Additionally, the use of a computer, phone, tablet, or equivalent technological device was necessary to complete this study which may limit access to individual's ability to take the study as well as obtaining individuals in higher age bands who may be less likely to utilize technology. This is a cross-sectional study, making it difficult to determine a temporal relationship. Furthermore, there are unequal sex and age group sizes, with underrepresentation of the general older adult population as well as males in this sample. Although higher resources were allocated to attempt to recruit males and older

adult populations, future studies may want to direct efforts toward non-digital advertising means, such as newspaper ads, subway ads, and flyers to increase recruitment of older populations, particularly in retirement communities. Regarding the difference in male and female participants and in order to close discrepancies, perhaps printed flyers in more male-dominated fields of study (e.g., engineering; Sibley; 2016) would be helpful in the future. Data must also be interpreted with caution as the associations found are bidirectional in nature and cause and effect cannot be established. Future longitudinal studies must be conducted before theoretical directions and cause and effect can be observed. Though it is not confirmed, wireless networking technology (i.e., Wi-Fi connectivity) may also be a limitation to some individuals completing the neurocognitive portion of the survey, whereby the data may have been rendered incomplete if a Wi-Fi connection failed during the administration of the neurocognitive portion of the study. Similarly, individuals who are given neurocognitive batteries are typically given longer administrations and thus the general population may show more cognitive fatigue than the current sample which only had two tests administered for this study. Additionally, considering the advertisements discussed how one's sleep may change over time, there may have been inherent bias for those who chose to complete the study (e.g., those who were more likely to have sleep difficulties chose to be a part of the current study). Lastly, due to the difficulty recruiting male participants, sex-related differences may not have been appropriately represented.

Future Directions

Future studies should seek to include objective measurements of sleep such as those obtained through PSG or actigraphy data. In addition, clinical interviews to aid in the assessment of anxiety, depression, and daytime impairment may also prove helpful. Given that sleep

complaints decrease with age, and that this study found that dysfunctional beliefs about sleep contributed to changes in sleep efficiency, future studies should look at levels to which this factor is addressed in CBT-i to see if this affects treatment outcomes. This may be an important factor to reducing health care cost for the 5.5 million annual consultations, high prevalence rate with other chronic medical conditions, and an upper range of 30% of individuals reporting insomnia in the U.S. alone (Winkelman, 2020). Additionally, given our study utilized only two neurocognitive measures for daytime impairment, leading to potential relationships not being captured and future studies may benefit from assessing a broader range of neurocognitive measures in a standardized environment. This addition may further help to understand the relationship between sleep and neurocognitive impairment beyond the known self-reported relationship as well as eliminate possible issues related to Wi-Fi. Lastly, given the proposal that deficits occurring in patients with insomnia may not be substantial enough to be elicited from a single testing episode (Scheider et al., 2004), future studies may want to incorporate repeated neurocognitive administration. Ideally, longitudinal collection of sleep continuity and subsequent testing of neurocognition post “normal” and disrupted sleep may more optimally capture daytime impairment as affected by sleep the prior night. Overall, future studies may benefit from capturing a national sample with prospective sleep data, and testing with analyzation of multiplicative effects of both good and poor sleep. Essentially, the ability to objectively capture via neurocognitive tests daytime impairment with utilization of multiple tests that assess attention, memory, and alertness after multiple consecutive days of good sleep (e.g., 3 days) and poor sleep would be ideal. This allows for both within and between participant analyzation of the sequelae of sleep on daytime functioning which would be helpful to begin to analyze at what

point sleep affects this, in turn possibly affecting activities of daily living, job functioning, and familial/social interactions.

References

- AlRasheed, M. M., Fekih-Romdhane, F., Jahrami, H., Pires, G. N., Saif, Z., Alenezi, A. F., ... & Vitiello, M. V. (2022). The prevalence and severity of insomnia symptoms during COVID-19: A global systematic review and individual participant data meta-analysis. *Sleep medicine*.
- American Psychiatric Association. (n.d.). *Desk reference guide to the Diagnostic Criteria From DSM-5*. American Psychiatric Association Publishing.
- Ancoli-Israel, S., & Roth, T. (1999). Characteristics of insomnia in the United States: Results of the 1991 National Sleep Foundation Survey. I. *Sleep*, 22, S347-53.
- Bastien, C. H., Vallières, A., & Morin, C. M. (2001). Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Medicine*, 2(4), 297–307.
- Baglioni, C., Battagliese, G., Feige, B., Spiegelhalder, K., Nissen, C., Voderholzer, U., ... & Riemann, D. (2011). Insomnia as a predictor of depression: a meta-analytic evaluation of longitudinal epidemiological studies. *Journal of affective disorders*, 135(1-3), 10-19.
- Baglioni, C., Altena, E., Bjorvatn, B., Blom, K., Bothelius, K., Devoto, A., ... & Riemann, D. (2020). The European Academy for Cognitive Behavioural Therapy for Insomnia: An initiative of the European Insomnia Network to promote implementation and dissemination of treatment. *Journal of sleep research*, 29(2), e12967.
- Bianchi, M. T., Wang, W., & Klerman, E. B. (2012). Sleep misperception in healthy adults: implications for insomnia diagnosis. *Journal of Clinical Sleep Medicine*, 8(5), 547-554.
- Bonnet, M. H., & Arand, D. L. (1997). Physiological activation in patients with sleep state misperception. *Psychosomatic medicine*, 59(5), 533-540.
- Brasure, M., Fuchs, E., MacDonald, R., Nelson, V. A., Koffel, E., Olson, C. M., ... Kane, R. L. (2016). Psychological and behavioral interventions for managing insomnia disorder: An

- evidence report for a clinical practice guideline by the American College of Physicians. *Annals of Internal Medicine*, **165**(2), 113–124.
- Buyse, D. J., Reynolds III, C. F., Monk, T. H., Hoch, C. C., Yeager, A. L., & Kupfer, D. J. (1991a). Quantification of subjective sleep quality in healthy elderly men and women using the Pittsburgh Sleep Quality Index (PSQI). *Sleep*, *14*(4), 331–338.
- Buyse, D. J., Reynolds III, C. F., Monk, T. H., Hoch, C. C., Yeager, A. L., & Kupfer, D. J. (1991b). Quantification of subjective sleep quality in healthy elderly men and women using the Pittsburgh Sleep Quality Index (PSQI). *Sleep*, *14*(4), 331–338.
- Carrier, J., Land, S., Buysse, D. J., Kupfer, D. J., & Monk, T. H. (2001). The effects of age and gender on sleep EEG power spectral density in the middle years of life (ages 20–60 years old). *Psychophysiology*, *38*(2), 232–242.
- Chasens, E. R., Ratcliffe, S. J., & Weaver, T. E. (2009). Development of the FOSQ-10: A short version of the Functional Outcomes of Sleep Questionnaire. *Sleep*, *32*(7), 915–919.
- Charlson, M. E., Pompei, P., Ales, K. L., & MacKenzie, C. R. (1987). A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *Journal of Chronic Diseases*, *40*(5), 373–383. [https://doi.org/10.1016/0021-9681\(87\)90171-8](https://doi.org/10.1016/0021-9681(87)90171-8)
- Chaytor, N. S., Barbosa-Leiker, C., Germine, L. T., Fonseca, L. M., McPherson, S. M., & Tuttle, K. R. (2021). Construct validity, ecological validity and acceptance of self-administered online neuropsychological assessment in adults. *The Clinical Neuropsychologist*, *35*(1), 148–164.
- Chen, X., Wang, R., Zee, P., Lutsey, P. L., Javaheri, S., Alcántara, C., Jackson, C. L., Williams, M. A., & Redline, S. (2015). Racial/Ethnic Differences in Sleep Disturbances: The Multi-Ethnic Study of Atherosclerosis (MESA). *Sleep*, *38*(6), 877–888. <https://doi.org/10.5665/sleep.4732>

- Cheng, P., Cuellar, R., Johnson, D. A., Kalmbach, D. A., Joseph, C. L., Cuamatzi Castelan, A., Sagong, C., Casement, M. D., & Drake, C. L. (2020). Racial discrimination as a mediator of racial disparities in insomnia disorder. *Sleep Health: Journal of the National Sleep Foundation*, 6(5), 543–549. <https://doi.org/10.1016/j.sleh.2020.07.007>
- Cho, Y. W., Lee, J. H., Son, H. K., Lee, S. H., Shin, C., & Johns, M. W. (2011). The reliability and validity of the Korean version of the Epworth sleepiness scale. *Sleep and Breathing*, 15(3), 377–384.
- Cirelli, C. (2012). Brain Plasticity, Sleep and Aging. *Gerontology*, 58(5), 441–445. <https://doi.org/10.1159/000336149>
- Clawson, B. C., Durkin, J., & Aton, S. J. (2016). Form and Function of Sleep Spindles across the Lifespan. *Neural Plasticity*, 2016, 6936381. <https://doi.org/10.1155/2016/6936381>
- Crowley, K., Trinder, J., Kim, Y., Carrington, M., & Colrain, I. M. (2002). The effects of normal aging on sleep spindle and K-complex production. *Clinical Neurophysiology*, 113(10), 1615–1622. [https://doi.org/10.1016/S1388-2457\(02\)00237-7](https://doi.org/10.1016/S1388-2457(02)00237-7)
- Daley, M., Morin, C. M., LeBlanc, M., Grégoire, J. P., Savard, J., & Baillargeon, L. (2009). Insomnia and its relationship to health-care utilization, work absenteeism, productivity and accidents. *Sleep Medicine*, 10(4), 427–438. <https://doi.org/10.1016/j.sleep.2008.04.005>
- Dietch, J. R., & Taylor, D. J. (2021). Evaluation of the consensus sleep diary in a community sample: comparison with single-channel electroencephalography, actigraphy, and retrospective questionnaire. *Journal of Clinical Sleep Medicine*, 17(7), 1389-1399.
- Dijk, D.-J., Duffy, J. F., & Czeisler, C. A. (2000). Contribution of circadian physiology and sleep homeostasis to age-related changes in human sleep. *Chronobiology International*, 17(3), 285–311. <https://doi.org/10.1081/CBI-100101049>

- Dinges, D. F., Pack, F., Williams, K., Gillen, K. A., Powell, J. W., Ott, G. E., Aptowicz, C., & Pack, A. I. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4–5 hours per night. *Sleep*, 20(4), 267–277.
- Dodell-Feder, D., Ressler, K. J., & Germine, L. T. (2020). Social cognition or social class and culture? On the interpretation of differences in social cognitive performance. *Psychological Medicine*, 50(1), 133–145.
- Dzierzewski, J. M., Donovan, E. K., & Sabet, S. M. (2021). The sleep regularity questionnaire: development and initial validation. *Sleep medicine*, 85, 45-53.
- Edinger, J. D. (2016). Should we finally include quantitative criteria in our definition of insomnia? *Sleep Medicine*, 26, 69–70.
- Edinger, J. D., Arnedt, J. T., Bertisch, S. M., Carney, C. E., Harrington, J. J., Lichstein, K. L., ... & Martin, J. L. (2021). Behavioral and psychological treatments for chronic insomnia disorder in adults: an American Academy of Sleep Medicine clinical practice guideline. *Journal of Clinical Sleep Medicine*, 17(2), 255-262.
- Edinger, J. D., Bonnet, M. H., Bootzin, R. R., Doghramji, K., Dorsey, C. M., Espie, C. A., Jamieson, A. O., McCall, W. V., Morin, C. M., & Stepanski, E. J. (2004). Derivation of research diagnostic criteria for insomnia: Report of an American Academy of Sleep Medicine Work Group. *Sleep*, 27(8), 1567–1596.
- Edinger, J. D., & Fins, A. I. (1995). The distribution and clinical significance of sleep time misperceptions among insomniacs. *Sleep*, 18(4), 232-239.
- Edinger, J. D., Fins, A. I., Glenn, D. M., Sullivan, R. J., Jr, Bastian, L. A., Marsh, G. R., Dailey, D., Hope, T. V., Young, M., Shaw, E., & Vasilas, D. (2000). Insomnia and the eye of the beholder: Are there clinical markers of objective sleep disturbances among adults with and without

insomnia complaints? *Journal of Consulting and Clinical Psychology*, 68(4), 586–593.

<https://doi.org/10.1037//0022-006X.68.4.586>

Edinger, J. D., & Krystal, A. D. (2003). Subtyping primary insomnia: is sleep state misperception a distinct clinical entity?. *Sleep medicine reviews*, 7(3), 203-214.

Edinger, J. D., Wohlgemuth, W. K., Radtke, R. A., Marsh, G. R., & Quillian, R. E. (2001). Does cognitive-behavioral insomnia therapy alter dysfunctional beliefs about sleep?. *Sleep*, 24(5), 591-599.

Ehlers, C., & Kupfer, D. (1997). Slow-wave sleep: Do young adult men and women age differently? *Journal of Sleep Research*, 6(3), 211–215.

Espie, C. A. (2002). Insomnia: Conceptual issues in the development, persistence, and treatment of sleep disorder in adults. *Annual Review of Psychology*, 53(1), 215–243.

<https://doi.org/10.1146/annurev.psych.53.100901.135243>

Foley, D. J., Monjan, A. A., Brown, S. L., Simonsick, E. M., Wallace, R. B., & Blazer, D. G. (1995). Sleep complaints among elderly persons: An epidemiologic study of three communities. *Sleep*, 18(6), 425–432.

