AN INVESTIGATION OF THE ASSOCIATION BETWEEN COGNITION AND DEPRESSION WITH SLEEP AS A MEDIATOR AMONG OLDER ADULTS

by

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ABSTRACT

Persons aged 65 and over account for an estimated 13% of the U.S. population, and, by 2030, they are predicted to account for almost 20% of the population. It is important to focus on the mental health of this segment of the population, because mental health issues frequently affect older adults. In addition, older adults commonly have co-morbid psychological disorders. In particular, older adults often experience issues with cognition, depression, and sleep, and the co- occurrence of these disorders results in greater negative outcomes for older adults. Therefore, this study investigated the relationship between depressive symptoms and cognitive performance with sleep quality as a mediating variable among older adults aged 65 and above. A secondary data analysis was performed using data from the Midlife in the United States Study II (MIDUS II). Specifically, wave two data from the Cognitive and Biomarkers Projects was analyzed using the Center for Epidemiologic Depression Scale, the Pittsburgh Sleep Quality Inventory, and the Brief Test of Adult Cognition by Telephone measures. Results suggest that being older and having more depressive symptoms was associated with worse cognitive performance, $R^2 = 0.12$, $F(4, 242) = 8.70$, $p < 0.001$. Poorer sleep quality did not underlie the association between greater depressive symptomatology and worse cognitive performance, (Percentile 95% CI [.-.01, .01]; Sobel test of mediation: z-score = .41, $p > .05$). Future research is needed to further investigate the role of sleep in the association between depression and cognitive performance in older adults.

DEDICATION

This thesis is dedicated to my committee members for helping me navigate the many challenges and celebrate the various successes I experienced while working on this project.

LIST OF ABBREVIATIONS AND SYMBOLS

a	Cronbach's index of internal consistency
df	Degrees of freedom: number of values free to vary after certain restrictions have been placed on the data
F	Fisher's *F* ratio: A ration of two variances
M	Mean: the sum of a set of measurements divided by the number of measurements in the set
p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
r	Pearson product-moment correlation
t	Computed value of *t* test
<	Less than
=	Equal to

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CHAPTER 1

INTRODUCTION

The number of individuals aged 65 and over (older adults) in the United States is steadily increasing, and currently they account for an estimated 13% of the U.S. population (U.S Census Bureau, 2010). Within the last 50 years, the older adult population has increased three-fold and is expected to experience another three-fold increase by 2050 (UN Department of Economic and Social Affairs). In fact, by 2030, persons age 65 and over are predicted to account for approximately 20% of the population (Federal Interagency Forum on Aging-Related Statistics, 2006).

Unfortunately, mental health issues often accompany advancing age, with the lifetime prevalence rate of older adults who have a diagnosis of at least one psychiatric disorder estimated at about 21% (Gum, King-Kallimanis, & Kohn, 2009). In addition, older adults often experience co-morbid psychological problems (Dautovich & Gum, 2011). Specifically, the association between cognition and mood, particularly depression, is a relationship that has been studied extensively in previous literature (Kindermann & Brown, 1997; Kumar, Ajilore, Kepe, Barrio, & Small, 2008; Lockwood, Alexopoulos, & Kakuma, 2008). However, the role of sleep as a mediating variable between cognition and depression is an area within the literature that has received less attention. Given the natural links between depressive symptoms and sleep, and between sleep and cognitive performance, examination of sleep as a mediator of the depression-cognition association is warranted.

The overall objective of the study was to examine sleep quality as a mediator of the

association between depressive symptomatology and cognitive performance in a nationally representative sample of older adults. First, research on the constructs of cognition, depression, and sleep will be presented individually, followed by a review of research on the associations between these constructs.

Cognition

Cognition is broadly defined as a variety of mental processes, which include attending, remembering, and reasoning, in addition to the subject matter of the processes (i.e., concepts and memories; American Psychological Association, 2014). Cognition can also be broken down into various domains, such as long-term memory, which includes semantic memory, working memory, and short-term memory, as well as language, attention, psychomotor processing speed, and executive functioning (AARP, 2014; Manin & Ducharme, 2010). Declarative memory is often called explicit memory and is defined as consciously being aware, deliberately recalling events, dates, objects, facts, and general participation in life (Manin & Ducharme, 2010). In addition, attention can be broken down into three phases: simple, divided, and sustained attention, and is known to vary with age, IQ level, novelty, and complexity (Manin & Ducharme, 2010). Psychomotor processing speed refers to an individual's ability to process information and can be different depending on age and IQ (Mannin & Ducharme, 2010). Executive functioning involves volition, planning purposive action, and effective performance (Lezak, Howieson, & Loring, 2004). For instance, problem solving, abstraction, multitasking, planning, conceptualization, sequencing, and responding to feedback are each examples of executive functioning (Mannin & Ducharme, 2010). The current study focused on working memory, quantitative reasoning, semantic memory, short-term memory, processing speed, long-term memory, and initiation and perseveration, which are the areas of cognition directly measured by

the cognitive assessment tool used in this study.

It is common for older adults to experience various changes in both neuropsychological functioning and cognition as they age (Mannin & Ducharme, 2010). Furthermore, cognition is often impaired at a high rate in this segment of the population, with estimates of impairment ranging from 17% to 36% (Koenig & Blazer, 1992). Cognitive functioning is also known to continue to decline with advancing age (Aartsen, Smits, van Tilburg, & Knipscheer, 2002). For instance, cognitive deficits can begin after mid-life, but frequently occur after age 70 (Aartsen et al., 2002). In addition, with increasing age, the brain experiences various losses, such as decreases in both gray matter and white matter (Potter, Koenig, & Blazer, 1992), deterioration of synapses, changes in neurochemistry, and a decline in blood flow (Cabeza, 2001; Raz, 2000).

