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Sleep, Depressive Symptoms and Cognition in Older Adults and Caregivers of Persons with Dementia

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Sleep, Depressive Symptoms and Cognition in Older Adults

and Caregivers of Persons with Dementia

by

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Keywords: crystallized abilities, fluid abilities, gerontology, insomnia, measurement invariance

Dedication

To my mom, Huelin Brewster.

Thank you is not enough.

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Abstract

Caregivers of persons with dementia, who are often older adults, report sleep disturbance, high rates of depressive symptoms and may be at risk for impaired cognition. This dissertation examined sleep, depressive symptoms, and cognition in older adults and caregivers of persons with dementia. The aims of the review of literature were to understand, in community dwelling adults 60 years and older, the relationships among sleep parameters (sleep onset latency, wake after sleep onset, sleep efficiency, total sleep time, and general sleep complaints), and the domains of cognition (Executive Function, Attention, Episodic Memory, Working Memory, Processing Speed), and global cognition. Based on the findings, the research on the association of subjective sleep parameters and cognition is inconclusive and there is insufficient evidence to confirm or deny the existence of a relationship between objective sleep parameters and cognition. The methods section examined whether in adults 60 years and older, Radloff's postulated 4-factor structure replicates across Afro-Caribbean Americans, African-Americans, Hispanic-Americans, and European-Americans and determine whether there is evidence for measurement invariance across the four ethnic groups in their responses to the Center for Epidemiologic Depression Scale (CES-D) statements. Radloff's postulated 4-factor model fit the data adequately and the results suggest that there is evidence for configural and partial metric invariance. The final section examined the relationships among subjective sleep parameters (Sleep Onset Latency, Wake After Sleep Onset, Total Sleep Time, Time in Bed, Sleep Efficiency, Sleep Quality), depressive symptoms, and, crystallized, fluid and total cognition in caregivers of persons with dementia with poor sleep. Based on the findings, depressive symptoms also did not mediate the ability of the sleep parameters to predict cognitive performance. With the knowledge that there are potential associations among sleep parameters, depressive symptoms and cognition in caregivers, healthcare providers should collect baseline assessments on sleep, depressive symptoms and cognition from caregivers and monitor them on an ongoing basis to identify changes and intervene in a timely manner. More research studies incorporating measures to capture sleep variability and similar cognitive measures, are needed to clarify the relationships both in older adults and caregivers of persons with dementia.

Keywords: crystallized abilities, fluid abilities, gerontology, insomnia, measurement invariance

Overview of Dissertation

Introduction

In the United States of America, there are approximately 15 million informal caregivers for someone with Alzheimer's disease and dementia (National Alliance for Caregiving and American Association of Retired Persons [AARP], 2009; Family Caregiver Alliance, 2004*;* Levine, Halper, Peist, & Gould, 2010). In 2010, an estimated 65.7 million persons with dementia received about 17 billion hours of unpaid care valued at an estimated $202 billion (Alzheimer's Association, 2011; National Alliance for Caregiving and AARP, 2009). With the population of older adults expected to be about 70 million by 2030 (Family Caregiving Alliance, 2004), more persons will take on the role of an informal caregiver. Although this responsibility is cost-effective for society and beneficial to the person with dementia, caregivers experience many negative consequences. According to the Alzheimer's Association (2011), in 2010, caregivers had additional health costs of almost 8 billion dollars due to their caregiving status. In addition, the Alzheimer's Association points out that close to two thirds of caregivers report high levels of stress and one third experience depressive symptoms. Research has also shown that caregivers have more sleep problems (Beaudreau et al., 2008; Castro et al., 2009; McCurry, Logsdon, Teri, & Vitiello, 2007), greater levels of depression (Beaudreau et al., 2008; Fonareva, Amen, Zajdel, Ellingson, & Oken, 2011; Vitaliano et al., 2009), and more cognitive impairment than non-caregivers (Caswell et al., 2003; Mackenzie, Wiprzycka, Hasher, & Goldstein, 2009; Vitaliano et al., 2009).

Sleep

During sleep, there is a reduction in response to stimuli and movement. This state is reversible and is driven by circadian, homeostatic, and ultradian mechanisms (Roehrs, 2000). Circadian mechanisms are biological rhythms that regulate the functions of the body such as hormone secretion, core body temperature, and the sleep-wake cycle (Ancoli-Israel & Ayalon, 2006; Roehrs, 2000). The homeostatic process is governed by the individual's previous sleep and wake times in that a reduction in sleep time the previous night shortens the sleep latency the following night while an increase in the sleep time the previous night increases the sleep latency the following night (Roehrs, 2000). The ultradian rhythm is the 90 to 120 minutes of both non-rapid eye movement (nREM) and rapid eye movement (REM) sleep that is repeated approximately 3 to 6 times nightly (Roehrs, 2000).