Foley, D. J., Monjan, A., Simonsick, E. M., Wallace, R. B., & Blazer, D. G. (1999). Incidence and remission of insomnia among elderly adults: An epidemiologic study of 6,800 persons over three years. *Sleep: Journal of Sleep Research & Sleep Medicine*.

Fortenbaugh, F. C., DeGutis, J., Germine, L., Wilmer, J. B., Grosso, M., Russo, K., & Esterman, M. (2015). Sustained attention across the life span in a sample of 10,000: Dissociating ability and strategy. *Psychological Science*, 26(9), 1497–1510.

- Germine, L., Nakayama, K., Duchaine, B. C., Chabris, C. F., Chatterjee, G., & Wilmer, J. B. (2012). Is the Web as good as the lab? Comparable performance from Web and lab in cognitive/perceptual experiments. *Psychonomic Bulletin & Review*, 19(5), 847–857.
- Gibson, E. S., Powles, A. P., Thabane, L., O'Brien, S., Molnar, D. S., Trajanovic, N., Ogilvie, R., Shapiro, C., Yan, M., & Chilcott-Tanser, L. (2006). “Sleepiness” is serious in adolescence: Two surveys of 3235 Canadian students. *BMC Public Health*, 6(1), 1–9.
- Grace, J., Mendelsohn, A., & Friedman, J. H. (2007). A comparison of fatigue measures in Parkinson’s disease. *Parkinsonism & Related Disorders*, 13(7), 443–445.
- Grandner, M. A., Patel, N. P., Gehrman, P. R., Xie, D., Sha, D., Weaver, T., & Gooneratne, N. (2010). Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep Medicine*, 11(5), 470–478. <https://doi.org/10.1016/j.sleep.2009.10.006>
- Grandner Michael A., Petrov Megan E. Ruiter, Rattanaumpawan Pinyo, Jackson Nicholas, Platt Alec, & Patel Nirav P. (n.d.). Sleep Symptoms, Race/Ethnicity, and Socioeconomic Position. *Journal of Clinical Sleep Medicine*, 09(09), 897–905. <https://doi.org/10.5664/jcsm.2990>
- Hagell, P., & Broman, J. (2007). Measurement properties and hierarchical item structure of the Epworth Sleepiness Scale in Parkinson’s disease. *Journal of Sleep Research*, 16(1), 102–109.
- Harris, P. A., Taylor, R., Minor, B. L., Elliott, V., Fernandez, M., O’Neal, L., McLeod, L., Delacqua, G., Delacqua, F., & Kirby, J. (2019). The REDCap consortium: Building an international community of software platform partners. *Journal of Biomedical Informatics*, 95, 103208.
- Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, 42(2), 377–381.

- Hartshorne, J. K., & Germine, L. T. (2015). When does cognitive functioning peak? The asynchronous rise and fall of different cognitive abilities across the life span. *Psychological Science*, 26(4), 433–443.
- Harvey, A. G. (2022). Treating sleep and circadian problems to promote mental health: perspectives on comorbidity, implementation science and behavior change. *Sleep*, 45(4), zsac026.
- Harvey, A. G., & Buysse, D. J. (2017). *Treating sleep problems: A transdiagnostic approach*. Guilford Publications.
- Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology*, 44(2), 227–239.
- Husain, S. A., Diaz, K. M., Schwartz, J. E., Parsons, F. E., Burg, M. M., Davidson, K. W., & Kronish, I. M. (2019). Behavioral economics implementation: Regret lottery improves mHealth patient study adherence. *Contemporary Clinical Trials Communications*, 15, 100387.
<https://doi.org/10.1016/j.conctc.2019.100387>
- Izci, B., Ardic, S., Firat, H., Sahin, A., Altinors, M., & Karacan, I. (2008). Reliability and validity studies of the Turkish version of the Epworth Sleepiness Scale. *Sleep and Breathing*, 12(2), 161–168.
- Jean-Louis, G., Magai, C., Casimir, G. J., Zizi, F., Moise, F., McKenzie, D., & Graham, Y. (2008). Insomnia Symptoms in a Multiethnic Sample of American Women. *Journal of Women's Health*, 17(1), 15–25. <https://doi.org/10.1089/jwh.2006.0310>
- Johns, M. W. (1991). A new method for measuring daytime sleepiness: The Epworth sleepiness scale. *Sleep*, 14(6), 540–545.
- Johns, M. W. (1992). Reliability and factor analysis of the Epworth Sleepiness Scale. *Sleep*, 15(4), 376–381.

- Kalmbach, D. A., Pillai, V., Arnedt, J. T., & Drake, C. L. (2016). DSM-5 Insomnia and Short Sleep: Comorbidity Landscape and Racial Disparities. *Sleep*, 39(12), 2101–2111.
<https://doi.org/10.5665/sleep.6306>
- Katz, D. A., & McHorney, C. A. (2002). The relationship between insomnia and health-related quality of life in patients with chronic illness. *The Journal of Family Practice*, 51(3), 229.
- Kaufmann, C. N., Mojtabai, R., Hock, R. S., Thorpe, R. J., Canham, S. L., Chen, L.-Y., Wennberg, A. M. V., Chen-Edinboro, L. P., & Spira, A. P. (2016). Racial/Ethnic Differences in Insomnia Trajectories Among U.S. Older Adults. *The American Journal of Geriatric Psychiatry*, 24(7), 575–584. <https://doi.org/10.1016/j.jagp.2016.02.049>
- Kennair, L. E. O., Hagen, R., Hjemdal, O., Havnen, A., Ryum, T., & Solem, S. (2022). Depression, Anxiety, Insomnia, and Quality of Life in a Representative Community Sample of Older Adults Living at Home. *Frontiers in psychology*, 13, 811082.
- Kenneth L. Lichstein, H. Heith Durrence, Brant W. Riedel, Daniel J. Taylor, & Andrew J. Bush. (2004). *Epidemiology of Sleep: Age, Gender, and Ethnicity*. Psychology Press; eBook Collection (EBSCOhost).<http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip.shib&db=nlebk&AN=112915&site=ehost-live&custid=s5822723>
- Kierlin, L., Olmstead, R., Yokomizo, M., Nicassio, P., & Irwin, M. R. (2012). Diagnostic and Statistical Manual criteria for insomnia related impairment in daytime functioning: Polysomnographic correlates in older adults. *Sleep Medicine*, 13(7), 958–960.
- Killgore, William DS, Sara A. Cloonan, Emily C. Taylor, Fabian Fernandez, Michael A. Grandner, and Natalie S. Dailey. "Suicidal ideation during the COVID-19 pandemic: the role of insomnia." *Psychiatry research* 290 (2020): 113134.

- Kim, S. Y., & Yeniova, A. Ö. (2022). Global, regional, and national incidence and mortality of COVID-19 in 237 countries and territories, January 2022: a systematic analysis for World Health Organization COVID-19 Dashboard. *Life Cycle*, 2.
- Klingman, K. J., Jungquist, C. R., & Perlis, M. L. (2017). Introducing the sleep disorders symptom checklist-25: A primary care friendly and comprehensive screener for sleep disorders. *Sleep Medicine Research*, 8(1), 17–25.
- Kocevska, D., Lysen, T. S., Dotinga, A., Koopman-Verhoeff, M. E., Luijk, M. P., Antypa, N., ... & Tiemeier, H. (2021). Sleep characteristics across the lifespan in 1.1 million people from the Netherlands, United Kingdom and United States: a systematic review and meta-analysis. *Nature human behaviour*, 5(1), 113-122.
- Krupp, L. B., LaRocca, N. G., Muir-Nash, J., & Steinberg, A. D. (1989). The fatigue severity scale: Application to patients with multiple sclerosis and systemic lupus erythematosus. *Archives of Neurology*, 46(10), 1121–1123.
- Lee, C., & Chung, K.-M. (2022). A Pilot Study for Testing the Effectiveness and Cost-Efficiency of Lottery Incentive in mHealth App that Promotes Walking. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*, 59, 00469580221091398.
<https://doi.org/10.1177/00469580221091398>
- Lichstein, K., Durrence, H., Taylor, D., Bush, A., & Riedel, B. (2003). Quantitative criteria for insomnia. *Behaviour Research and Therapy*, 41(4), 427–445.
- Lichstein, K. L., Durrence, H. H., Riedel, B. W., Taylor, D. J., & Bush, A. J. (2004). *Epidemiology of sleep: Age, gender, and ethnicity*.
- Lichstein, K. L., Means, M. K., Noe, S. L., & Aguillard, R. (1997). Fatigue and sleep disorders. *Behaviour Research and Therapy*, 35(8), 733–740.

- Loomis, A. L., Harvey, E. N., & Hobart, G. (1935). POTENTIAL RHYTHMS OF THE CEREBRAL CORTEX DURING SLEEP. *Science*, 81(2111), 597. <https://doi.org/10.1126/science.81.2111.597>
- Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy*, 33(3), 335–343.
- Maich, K. H., Lachowski, A. M., & Carney, C. E. (2018). Psychometric properties of the consensus sleep diary in those with insomnia disorder. *Behavioral sleep medicine*, 16(2), 117-134.
- Martin, N., Lafortune, M., Godbout, J., Barakat, M., Robillard, R., Poirier, G., Bastien, C., & Carrier, J. (2013). Topography of age-related changes in sleep spindles. *Neurobiology of Aging*, 34(2), 468–476. <https://doi.org/10.1016/j.neurobiolaging.2012.05.020>
- Meers, J., Stout-Aguilar, J., & Nowakowski, S. (2019). Sex differences in sleep health. *Sleep and health*, 21-29.
- Morin, C. M., & Benca, R. (2012). Chronic insomnia. *The Lancet (British Edition)*, 379(9821), 1129–1141. [https://doi.org/10.1016/S0140-6736\(11\)60750-2](https://doi.org/10.1016/S0140-6736(11)60750-2)
- Morin C. M. Insomnia: psychological assessment and management. New York: Guilford Press, 1993.
- Morin, C. M., Stone, J., Trinkle, D., Mercer, J., & Remsberg, S. (1993). Dysfunctional beliefs and attitudes about sleep among older adults with and without insomnia complaints. *Psychology and Aging*, 8(3), 463.
- Morin CM, Jarrin DC, Ivers H, Mérette C, LeBlanc M, Savard J. Incidence, Persistence, and Remission Rates of Insomnia Over 5 Years. *JAMA Netw Open*. 2020 Nov 2;3(11):e2018782. doi: 10.1001/jamanetworkopen.2020.18782. PMID: 33156345; PMCID: PMC7648256.
- Morin, C. M., Vallières, A., & Ivers, H. (2007a). Dysfunctional beliefs and attitudes about sleep (DBAS): Validation of a brief version (DBAS-16). *Sleep*, 30(11), 1547–1554.

- Morin, C. M., Vallières, A., & Ivers, H. (2007b). Dysfunctional beliefs and attitudes about sleep (DBAS): Validation of a brief version (DBAS-16). *Sleep (New York, N.Y.)*, 30(11), 1547–1554.
- Nelson, P. T., Abner, E. L., Scheff, S. W., Schmitt, F. A., Kryscio, R. J., Jicha, G. A., Smith, C. D., Patel, E., & Markesbery, W. R. (2009). Alzheimer's-type neuropathology in the precuneus is not increased relative to other areas of neocortex across a range of cognitive impairment. *Neuroscience Letters*, 450(3), 336–339. <https://doi.org/10.1016/j.neulet.2008.11.006>
- Nowakowski, S., & Meers, J. M. (2019). Cognitive Behavioral Therapy for Insomnia and Women's Health. *Sleep Medicine Clinics*, 14(2), 185–197. <https://doi.org/10.1016/j.jsmc.2019.01.002>
- Nutt, D., Wilson, S., & Paterson, L. (2008). Sleep disorders as core symptoms of depression. *Dialogues in Clinical Neuroscience*, 10(3), 329–336.
- Ohayon, M. M. (2002). Epidemiology of insomnia: What we know and what we still need to learn. *Sleep Medicine Reviews*, 6(2), 97–111.
- Ohayon, M. M., Carskadon, M. A., Guilleminault, C., & Vitiello, M. V. (2004). Meta-Analysis of Quantitative Sleep Parameters From Childhood to Old Age in Healthy Individuals: Developing Normative Sleep Values Across the Human Lifespan. *Sleep*, 27(7), 1255–1273. <https://doi.org/10.1093/sleep/27.7.1255>
- Ohayon, M. M., Krystal, A., Roehrs, T. A., Roth, T., & Vitiello, M. V. (2010). Using difficulty resuming sleep to define nocturnal awakenings. *Sleep Medicine*, 11(3), 236–241.
- Ohayon, M. M., Riemann, D., Morin, C., & Reynolds III, C. F. (2012). Hierarchy of insomnia criteria based on daytime consequences. *Sleep Medicine*, 13(1), 52–57.
- Page, A. C., Hooke, G. R., & Morrison, D. L. (2007). Psychometric properties of the Depression Anxiety Stress Scales (DASS) in depressed clinical samples. *British Journal of Clinical Psychology*, 46(3), 283–297.