In addition to changes in global cognitive functioning, previous research also suggests that between 25% and 50% of older adults experience memory issues (Jonker, Geerlings, & Schmand, 2000). This, in turn, causes problems with completing memory tasks for older compared to younger adults (Craik & Salthouse, 2000), such as those that require the use of working memory (Salthouse, 1996; Schaie, 2005). Due to the aforementioned brain alterations, older adults often experience diminished performance compared to younger adults on various cognitive tasks, such as tasks that require perception and attention (Craik & Salthouse, 2000), processing speed, inductive reasoning, spatial orientation, and word fluency (Salthouse, 1996; Schaie, 2005). Moreover, decreases in cognitive functioning can result in various issues for older adults, such as a loss of autonomy and decreased personal comfort (Aartsen, 2002). Furthermore, cognitive impairment, especially when it is concomitant with depression increases older adults' risk threefold for transitioning to Alzheimer's disease when compared to same-age healthy peers (Alexopoulos, Meyers, Young, Mattis, & Kakuma, 1993; Devanand, Sano, & Tang, 1996;

Devanand, Pelton, & Marston, 2003).

Depression

Depression is an important construct to focus on among the older adult population, and especially within the context of the study, because depressive symptoms can impact cognitive performance. According to the World Health Organization, major depression is considered the 4th leading cause of disease (World Health Organization, 2011). Depression can result in feelings of sadness, problems with sleep, appetite, thought processes, concentration, and energy (Potter & Steffens, 2007). In addition, as defined by the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5),* depression occurs when an individual meets at least five of nine symptoms on a daily basis (or almost daily) that significantly impair functioning in various life domains, with at least one symptom related to dysphoria or anhedonia, and others associated with the following: 1) significant weight loss, weight gain, or appetite change, 2) insomnia or hypersomnia, 3) psychomotor agitation or retardation, 4) loss of energy or fatigue, 5) feelings of worthlessness, or excessive or inappropriate guilt, 6) decreased ability to think or concentrate, or indecisiveness, 7) recurrent suicidal thoughts or attempts, or plans to commit suicide (American Psychiatric Association, 2013).

Depressive symptoms are common in older adults and can often have debilitating consequences (Reynolds, Haley, & Kolzlenko, 2008), such as increases in health care costs, suicide risk, morbidity, and mortality (Vieira, Brown, & Raue, 2014). A review that included 146 articles found that major depression among older adults ranges from 0.9% to 42%, and depressive symptoms range between 7.2% and 49% (Djernes, 2006), Additionally, sub-threshold depression is between 10% and 15% for this segment of the population (Gum, King-Kallimanis, & Kohn, 2009; Xavier et al., 2002). Moreover, depression affects older women more often than

older men (Djernes, 2006), with women between 1.3 to 3.4 times as likely to experience depression compared to men (Gostynski, Ajdacic-Gross, Gutwiller, Michel, & Herman, 2002; Roberts, Kaplan, Shema, & Strawbridge, 1997; Schoevers, Beekman, Deeg, Jonker, & van Tilburg, 2003). Furthermore, the prevalence rates of depression among older adults differs from one setting to another, in that it is frequently higher in inpatient settings as opposed to outpatients settings (Lichtenberg, 2010).

Depression can be difficult to assess in older adults for various reasons. For instance, it is important to consider how depression is manifested in this segment of the population, the co-occurrence of physical and mental health issues, as well as alterations in cognition due to age (Edelstein, Drozdick, & Ciliberti, 2010). In addition to examining depression in isolation, it is also important to examine consequences of depressive symptoms, such as poor sleep and effects on cognition.

Sleep

Understanding sleep quality as mediator of the association between depressive symptoms and cognitive performance in a nationally representative sample of older adults was the study's overall objective. Therefore, it is important to identify the function sleep serves for this segment of the population, to operationally define sleep, and to recognize how it is experienced among older adults. Sleep serves an important role, because it contributes to overall quality of life as well as to immune system functioning, appetite regulation, and as it relates to this study, is associated with cognitive performance (i.e., memory consolidation, concentration, decision-making abilities) and affect (i.e., how we feel each day; National Sleep Foundation, 2014). Sleep is comprised of stages 1 through 3 (National Sleep Foundation, 2014). Stage 1 consists of light sleep and is analogous to a state of not being fully awake and starting to fall asleep. During stage

2 of sleep, when sleep onset occurs, an individual experiences a drop in body temperature and disengagement from his or her environment; however, there are no changes in breathing or heart rate while in this stage (National Sleep Foundation, 2014). Stage 3, known as slow-wave sleep, is the deepest and most restorative period of sleep, where an individual experiences slowed breathing, relaxed muscles, decreased blood pressure, tissue growth and repair, restored energy, a release of hormones (i.e., growth hormone), and enhanced blood supply to muscles (National Sleep Foundation, 2014).

Moreover, stages 1 through 3 are classified as non-rapid eye movement sleep (NREM), and persons typically spend approximately 75% of their night in these stages (National Sleep Foundation, 2014). Rapid eye-movement (REM) sleep, which sequentially follows NREM, comprises about 25% of individuals' nightly sleep and provides both energy to the brain and the body (National Sleep Foundation, 2014). REM sleep is characterized by changes in eye movements, in which eyes are known to dart back and forth (National Sleep Foundation, 2014). In addition, during REM sleep, persons experience a relaxed body posture, where muscles are immobilized; however, the brain remains active and dreaming frequently occurs (National Sleep Foundation, 2014). Furthermore, the REM stage is known as the "paradoxical sleep" stage, because brain activity is similar to that of an individual who is awake, but the rest of the body remains in a paralyzed state (Siegel, Kryger, Roth, & Dement, 2010).