Sleep patterns start changing in early adulthood and progress steadily across the full continuum of the adult lifespan (Vitiello, 2006). Putilov, Munch, and Cajochen (2013) examined EEG indicators of sleep and concluded that with aging, the sleep-promoting processes weaken while the wake-promoting processes become stronger. This process may not continue indefinitely into older adulthood, as Ohayon, Carskadon, Guilleminault, and Vitiello (2004) suggest that there is a possible plateau and minimal changes in sleep pattern after age 60. These researchers postulate that most of the changes in sleep during aging occur between 19 to 60 years since results from the meta-analysis indicate that sleep parameters like total sleep time, sleep efficiency, percent slow wave sleep, and percent REM decreased between ages 9 and 60; wake after sleep onset, percent stage 1 and percent stage 2 sleep increased and there were no changes in sleep latency and REM latency over the lifetime (Ohayon et al., 2004). Only sleep efficiency showed continued decline after age 60 (Ohayon et al., 2004). However, Vitiello (2006) suggests that these trends may be different for older adults who have concurrent medical disorders, psychiatric illnesses, or sleep-related disorders.

Sleep disturbances encompass difficulty with initiating or maintaining sleep or sleep that is not restorative and results in impairment the following day. Sleep disturbances can be transient, acute, or chronic, and primary or secondary (Kamel & Gammack, 2006; Roehrs, 2000). Transient sleep disturbances last for a few nights; acute sleep disturbances last for less than three to four weeks, and chronic sleep disturbances last for more than 4 weeks (Kamel & Gammack, 2006). Transient and acute sleep disturbances are usually reported by persons without a history of sleep disturbances and are often due to disruptions in sleep schedules, non-conducive sleep environments, or a stressful life experiences (Kamel & Gammack, 2006; Roehrs, 2000). However, acute sleep disturbances can become chronic if they continue for an extended period of time. This is the case for many caregivers; they experience sleep disturbances when they adopt the caregiving role and this role along with the sleep disturbances continue for an extended period of time. Chronic and secondary sleep disturbances are similar in that both are usually secondary to medical or psychiatric conditions, and/or other sleep-related disorders (Roehrs, 2000). Primary insomnia occurs when there is a learned association of physiologic and cognitive arousal with sleep and the sleep environment (Roehrs, 2000). Sleep problems are reported by more than 60 percent of persons with major depression (Ohayon & Roth, 2001).

Depression

According to the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; American Psychiatric Association, 2013), depression is characterized by depressed mood or loss of interest or pleasure in everyday activities for more than 2 weeks which results in impaired social, occupational and/or educational function. Some symptoms of depression include: irritable or depressed mood; loss of interest or pleasure activities once thought pleasurable; reduced appetite or weight change; sleep disturbance, most often insomnia; psychomotor agitation or retardation; decreased energy or fatigue; a sense of worthlessness or guilt; reduced concentration; and./or suicidal thoughts or attempts (APA, 2013). The diagnosis of depression is often made by a healthcare provider after conducting a psychiatric interview; however, there are also instruments that are commonly used in healthcare settings and epidemiological studies to measure depression. One such instrument is the Center of Epidemiologic Studies-Depression Scale (CES-D, Radloff, 1977).

The CES-D is a 20-item, self-report questionnaire that was developed to evaluate symptoms of depression in community populations (Radloff, 1977). The CES-D asks respondents to rate how often over the past week they have experienced 20 symptoms. It is rated on a 4-point scale from “rarely or none of the time” to “most of the time”. CES-D scores range from 0 to 60 with higher scores representing more severe depressive symptoms and a score of 16 or more used as a suggested cut-off for individuals with depression (Radloff, 1977). CES-D scores are usually reported as a total score in the literature; this assumes that the scale is invariant across the participants in the particular study. However, there may be measurement invariance across the factors of the scale and this can lead to incorrect conclusions. The methods paper of my dissertation aims to determine (1) whether in adults 60 years and older, the postulated 4-factor structure by Radloff replicates across Afro-Caribbean Americans, African-Americans, Hispanic-Americans, and European-Americans and (2) whether there is evidence for measurement invariance across the four racial/ethnic groups in their responses to the CES-D statements.

Cognition

Cognition is a higher level function of the brain which includes all of one's mental activities (Slotkin et al., 2012). Cattell (1943) theorized that cognition consists of crystallized and fluid domains. Crystallized abilities are an individual's verbal knowledge and skills. They are heavily influenced by education and cultural exposure, mainly during childhood (Flanagan & Dixon, 2013; Nisbett et al., 2012). During childhood, marked developmental changes are observed in these abilities; they typically continue to improve slightly into middle adulthood and then remain relatively stable thereafter (Flanagan & Dixon, 2013; Nisbett et al., 2012). Language and vocabulary are domains of crystallized cognition. Fluid abilities are used for problem solving and encoding new episodic memories; they are important for adapting to novel situations in everyday life (Flanagan & Dixon, 2013; Nisbett et al., 2012). These abilities improve rapidly during childhood, usually peak in early adulthood, and then decline with age (Bugg, Zook, DeLosh, Davalos, & Davis, 2006; Parkin & Java, 1999). Executive function, processing speed, memory, and attention are domains of fluid cognition.