- Park, S., Park, K., Shim, J. S., Youm, Y., Kim, J., Lee, E., & Kim, H. C. (2020). Psychosocial factors affecting sleep misperception in middle-aged community-dwelling adults. *PloS one*, *15*(10), e0241237.
- Perlis, M., Giles, D., Mendelson, W., Bootzin, R. R., & Wyatt, J. (1997). Psychophysiological insomnia: The behavioural model and a neurocognitive perspective. *Journal of Sleep Research*, *6*(3), 179–188.
- Perlis, M. L., Smith, M. T., Andrews, P. J., Orff, H., & Giles, D. E. (2001). Beta/Gamma EEG activity in patients with primary and secondary insomnia and good sleeper controls. *Sleep*, *24*(1), 110-117.
- Peterson, M. J., MD, PhD, & Benca, R. M., MD, PhD. (2008). Sleep in Mood Disorders. *Sleep Medicine Clinics*, *3*(2), 231–249. <https://doi.org/10.1016/j.jsmc.2008.01.009>
- Pigeon, W. R., Heffner, K., Duberstein, P., Fiscella, K., Moynihan, J., & Chapman, B. P. (2011, March 1). *Elevated sleep disturbance among blacks in an urban family medicine practice*. American Board of Family Medicine. <https://www.jabfm.org/content/24/2/161>
- Puzino, K., Amatrudo, G., Sullivan, A., Vgontzas, A. N., & Fernandez-Mendoza, J. (2020). Clinical significance and cut-off scores for the Pre-Sleep Arousal Scale in chronic insomnia disorder: a replication in a clinical sample. *Behavioral Sleep Medicine*, *18*(6), 705-718.
- Qaseem, A., Kansagara, D., Forciea, M. A., Cooke, M., & Denberg, T. D. (2016). Management of chronic insomnia disorder in adults: A clinical practice guideline from the American College of Physicians. *Annals of Internal Medicine*, *165*(2), 125–133.
- Resnick, S. M., Pham, D. L., Kraut, M. A., Zonderman, A. B., & Davatzikos, C. (2003). Longitudinal magnetic resonance imaging studies of older adults: A shrinking brain. *The Journal of*

Neuroscience : The Official Journal of the Society for Neuroscience, 23(8), 3295–3301. PubMed.

<https://doi.org/10.1523/JNEUROSCI.23-08-03295.2003>

- Riemann, D., & Perlis, M. L. (2009). The treatments of chronic insomnia: A review of benzodiazepine receptor agonists and psychological and behavioral therapies. *Sleep Medicine Reviews*, 13(3), 205–214. <https://doi.org/10.1016/j.smrv.2008.06.001>
- Ronk, F. R., Korman, J. R., Hooke, G. R., & Page, A. C. (2013). Assessing clinical significance of treatment outcomes using the DASS-21. *Psychological Assessment*, 25(4), 1103.
- Sateia, M. J. (2014). International Classification of Sleep Disorders-Third Edition. *Chest*, 146(5), 1387–1394. <https://doi.org/10.1378/chest.14-0970>
- Schneider, C., Fulda, S., & Schulz, H. (2004). Daytime variation in performance and tiredness/sleepiness ratings in patients with insomnia, narcolepsy, sleep apnea and normal controls. *Journal of Sleep Research*, 13(4), 373–383.
- Scullin, M. K. (2017). Do Older Adults Need Sleep? A Review of Neuroimaging, Sleep, and Aging Studies. *Current Sleep Medicine Reports*, 3(3), 204–214. <https://doi.org/10.1007/s40675-017-0086-z>
- Sharman, R. L., Perlis, M. L., Bastien, C. H., Barclay, N. L., Ellis, J. G., & Elder, G. J. (2022). Pre-sleep cognitive arousal is negatively associated with sleep misperception in healthy sleepers during habitual environmental noise exposure: An actigraphy study. *Clocks & Sleep*, 4(1), 88-99.
- Shekleton, J. A., Rogers, N. L., & Rajaratnam, S. M. (2010). Searching for the daytime impairments of primary insomnia. *Sleep Medicine Reviews*, 14(1), 47–60.
- Shoji, K. D., Tighe, C. A., Dautovich, N. D., & McCrae, C. S. (2015). Beyond mean values: Quantifying intraindividual variability in pre-sleep arousal and sleep in younger and older community-dwelling adults. *Sleep Science*, 8(1), 24-30.

- Silbey, S. S. (2016). Why do so many women who study engineering leave the field. *Harvard Business Review*, 23.
- Singareddy, R., Vgontzas, A. N., Fernandez-Mendoza, J., Liao, D., Calhoun, S., Shaffer, M. L., & Bixler, E. O. (2012). Risk factors for incident chronic insomnia: A general population prospective study. *Sleep Medicine*, 13(4), 346–353. <https://doi.org/10.1016/j.sleep.2011.10.033>
- Singh, S., Strong, R. W., Jung, L., Li, F. H., Grinspoon, L., Scheuer, L. S., ... & Germine, L. (2021). The TestMyBrain digital neuropsychology toolkit: Development and psychometric characteristics. *Journal of Clinical and Experimental Neuropsychology*, 43(8), 786-795.
- Sivertsen, B., Overland, S., Neckelmann, D., Glozier, N., Krokstad, S., Pallesen, S., ... & Mykletun, A. (2006). The long-term effect of insomnia on work disability: the HUNT-2 historical cohort study. *American journal of epidemiology*, 163(11), 1018-1024.
- Suka, M., Yoshida, K., & Sugimori, H. (2003). Persistent insomnia is a predictor of hypertension in Japanese male workers. *Journal of occupational health*, 45(6), 344-350.
- Svetnik, V., Snyder, E. S., Ma, J., Tao, P., Lines, C., & Herring, W. J. (2017). EEG spectral analysis of NREM sleep in a large sample of patients with insomnia and good sleepers: Effects of age, sex and part of the night. *Journal of Sleep Research*, 26(1), 92–104. <https://doi.org/10.1111/jsr.12448>
- Taylor, D. J., Pruiksma, K. E., Hale, W. J., Kelly, K., Maurer, D., Peterson, A. L., Mintz, J., Litz, B. T., & Williamson, D. E. (2016). Prevalence, Correlates, and Predictors of Insomnia in the US Army prior to Deployment. *Sleep*, 39(10), 1795–1806. <https://doi.org/10.5665/sleep.6156>
- Thambisetty, M., Wan, J., Carass, A., An, Y., Prince, J. L., & Resnick, S. M. (2010). Longitudinal changes in cortical thickness associated with normal aging. *NeuroImage*, 52(4), 1215–1223. <https://doi.org/10.1016/j.neuroimage.2010.04.258>

- Tutek, J., Mulla, M. M., Emert, S. E., Molzof, H. E., Lichstein, K. L., Taylor, D. J., Riedel, B. W., & Bush, A. J. (2019). Health and demographic discriminators of an insomnia identity and self-reported poor quantitative sleep. *Sleep Health*, 5(3), 221–226.
<https://doi.org/10.1016/j.sleh.2019.01.009>
- van der Heide, A., van Schie, M. K., Lammers, G. J., Dauvilliers, Y., Arnulf, I., Mayer, G., Bassetti, C. L., Ding, C.-L., Lehert, P., & van Dijk, J. G. (2015). Comparing treatment effect measurements in narcolepsy: The sustained attention to response task, Epworth sleepiness scale and maintenance of wakefulness test. *Sleep*, 38(7), 1051–1058.
- Vitiello, M. V., Larsen, L. H., & Moe, K. E. (2004). Age-related sleep change: Gender and estrogen effects on the subjective–objective sleep quality relationships of healthy, noncomplaining older men and women. *Journal of Psychosomatic Research*, 56(5), 503–510.
- Wilt, T. J., MacDonald, R., Brasure, M., Olson, C. M., Carlyle, M., Fuchs, E., ... Kane, R. L. (2016). Pharmacologic treatment of insomnia disorder: An evidence report for a clinical practice guideline by the American College of Physicians. *Annals of Internal Medicine*, 165(2), 103–112. <https://doi.org/10.7326/M15-1781>
- Winkelman, J. W. (2020). Insomnia. *BMJ Best Practice, Generic*.
- World Health Organization. (1991). *International classification of diseases (ICD-10)* (10th ed.).
- World Health Organization. (2022). *Public health surveillance for COVID-19: interim guidance*, 22 July 2022 (No. WHO/2019-nCoV/SurveillanceGuidance/2022.2). World Health Organization.
- Zee, P. C., & Turek, F. W. (2006). Sleep and health: Everywhere and in both directions. *Archives of Internal Medicine*, 166(16), 1686–1688.
- Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, 67(6), 361–370.

Table 1.
Self-Reported Demographic Characteristic

Variable (response rate)	Group	Frequency (Percentage)
Sex (176)	Male	56 (31.8%)
	Female	120 (68.2%)
BMI (175)	Underweight	11(6.3%)
	Healthy Weight	56(31.8%)
	Overweight	51(29.0%)
	Obese	4(2.3%)
	Morbidly Obese	15(8.5%)
Age Decades (176)	20-29	41(23.3%)
	30-39	27(15.3%)
	40-49	28(15.9%)
	50-59	26(14.8%)
	60-69	30(17.0%)
	70-79	19(10.8%)
	80-89	5(2.8%)
Education (175) (highest level completed)	Less than 9th Grade	0(0%)
	9th-11th Grade	2(1.1%)
	High School or GED	19(10.8%)
	Some College (But no Degree)	35(19.9%)
	Associates Degree	19(10.8%)
	Bachelors Degree	55(31.3%)
	Masters Degree	31(17.6%)
Relationship Status (176)	Doctoral Degree	14(8.0%)
	Married, live together	64(36.4%)
	Married, live apart	3(1.7%)
	In relationship; living w/partner	13(7.4%)
	In a relationship and not living with partner	14(8.0%)
	Single and never married	50(28.4%)
	Divorced	20(11.4%)
	Widowed	4(2.3%)
	Separated	6(3.4%)
Employment Status (174)	Preferred not to answer	2(1.1%)
	Full-Time	54(30.7%)
	Multiple Jobs	4(2.3%)
	Part Time	16(9.1%)
	Self-employed	15(8.5%)
	Retired	37(21%)
	Homemaker	12(6.8%)
	Student	14(8.0%)
	Unemployed < 1 Year	8(4.5%)
	Unemployed >1 Year	1(0.6%)
	Unable to Work	12(6.8%)
	I prefer not to answer	1(0.6%)

Table 1. Continued

Variable (response rate)	Group	Frequency (Percentage)
Work Hours (107)	Primarily Day (9:00am - 5:00pm)	94(53.4%)
	Primarily Evening (4:00pm - 12:00am)	12(6.8%)
	Primarily Night (12:00am - 8:00am)	1(0.6%)
Shift Worker (158)	No	127(72.2%)
	Yes	31(17.6%)
Shift Type (31)	Standard	20(11.4%)
	Rotating	11(6.3%)
Ethnicity (176)	Non-Hispanic White	124(70.5%)
	Hispanic/Latino (Mexican)	3(1.7%)
	Hispanic/Latino (Cuban)	2(1.1%)
	Hispanic/Latino (Other Caribbean/Central American)	1(0.6%)
	Hispanic/Latino (Other South American)	2(1.1%)
	Hispanic/Latino (Other)	2(1.1%)
	Black (African-American)	14(8.0%)
	Black (Afro-Caribbean)	1(0.6%)
	Black (African)	4(2.3%)
	Asian	16(9.1%)
	Multiracial*	4(2.3%)
	Other (text input was "human" and N/A)	2(1.1%)
Annual Household Income (174)	Preferred not to answer	1(0.6%)
	Less than \$10,000	14(8.0%)
	\$10,000-\$19,999	10(5.7%)
	\$20,000-\$29,999	19(10.8%)
	\$30,000-\$39,999	17(9.7%)
	\$40,000-\$49,999	12(6.8%)
	\$50,000-\$59,999	17(9.7%)
	\$60,00-\$69,999	10(5.7%)
	\$70,000-\$79,999	16(9.1%)
	\$80,000-\$89,999	6(3.4%)
	\$90,000-\$99,999	9(5.1%)
	\$100,000-\$119,999	15(8.5%)
	\$120,000-\$129,999	5(2.8%)
	\$130,000- \$139,999	2(1.1%)
	\$140,000-\$149,999	3(1.7%)
	\$150,000 and above	12(6.8%)
	Not Applicable	1(0.6%)
	I prefer not to answer	6(3.4%)

*Multiracial responses included (N = 1 of Non-Hispanic White and Asian; N = 1 of prefer not to define; N = 1 of Hispanic/Latino (Mexican), Black (Afro-Caribbean), Black (African-American), and Pacific Islander; and N = 1 of Non-Hispanic White and Native American).

Table 2.