Regarding the sleep of older adults, NREM stage 1 is the particular stage where older adults spend approximately 18% of their total sleep time (Moser et al., 2009). In addition, older adults spend about 48% of their total sleep time in NREM stage 2 and approximately 16% of their total sleep time in NREM stage 3 (Moser et al., 2009). Moreover, compared to younger adult counterparts, older adults (age 60 and above) sleep, on average, 6.5 hours per day, while

younger adults sleep between 7 and 8 hours daily (Rajput & Bromley, 1999). According to Moser and colleagues (2009), the REM stage of sleep is where older adults spend about 18% of their total sleep time. Past research suggests that with age, sleep patterns undergo various changes, such as a decreased amount of time spent in SWS and REM sleep, in addition to a reduced amount of total sleep time (Ohayon, Carskadon, Guilleminault, & Vitiello, 2004; Pace-Schott & Spencer, 2011; Wolkove, Elkholy, Baltzan, & Palayew, 2007). In addition, sleep efficiency, which is defined as the percentage of time in bed that is actually spent sleeping, also decreases with age (specifically after age 60; Ohayon et al. 2004). Moreover, older adults often experience difficulty initiating sleep, more fragmented sleep (Ohayon et al., 2004; Pace-Schott & Spencer, 2011; Wolkove et al., 2007), and go to sleep earlier at night and awaken earlier in the morning compared to younger adults (Wolkove et al., 2007).

As alluded to above, as adults age, they often experience an increase in sleep problems (Dautovich & Gum, 2011). For instance, a study by Foley and colleagues (1995) revealed that approximately 57% of community-dwelling older adults experience sleep disturbances. In addition, other more recent estimates of sleep problems among community-dwelling older adults are similar, and suggest that around 60% of older adults experience sleep disturbances (National Sleep Foundation, 2002; Ohayon, 2002). Moreover, other research by Foley and colleagues (1995) suggests that half of older adults specifically experience trouble initiating and maintaining sleep (Foley et al., 1995). Importantly, poor sleep is not an inevitable consequence of aging and is likely multifactorial in origin (Fragoso & Gill, 2007; Vitiello, 2007). Various factors contribute to older adults experiencing sleep issues, such as fluctuations in circadian rhythms (Crowley, 2011), psychosocial changes that occur with age (Castro et al., 2009; Morgan, 2003), and older adults experiencing more chronic medical conditions as they age (Foley, Ancoli-Israel,

Britz, & Walsh, 2004; Vitiello, Moe, & Prinz, 2002).

Previous research suggests that insomnia is the most frequently occurring sleep problem among older adults and affects women at a greater rate than men; prevalence rates for insomnia among this segment of the population range from 20% to 40% (Foley et al., 1995). In addition, insomnia is one of the most expensive sleep issues affecting older adults (National Institute of Health, 2005), and sleep disturbances, such as insomnia, can have negative implications for older adults, in terms of cognitive issues, a reduction in quality of life, an increase in depressive symptoms, and greater functional limitations (Buysse, Germain, & Moul, 2005; Nebes, Buysse, Halligan, Houck, & Monk, 2009; Newman, Enright, Manolio, Haponik, & Wahl, 1997). Sleep quality (i.e., "sleep duration, sleep latency, number of arousals, and depth/restfulness of sleep)(Buysse et al., 1988)) also suffers with advancing age, even if insomnia is not present, and can result in problems with sleep continuity, depth of sleep, and sleep regularity (Boselli, Parrino, Smerieri, & Terzano, 1998; Nau et al., 2005). As indicated above, because older adults frequently experience sleep disturbances that often result in adverse consequences, it is important to understand the role sleep plays in the association between depressive symptoms and cognitive performance, which is the main goal of the proposed study.

Cognition and Depression

Older adults with depression often experience problems with cognitive performance, (Boone et al., 1995; Bassuk, Berkman, & Wypij, 1998; Yaffe et al., 1999). In fact, comorbidity estimates of depression and cognitive impairment range from 15% to nearly 30% for this segment of the population (Hannienn et al., 1995; Kinderman & Brown, 1997).

Specifically, among older adults, both memory complaints and concentration problems are common symptoms of depression (Butters et al., 2004; Potter, 2007). As a result, it is not

surprising that depression is often associated with various deficits in neuropsychological functioning, such as problems with executive functioning (Boone et al., 1995; Beats, Sahakian, & Levy, 1996) processing speed (Nebes et al., 2000) and memory (Austin et al., 1999; Beats, Sahakian, & Levy, 1996). Moreover, problems with cognitive functioning often occur more frequently with older adults that have experienced late-onset depression. Similarly, concerning memory problems, older adults that received a depression diagnosis earlier in life often have worse issues with memory (Rapp et al., 2005).

Moreover, co-morbid depression and cognitive impairment is problematic for older adults, especially concerning completing neuropsychological tasks, involving executive functioning, memory (Boone et al., 1995; Beats et al., 1996), and processing speed (Nebes et al., 2000), which are domains that the proposed study will focus on. It is also important to focus on the co-occurrence of cognitive problems and depressive symptoms, because having the two concomitantly increases older adults' risk of developing Alzheimer's disease (AD; Alexopoulos, 2005; Schweitzer et al., 2002). In fact, approximately 40% of older adults in the aforementioned situation develop AD between three and five years (Alexopoulos, 2005; Schweitzer et al., 2002). Furthermore, having both of the aforementioned problems is often associated with negative outcomes related to functional status, physical health, as well as mortality (Mehta et al., 2003).