Theoretical Framework – Does Caring for a Spouse with Dementia Promote Cognitive Decline: A Hypothesis and Proposed Mechanisms

Vitaliano, Murphy, Young, Echeverria, and Borson (2011) conducted a literature review examining why spousal caregivers of persons with dementia may be at higher risk for cognitive problems and decline than non-caregivers. Using a theoretical model of chronic stress, they suggested that there are mediators that may increase the risk of cognitive impairment and dementia in spousal caregivers (Figure 1.1.). They theorized that caregiver stress exposure can influence and is influenced by psychosocial and/or behavioral variables, physiological variables and cognitive impairment and/or dementia. Some of the mediators and contributors to caregiver stress reported by Vitaliano et al. (2011) are modifiable and, as such, can be the targets for research and intervention studies.

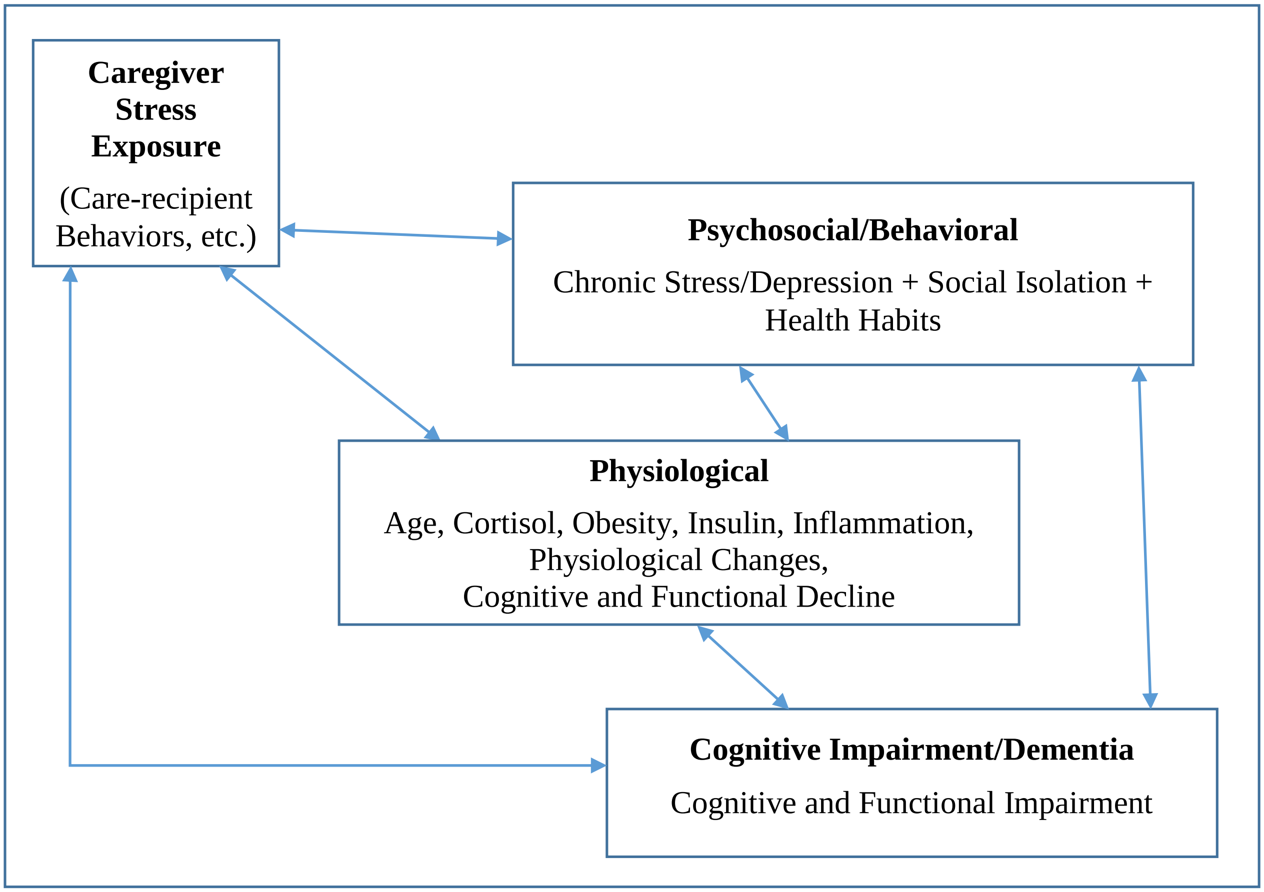

Figure 1.1. *Bidirectional pathways of chronic caregiver stress and cognitive impairment and dementia with psychosocial, behavioral, and physiological intervening variables*

Using this proposed theory, this dissertation will ultimately examine the association among sleep, depressive symptoms, and cognition in caregivers of persons with dementia. While the average age of a caregiver is 48 years, the average age of a caregiver caring for an older adult is 63 years (Family Caregiver Alliance, 2012). Due to the paucity of research examining these variables in caregivers, the first section of the dissertation will explore the relationships among sleep parameters and cognition in community-dwelling older adults and examine what other factors influenced the association between the sleep parameters and cognition.