Internal Consistency of Scale Measures

Measure	Mean	Standard Deviation	Cronbach's Alpha	Number of People
Insomnia Severity Index	12.19	6.91	0.91	145
Dysfunctional Beliefs and Attitudes About Sleep	83.86	29.27	0.90	152
Fatigue Severity Scale	44.06	12.59	0.86	145
Depression and Anxiety Stress Scale-Anxiety Subscale	3.98	4.46	0.87	148
Depression and Anxiety Stress Scale-Depression Subscale	6.43	5.70	0.94	148

Table 3.***Means of Sleep Continuity Variables of Total Sample***

Sleep Continuity Variable	N	Mean	SD
Sleep latency (in minutes)	161	31.29	23.49
Number of nighttime awakenings	146	2.49	1.67
Wake after sleep onset (in minutes)	154	28.24	23.58
Early morning awakenings (in minutes)	95	71.45	48.66
Time in bed (in hours)	167	8.74	1.88
Total sleep time (in hours)	168	6.52	1.49
Sleep efficiency (%)	151	79.89	13.70

Table 4.***Means of Sleep Continuity Variables by Age Decade***

Age Decade	Average Sleep Latency (in minutes)	SD	Average NWAK	SD	Average WASO (in minutes)	SD	Average EMA (in minutes)	SD
20-29	38.46	28.5	3.02	3.45	44.29	56.97	76	67.25
30-39	47.77	47.1	7.46	9.36	36.62	39.64	76.4	46.41
40-49	32.92	25.41	5.92	7.14	37.69	32.96	62.31	38.39
50-59	41.73	57.51	5.81	7.79	37.77	34.48	62.5	43.58
60-69	34.83	36.56	7.55	10.2	42.59	55.17	75.94	43.29
70-79	40.42	47.16	9.11	18.21	36.11	39.45	76.36	42.67
80-89	19	14.75	6.5	9.04	39.5	42.79	60	51.96

Table 4.***Continued Means of Sleep Continuity Variables by Age Decade***

Age Decade	Average Total Time in Bed (in hours)	SD	Average Total Sleep Time (in hours)	SD	Average Sleep Efficiency (%)	SD
20-29	9.21	1.59	6.84	1.41	75.8	16.92
30-39	8.79	2.1	6	1.34	71.02	18.19
40-49	8.35	1.95	6.21	1.5	76.01	16.48
50-59	8.83	2.26	6.43	1.21	75.68	17.04
60-69	8.19	0.96	6.45	1.67	78.89	17.89
70-79	9.04	2.36	6.76	1.68	77.46	18.95
80-89	8.94	2.2	7.36	2.26	81.69	22.67

Table 5.***Sleep Continuity Variables by Sex***

Sleep Continuity Variable	Mean for Males	SD for Males	Mean for Females	SD for Females
Average Sleep Latency (in minutes)	42	54.45	36.91	30.58
Average NWAK	4.96	6.48	6.62	10.59
Average WASO (in minutes)	36.16	49.41	41.55	43.1
Average EMA (in minutes)	63.52	49.41	74.72	48.08
Average Total Time in Bed (in hours)	8.46	2.1	8.9	1.75
Average Total Sleep Time (in hours)	6.43	1.61	6.53	1.46
Average Sleep Efficiency (%)	78.07	18.58	74.91	16.89

Table 6.***Sleep Continuity Variables by Race***

Race	Average Sleep Latency (in minutes)	SD	Average NWAK	SD	Average WASO (in minutes)	SD	Average EMA (in minutes)	SD
Non-Hispanic White	36.36	35.12	6.57	10.45	39.37	43.17	67.82	43.27
Asian	25.63	18.96	4.25	5.73	35.19	47.29	73.93	44.73
Black (African-American)	66.54	73.84	4.15	5.12	62.77	77.60	81.80	65.36
Black (Afro-Caribbean) & Black (Afriacn)	29.60	23.92	9.00	10.08	34.00	26.07	68.33	50.08
Hispanic/Latino (Mexican, Cuban, other South American, other Caribbean/Central American, and other)	35.50	34.84	5.12	7.15	39.82	45.15	71.84	48.41
Multi-Racial	83.75	67.50	2.25	0.50	41.25	22.50	90.00	34.64

Table 6.***Continued Sleep Continuity Variables by Race***

Race	Average Total Time in Bed (in hours)	SD	Average Total Sleep Time (in hours)	SD	Average Sleep Efficiency (%)	SD
Non-Hispanic White	8.70	1.72	6.63	1.59	77.47	17.40
Asian	8.69	2.41	6.11	1.33	74.12	19.93
Black (African-American)	10.29	2.48	6.34	0.92	64.94	17.05
Black (Afro-Caribbean) & Black (Afriacn)	8.84	1.98	6.60	1.98	74.31	9.52
Hispanic/Latino (Mexican, Cuban, other South American, other Caribbean/Central American, and other)	8.76	1.88	6.49	1.51	75.94	17.46
Multi-Racial	7.83	1.35	5.00	1.08	64.74	15.62

Table 7.

Correlation Matrix of Primary Variables of Interest

	SL	NWAK	WASO	EMA	TST	SE	Sleep Quality	Minutes Napping	ISI	DASS_ANX	DASS_DEP	DBAS	FSS	CPT DPrime	Visual Outcomes Accuracy	Comorbidity Index
SL																
NWAK	.12															
WASO	.28**	.50**														
EMA	-.10	.13	.14													
TST	-.24**	-.24**	-.32**	-.20*												
SE	-.29**	-.26**	-.46**	-.10	.55**											
Sleep Quality	.33**	-.30**	-.34**	-.06	.39**	.46**										
Minutes Napping	.19	-.01	.26*	.29*	.01	-.08	-.01									
ISI	.46**	.33**	.45**	.20	-.55**	-.49**	-.66**	.26*								
DASS_ANX	.25**	.03	.30**	.02	-.31**	-.34**	-.37**	.09	.59**							
DASS_DEP	.26**	-.04	.12	.01	-.20*	-.28**	-.31**	.11	.45**	.62**						
DBAS	.34**	.11	.25**	.15	-.34**	-.30**	-.40**	.16	.67**	.59**	.41**					
FSS	.27**	.21*	.23**	.13	-.31**	-.24**	-.50**	.20	.70**	.58**	.50**	.74**				
CPT DPrime	-.21*	-.01	-.03	-.03	.18	.22*	-.01	-.05	-.19*	-.13	-.02	-.22*	-.08			
Visual Outcomes Accuracy	-.15	-.10	.07	-.12	.30**	.16	.01	.17	-.20*	-.18	-.13	-.22*	-.10	.44**		
Comorbidity Index	.00	.12	.07	.06	-.02	-.10	-.16*	.09	.00	.17*	.17*	.00	.10	.04	-.08	

Sleep Latency (SL)

Number of Nighttime Awakenings (NWAK)

Wake After Sleep Onset (WASO)

Early Morning Awakenings (EMA)

Total Sleep Time (TST)

Sleep Efficiency (SE)

Sleep Quality

Minutes Napping

Insomnia Severity Index (ISI)

Depression Anxiety Stress – Anxiety Subscale (DASS_ANX)

Depression Anxiety Stress – Depression Subscale (DASS_DEP)

Fatigue Severity Scale (FSS)

TMB Gradual Onset Continuous Performance Test d' (CPT Dprime)

Visual Paired Associates Accuracy Score (proportion correct)

Charleson Comorbidity Index (comorbidity index)

**p<.01

*p<.05

Bold/Italicized – Non-parametric correlation analysis performed due to skewed data

Table 8.

Means and Standard Deviations of Sample and Normative Neurocognitive Assessment Outcomes

Measure	Sample Mean (SD)	Normative Mean (SD)
CPT Dprime	2.14 (0.89)	2.46 (0.92)
Visual Paired Associates Score	12.35 (5.19)	14.44 (5.27)

Table 9.

Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Square Root

Transformed Variable Of Sleep Latency

Age Decade	Sex	Mean	Std. Deviation	N
20-29	Male	5.21	2.14	14
	Female	5.72	1.83	25
	Total	5.54	1.93	39
30-39	Male	4.90	1.90	8
	Female	6.21	1.93	15
	Total	5.75	1.98	23
40-49	Male	5.13	2.60	7
	Female	5.32	2.29	19
	Total	5.27	2.32	26
50-59	Male	6.11	2.67	6
	Female	4.84	2.11	19
	Total	5.15	2.26	25
60-69	Male	4.50	2.01	9
	Female	4.72	1.87	17
	Total	4.65	1.89	26
70-79	Male	3.11	0.67	4
	Female	5.01	2.90	13
	Total	4.57	2.67	17
80-89	Male	3.40	0.41	3
	Female	5.29	2.00	2
	Total	4.16	1.47	5
Total	Male	4.86	2.13	51
	Female	5.32	2.13	110
	Total	5.17	2.13	161

Table 10.

Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Raw Variable Of Sleep Latency

Age Decade	Sex	Mean	Std. Deviation	N
20-29	Male	31.43	24.53	14
	Female	35.88	20.92	25
	Total	34.28	22.07	39
30-39	Male	27.13	19.94	8
	Female	42.00	22.42	15
	Total	36.83	22.34	23
40-49	Male	32.14	30.26	7
	Female	33.21	24.32	19
	Total	32.92	25.41	26
50-59	Male	43.33	31.89	6
	Female	27.63	19.89	19
	Total	31.40	23.56	25
60-69	Male	23.89	25.59	9
	Female	25.59	22.21	17
	Total	25.00	22.94	26
70-79	Male	10.00	4.08	4
	Female	32.92	29.59	13
	Total	27.53	27.57	17
80-89	Male	11.67	2.89	3
	Female	30.00	21.21	2
	Total	19.00	14.75	5
Total	Male	28.08	24.67	51
	Female	32.78	22.88	110
	Total	31.29	23.49	161

Table 11.

Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Log Transformed Variable Of Nightly Awakenings After Sleep Onset

Age Decade	Sex	Mean	Std. Deviation	N
20-29	Male	0.87	0.63	13
	Female	1.12	0.56	26
	Total	1.03	0.59	39
30-39	Male	1.05	0.57	8
	Female	1.03	0.41	13
	Total	1.04	0.46	21
40-49	Male	1.42	0.46	4
	Female	1.23	0.38	17
	Total	1.26	0.39	21
50-59	Male	1.12	0.73	6
	Female	1.27	0.36	17
	Total	1.23	0.47	23
60-69	Male	1.35	0.50	9
	Female	1.04	0.44	13
	Total	1.17	0.48	22
70-79	Male	1.04	0.66	6
	Female	1.27	0.38	11
	Total	1.19	0.49	17
80-89	Male	0.69	.	1
	Female	1.24	0.20	2
	Total	1.06	0.35	3
Total	Male	1.09	0.60	47
	Female	1.16	0.44	99
	Total	1.14	0.49	146

Table 12.

*Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Raw Variable Of
Nightly Awakenings After Sleep Onset*

Age Decade	Sex	Mean	Std. Deviation	N
20-29	Male	1.85	1.77	13
	Female	2.50	1.79	26
	Total	2.28	1.79	39
30-39	Male	2.25	1.58	8
	Female	2.00	1.16	13
	Total	2.10	1.30	21
40-49	Male	3.50	2.38	4
	Female	2.65	1.32	17
	Total	2.81	1.54	21
50-59	Male	2.83	3.13	6
	Female	2.76	1.30	17
	Total	2.78	1.86	23
60-69	Male	3.33	2.24	9
	Female	2.08	1.19	13
	Total	2.59	1.76	22
70-79	Male	2.33	2.07	6
	Female	2.82	1.66	11
	Total	2.65	1.77	17
80-89	Male	1.00	.	1
	Female	2.50	0.71	2
	Total	2.00	1.00	3
Total	Male	2.51	2.09	47
	Female	2.48	1.45	99
	Total	2.49	1.67	146

Table 13.

Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Square Root

Transformed Variable Of Minutes Spent Napping

Age Decade	Sex	Mean	Std. Deviation	N
20-29	Male	8.86	2.85	8
	Female	7.54	2.35	15
	Total	8.00	2.55	23
30-39	Male	5.02	2.55	5
	Female	7.59	2.78	8
	Total	6.60	2.89	13
40-49	Male	3.25	1.62	3
	Female	6.78	2.56	15
	Total	6.19	2.75	18
50-59	Male	5.36	2.08	3
	Female	7.37	1.25	7
	Total	6.77	1.72	10
60-69	Male	5.67	2.83	6
	Female	5.90	1.85	12
	Total	5.82	2.14	18
70-79	Male	6.39	0.53	5
	Female	5.51	1.30	8
	Total	5.85	1.13	13
80-89	Male	9.35	2.27	2
	Female	4.47	.	1
	Total	7.72	3.24	3
Total	Male	6.45	2.87	32
	Female	6.76	2.24	66
	Total	6.66	2.45	98

Table 14.

Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Raw Variable Of Minutes Spent Napping

Age Decade	Sex	Mean	Std. Deviation	N
20-29	Male	85.63	52.33	8
	Female	62.00	36.59	15
	Total	70.22	43.08	23
30-39	Male	30.40	24.15	5
	Female	64.38	42.21	8
	Total	51.31	39.11	13
40-49	Male	12.33	9.29	3
	Female	52.07	32.77	15
	Total	45.44	33.57	18
50-59	Male	31.67	24.66	3
	Female	55.71	18.80	7
	Total	48.50	22.49	10
60-69	Male	38.83	32.59	6
	Female	37.92	23.50	12
	Total	38.22	25.88	18
70-79	Male	41.00	6.52	5
	Female	31.88	14.87	8
	Total	35.38	12.82	13
80-89	Male	90.00	42.43	2
	Female	20.00	.	1
	Total	66.67	50.33	3
Total	Male	49.59	40.90	32
	Female	50.70	31.71	66
	Total	50.34	34.77	98

Table 15.