Depression and Sleep

Lack of sleep has been negatively associated with mood disturbances as identified in a meta-analytic review (Pilcher & Huffcutt, 1996). Depression is the most common psychiatric disorder that is co-morbid with insomnia (Cho et al., 2002), and prevalence rates of this co-occurrence are approximately 61% (Ohayon & Roth, 2003). A recent review suggests a strong positive association between insomnia and depression, with a greater degree of insomnia more

highly correlated with more severe depression (Manber & Chambers, 2009). Moreover, the presence of depressive symptoms can have a deleterious effect on sleep architecture (Manbar & Chambers, 2009), in that sleep stages are disrupted (Krystal, Thakur, & Roth, 2008), specifically REM sleep and slow-wave sleep (Armitage, 2007).

A major question is whether sleep disturbances precede depressive symptoms or whether the reverse association is true. This is a difficult question to answer due to the bi-directionality of the aforementioned association (Manbar & Chambers, 2009). Past research suggests that insomnia often occurs within the context of depression, as a symptom of the disorder (Cho et al., 2008; McCall et al., 2000). However, more recent research evidence suggests that insomnia often occurs prior to the onset of depression for older adults (Perlis et al., 2006; Manbar & Chambers, 2009). Lastly, previous research studies suggest that having a history of sleep problems often results in depressive symptomatology (Breslau, Roth, Rosenthal, & Andreski, 1996; Ford & Kamerow, 1989).

Sleep issues frequently co-occur with depression among older adults (Dautovich & Gum, 2011). Among older adults, problems with sleep can result in decreases in health functioning as well as increases in mortality risk (Newman, Enright, Manolion, Haponik, & Wahl, 1997; Pollak, Perlick, Linsner, Wenston, & Hsieh, 1990), which is compounded when depression symptomatology is present (Cho et al., 2008). In addition, experiencing sleep issues in early life can often result in late life depression for older adults (Cho et al., 2008). A recent longitudinal study that included community-dwelling older adults age 60 and over found that among older adults with a history of depression, the presence of sleep issues were positively associated with an increased risk of depression recurrence (Cho et al., 2008). Because of the previously noted findings, Cho and colleagues (2008) concluded that sleep disturbances potentially serve as a risk

factor for depression for older adults with a history of depression. As evidenced above, the association between sleep and depression is important to consider among older adults, due to the negative health outcomes that can occur when older adults experience these issues concurrently. Additionally, it is also important to understand how the relationship between sleep and depression predicts cognitive performance in this segment of the population.

Sleep and Cognition

The association between sleep and cognition is not an extensively researched area, especially concerning daytime cognitive performance in older adults (Shekleton, Rogers, & Rajaratnam, 2010). Various studies have been conducted via controlled experimental trials where younger participants were deprived of sleep for at least one day and then received neuropsychological evaluation after either one or two nights of polysomnography to assess their sleep (Binks, Waters, & Hurry, 1999; Cain, Silva, Chang, Ronda, & Duffy, 2011; Drummond et al., 1999; Drummond et al., 2000; Harrison & Horne 1997, 1999; Horne, 1988; May & Kline, 1987; Pace-Schott et al. 2009). Results from the aforementioned studies are mixed and indicate that when participants were sleep deprived they sometimes experienced problems with either all (Drummond et al., 1999; Drummond et al., 2000; Harrison & Horne 1997, 1999; Horne, 1988), some (Cain et al., 2011; May & Kline, 1987), or no (Binks et al., 1999; Pace-Schott et al. 2009) measures of cognition, including, executive functioning and processing speed. Moreover, results from experimental studies within this area suggest that when compared to their younger adult counterparts, older adults performed worse on tests related to vigilance, visual search, reaction times, word detection, addition, anagrams, and object uses, after being deprived of sleep for two nights (Webb, 1985; Webb & Levy, 1982).

Limited research has been conducted in the area of sleep and cognition in older adults

using naturalistic approaches (McCrae, Vatthauer, Dzierzewski, & Marsiske, 2012). One study investigated the association among habitual sleep, reasoning, and processing speed with an older adult sample who had sleep complaints (McCrae et al., 2012). The authors found that processing speed and average nighttime awakening were correlated, but older adults' reasoning abilities were unrelated to sleep fragmentation and total sleep time (McCrae et al., 2012). Moreover, McCrae and colleagues (2012) discovered that increased time spent awake during the night was associated with older adults demonstrating better performance on the symbol digit task. Previous research suggests that executive functioning is the aspect of cognition most likely to undergo changes when sleep disturbances arise for older adults (Altena, Van Der Werf, Strijers, & Someren, 2008). The current study expanded on previously conducted research by examining to what extent sleep quality underlies the association between depressive symptoms and older adults' performance on neuropsychological tests assessing cognitive performance.

Aims of the Current Study

Previous research has investigated associations between cognition and depression, depression and sleep, and sleep and cognition among older adults. However, there exists a paucity of research examining how sleep plays a role in the association between depression and cognition in this segment of the population. As a result, the first aim of the study was to examine the associations between depressive symptomatology and cognitive performance among community-dwelling adults aged 65 and over. Next, a second aim of this study was to investigate global sleep quality as a mediator of cognitive performance and depressive symptomatology. I hypothesized that the presence of depressive symptomatology would be positively associated with worse cognitive performance. In particular, participants who scored higher on the Center for Epidemiological Depression Scale (CES-D) would demonstrate worse cognitive performance, as

evidenced by lower scores on the Brief Test of Adult Cognition by Telephone (BTACT). In addition, I hypothesized that global sleep quality, as measured by the Pittsburgh Sleep Quality Index (PSQI), would serve as a mediating variable between depressive symptomatology and cognitive performance among older adults. Specifically, I posited that participants with greater depressive symptoms would show poorer overall sleep quality, and, in turn, would demonstrate worse cognitive performance.

CHAPTER 2

METHODOLOGY

Participant Characteristics

This study included individuals age 65 and over. Our sample was comprised of individuals from the Midlife in the United States Project II (MIDUS II), $N = 256$, $M = 71.84$, $SD = 5.40$, Males = 43.8%, Females = 56.3%, which occurred from 2004 to 2009 and was a longitudinal follow-up of MIDUS I (Ryff et al., 2012).