Caregivers of persons with dementia report poor sleep-wake patterns, higher depressive symptoms and poorer cognition (Beaudreau et al., 2008; Caswell et al., 2003; de Vugt et al, 2006; Rowe et al., 2008; Vitaliano et al., 2009). It is possible that sleep disturbances are associated with poorer cognition and that depressive symptoms influence this association. The third section aims to understand the relationships among sleep, depressive symptoms, and crystallized, fluid and total cognition in caregivers of persons with dementia. It hypothesizes that: poor sleep will be associated with lower crystallized, fluid and total cognition; higher depressive symptoms will be associated with lower crystallized, fluid and total cognition; depressive symptoms will mediate the association between poor sleep and lower crystallized, fluid and total cognition; and depressive symptoms will have a moderating effect between poor sleep and cognition such that caregivers with poor sleep and high depressive symptoms will have worse crystallized, fluid and total cognition.

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Section One: Sleep and Cognition in Community-Dwelling Older Adults: A Review of Literature

Abstract

About half of the older adult population reports sleep problems not related to sleep-related diseases. A large proportion of this population also experience changes in cognition. The purposes of this literature review were to explore what relationships, if any, exist between sleep parameters and the global and domains of cognition, and to determine whether the relationships would persist after controlling for sleep-disordered breathing, depression/ depressive symptoms, and chronic illness. Systematic, computer-aided searches were conducted using multiple sleep and cognitive-related search terms in PUBMED, PsycINFO, and CINAHL. The articles had to include participants who were 60 years and older and living independently in the community. Twenty-four articles were included in the review. The findings were inconsistent across studies in terms of relationships between sleep parameters and cognition. In several of the studies, the relationship appeared to be influenced by depressive symptoms or medical conditions. In older adults without sleep-related disorders, the relationship appears to be mixed between many of the sleep parameters and global cognition. Similarly, a clear pattern does not emerge when evaluating the relationship between the specific sleep parameters and the domains of cognition. As a result, more studies are needed that delve further into examining and clarifying whether a relationship exists among these variables.

Keywords: older adult, cognition, insomnia, sleep efficiency, sleep duration

Introduction

Approximately 50% of older persons report that they experience chronic sleep problems (Vitiello, 2006). Specifically, older individuals have reductions in total sleep time and sleep efficiency along with increases in wake time after falling asleep (Vitiello, 2006). A significant portion of older adults with sleep problems also have co-existing sleep apnea, which also contributes to sleep disturbances, with reported percentages ranging from 29% to 61% (Luyster, Buysse, & Strollo, 2010). These sleep changes have potentially negative consequences since sleep is necessary for healthy brain and bodily function and repair (National Heart, Lung, and Blood Institute, 2012; Shapiro & Flanigan, 1993). Consequently, sleep problems may contribute to inadequate central nervous system restoration (Cricco, Simonsick, & Foley, 2001) with the potential to impair cognition.

Some older adults with sleep disorders exhibit cognitive impairment. For example, researchers have reported that sleep apnea is associated with poorer cognition (Engleman & Joffe, 1999). In one meta-analysis, individuals with obstructive sleep apnea had mild to moderate impairments in the cognitive domains of attention, perception, executive function, vigilance, verbal and visual memory, and verbal fluency (Engleman & Joffe, 1999). In a more recent meta-analysis, Kylstra, Aaronson, Hofman, and Schmand (2013) found that vigilance, attention, executive functioning, and memory were associated with obstructive sleep apnea while there was no association between obstructive sleep apnea and intelligence, verbal functioning, or visual perception

Another factor that may also contribute to an association between poor sleep and changes in cognition is depression. Depression affects approximately 6.5 million older adults (Duckworth, 2009). It is a common cause of sleep problems in this population and is also associated with neurocognitive impairments like slower processing speed and executive dysfunction (Thomas & O'Brien, 2008). However, it is unclear whether these cognitive problems are caused specifically by lack of sleep, depression, or an interaction of the two (Nebes, Buysse, Halligan, Houck, & Monk, 2009).

There are multiple sleep parameters that are examined in the literature and it is important to identify whether any of these are specifically associated with cognition independent of other contributing factors like sleep apnea, depressive symptoms, and other chronic illnesses. Therefore, the research questions for this exploratory review were:

1. What are the relationships between general and specific elements of sleep and the global and specific domains of cognition in community-dwelling adults?
2. Would the relationships remain after controlling for sleep apnea, depression/depressive symptoms, and chronic illness?

Overview of the Measurement of Sleep and Cognition

Sleep. Sleep is measured both objectively and subjectively. Objective sleep is assessed using polysomnography (PSG) and actigraphy while sleep diaries and questionnaires measure subjective sleep. The gold standard of measuring objective sleep architecture is PSG conducted in a sleep clinic. PSG uses electroencephologography, electrooculography, and electromyography to assess the sleep stages (Roehrs, 2000). A more convenient assessment of the sleep-wake pattern is actigraphy which is completed in a person's normal environment and measures activity to decipher sleep-wake patterns for multiple nights (Ancoli-Israel et al., 2003). Actigraphy is widely used in sleep research and has been shown to be a valid measure of objective sleep parameters (Littner et al., 2003; Sadeh & Acebo, 2002).

Sleep diaries record subjective data like bedtime, time to fall asleep, number and duration of awakenings during the night, wake-up time, out-of-bed time, and times and duration of daytime naps. Often sleep diaries also include questions about sleep quality, and types and amounts of medications, caffeine, and alcohol consumed (Schutte-Rodin, Broch, Buysse, Dorsey, & Sateia, 2008). Sleep diaries should be completed for approximately two weeks to characterize sleep patterns and daily sleep variability, and to identify sleep problems (Schutte-Rodin et al., 2008).