Descriptive Statistics Of The 2 X 7 MANOVA For Sex And Age Decade On The Square Root Transformed Variables Of Wake After Sleep Onset And Sleep Efficiency And Raw Variables Of Total Sleep Time And Sleep Quality Rating

Variable	Sex	Age Decades	Mean	Std. Deviation	N
Square Root Transformed Wake After Sleep Onset	Male	20-29	3.6844	2.17634	12
		30-39	3.7621	2.91334	7
		40-49	3.7178	1.65006	5
		50-59	3.8213	2.59758	5
		60-69	4.2404	1.93293	8
		70-79	2.7189	2.26793	4
		80-89	5.8615	5.12707	2
		Total	3.8317	2.30768	43
	Female	20-29	4.7616	2.72835	21
		30-39	4.8707	3.11164	14
		40-49	5.0823	2.1049	17
		50-59	5.0937	2.63299	17
		60-69	4.4681	2.16371	15
		70-79	4.4064	2.78249	11
		80-89	1.7321	.	1
		Total	4.775	2.54467	96
	Total	20-29	4.3699	2.56076	33
		30-39	4.5012	3.02101	21
		40-49	4.7722	2.05837	22
		50-59	4.8045	2.62013	22
		60-69	4.3889	2.04458	23
		70-79	3.9564	2.68868	15
		80-89	4.485	4.33905	3
		Total	4.4832	2.50398	139
Square Root Transformed Sleep Efficiency	Male	20-29	9.1134	0.65456	12
		30-39	8.7484	0.49659	7
		40-49	9.3312	0.59464	5
		50-59	9.3127	0.58744	5
		60-69	9.3784	0.43632	8
		70-79	9.6869	0.36192	4
		80-89	9.5644	0.6161	2

	Female	Total	9.2261	0.58142	43
		20-29	8.8409	0.8632	21
		30-39	8.7031	0.7784	14
		40-49	8.6294	0.8188	17
		50-59	8.8628	0.73486	17
		60-69	9.1216	0.67249	15
		70-79	8.7548	1.07497	11
		80-89	9.7015	.	1
		Total	8.8302	0.81474	96
	Total	20-29	8.94	0.79416	33
		30-39	8.7182	0.68432	21
		40-49	8.7889	0.81779	22
		50-59	8.965	0.71723	22
		60-69	9.2109	0.60332	23
		70-79	9.0033	1.0176	15
		80-89	9.6101	0.44279	3
		Total	8.9527	0.77044	139
Total Sleep Time	Male	20-29	6.9625	1.46739	12
		30-39	6.1071	1.28984	7
		40-49	6.1	1.0247	5
		50-59	6.4	0.74162	5
		60-69	7.4375	1.67838	8
		70-79	6.25	1.32288	4
		80-89	7.75	3.88909	2
		Total	6.7163	1.48848	43
	Female	20-29	7.2548	1.20685	21
		30-39	6.2643	1.29769	14
		40-49	6.2206	1.6387	17
		50-59	6.5912	1.40448	17
		60-69	6.78	0.9608	15
		70-79	7.1091	1.74382	11
		80-89	8	.	1
		Total	6.7266	1.39801	96
	Total	20-29	7.1485	1.29262	33
		30-39	6.2119	1.2647	21
		40-49	6.1932	1.49955	22
		50-59	6.5477	1.27059	22
		60-69	7.0087	1.25948	23
		70-79	6.88	1.64369	15

		80-89	7.8333	2.75379	3
		Total	6.7234	1.42118	139
Sleep Quality	Male	20-29	2.83	0.937	12
		30-39	1.29	0.756	7
		40-49	2.4	0.894	5
		50-59	1.6	1.342	5
		60-69	2.75	1.389	8
		70-79	4.25	0.957	4
		80-89	4.5	0.707	2
		Total	2.58	1.349	43
	Female	20-29	2.24	1.179	21
		30-39	2.43	1.453	14
		40-49	2.24	1.091	17
		50-59	1.82	1.015	17
		60-69	2.8	1.146	15
		70-79	3	1.483	11
		80-89	2	.	1
		Total	2.36	1.232	96
	Total	20-29	2.45	1.121	33
		30-39	2.05	1.359	21
		40-49	2.27	1.032	22
		50-59	1.77	1.066	22
		60-69	2.78	1.204	23
		70-79	3.33	1.447	15
		80-89	3.67	1.528	3
		Total	2.43	1.269	139

Table 16.

Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Continuous Performance Test Dprime Variable

Age Decade	Sex	Mean	Std. Deviation	N
20-29	Male	2.48	1.28	6
	Female	2.14	0.93	23
	Total	2.21	1.00	29
30-39	Male	2.45	0.59	9
	Female	1.76	1.05	11
	Total	2.07	0.93	20
40-49	Male	2.15	1.86	4
	Female	1.90	0.52	12
	Total	1.96	0.95	16
50-59	Male	1.84	0.28	2
	Female	2.51	0.87	12
	Total	2.41	0.84	14
60-69	Male	1.94	0.86	7
	Female	2.25	0.94	12
	Total	2.14	0.90	19
70-79	Male	1.54	0.18	2
	Female	2.19	0.64	10
	Total	2.08	0.63	12
80-89	Male	1.91	.	1
	Female	2.14	0.91	2
	Total	2.06	0.66	3
Total	Male	2.18	0.98	31
	Female	2.13	0.86	82
	Total	2.14	0.89	113

Table 17.

Descriptive Statistics Of The 2 X 7 ANOVA For Sex And Age Decade On The Fatigue Severity

Scale

Age Decade	Sex	Mean	Std. Deviation	N
20-29	Male	41.82	10.60	11
	Female	48.62	10.69	26
	Total	46.59	10.98	37
30-39	Male	49.44	10.88	9
	Female	47.86	15.86	14
	Total	48.48	13.87	23
40-49	Male	45.33	13.75	6
	Female	47.60	12.47	15
	Total	46.95	12.54	21
50-59	Male	50.25	9.18	4
	Female	42.50	13.65	18
	Total	43.91	13.13	22
60-69	Male	40.11	12.04	9
	Female	37.53	11.29	15
	Total	38.50	11.38	24
70-79	Male	39.25	8.96	4
	Female	37.36	11.66	11
	Total	37.87	10.72	15
80-89	Male	24.00	.	1
	Female	41.00	16.97	2
	Total	35.33	15.50	3
Total	Male	43.64	11.59	44
	Female	44.25	13.05	101
	Total	44.06	12.59	145

Figure 1.

Line Graph of Means for Interaction Effect of Age and Sex on Minutes Spent Napping

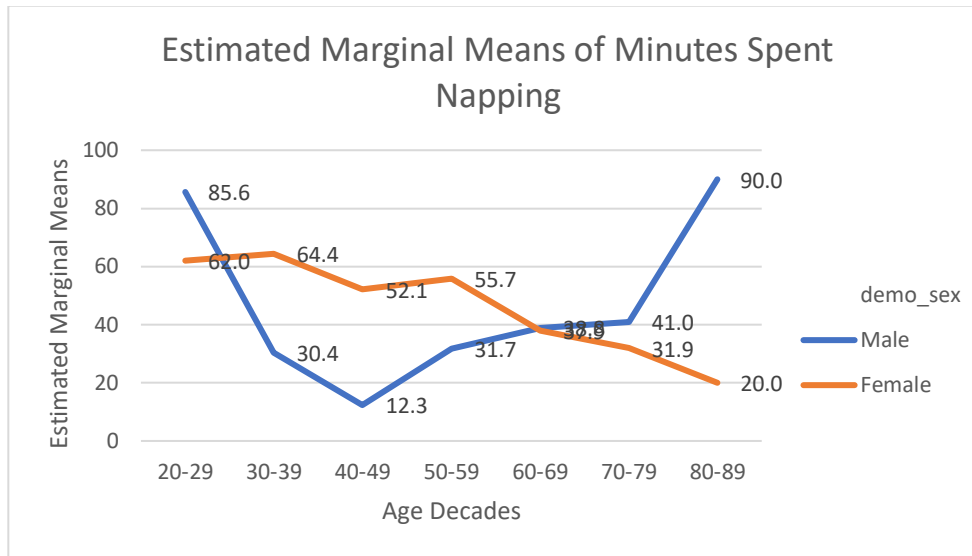


Figure 2.

Line Graph of Means for Main Effect of Sex on Sleep Efficiency

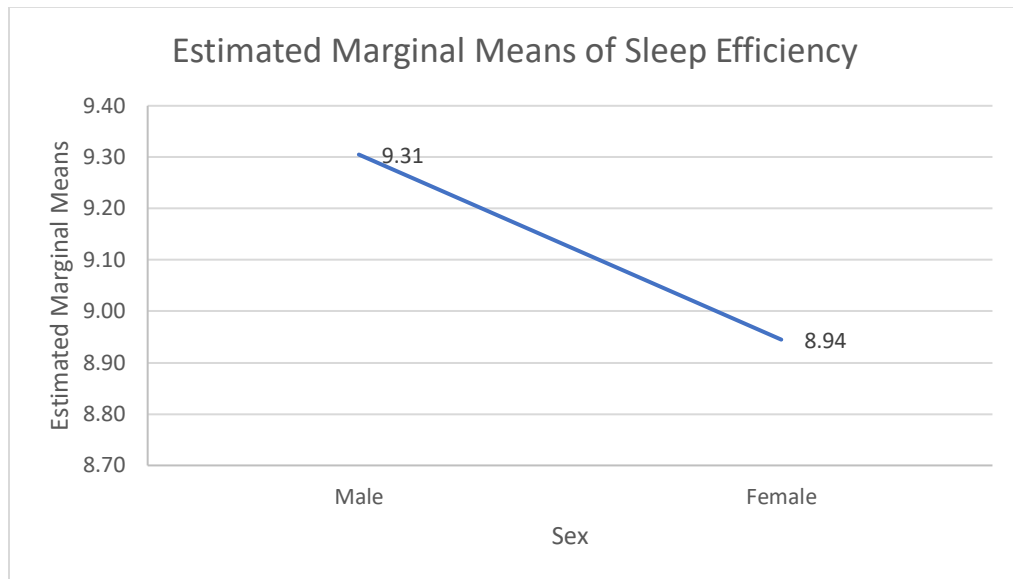


Figure 3.

Line Graph of Means for Main Effect of Age on Sleep Quality

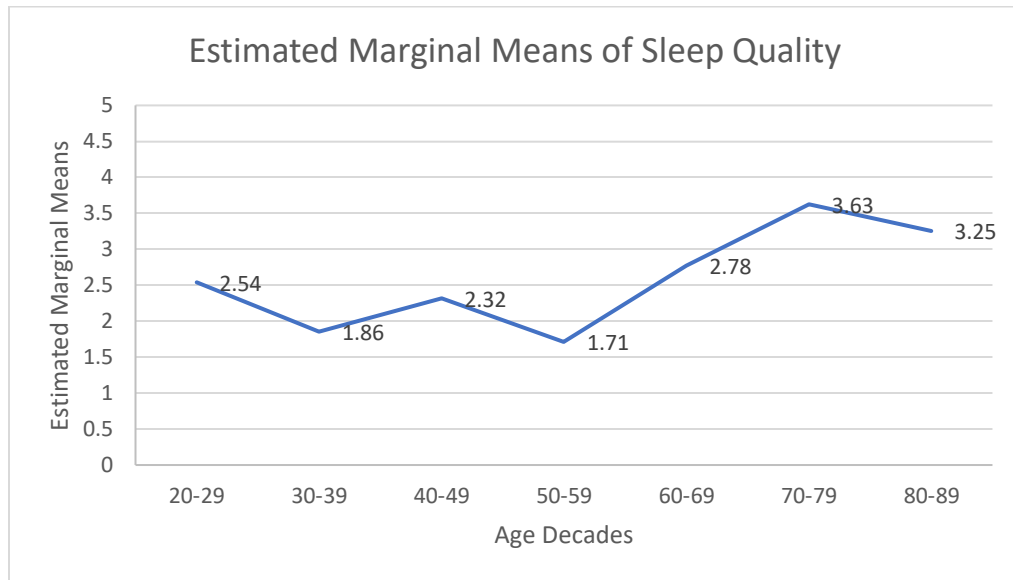


Figure 4.