Procedure

In particular, this study used data from the follow-up data collection period from MIDUS I, specifically the MIDUS II Cognitive Project (Project 3), which took place between 2004 and 2006 (Ryff & Lachman, 2013), and the MIDUS II Biomarker Project (Project 4), which occurred from 2004 to 2009 (Ryff, Seeman, & Weinstein, 2013). The MIDUS I Project was initially conducted from 1994 to 1995 by the MacArthur Research Network and included a national survey of approximately 7,000 Americans aged 25 to 74 (Brim et al., 2011). The goal of the aforementioned project was to gain an understanding of how behavioral, psychological, and social factors influence mental and physical health and whether or not age related differences are present (Brim et al., 2011). MIDUS II contained five projects and served as a longitudinal follow-up to MIDUS I and included a Cognitive Project (Project 3) and a Biomarker Project (Project 4) (Ryff et al., 2012), which are the two projects of interest for this study. Data from participants who completed both the BTACT and the CES-D from the Cognitive Project and the PSQI from Biomarker Project's datasets were included in this study.

The Cognitive Project was conducted in order to describe the quality and breadth of cognitive performance during midlife in comparison to persons of older ages (Ryff & Lachman, 2013). In addition, the aforementioned project examined the association amongst various biopsychosocial factors, such as socioeconomic status, health status, health-promoting behaviors, metabolic and cardiovascular biomarkers, depression, personality, control beliefs, stressful life events, in addition to individual differences in cognitive functioning (Ryff & Lachman, 2013). Cognitive testing occurred via the Brief Test of Adult Cognition by Telephone (BTACT), and the BTACT had an 86% response rate for the MIDUS-II Project (Ryff & Lachman, 2013). The BTACT composite score for the complete sample for persons age 65 and over was used as the outcome variable for this study. In addition, the self-report data of the complete sample from participants aged 65 and over from the Center for Epidemiologic Studies Depression Scale (CES-D) total score served as the independent variable of this study.

The Biomarker Project for MIDUS II was conducted with 1,255 participants, and data was collected at research centers at UCLA, University of Wisconsin, and Georgetown University (Ryff, Seeman, & Weinstein, 2013). The variable of interest from this project was the self-report data from the Pittsburg Sleep Quality Index (PSQI) global score (i.e., the mediating variable) from participants aged 65 and over.

Measures

Center for Epidemiologic Depression Scale. The Center for Epidemiologic Depression Scale (CES-D) is a structured self-report measure for depressive symptomatology for use in the general population (Radloff, 1977) and was completed by phone. The CES-D is a short scale comprised of 20 symptoms related to depression and was developed to measure present levels of depressive symptoms, in particular the affective component (i.e., depressed mood), over the

course of the past week (Radloff, 1977). Participants were prompted with the following directions, “Below is a list of ways you might have felt or behaved. Please tell me how often you have felt this way during the past week.” There are four response choices, which include “rarely or none of the time (less than 1 day),” “some of a little of the time (1-2 days),” “occasionally or a moderate amount of time (3-4 days),” to “most or all of the time (5-7 days).” Moreover, “I felt that everything I did was an effort,” and “I had crying spells,” are two examples of the questions provided on the CES-D.

The CES-D is not intended to be used to diagnose depression at the time of clinical intake or to determine the severity of depressive symptoms throughout the treatment period (Radloff, 1977). Concerning validity, the CES-D has strong associations with other self-report measures of depression as well with clinical ratings of depression (Radloff, 1977). In addition, the CES-D has good internal consistency for both the coefficient alpha (.85) regarding the general population and the Spearman-Brown (.90) split-halves method concerning patient samples (Nunnally, 1967). Regarding reliability, the CES-D has adequate test-retest reliability ranging from .51 to .67 (Radloff, 1977).

Pittsburg Sleep Quality Index. The Pittsburg Sleep Quality Index (PSQI) is a self-report measure that evaluates sleep quality, during the past month (Buysse, Reynolds, Monk, Berman, & Kupfer, 1988) and was completed by participants at home prior to their clinic visit or at the clinic before their visit occurred. In addition, the PSQI was developed with various goals in mind, which included creating a measure for sleep quality that is standardized, reliable, and valid and an instrument that effectively differentiates between “good” and “poor” sleepers (Buysse et al., 1988). Moreover, the PSQI was developed to provide a brief but easily interpretable instrument for both clinicians and researchers that successfully assess multiple sleep issues

affecting sleep quality (Buysse et al., 1988).

The PSQI directly measures sleep quality and sleep disturbances over a one-month duration. The PSQI includes 19 items, which assess sleep quality. Respondents are instructed to answer all questions based on usual sleep habits during the past month, with particular emphasis on providing answers based on the majority of days and night. Questions are open-ended such as, "During the past month, what time have you usually gotten up in the morning?" and also require participants to rate their sleep behaviors such as "Wake up in the middle of the night or early morning" on a scale from "not during the past month," "less than once a week," "once or twice a week," to "three or more times a week."

The aforementioned 19 items on the PSQI comprise seven component scores (with equivalent weightings on a 0 to 3 scale) related to: 1) subjective sleep quality, 2) sleep latency, 3) sleep duration, 4) habitual sleep efficiency, 5) sleep disturbances, 6) using sleep medication, and 7) daytime dysfunction. Summing together the aforementioned component scores generates a global score ranging from 0 to 21, with higher scores indicating poorer sleep quality. The Global Sleep Quality score was used as the measure of sleep quality in the present study.