The Pittsburgh Sleep Quality Index (PSQI) is a self-reported questionnaire that assesses perceived sleep quality over the past month (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). This 19-item questionnaire focuses on 7 components including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction.

Parameters that are commonly calculated for both objective and subjective sleep include sleep latency, wake after sleep onset, time in bed, total sleep time, and sleep efficiency. Definitions provided by Schutte-Rodin et al. (2008) are: *sleep latency*, the time from intention to fall asleep to actually falling asleep; *wake after sleep onset*, the sum of minutes awake from sleep onset to the final awakening; *time in bed*, the time from bed time to getting out of bed; *total sleep time*, the time in bed that the individual was actually asleep; and *sleep efficiency*, the percentage of time the individual is asleep while actually in bed.

Cognition. Cognition is an aspect of consciousness that is controlled by the cerebral cortex and includes all of one’s mental activities (Lomen-Hoerth & Messing, 2010). Cognition is assessed globally or using domains like attention, executive function, memory, processing speed, and verbal fluency (Lomen-Hoerth & Messing, 2010). Cognition varies as a person ages with marked changes observed in fluid abilities like working memory and processing speed; while, crystallized abilities like vocabulary and general knowledge tend to remain relatively stable (Nisbett et al., 2012).

One common measure of global cognition, particularly in older adults, is the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975). The MMSE assesses orientation, attention, concentration, language, ability to follow commands, praxis, and immediate and delayed memory (Guerrero-Berroa et al., 2009). This tool is often used to screen for dementia but may be less sensitive to small cognitive changes (Guerrero-Berroa et al., 2009).

The domains of cognition include attention, executive function, processing speed, memory, and verbal fluency and there are specific tests used to assess each of these domains. Attention, which can be sustained, selective, or divided, is the foundation for all mental processes. It is the ability to focus on one or multiple pieces of information in order for the information to register and be used in a meaningful manner (Galvin, 2009). Executive function involves the ability to reason, and generate goals and plans integrated with the ability to maintain the focus and motivation necessary to follow through or the flexibility to alter these goals and plans (Suchy, 2009). Processing speed is either the amount information that can be processed in a given amount of time or the time taken to process a given amount of information (Kalmar & Chiaravalloti, 2008). Memory includes the encoding, retaining, and retrieving of information and experiences (Hoyer & Verhaeghen, 2006). There are many types of memory including episodic and working memory. Episodic memory refers to the acquisition, storage, and retrieval of new information learned within a particular context (Craft, Cholerton, & Reger, 2009; Hoyer & Verhaeghen, 2006). Working memory describes to the ability of an individual to process information across a series of tasks; the individual keeps the information in a short-term buffer, manipulates the information, then hold the products of the manipulation in the same short-term buffer (Hoyer & Verhaeghen, 2006). Finally, verbal fluency is the ability to search and to retrieve data from lexical or semantic memory (Hurks et al., 2006).

Methods

Systematic, computer-aided searches were conducted using Pubmed, PsycINFO, and CINAHL (last search 1.06.2014). The terms used for searching each database were ‘cognitive’, ‘cognition’, older’, ‘sleep’, ‘attention’, ‘episodic memory’, ‘executive function’, ‘processing speed’, ‘verbal fluency’, and ‘working memory’. In total 3,782 articles were screened for relevance. Additionally, reference lists from these articles were used to retrieve relevant publications which had not been identified by the computer-aided search.

To qualify for inclusion in the review, the studies had to include participants who had a mean age of 60 years and older who were living independently in the community. The articles also had to report outcome measures of cognition and/or cognitive impairment, have predictor variables of subjective or objective measures of sleep, report original quantitative analyses, and be published in a peer-reviewed journal. Twenty-four articles were identified as fulfilling the inclusion criteria and were included in the review.

All the studies meeting the inclusion criteria utilized non-experimental designs. The studies that were longitudinal in nature with valid sleep and cognition measures were scored A. The studies with a longitudinal design with either valid sleep or valid cognition measures were scored B. The studies that were cross-sectional with valid sleep and cognition variables were scored C. Finally, D studies were cross-sectional with either valid sleep or valid cognition variables. The comparison of the sleep variables to the cognition variables is presented in Table 1 and the design, sample, instruments, and results of the reviewed studies are presented in Table 2.

Results

In order to understand the relationships between sleep and cognition, each parameter of sleep and its association with cognition is discussed in the following section (see Table 1).

Total Sleep Time and Domains of and Global Cognition

In some of the studies, sleep duration was examined as a continuous variable, while in other studies sleep duration was dichotomized into short and long sleep duration. There appears to be no relationship between total sleep time and global or specific domains of cognition. Only Blackwell et al. (2006) reported that there was a cross-sectional relationship between total sleep time and global cognition. Nebes et al. (2009) and Saint Martin et al. (2012) found no relationship between these two variables. When examining the relationship between total sleep time and the specific domains of cognition, neither Blackwell et al. (2006), McCrae, Vatthauer, Dzierzewski, & Marsiske (2012), Nebes et al. (2009), nor Saint Martin et al., (2012) reported an association between the variables.