Line Graph of Means for Main Effect of Age on Fatigue Level

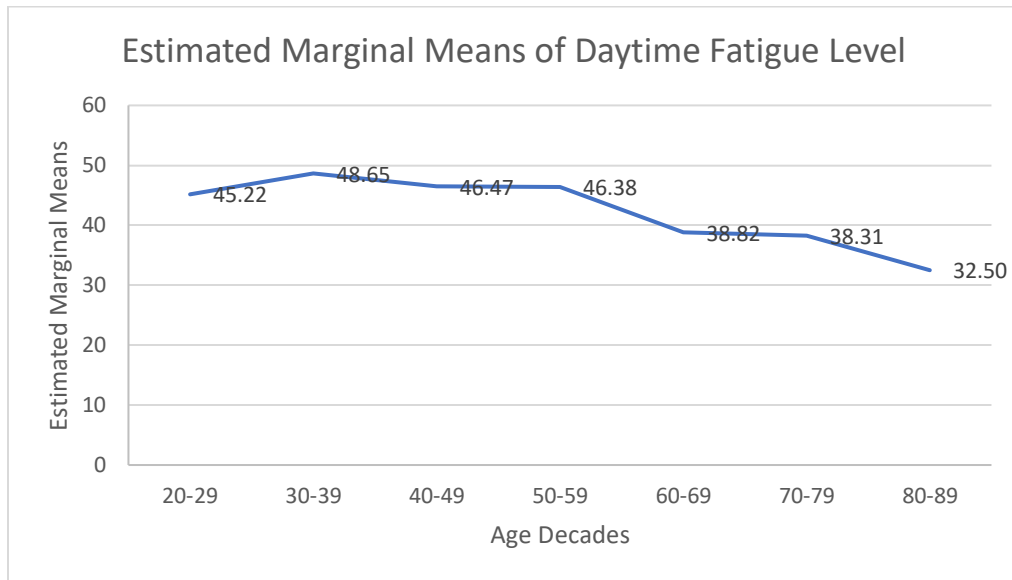
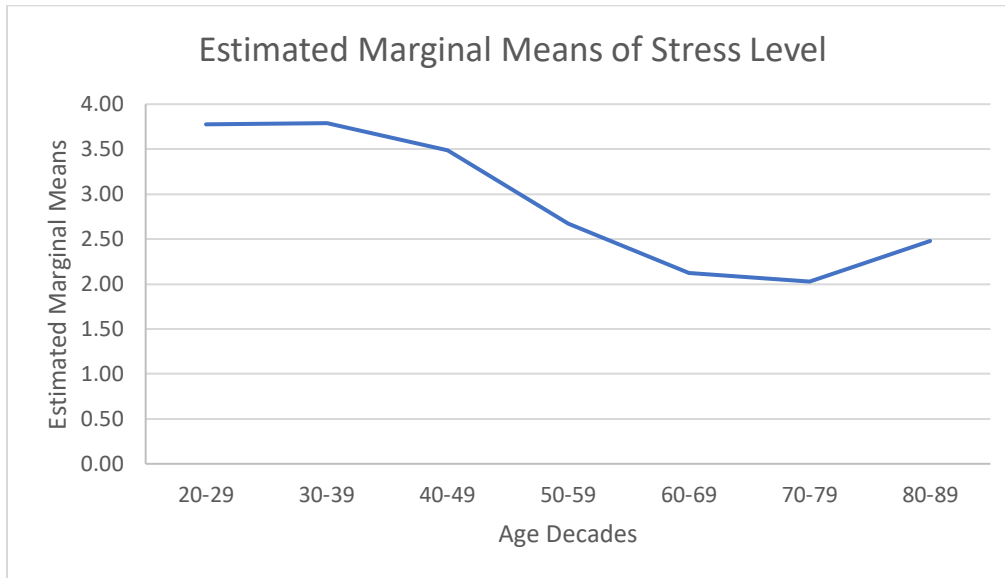


Figure 5.

Line Graph of Means for Main Effect of Age on Stress Level



Appendix A: Demographics Questionnaire

Descriptive Information Form

Instructions to Participants: *This study is about sleep and daytime functioning. Our preference, of course, is for you to answer all the given questions. If you find, however, that some questions make you too uncomfortable to answer, you may choose not to answer those specific items. As described in the consent to participate, all of the information that you provide will be kept private and confidential. Thank you for your willingness to participate.*

1. Where did you hear about us? (Please check what applies)

- ☐ From a YouTube comment
- ☐ From Facebook
- ☐ From Instagram
- ☐ My partner completed the questionnaire
- ☐ Other: _____

2. Age: _____

3. Sex

- ☐ Male
- ☐ Female
- ☐ Intersex

4. Date of Birth (Month/Day/Year): _____

5. I suffer from sleep disturbance that I identify as insomnia:

- ☐ Yes for _____ months
- ☐ No

6. What is your race/ethnicity (select all that apply)?

- ☐ Non-Hispanic White
- ☐ Black (African American)
- ☐ Black (Afro-Caribbean)
- ☐ Black (African)
- ☐ Black (Other): _____
- ☐ Hispanic/Latino (Mexican)
- ☐ Hispanic/Latino (Puerto Rican)
- ☐ Hispanic/Latino (Cuban)

- ☐ Hispanic/Latino (Other Central American)
- ☐ Hispanic/Latino (Brazilian)
- ☐ Hispanic/Latino (Other South American)
- ☐ Hispanic/Latino (Other): _____
 - ☐ Asian (Indian/Pakistani/Bangladeshi/Indian Subcontinent)
 - ☐ Asian (Arab/Persian/Middle-Eastern)
 - ☐ Asian (Chinese Taiwanese)
 - ☐ Asian (Japanese)
 - ☐ Asian (Korean)
 - ☐ Asian (Southeast Asian – Vietnamese, Laotian, Thai, Hmong, etc.)
 - ☐ Asian (Other): _____
 - ☐ American Indian/Native American
 - ☐ Alaskan Native
 - ☐ Other: _____

7. What is your relationship status?

- ☐ Re-married
- ☐ Married
- ☐ In a relationship and living with partner
- ☐ In a relationship and not living with partner
- ☐ Single and never married
- ☐ Divorced
- ☐ Widowed
- ☐ Separated

8. Which of the following best describes you?

- ☐ heterosexual (straight)
- ☐ bisexual
- ☐ gay or lesbian
- ☐ not sure
- ☐ none of the above
- ☐ prefer not to answer

9. What is your highest level of education?

- ☐ Less than 9th grade
- ☐ 9th -11th grade
- ☐ High school or GED
- ☐ Some college but no degree
- ☐ Associates degree (AA, AS, etc.)
- ☐ Bachelor's degree (BA, BS, etc.)
- ☐ Master's degree (MA, MS, MBA, MFA, etc.)

☐ Doctoral degree (PhD, MD, JD, DO, etc.)

10. What is your employment status?

- ☐ Full time
- ☐ Multiple jobs
- ☐ Part time
- ☐ Self-employed
- ☐ Retired
- ☐ Homemaker
- ☐ Student
- ☐ Unemployed less than 1 year
- ☐ Unemployed greater than 1 year
- ☐ Unable to work

11. Occupation/Please specify: _____

12. If employed or in school full-time, please select the work schedule that you typically work. Choose the shift that most closely applies to your schedule and indicate how many times per week and month that you engage in that shift.

- ☐ Primarily Day 9:00am-5:00pm
Occasions per week 0-7: _____
Occasions per month 0-30: _____
- ☐ Primarily Evening 4:00pm-12:00am
Occasions per week 0-7: _____
Occasions per month 0-30: _____
- ☐ Primarily Night 12:00am-8:00 am
Occasions per week 0-7: _____
Occasions per month 0-30: _____
- ☐ Not applicable-Indicate the start and end times that you are most likely to work (circling a.m. or p.m.):
Start time: hour: _____ Minute: _____ a.m./p.m.

End time: hour: _____ Minute: _____ a.m./p.m.

13. Do you engage in shift work?

- ☐ Yes
- ☐ No [If 'No', skip to Q15]

14. Is your shift work standard (same every week) or rotating (varies over time)?

- ☐ Standard

☐Rotating

15. What is your household annual income (before taxes)?

- ☐ Less than \$10,000
- ☐ \$10,000 - \$19,999
- ☐ \$20,000 - \$29,999
- ☐ \$30,000 - \$39,999
- ☐ \$40,000 - \$49,999
- ☐ \$50,000 - \$59,999
- ☐ \$60,000 - \$69,999
- ☐ \$70,000 - \$79,999
- ☐ \$80,000 - \$89,999
- ☐ \$90,000 - \$99,999
- ☐ \$100,000 - \$109,999
- ☐ \$110,000 - \$119,999
- ☐ \$120,000 - \$129,999
- ☐ \$130,000 - \$139,999
- ☐ \$140,000 - \$149,999
- ☐ \$150,000 or more

16. Do you have access to health insurance? (check all that apply)

- ☐No health insurance
- ☐Health insurance through work or school
- ☐Health insurance bought directly by you or your family
- ☐Public health insurance (Medicare, Medicaid, etc.)

17. Have you been without health insurance during the past year?

- ☐No
- ☐Yes (less than 6 months)
- ☐Yes (more than 6 months but not all year)
- ☐Yes (all year)

18. On a scale of 1 – 100 (50 being neutral), how would you rate your

18a. Overall satisfaction with your **life in general**?_____

18b. Overall satisfaction with your **financial situation**?_____

18c. Overall satisfaction with your **health**?_____

18d. Overall satisfaction with your **marriage, current relationship, or relationship status (if not in a relationship)**?_____

18e. Overall satisfaction with your **sleep**?_____

Basic Sleep Information ^[SEP]- To get a better idea of your sleeping habits, please answer these questions according to both your weekend and weekday sleeping patterns/schedule

1. I typically (3 or more nights per week; 1-2 for weekends) go to bed with the intent to fall asleep at
 - a. _____(h/mm/am or pm) on **weekdays**
 - b. _____(h/mm/am or pm) on **weekends**
2. I typically (3 or more nights per week; 1-2 for weekends) spend
 - a. _____hours sleeping on **weekdays**
 - b. _____hours sleeping on **weekends**
3. I typically (3 or more nights per week; 1-2 for weekends) get out of bed with the intent to start the day at
 - a. _____(h/mm/am or pm) on **weekdays**
 - b. _____(h/mm/am or pm) on **weekends**
4. On a typical night (4 or more nights per week; 1-2 for weekends) how many minutes does it take you to fall asleep?
 - a. _____ minutes on **weekdays**
 - b. _____ minutes on **weekends**
5. How many nights a week does it take you more than 30 minutes to fall asleep?

 - 5a. Do you consider this a problem?
 - ☐Yes
 - ☐No (If 'No' go to 6)
 - 5b. How long have you had this problem?
_____ (days, weeks, months, or years)
6. On a typical night (4 or more nights per week), how many times do you awaken in the middle of the night *but fall back asleep*?_____
 - 6a. How many nights a week does this occur? _____
 - 6b. Do you consider this a problem?
 - ☐Yes
 - ☐No^[SEP](If 'No' go to 7)

6c. How long have you had this problem?

_____ (days, weeks, months, or years)

7. On a typical night (4 or more nights per week), how long are you awake altogether across the night (from time to bed to time out of bed) _____ Hours _____ minutes

7a. How many nights a week are you awake for 30 minutes or more? _____^[SEP]

7b. Do you consider this a problem?

☐ Yes

☐ No^[SEP] (If 'No' go to 8)

7c. How long have you had this problem?

_____ (days, weeks, months, or years)

8. Do you typically (4 or more nights per week), wake up before you intend to or before the alarm clock goes off in the morning?

☐ Yes

☐ No

8a. Typically, how many minutes before you want to awaken for the day ? _____ minutes

8b. How many mornings a week do you wake up 30 minutes early or more? _____^[SEP]

8c. Do you consider this a problem?

☐ Yes

☐ No (If 'No' go to 9)

8d. How long have you had this problem?

_____ (days, weeks, months, or years)

9. On a typical (4 or more nights per week) night, how much sleep do you get ? _____ Hours _____ minutes

9a. How many nights a week do you get at least this much sleep? _____

9b. Do you consider this a problem? (If “no” go to 10)

9c. How long have you had this problem?

_____ (days, weeks, months, or years)

10. If you can go to bed and get out of bed any time you choose, can you sleep as much as you want to?

☐ Yes

☐ No

If ‘yes’, how long is a typical “long sleep” period for you ?

_____ Hours _____ minutes

10a. What is your preferred bed-time? That is, if you could go to bed any time you choose, what time would that be?

Preferred *Bed-time*: hour: _____ Minute: _____ a.m./p.m.

10b. What is your preferred wake-time? That is, if you could wake at any time you choose, what time would that be?

Preferred *Wake-time*: hour: _____ Minute: _____ a.m./p.m.

11. How often do you take naps, including unintentional naps?

(1) rarely

(2) less than once a month

(3) about twice a month

(4) 1-2 times a week

(5) 3-4 times a week

(6) 5 or more times a week

(7) once a day

(8) more than once a day

12. Average length of naps: (minutes, hours?) _____

13. Have you previously been treated for sleep problems?

- ☐Yes
- ☐No

13a. If yes, please describe:

14. Have you been diagnosed with COVID-19 since the pandemic?

- ☐Yes ☐No

15. If yes, please describe the date you (DD/MM/YY) were diagnosed and for how long you experienced symptoms:

16. Do you feel your sleep was altered during or after contracting COVID-19?

- ☐Yes ☐No

17. If yes, please describe:

General Health Questions

1. During the past 3-6 months, have you been taking any prescription medications, over-the-counter medications, vitamins, or herbal supplements?