The PSQI has good internal homogeneity. Specifically the PSQI has a reliability coefficient of $\alpha = .83$ (Cronbach's alpha) for the seven component scales, which means that the PSQI has high internal consistency (Buysse et al., 1988). In particular, concerning habitual sleep efficiency and subjective sleep quality, large component-total correlation coefficients were discovered (i.e., $r = 76$ for both habitual sleep efficiency and subjective sleep quality; Buysse et al., 1988). Regarding test-retest reliability, the Pearson product-moment correlation for time one of measurement and time two of measurement for global PSQI scores was $r = .85$, $p < 0.001$. In terms of validity, the PSQI is able to differentiate good and poor sleepers comparable to

laboratory and clinical diagnosis (Buysse et al., 1988).

Brief Test of Adult Cognition by Telephone. The Brief Test of Adult Cognition by Telephone (BTACT) takes approximately 20 minutes to administer by phone and was designed to investigate the domains of cognitive functioning that are frequently affected by aging, such as episodic verbal memory (Craik & Anderson, 1999), working memory span and executive function (Baddeley, 1986; 1996), reasoning (Miller & Lachman, 2000; Schaie, 1996), and speed of processing (Meyerson, Hale, Wagstaff, Poon, & Smith, 1990; Salthouse, 1996; Verhaeghen & Salthouse, 1997). In addition, The BTACT was developed as a means to provide a brief and reliable test battery that can be easily administered by telephone as a method to assess individual variations in cognition in middle-aged and older adults (Tun & Lachman, 2005). The BTACT is a comprehensive measure that uses the following tests to measure cognitive functioning: 1) Word List Immediate Recall, 2) Digits Backward, 3) Category Fluency, 4) Number Series, 5) Backward Counting, 6) Word List Delayed Recall, and the 7) Stop-Go-Stop Task (Tun & Lachman, 2005).

Participants are instructed to complete exercises that require them to make decisions about words and numbers, and examiners are not permitted to repeat any items that are administered (Lachman & Tun, 2012). Regarding both World List Immediate Recall and Word List Delayed Recall, the total number of correct responses is recorded with a possible range of 0 to 15 (Lachman & Tun, 2012). Concerning Digits Backward, the score is determined based on the highest number of digits a participant reaches (score is either 0 or ranges from 2-8; Lachman & Tun, 2012). In addition, for the Category Fluency Task, the total number of correct responses is recorded, and the same procedure is used for the Number Series Task (score ranges from 0-5: Lachman & Tun, 2012). The scoring for the Backward Counting Task is less straightforward and

is determined by adding together the last number a participant reaches with the number of errors and subtracting it from 100 (i.e., 100 – [last number reached + number of errors; Lachman & Tun, 2012]). For the Stop-Go-Stop Task, participants receive a score for the normal condition (ranging from 0-20), the reverse condition (ranging from 0-20), and the experimental condition (ranging from 0-32; Lachman & Tun, 2012). The total score is decided by adding together all of the individual scores on the different tests that comprise the BTACT.

A validation study of the BTACT indicated that the individual tests that comprise the BTACT have good psychometric properties (Tun & Lachman, 2005).

Data Analysis Plan

The current study was a secondary data analysis, using data from the second wave of the Midlife in the United States Project (MIDUS II), specifically Projects 3 and 4. The first aim of the study was to examine the associations between depressive symptomatology and cognitive performance among community-dwelling adults aged 65 and over. To accomplish this aim, a hierarchical multiple regression was conducted using the CES-D total as the predictor and cognitive performance as the outcome variable (BTACT composite variable). Selected covariates, such as self-rated health status, gender, and age, were entered in the first step of the hierarchical regression, followed by the CES-D total score in the second step.

In addition, the second aim of this study was to investigate global sleep quality as a mediator of cognitive performance and depressive symptomatology. To accomplish the second aim, which is to test for sleep as a mediator of the depressive symptoms and cognitive functioning association, I followed the recommendations of Hayes (2012). Using the SPSS PROCESS macro designed by Hayes, I conducted a nonparametric bootstrapping procedure to compute a confidence interval around the indirect effect. If zero fell outside of the confidence

interval, mediation was present (Hayes, 2012). The final estimate of the indirect effect was represented by the mean indirect effect computed across 5,000 bootstrap samples. Additionally, the Sobel test of mediation was reported. SPSS version 21 was used for all analyses.

Power calculations using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) showed that for a hierarchical multiple regression analysis with 4 predictors, a sample size of 256 participants is sufficient to predict an R^2 of at least 0.35, at an alpha level of .05, with a power of 1.00.

CHAPTER 3

RESULTS

Sample Characteristics

Descriptive characteristics of the sample are shown in Table 1.

Association Between Depressive Symptomatology and Cognitive Performance

Table 2 shows the associations between selected covariates, depressive symptomatology, and cognitive performance. In step 1, selected covariates were entered and accounted for 9% of the variance in cognitive performance, $R^2 = 0.09$ $F(3, 243) = 8.69$, $p < 0.001$. Age, self-rated health, and gender were significant predictors of cognitive performance. In step 2, depressive symptomatology was a significant addition and this model accounted for 12% of the explained variance of cognitive performance, $R^2 = 0.12$, $F(4, 242) = 8.70$, $p < 0.001$. Moreover, step 2 explained an additional 3% of the variance in cognitive performance beyond the contribution of the covariates, and this was a significant improvement over the previous step, $p < .005$. In the final step of the model, being older and having more depressive symptoms was associated with worse cognitive performance.

Association Between Depressive Symptomatology and Sleep Quality

Table 3 shows the associations between selected covariates, depressive symptomatology, and global sleep quality. In step 1, the entry of selected covariates accounted for 8% of the variance in the sleep outcome, $R^2 = 0.28$, $F(3, 237) = 6.93$, $p < 0.001$. Gender was a significant predictor. The addition of depressive symptomatology significantly improved the model, with step 2 explaining 18% of the variance, $R^2 = 0.43$, $F(4, 236) = 13.04$, $p < 0.001$. Moreover, in step

2, the addition of depressive symptomatology explained an additional 10% of the variance beyond the contribution of the covariates and was a significant improvement over the previous model, $p < .001$. In the final model, being female was associated with worse sleep quality and greater depressive symptomatology was also associated with worse sleep.