Short Sleep Duration and Global Cognition

There were inconsistent findings about the relationship between short sleep duration and global cognition. Potvin and colleagues (2012) had mixed results based on gender. Men with short sleep duration had worse global cognition after one year while there was no longitudinal relationship between short sleep duration and global cognition in women (Potvin et al, 2012). Benito-Leon et al. (2013) reported that there was a cross-sectional association between short sleep duration and global cognition; however, this association was no longer present at the 3-year follow-up. Tworoger et al. (2006) had similar results in their cross-sectional and longitudinal (2 years) analyses. Keage et al. (2012) had contrasting results with no association between short sleep duration and global cognition at baseline but an association between short sleep duration and global cognition at two and 10 years. Finally, Loerbroks et al. (2010) reported no cross-sectional or longitudinal association between short sleep duration and global cognition. Blackwell et al. (2011) reported that there was a cross-sectional association between short sleep duration and global cognition when using subjective assessment (PSQI) but not with actigraphy and Auyeung et al. (2013), Faubel et al. (2009), Ohayon & Vecchierini, (2002), and Ramos et al. (2013) all reported no association between short sleep duration and global cognition.

Short Sleep Duration and Domains of Cognition

There appears to be no relationship between short sleep duration and specific domains of cognition. Tworoger et al. (2006) found an association between short sleep duration and verbal fluency at baseline, which was no longer significant at follow-up. Loerbroks et al. (2010) found no assocaitions with sleep duration and episodic memory. Miyata et al. (2013) reported a relationship between short sleep duration and working memory using the 0-back test. However, using the 1-back test, Miyata et al. (2013) found no relationship between short sleep duration and working memory. Miyata et al. also reported no relationship between short sleep duration and attention. Similarly, Blackwell et al. (2011) reported no relationship between short sleep duration and executive function and attention. Finally, Schmutte et al. (2007) reported no associations between sleep duration and the domains of cognition (i.e., executive function, attention, episodic memory, working memory, verbal fluency, and processing speed).

Long Sleep Duration and Global Cognition

There appears to be a weak relationship between long sleep duration and global cognition, as reported in ten of the studies. Potvin et al. (2012), for example, found that in women but not men, long sleep duration (≥ 9hrs) was associated with incident cognitive impairment over 1 year. Tworoger et al. (2006), Keage et al. (2012), and Loerbroks et al. (2010)

reported that long sleep duration was neither cross-sectionally nor longitudinally related to global cognition. However, in another longitudinal study, Benito-Leon et al. (2013) reported that while there was no cross-sectional relationship between long sleep duration and global cognition, a relationship emerged between the two variables at the three year follow-up. Blackwell et al. (2011) reported cross-sectional relationships between long sleep duration and worse global cognition, as did Auyeung et al. (2013), Faubel et al. (2009), and Ramos et al. (2013). Ohayon and Vecchierini (2002), however, reported no cross-sectional relationship between long sleep duration and global cognition.

Long Sleep Duration and Domains of Cognition

There appears to be no relationship between long sleep duration and the specific domains of cognition. In a longitudinal study, long sleep duration was not related to attention, episodic memory, working memory, or verbal fluency (Loerbroks et al., 2010). Blackwell et al. (2011), Miyata et al. (2013), and Tworoger et al. (2006) reported a significant association between long sleep duration and worse executive function and attention when using the subjective but not the objective measure of sleep duration. Using validated measures for both sleep and cognition, long sleep duration was not cross-sectionally associated with executive function (Blackwell et al., 2011), attention (Blackwell et al., 2011; Miyata et al., 2013), episodic memory (Tworoger et al., 2006), working memory (Miyata et al., 2013), or verbal fluency (Tworoger et al., 2006). Using validated measures for cognition, long sleep duration was not cross-sectionally related to executive function (Ohayon & Vecchierini, 2002), attention (Schmutte et al., 2007), episodic memory (Ohayon & Vecchierini, 2002; Schmutte et al., 2007), working memory (Schmutte et al., 2007), verbal fluency (Schmutte et al., 2007), or processing speed (Schmutte et al., 2007). However, in ANCOVA analyses, Schmutte et al. (2007) pointed out that longer sleep duration was significantly associated with worse episodic memory before and after controlling for demographic variables, depressive symptoms, and medical co-morbidities.

Sleep Latency and Global Cognition

The evidence for a relationship between sleep latency and global cognition appears to be inconclusive. In a primary study of sleep and cognition in 65-80 year olds, Nebes et al. (2009) found longer sleep latency was cross-sectionally associated with poorer overall cognition even after controlling for depression in the sample. The only study that reported on sleep latency using actigraphy revealed that even after adjustment for a variety of demographic variables, physical health, and depression measures, there was a cross-sectional relationship between sleep latency and global cognition (assessed with the MMSE), with longer sleep latency being associated with poorer global cognition in 2,932 older women (Blackwell et al., 2006). Also utilizing data from one point in a longitudinal study, Chang-Quan et al. (2012) reported that longer sleep latency (assessed by the PSQI), correlated with cognitive impairment (assessed with the MMSE). Similarly, Auyeung et al. (2013) did a secondary analysis of longitudinal aging study data and reported that longer sleep latency was cross-sectionally associated with poorer overall cognition scores with the relationship persisting after controlling for demographic, health, and depression factors. Despite consistent cross-sectional findings by four research teams, there was contradictory evidence as well. Utilizing data from one point in a longitudinal study in which in-home polygraphy was used to exclude anyone with sleep apnea, Saint Martin et al. (2012) reported that no relationship was found in cross-sectional analyses between sleep latency and global cognition. In additon, after controlling for demographic, health, and depression variables, no cross-sectional or longitudinal relationships were found after one year (Potvin et al., 2012), 2 years, or 10 years (Keage et al., 2012) between sleep latency and global cognition.