- ☐Yes
- ☐No

2. Please list of all medications that you have taken during past 3-6 months.

Medication _____

Current

☐Yes/☐No

Reason for use:

Past

start/stop

3. Are you in good physical health?

- ☐ Yes
- ☐ No

4. Please rate your overall physical health below next to the scale that most closely describes you

- ☐ 1 I am in excellent physical condition for my age
- ☐ 2 I have no chronic conditions, but I am not in peak physical condition
- ☐ 3 I have a chronic condition, but it is stable and well managed
- ☐ 4 I have a chronic condition, and it is not stable or well managed
- ☐ 5 I have multiple chronic conditions, but they are stable and well managed
- ☐ 6 I have multiple chronic conditions, and they are not stable or well managed

5. Are you in good overall mental health?

- ☐ Yes
- ☐ No

6. Please rate your overall mental health on the scale below next to the statement that most closely describes you:

- ☐ 1 I am in excellent mental health
- ☐ 2 I have no mental health conditions
- ☐ 3 I have a chronic mental health condition, but it is stable and well managed
- ☐ 4 I have a chronic mental health condition, and it is not stable or well managed
- ☐ 5 I have multiple chronic mental health conditions, but they are stable and well managed
- ☐ 6 I have multiple chronic mental health conditions, and they are not stable or well managed

Medical and Psychiatric History

1. Please indicate your current and past history by the checking the appropriate box.

NOTE: FOR EACH CONDITION BELOW (WHEN ENDORSED) PROMPT

- ☐ Current
- ☐ Past
- ☐ No

Conditions:

Depression^[SEP]
Generalized Anxiety Disorder^[SEP]
PTSD^[SEP]
Substance and/or alcohol Use or Dependence^[SEP]

2. Have you EVER taken any psychiatric medications?

- ☐ Yes
- ☐ No

2a. If yes, please describe: ^[SEP]Name _____ Dose _____ times per day _____
Duration of use _____ Started _____ Stopped _____

3. Based on the past year, how often do you have a drink containing alcohol?

- ☐ Never
- ☐ Monthly or Less^[SEP]
- ☐ Two to four times per month
- ☐ Two or three times per week
- ☐ Four or more times per week

4. How many drinks did you have on a typical day when you were drinking in the past year?

- ☐ 1 or 2
- ☐ 3 or 4^[SEP]
- ☐ 5 or 6^[SEP]
- ☐ 7 to 9^[SEP]
- ☐ 10 or more

5. How often did you have six or more drinks on one occasion in the past year?

- ☐ Never
- ☐ Less than monthly
- ☐ Monthly^[SEP]
- ☐ Weekly^[SEP]
- ☐ Daily or Almost Daily

6. Have you smoked cigarettes, cigars, or a pipe in the past 12 months?

- ☐ Yes
- ☐ No

7. Do you currently smoke or use any form of nicotine?

- ☐Yes
- ☐No

8. Please estimate the number of years you have smoked in total. _____years

9. How many caffeinated beverages (1, 8oz cup=1 beverage) do you drink per day?

Coffee _____

Tea _____

Soda _____

10. How many hours per week do you exercise on average? _____

11. What kind of exercise do you typically do?

- ☐walking
- ☐running
- ☐weights
- ☐dancing
- ☐swimming
- ☐aerobics/cardio
- ☐yoga/pilates
- ☐sports (boxing, karate)
- ☐biking
- ☐other _____

Appendix A Notes/Further Explanation:

Directions indicating circling or checking boxes can/will be changed contingent upon
website/platform restrictions.

Appendix B: Retrospective Sleep Continuity Assessment Questionnaire

RETROSPECTIVE SLEEP CONTINUITY ASSESSMENT QUESTIONNAIRE (RSCAQ)

In the last month ...

what time have you typically gotten into bed? (TTB)

what time do you typically start trying to fall asleep? (TTS)

how long does it typically take you to fall asleep? (SL)

do you consider this a problem?

how many times have you typically awoken during the night after falling asleep? (NWAK)

after falling asleep, how much time do you typically spend awake during the night? (WASO)

Do you consider this a problem?

what time have you typically awoken? (TFA)

how long are you awake before you need to be awake? (EMA)

what time do you typically get out of bed to start your day? (TOB)

how much sleep do you get per night on average? (TST)

SQUAL

For a typical night, how would you rate the quality of your sleep?
(Poor 0 - 1 - 2 -3 - 4 -5 Excellent)

REST

For a typical morning, how refreshed/restored did you feel when you awoken?
(Not very 0 - 1 - 2 -3 - 4 -5 Very)

NAP-N

How many times a day did you typically nap (from morning until 6pm)?

NAP-D

How much time did you spend napping per day (from morning until 6pm)?

DOZE-N

How many times a day, from 6pm until bedtime, do you typically doze (i.e., for any period of time while watching TV or reading)?

DOZE-D

How much time do you spend dozing from 6pm until bedtime?

Given participant responses to the above questions, several additional variables can be calculated including: Time in Bed [TIB] Total Sleep Time [TST (as a calculated variable)], and Sleep Efficiency [SE%].

Appendix C: Insomnia Severity Index

Insomnia Severity Index

The Insomnia Severity Index has seven questions. The seven answers are added up to get a total score. When you have your total score, look at the 'Guidelines for Scoring/Interpretation' below to see where your sleep difficulty fits.

For each question, please CIRCLE the number that best describes your answer.

Please rate the CURRENT (i.e. LAST 2 WEEKS) SEVERITY of your insomnia problem(s).

Insomnia Problem	None	Mild	Moderate	Severe	Very Severe
1. Difficulty falling asleep	0	1	2	3	4
2. Difficulty staying asleep	0	1	2	3	4
3. Problems waking up too early	0	1	2	3	4

4. How SATISFIED/DISSATISFIED are you with your CURRENT sleep pattern?

Very Satisfied Satisfied Moderately Satisfied Dissatisfied Very Dissatisfied
0 1 2 3 4

5. How NOTICEABLE to others do you think your sleep problem is in terms of impairing the quality of your life?

Not at all
Noticeable A Little Somewhat Much Very Much Noticeable
0 1 2 3 4

6. How WORRIED/DISTRESSED are you about your current sleep problem?

Not at all
Worried A Little Somewhat Much Very Much Worried
0 1 2 3 4

7. To what extent do you consider your sleep problem to INTERFERE with your daily functioning (e.g. daytime fatigue, mood, ability to function at work/daily chores, concentration, memory, mood, etc.) CURRENTLY?

Not at all
Interfering A Little Somewhat Much Very Much Interfering
0 1 2 3 4

Guidelines for Scoring/Interpretation:

Add the scores for all seven items (questions 1 + 2 + 3 + 4 + 5 + 6 + 7) = _____ your total score

Total score categories:

0–7 = No clinically significant insomnia

8–14 = Subthreshold insomnia

15–21 = Clinical insomnia (moderate severity)

22–28 = Clinical insomnia (severe)

Used via courtesy of www.myhealth.va.gov with permission from Charles M. Morin, Ph.D., Université Laval

Appendix D: Epworth Sleepiness Scale

Epworth Sleepiness Scale

Name: _____ Today's date: _____

Your age (Yrs): _____ Your sex (Male = M, Female = F): _____

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired?

This refers to your usual way of life in recent times.

Even if you haven't done some of these things recently try to work out how they would have affected you.

Use the following scale to choose the **most appropriate number** for each situation:

- 0 = would **never** doze
- 1 = **slight chance** of dozing
- 2 = **moderate chance** of dozing
- 3 = **high chance** of dozing

It is important that you answer each question as best you can.

Situation

Chance of Dozing (0-3)

Sitting and reading _____

Watching TV _____

Sitting, inactive in a public place (e.g. a theatre or a meeting) _____

As a passenger in a car for an hour without a break _____

Lying down to rest in the afternoon when circumstances permit _____

Sitting and talking to someone _____

Sitting quietly after a lunch without alcohol _____

In a car, while stopped for a few minutes in the traffic _____

THANK YOU FOR YOUR COOPERATION

Appendix E: Fatigue Severity Scale

FATIGUE SEVERITY SCALE (FSS)

Date _____ Name _____

Please circle the number between 1 and 7 which you feel best fits the following statements. This refers to your usual way of life within the last week. 1 indicates “strongly disagree” and 7 indicates “strongly agree.”

Read and circle a number.	Strongly Disagree	→	Strongly Agree
1. My motivation is lower when I am fatigued.	1	2	3 4 5 6 7
2. Exercise brings on my fatigue.	1	2	3 4 5 6 7
3. I am easily fatigued.	1	2	3 4 5 6 7
4. Fatigue interferes with my physical functioning.	1	2	3 4 5 6 7
5. Fatigue causes frequent problems for me.	1	2	3 4 5 6 7
6. My fatigue prevents sustained physical functioning.	1	2	3 4 5 6 7
7. Fatigue interferes with carrying out certain duties and responsibilities.	1	2	3 4 5 6 7
8. Fatigue is among my most disabling symptoms.	1	2	3 4 5 6 7
9. Fatigue interferes with my work, family, or social life.	1	2	3 4 5 6 7

VISUAL ANALOGUE FATIGUE SCALE (VAFS)

Please mark an “X” on the number line which describes your global fatigue with 0 being worst and 10 being normal.

0	1	2	3	4	5	6	7	8	9	10
<hr/>										

Appendix F: Depression Anxiety Stress Scales-21

DASS21

Name: _____

Date: _____

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you **over the past week**. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

- 0 Did not apply to me at all
- 1 Applied to me to some degree, or some of the time
- 2 Applied to me to a considerable degree or a good part of time
- 3 Applied to me very much or most of the time

1 (s)	I found it hard to wind down	0	1	2	3
2 (a)	I was aware of dryness of my mouth	0	1	2	3
3 (d)	I couldn't seem to experience any positive feeling at all	0	1	2	3
4 (a)	I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5 (d)	I found it difficult to work up the initiative to do things	0	1	2	3
6 (s)	I tended to over-react to situations	0	1	2	3
7 (a)	I experienced trembling (e.g. in the hands)	0	1	2	3
8 (s)	I felt that I was using a lot of nervous energy	0	1	2	3
9 (a)	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10 (d)	I felt that I had nothing to look forward to	0	1	2	3
11 (s)	I found myself getting agitated	0	1	2	3
12 (s)	I found it difficult to relax	0	1	2	3
13 (d)	I felt down-hearted and blue	0	1	2	3
14 (s)	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15 (a)	I felt I was close to panic	0	1	2	3
16 (d)	I was unable to become enthusiastic about anything	0	1	2	3
17 (d)	I felt I wasn't worth much as a person	0	1	2	3
18 (s)	I felt that I was rather touchy	0	1	2	3
19 (a)	I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)	0	1	2	3
20 (a)	I felt scared without any good reason	0	1	2	3
21 (d)	I felt that life was meaningless	0	1	2	3

Appendix G: Sleep Disorder Symptom Checklist-25

SDS-CL-25

Date: __/__/__ ID/Initials __ Age: __ Sex: __ Height __ Weight __ H1: Work Shift: n/a First (9-5pm) Second (4-12am) Third (12to 8am) H2: Work Hours: __0 __10-19 __20-40 __ > 40 Hours per week H3: Do you regularly have a bed partner? (3 or more days/week) (Yes/No) H4: How much sleep do you typically get per night? __ hours (e.g., 8.5 hrs.) H5: How much time do you typically spend in bed per night? __ hours (e.g., 9.0 hrs.) Answer all questions for what has been typical for you for the last 3 months	0 NEVER	1 ONCE A MONTH	2 1-2 TIMES A WEEK	3 3-5 TIMES A WEEK	4 > 5 TIMES A WEEK
1. My work or other activities prevent me from getting at least 6 hours of sleep					
2. My bedtime or waketime varies by more than 3 hours					
3. It takes me 30 minutes or more to fall asleep					
4. I am awake for 30 minutes or more during the night					
5. I wake up 30 or more minutes before I have to and can't fall back asleep					
6. I am tired, fatigued, or sleepy during the day					
7. I sleep better if I go to bed before 9pm and wake up before 4:30am					
8. I sleep better if I go to bed late (after 1am) and wake up late (after 9am)					
9. I am prone to fall asleep at inappropriate times or places					
10. I snore					
11. I wake up with a dry mouth in the morning (cotton mouth)					
12. My snoring is so loud, that my bed partner complains					
13. I have to be told that I stop breathing in my sleep					
14. I wake up choking or gasping for air					
15. I feel uncomfortable sensations in my legs, especially when sitting or lying down, that are relieved by moving them					
16. I have an urge to move my legs that is worse in the evenings and nights					
17. I wake up frequently during the night for no reason					
18. When angered, humored, frightened, I experience sudden muscle weakness					
19. When falling asleep or waking up, I experience scary dream like images					
20. When I am first awakening, I feel like I can't move					
21. I have nightmares					
22. For no reason, I awaken suddenly, feeling startled and afraid					
23. I have been told that I walk, talk, eat, act strangely or violently when asleep					
24. I grind my teeth or clench my jaw while I sleep					
25. My sleep difficulties interfere with my daily activities					

Klingman K, Jungquist C, Perlis M. Introducing the Sleep Disorders Symptom Checklist-25: A Primary Care Friendly and Comprehensive Screener for Sleep Disorders. 2017. *Sleep Med Res*; 8(1): 17-25.

8. When I sleep poorly on one night, I know it will disturb my sleep schedule for the whole week.

0 1 2 3 4 5 6 7 8 9 10

9. Without an adequate night's sleep, I can hardly function the next day.

0 1 2 3 4 5 6 7 8 9 10

10. I can't ever predict whether I'll have a good or poor night's sleep.

0 1 2 3 4 5 6 7 8 9 10

11. I have little ability to manage the negative consequences of disturbed sleep.

0 1 2 3 4 5 6 7 8 9 10

12. When I feel tired, have no energy, or just seem not to function well during the day, it is generally because I did not sleep well the night before.