Association Between Sleep Quality and Cognitive Performance

Table 4 shows the associations between selected covariates, global sleep quality, and cognitive performance. In step 1, the entry of selected covariates accounted for 10% of the variance in cognitive performance, $R^2 = 0.33$, $F(3, 228) = 9.00$, $p < 0.001$. Age was a significant predictor. In step 2, the addition of global sleep quality explained 10% of the variance, $R^2 = 0.33$, $F(4, 227) = 6.77$, $p < 0.001$ but sleep quality was not a significant predictor, and the addition of step 2 was not a significant improvement over the previous model, $p = .687$. In sum, being older was associated with worse cognitive performance.

Sleep Quality as a Mediator of Depressive Symptomatology and Cognitive Performance Association

After controlling for the selected covariates, sleep quality was not found to be a significant mediator of the depressive symptomatology and cognitive performance association (Percentile 95% CI [.-.01, .01]; Sobel test of mediation: z-score = .41, $p > .05$). Poorer sleep quality did not underlie the association between greater depressive symptomatology and worse cognitive performance.

Table 1

Descriptive Statistics (n = 256)

Variable		Range	% or Mean (*SD*)
age		65 – 84 years	71.84 (5.40)
sex %			
	Male		43.8%
	Female		56.3%
health[a]		0 – 4	1.24 (1.39)
global sleep quality[b]		0 – 17	5.78 (3.35)
depressive symptoms[c]		0 – 27	6.38 (5.86)
cognitive performance[d]		-2.05 – 1.72	.427 (.793)

[a]number of health conditions. [b]Pittsburg Sleep Quality Index. [c]Center for Epidemiologic Studies Depression Scale. [d]Brief Test of Adult Cognition by Telephone.

Table 2

Hierarchical Multiple Regression Analyses Predicting Cognitive Performance by Selected Covariates and Depressive Symptoms (n = 247)

Variable	R^2	ΔR^2	*b*	*SE b*	*b**	*T*	*df*	*p*	CI
Step 1	.31	.10							
age			-.04	.01	-.30	-4.86	243	.000	[-.06, -.03]
gender			.02	.10	.01	.16	243	.871	[-.18, .21]
health[a]			.05	.04	.08	1.35	243	.177	[-.02, .12]
Step 2	.36	.13*							
depressive symptoms[b]			.-.02	.01	-.17	-2.83	242	.005	[-.04, -.01]

Note. *b* refers to unstandardized regression coefficients and *b** refers to standardized regression coefficients.

[a]number of health conditions. [b]Center for Epidemiologic Studies Depression Scale

*$p < .05$.

Table 3

Hierarchical Multiple Regression Analyses Predicting Global Sleep Quality by Selected Covariates and Depressive Symptoms (n = 241)

Variable	R^2	ΔR^2	*b*	*SE b*	*b**	*T*	*df*	*p*	CI
Step 1	.28	.08							
age			.06	.04	.10	1.50	237	.134	[-.02, .14]
gender			1.83	.43	.27	4.30	237	.001	[.99, 2.67]
health[a]			.21	.15	.09	1.39	237	1.66	[-.09 , .51]
Step 2	.43	.18***							
depressive symptoms[b]			.19	.03	.32	5.38	236	.001	[.12, .25]

Note. *b* refers to unstandardized regression coefficients and *b** refers to standardized regression coefficients.

[a]number of health conditions. [b]Center for Epidemiologic Studies Depression Scale

***$p < .001$.

Table 4

Hierarchical Multiple Regression Analyses Predicting Cognitive Performance by Selected Covariates and Global Sleep Quality (n = 232)

Variable	R^2	ΔR^2	*b*	*SE b*	*b**	*T*	*df*	*p*	CI
Step 1	.33	.11							
age			-.05	.01	-.32	-4.99	228	.001	[-.06, -.03]
gender			.02	.10	.01	.17	228	.866	[-.18, .21]
health[a]			.04	.04	.07	1.16	228	.249	[-.03 , .11]
Step 2	.43	.11							
global sleep quality[b]			-.01	.02	-.03	-.40	227	.687	[-.04, .02]

Note. *b* refers to unstandardized regression coefficients and *b** refers to standardized regression coefficients.

[a]number of health conditions.. [b]Pittsburg Sleep Quality Index

CHAPTER 4

DISCUSSION

Overall, the results of the study support aim 1 but not aim 2 of the study. The results pertaining to aim 1 will be discussed first, followed by a discussion of the mediation results (aim 2), the depressive symptomatology and sleep association, and ending with a discussion of limitations, implications, and future research directions.

Depressive Symptoms Predicting Cognitive Performance

Within the study sample, depressive symptomatology was predictive of cognitive performance. This finding is in line with previous research that suggests that older adults with depression often experience issues with cognitive performance (Boone et al., 1995; Bassuk, Berkman, & Wypij, 1998; Yaffe et al., 1999). Previous research estimates that depression and cognitive impairment occur concomitantly between 15% and 30% for this segment of the population (Hannienn et al., 1995; Kinderman & Brown, 1997). Additionally, results from the present study suggest that within older adults from this sample, older age is associated with worse cognitive performance on the composite measure of the Brief Test of Adult Cognition by Telephone. This finding supports previous research that suggests that older adults experience various changes in both neuropsychological functioning and cognition as they age (Mannin & Ducharme, 2010). This may be due, in part, to the brain experiencing various losses with age, including a decrease in both gray matter and white matter (Potter et al., 1992), deterioration of synapses, changes in neurochemistry, and a decline in blood flow (Cabeza, 2001; Raz, 2000). As a result, cognitive functioning decreases as age increases (Aartsen et al., 2002). Lastly, gender

was not a significant predictor of cognitive performance, suggesting that older men and older women experienced similar cognitive performance in this sample. The results from this study are important to consider, because they add to existing literature on depression and cognition, as the study's sample was comprised of a nationally representative group of older adults. As such, the present results confirm previous findings in a nationally representative sample of older adults.