Sleep Latency and Domains of Cognition

The evidence for a relationship between sleep latency and specific domains of cognition also appears to be inconclusive. Blackwell et al. (2006) reported that longer sleep latency was associated with worse executive function and attention. Using baseline data from the Bronx Aging study, Schmutte et al. (2007) found that participants over age 75 with longer sleep latency performed worse on measures of attention, working memory, verbal fluency, and had prolonged processing speed than those with short sleep latency. There were significant relationships between sleep latency and both depression and hypnotic use, and when these variables were added as statistical controls, sleep latency was significantly related to verbal fluency only. In this study, sleep latency length was not associated with episodic memory. Although Nebes et al. (2009) found a relationship between sleep latency and global cognition, they reported no significant relationship between sleep latency (measured subjectively) and the specific domains of executive function, attention, episodic memory, working memory, and processing speed. These findings were corroborated by Saint Martin et al. (2012) who reported no relationship between sleep latency and the specific cognition domains of executive function, attention, episodic memory, working memory, verbal fluency, and processing speed. Similarly, Miyata et al. (2013) reported no relationship between sleep latency and attention or working memory. The discrepancy in the results could be partially due to the variety of measures for both sleep and cognition used in the studies.

Wake After Sleep Onset and Global Cognition

There is potential evidence to support the relationship between wake after sleep onset and global cognition. When an investigator-developed questionnaire was used, Keage et al., (2012) reported that longer wake after sleep onset was not associated cross-sectionally or longitudinally with global cognition. In two gender-specific studies using actigraphy, wake after sleep onset was associated with worse global cognition in both men and women after adjustment for depression and multiple demographic, physical, and health factors (Blackwell et al., 2011; Blackwell et al., 2006). Using a validated subjective measure, the PSQI, longer wake after sleep onset was also associated with worse global cognition (Chang-Quan et al., 2012).

Wake After Sleep Onset and Domains of Cognition

There is potential, but weak, evidence regarding the relationship between wake after sleep onset and specific domains of cognition. Blackwell et al. (2011) and Blackwell et al. (2006) reported that longer objective wake after sleep onset was associated with worse attention and executive function. When wake after sleep onset was measured subjectively using the PSQI, Miyata et al. (2013) did not find any associations between wake after sleep onset and attention or working memory.

Sleep Efficiency and Global Cognition

It is difficult to determine the strength of the relationship between sleep efficiency and global cognition. Potvin et al. (2012) reported that as sleep efficiency decreased, global cognition worsened longitudinally. However, the relationship was significant for male but not female participants. Using an investigator-developed questionnaire, Tworoger et al. (2006) reported no longitudinal relationship between sleep efficiency and global cognition. Additionally, Blackwell et al. (2006), Blackwell et al. (2011), Chang-Quan et al. (2012), and Nebes et al. (2009) reported that, based on cross-sectional analyses, as sleep efficiency decreased, global cognition worsened. There were contrasting results reported in Blackwell and colleague’s two studies: in the study with only female participants (2006) they found that a relationship was present between the two variables, while in the study with only male participants (2011) they reported no relationship.

Sleep Efficiency and Domains of Cognition

There appears to be a weak relationship between sleep efficiency and domains of cognition. As sleep efficiency decreased, executive function, attention (Blackwell et al., 2011; Blackwell et al., 2006), and working memory (Miyata et al., 2013) worsened. Miyata et al. (2013) and Nebes et al. (2009), however, reported that there was no relationship between sleep efficiency and attention. Nebes et al. (2009) also reported that sleep efficiency was not associated with executive function. Finally, Nebes et al. (2009) reported no relationship between sleep efficiency and working memory, episodic memory, or processing speed. Since all the studies were cross-sectional, the difference in the results could be due to different studies using only one measure versus multiple measures for the same domain. For example, Nebes and colleagues (2009) used multiple measures to evaluate executive function while Blackwell and colleagues (2006, 2011) only used one measure. In addition, Blackwell and colleagues used objective measures to evaluate sleep efficiency (actigraphy) while Nebes, Buysse, Halligan, Houck, & Monk (2009) and Miyata et al. (2013) used the subjective assessment for sleep efficiency (the PSQI).