0 1 2 3 4 5 6 7 8 9 10

13. I believe insomnia is essentially the result of a chemical imbalance.

0 1 2 3 4 5 6 7 8 9 10

14. I feel insomnia is ruining my ability to enjoy life and prevents me from doing what I want.

0 1 2 3 4 5 6 7 8 9 10

15. Medication is probably the only solution to sleeplessness.

0 1 2 3 4 5 6 7 8 9 10

16. I avoid or cancel obligations (social, family) after a poor night's sleep.

0 1 2 3 4 5 6 7 8 9 10

© Morin, C. 1993

Appendix I: Functional Outcomes of Sleep Questionnaire: Reduced Version

FUNCTIONAL OUTCOMES OF SLEEP QUESTIONNAIRE (FOSQ) - PAGE 1

Site: _____ ID#: _____
 Technician: _____ Date of Data Entry: _____
 Trial: _____
 Name: _____ Date: _____

Some people have difficulty performing everyday activities when they feel tired or sleepy. The purpose of this questionnaire is to find out if you generally have difficulty carrying out certain activities because you are too sleepy or tired. In this questionnaire, when the words "sleepy" or "tired" are used, it means the feeling that you can't keep your eyes open, your head is droopy, that you want to "nod off", or that you feel the urge to take a nap. These words do not refer to the tired or fatigued feeling you may have after you have exercised.

DIRECTIONS: Check the circle for your answer to each question. Select only one answer for each question. Please try to be as accurate as possible. All information will be kept confidential.

	(0) I don't do this activity for other reasons	(4) No difficulty	(3) Yes, a little difficulty	(2) Yes, moderate difficulty	(1) Yes, extreme difficulty
1. Do you have difficulty concentrating on the things you need to do because you are sleepy or tired?		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Do you generally have difficulty remembering things, because you are sleepy or tired?		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Do you have difficulty operating a motor vehicle for short distances (less than 100 miles) because you become sleepy or tired?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Do you have difficulty operating a motor vehicle for long distances (greater than 100 miles) because you become sleepy or tired?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. Do you have difficulty visiting with your family or friends in their home because you become sleepy or tired?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. Has your relationship with family, friends or work colleagues been affected because you were sleepy or tired?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Do you have difficulty watching a movie or video because you become sleepy or tired?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. Do you have difficulty being as active as you want to be in the evening because you are sleepy or tired?		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. Do you have difficulty being as active as you want to be in the morning because you are sleepy or tired?		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	(0) I don't engage in sexual activity for other reasons	(4) No	(3) Yes, a little	(2) Yes, moderately	(1) Yes, extremely
10. Has your desire for intimacy or sex been affected because you were sleepy or tired?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Appendix J: Charlson Comorbidity Index

Components of classical Charlson Comorbidity Index¹

1. Has the patient had a myocardial infarction? (MI)

☐ No
☐ Yes

Criteria: Myocardial infarction includes patients with one or more definite or probable myocardial infarction. These patients should have been hospitalized for chest pain or an equivalent clinical event and have had electrocardiographic and/ or enzyme changes. Patients with electrocardiographic changes alone who have no clinical history are not designated as having had an infarction.

2. Has the patient been hospitalized or treated for heart failure? (CHF)

☐ No
☐ Yes

Criteria: Congestive heart failure includes patients who have had exertional or paroxysmal nocturnal dyspnea and who have responded symptomatically (or on physical examination) to digitalis, diuretics, or afterload reducing agents. It does not include patients who are on one of those medications but who have had no response and no evidence of improvement of physical signs with treatment.

3. Does the patient have peripheral vascular disease? (PVD)

☐ No
☐ Yes

Criteria: Peripheral vascular includes patients with intermittent claudication or those who had a bypass for arterial insufficiency, those with gangrene or acute arterial insufficiency, and those with a treated or untreated thoracic or abdominal aneurysm (6 cm or more).

4. Has the patient had a CVA or transient ischemic disease? (CVA)

☐ No
☐ Yes

Criteria: Cerebrovascular disease includes patients with a history of a cerebrovascular accident with minor or no residua, and patients who have had transient ischemic attacks. If the CVA resulted in hemiplegia, code only hemiplegia.

¹ Charlson, ME, Ales, KA, Pompei, P, MacKenzie, CR. A new method of classification of prognostic comorbidity for longitudinal studies: development and validation. J Chron Disease. 1987; 40(5): 373-383

5. Does the patient have hemiplegia? (PLEGIA)

- ☐ No
☐ Yes

Criteria: This includes patients with a hemiplegia or paraplegia, whether it occurred as a result of a cerebrovascular accident or other condition.

6. Does the patient have asthma, chronic lung disease, chronic bronchitis or emphysema? (COPD)

- ☐ No
☐ Yes

Criteria: Pulmonary disease includes patients with asthma, chronic bronchitis, emphysema, and other chronic lung disease who have ongoing symptoms such as dyspnea or cough, with mild or moderate activity. This includes patients who are dyspneic with slight activity, with or without treatment and those who are dyspneic with moderate activity despite treatment, as well as patients who are dyspneic at rest, despite treatment, those who require constant oxygen, those with CO₂ retention and those with a baseline PO₂ below 50 torr.

7. Does the patient have diabetes that requires treatment? (DM)

- ☐ No
☐ Yes

Criteria: Diabetes includes all patients with diabetes treated with insulin or oral hypoglycemic, but not diet alone. Diabetes during pregnancy alone is not counted.

7a. Does the patient have end organ damage from diabetes? (DMENDORGAN)

- ☐ No
☐ Yes

Criteria: This includes patients with retinopathy, neuropathy, or nephropathy attributable to diabetes.

8. Does the patient have moderate or severe renal disease? (RENAL)

- ☐ No
☐ Yes

Criteria: Moderate renal insufficiency includes patients with a serum creatinine >3 mg/dl. Severe renal disease includes patients on dialysis, those who had a transplant, and those with uremia.

9. Does the patient have a chronic liver disease? (MILDLIVER)

- ☐ No
☐ Yes

Criteria: Mild liver disease consists of chronic hepatitis (B or C) or cirrhosis without portal hypertension.

9a. Does the patient have moderate to severe liver disease? (SEVERELIVER)

- ☐ No
☐ Yes

Criteria: Moderate liver disease consists of cirrhosis with portal hypertension, but without bleeding. Severe liver disease consists of patients with ascites, chronic jaundice, portal hypertension or a history of variceal bleeding or those who have had liver transplant.

10. Has the patient had gastric or peptic ulcers? (ULCER)

- ☐ No
☐ Yes

Criteria: Peptic ulcer disease includes patients who have required treatment for ulcer disease, including those who have bled from ulcers.

11. Has the patient had cancer (other than basal cell skin cancer)? (CANCER)

- ☐ No
☐ Yes

If yes, which:

- ☐ Lymphoma?
☐ Leukemia?
☐ Solid tumor (which?) _____

Criteria: Lymphoma includes patients with Hodgkins, lymphosarcoma, Waldenstrom's macroglobulinemia, myeloma, and other lymphomas. Leukemia includes patients with acute and chronic myelogenous leukemia, acute and chronic lymphocytic leukemia, and polycythemia vera. Solid tumor consists of patients with solid tumors without documented metastases, including breast, colon, lung, prostate, and a variety of other tumors.

11a. Has the patient had a metastatic solid tumor? (METASTASES)

- ☐ Breast
☐ Colon
☐ Prostate
☐ Lung
☐ Melanoma
☐ Other _____

Criteria: Metastatic cancer includes patients with metastatic solid tumors, including breast, lung, colon and other tumors

12. Does the patient have Alzheimer's, dementia from any etiology or any serious cognitive impairment? (DEMENTIA)

☐ No
☐ Yes

Criteria: Dementia includes patients with moderate to severe chronic cognitive deficit resulting in impaired function from any cause.

13. Does the patient have any rheumatic or connective tissue disease? (RHEUMATIC)

☐ No
☐ Yes

Criteria: Rheumatologic disease includes patients with systemic lupus erythematosus, polymyositis, mixed connective tissue disease, rheumatoid arthritis, polymyositis, polymyalgia rheumatica, vasculitis, sarcoidosis, Sjogrens syndrome or any other systemicvasculitis

14. Does the patient have HIV or AIDS? (HIV)

☐ No
☐ Yes

Criteria: Acquired immune deficiency syndrome includes patients with definite or probable AIDS, i.e. AIDS related complex, and those who are HIV positive and asymptomatic.

Additional components of Charlson Comorbidity Index adapted to predict cost²

15. Does the patient have hypertension? (HBP)

☐ No
☐ Yes

Criteria: Hypertension includes patients who have systolic pressures >140 mm Hg and/or diastolic pressures >90 mm Hg if without diabetes or renal disease, as well as controlled hypertensives; or patients with diabetes or renal disease who have systolic pressures >140 mm Hg or diastolic pressures >80 mm Hg.

16. Has the patient had decubitus ulcers, peripheral skin ulcers or repeated episodes of cellulitis? (SKINULCER)

- ☐ No
☐ Yes

Criteria: Partial thickness loss of skin over legs or back with open ulcers or two or more episodes of cellulitis requiring treatment with antibiotics, regardless of etiology.

17. Does the patient have depression? (DEPRESSION)

- ☐ No
☐ Yes

Criteria: Patients who are currently receiving treatment for depression, whether pharmacologic or psychotherapy, or cognitive behavioral therapy, or notes indicating that the patient has probable or definite depression.

18. Is the patient on warfarin or coumadin? (WARFARIN)

- ☐ No
☐ Yes

Conditions that are not assigned weights

- Angina includes patients with chronic exertional angina, those who had coronary artery bypass graft, and those initially admitted with unstable angina.
- Arrhythmia includes patients with chronic atrial fibrillation or flutter, sick sinus syndrome, or ventricular arrhythmias requiring chronic treatment.
- Valvular disease includes patients with hemodynamically significant aortic stenosis and/or insufficiency, those with significant mitral stenosis and/or insufficiency, and those with prosthetic aortic or mitral valves, asymmetric septal hypertrophy requiring treatment, or tricuspid insufficiency.
- Other neurologic conditions includes patients with Parkinson's disease, uncontrolled seizures, or syncope without an identified cause or treatment.
- Other endocrine includes patients with hypopituitarism, adrenal insufficiency, and recurrent acidosis.
- Inflammatory bowel disease includes patients with ulcerative colitis or regional enteritis.
- Gastrointestinal bleeding includes those who have had bleeding requiring transfusions from causes other than ulcer disease.
- Coagulopathy includes patients with a circulating anticoagulant, or other coagulopathy.

Charlson Comorbidity Index Scoring

Condition	Variable name	Points	Notes
Myocardial infarction	MI	1	
Congestive heart failure	CHF	1	
Peripheral vascular disease or bypass	PVD	1	
Cerebrovascular disease or transient ischemic disease	CVA	1	CVA only
Hemiplegia	PLEGIA	2	If hemiplegia, do not count CVA separately
Pulmonary disease/ asthma	COPD	1	
Diabetes	DM	1	DM only
Diabetes with end organ damage	DMENDORGAN	2	If end organ damage, do not count DM separately
Renal disease	RENAL	2	
Mild liver disease	MILDLIVER	2	
Severe liver disease	SEVERELIVER	3	
Gastric or peptic ulcer	ULCER	1	
Cancer (lymphoma, leukemia, solid tumor)	CANCER	2	Nonmetastatic cancer only
Metastatic solid tumor	METASTASES	6	If Metastatic, do not count cancer separately
Dementia or Alzheimer's	DEMENTIA	1	
Rheumatic or connective tissue disease	RHEUMATIC	1	
HIV or AIDS	HIV	6	
Hypertension	HBP	1	
Skin ulcers/ cellulitis	SKIN ULCER	2	
Depression	DEPRESSION	1	
Warfarin	WARFARIN	1	

Appendix K: Institutional Review Board Approval Letter



EAST CAROLINA UNIVERSITY

University & Medical Center Institutional Review Board

4N-64 Brody Medical Sciences Building · Mail Stop 682

600 Moye Boulevard · Greenville, NC 27834

Office 252-744-2914 · Fax 252-744-2284

rede.ecu.edu/umcirm/

Notification of Exempt Certification

From: Social/Behavioral IRB
To: [Amy Gencarelli](#)
CC: [Daniel Everhart](#)
Date: 1/31/2022
Re: [UMCIRB 21-002212](#)
Sleep Disturbance Severity and Neurocognitive Impairment Mapped onto Age

I am pleased to inform you that your research submission has been certified as exempt on 1/29/2022. This study is eligible for Exempt Certification under category # 2c.

It is your responsibility to ensure that this research is conducted in the manner reported in your application and/or protocol, as well as being consistent with the ethical principles of the Belmont Report and your profession.

This research study does not require any additional interaction with the UMCIRB unless there are proposed changes to this study. Any change, prior to implementing that change, must be submitted to the UMCIRB for review and approval. The UMCIRB will determine if the change impacts the eligibility of the research for exempt status. If more substantive review is required, you will be notified within five business days.

Document	Description
Final Ads for Dissertation.pdf(0.01)	Recruitment Documents/Scripts
Gencarelli Dissertation Proposal.docx(0.01)	Study Protocol or Grant Application
Measures for Dissertation Edited.docx(0.01)	Surveys and Questionnaires
Survey Consent Paragraph 1.23.22.doc(0.01)	Consent Forms

For research studies where a waiver or alteration of HIPAA Authorization has been approved, the IRB states that each of the waiver criteria in 45 CFR 164.512(i)(1)(i)(A) and (2)(i) through (v) have been met. Additionally, the elements of PHI to be collected as described in items 1 and 2 of the Application for Waiver of Authorization have been determined to be the minimal necessary for the specified research.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.