Sleep Quality as a Mediator of the Depressive Symptoms-Cognition Association

Concerning sleep quality as a mediator between depressive symptomatology and cognitive performance, results indicated that poor sleep quality does not underlie the depressive symptoms and cognitive performance association. In particular, the regression analysis with sleep quality predicting cognitive performance showed that poor sleep did not necessarily translate into worse cognitive performance for older adults in this sample. A possible explanation for this finding is that the present sample was comprised of mostly healthy older adults, which suggests a decreased amount of health issues that could negatively affect sleep quality. Concerning sleep, the average score on the PSQI was a 5.78 and the range was 0 to 17, which demonstrates that the sample did experience sleep issues (typical cut-off for poor sleepers is a score of 5), but most participants did not have poor global sleep quality overall. Consequently, the range of this sample was restricted in that most individuals scored on the lower end of the PSQI, and, as a result, a wide range of sleepers were not present in this study, which might explain why a mediation was not present. For instance, if a wider range of scores on the PSQI was observed within this sample, there might have been enough participants who experienced poor global sleep quality to help contribute to a mediation effect. Furthermore, the above-mentioned finding might have occurred due to the fact that there is already a significant

association between having more depressive symptomatology and worse cognitive performance; therefore, sleep quality is not needed to help indirectly explain this association.

Depressive Symptoms Predicting Sleep Quality

Within the study's sample, depressive symptomatology is associated with poorer global sleep quality. As the DSM-5 criteria for depression has a specific criterion that focuses on sleep, it is not surprising that having more depressive symptoms was associated with worse sleep quality. However, it is important to be mindful that, on average, the present sample scored a 6.38 on the CES-D, which is not indicative of depression. Past research indicates that depression affects older women more often than older men (Djernes, 2006) and sleep disturbances are also experienced more frequently by older women (Zhang & Wing, 2006), which is in line with the results form the current study which suggest that females had worse sleep and more symptoms of depression, and having greater depressive symptomatology was associated with worse sleep for them.

Limitations

The current study does have limitations. For instance, both the PSQI and CES-D are screening instruments, and, as a result, their primary purposes are to identify symptoms as opposed to being utilized for the purpose of diagnoses. In addition, the BTACT is also a screening instrument, and similar to the PSQI and CES-D, it is used as a screening instrument as opposed to a diagnostic measure for cognitive impairment. Moreover, the screening instruments used in the study limit the ability to capture the above-mentioned constructs of interest in entirety (e.g., depression, insomnia, and cognitive impairment). However, the aforementioned screening instruments do have clinical utility in that they can help clinicians identify individuals who might be at risk of developing insomnia, depression, or cognitive impairment. A further limitation of

the study is that the sample is comprised of primarily healthy older adults; therefore, these individuals are less prone to sleep disturbances, symptoms of depression, and cognitive errors than same-aged peers with worse health. As a result, the current findings are not generalizable to persons who experience a great deal of sleep disturbances, elevated levels of depression, severe cognitive impairment, or those with a lot of health issues. Furthermore, the sample consisted of community-dwelling older adults who were relatively healthy (i.e., mean number of health conditions =1.24), therefore the results of this study are not generalizable to older adults who experience a large number of health problems.

Implications

This study has multiple implications. For instance, it replicates previous findings regarding the association between depressive symptomatology and cognitive performance in a nationally representative sample of older adults. Based on these findings, it could be useful to intervene early with older adults experiencing depressive symptoms, in order to prevent these symptoms from adversely contributing to cognitive performance. In addition, regarding clinical utility, the results from this study suggest that it might be beneficial for clinicians to screen for depressive symptoms if an older adult client is having issues with cognitive performance, in order to gauge whether these depressive symptoms are associated with declines in cognitive performance.

Future Research Directions

Future research should aim to use a more heterogeneous sample of older adults, specifically as it relates to overall health and age, in order to determine if there exist differences in cognitive functioning between younger adults and older adults. Specifically, it might be interesting to investigate whether younger adults with multiple health issues exhibit similar

cognitive performance compared to older adults with the same number of health problems. Additionally, it might be useful to investigate the interrelationships between depressive symptomatology, sleep quality, and cognitive functioning in a younger adult sample, in order to compare this younger segment of the population's cognitive functioning to that of an older adult sample. Moreover, because this study focused only on general cognitive performance of this sample of older adults, it would be worthwhile to look at individual domains of cognitive functioning (i.e., executive functioning, processing speed) among older adults in future studies. Because the measures used in this study did not ask participants to reflect upon the same time period, it may also be helpful for future research to have participants report on the same period of time for each construct being measured. Likewise, because this study was cross-sectional in nature, measuring depressive symptomatology, cognitive performance, and global sleep quality longitudinally might add novel information to existing literature. Furthermore, due to the lack of significant findings for sleep as a mediator in the depressive symptomatology and cognitive functioning association, future research may benefit from the use of alternative measures of sleep, such as actigraphy or sleep diaries, as a means to help detect the presence of a mediation effect.

Conclusion

Overall, depressive symptoms were associated with decreased cognitive performance among the older adults in this study. However, global sleep quality did not mediate the association between depressive symptomatology and cognitive performance. Future research is needed to further investigate the role of sleep in the association between depression and cognitive performance in older adults.

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