General Sleep Problems and Global Cognition

There is not enough research to conclude whether or not a relationship exists between general sleep problems and global cognition. Potvin et al. (2012) reported on general sleep problems using a sleep disturbance score and sleep quality. In their study, men and women had opposite results. The sleep quality score in men and the sleep disturbance score in women were associated with global cognition while there was no association between the sleep quality score in women and the sleep disturbance score in men with global sleep function. Tworoger et al. (2006) reported that there was a cross-sectional but not longitudinal relationship between general sleep problems and global cognition. Lim et al. (2013) reported that there was a relationship between general sleep problems and global cognition. Cricco et al. (2001) reported that in men, chronic sleep problems were associated with worse global cognition longitudinally but there was no association with incident sleep problems in both genders or chronic sleep problems in women. Foley et al. (2001) and Keage et al. (2012) reported no associations between general sleep problems and global cognition. Nebes et al. (2009) and Chang-Quan et al. (2012) reported that there was a relationship between general sleep problems and global cognition. Contrary to the previous studies, Blackwell et al. (2011) and Zimmerman et al. (2012) reported no associations between general sleep problems and global cognition. Saint Martin et al. (2012) reported that the global PSQI score was associated with worse cognition while the PSQI sleep quality score was not associated with cognition. Sampaio et al. (2013) reported a relationship between general sleep problems and global cognition; however, Gamaldo et al. (2008) reported no associations between general sleep problems and global cognition. Auyeung et al. (2013) revealed that in univariate analyses sleep problems were associated with global cognition but were no longer associated after multivariate analyses.

General Sleep Problems and Domains of Cognition

There is not enough research to conclude whether or not a relationship exists between general sleep problems and the specific domains of cognition. Saint Martin et al. (2012), Sutter et al. (2012), and Nebes et al. (2009) reported that as sleep problems (sleep quality) worsened, attention also worsened, while Blackwell et al. (2011), Miyata et al. (2013), and Zimmerman et al. (2012) reported no relationship between general sleep complaints and attention. Only Saint Martin et al. (2012) reported an association between general sleep complaints and episodic memory. Tworoger et al., (2006) , Nebes et al. (2009), Sutter et al. (2012), Zimmerman et al.

(2012), and Gamaldo et al. (2008) found no associations between general sleep problems and episodic memory. Tworoger et al. (2006) reported over a two year period that, as sleep problems worsened, working memory also worsened Gamaldo et al. (2008) had similar results using cross-sectional analyses. However, Miyata et al. (2013) and Zimmerman et al. (2012) did not report cross-sectional relationships between general sleep complaints and working memory. Nebes et al. (2009) had contrasting results with the relationship between general sleep complaints and executive function and working memory. When the Trail Making Test Part B and the N-Back were used to measure executive function and working memory respectively, there was a relationship between general sleep complaints and the variables. However, when the Computerized Strop Test, the Hayling Test, and the Letter-Number Sequencing subtest of the Wechsler Adult Intelligence Scale III were used to measure the same two variables there were no relationships between general slep complaints and executive function and working memory. Examining verbal fluency, Sutter et al. (2012) reported an association between general sleep complaints and worse verbal fluency while Tworoger et al. (2006) and Saint Martin et al. (2012) and Zimmerman et al. (2012) reported no relationship between the two variables. Regarding general sleep problems and processing speed, McCrae et al. (2012) reported a relationship between both variables and the increase in general sleep problems associated with worse performance on a test of processing speed.

Discussion

This review of literature summarized the current evidence regarding the association between sleep and cognition in older adults who are free of sleep-related diseases. In older adults without sleep-related disorders, the relationship appears to be mixed between the sleep parameters examined and global cognition. Similarly, a clear pattern does not emerge when evaluating the relationship between the specific sleep components and the specific cognitive domains; as a result, more studies, particularly longitudinal studies, are needed that further explore the relationship among these variables. Interestingly, sleep duration, a sleep variable most consistently related to disease states such as cardiovascular disease (Ayas et al., 2003; Sabanayagam & Shankar, 2010), was not consistently associated with changes in cognition. A recent review suggests that older adults may actually be more resistant to the cognitive effects of sleep problems, such as deprivation and restriction (Pace-Schott & Spencer, 2011) possibly because throughout the aging process, they have adapted to the typical changes that occur with sleep.

Researchers must be willing to consider that the presence of depression/depressive symptoms could be a possible mediator in the association between sleep and cognition in the older adult population and thus be one explanation for the inconsistent findings. For example, in the study by Schmutte et al. (2007), depression was moderately related to sleep latency and total sleep time. In addition, Nebes et al. (2009) pointed out that the participants who reported poor sleep had more depressive symptomatology than those reporting good sleep. It is possible that poorer sleep was related to depression which then contributed to poorer cognition for that specific group of older adults. For example, Saint Martin and colleagues (2012) also reported that subjective judgment of cognition was related to the depression score. Also, Foley et al. (2001) reported that after controlling for depression, sleep problems did not predict cognitive decline; however, depression at baseline significantly increased the probability of a decline in cognition at follow-up. Additional researchers, Zimmerman et al. (2012), Roose, Devanand, and Hamilton (2007), and Steffens et al., (2006) have also posited that depression and depressive symptoms are associated with a decline in cognition.

Another alternative explanation is that study participants with undiagnosed sleep apnea may be another factor contributing to the inconsistency in the association between sleep parameters and cognition. Most studies in the review did not screen for or ask about a sleep apnea diagnosis and so did not account for the possible confounding effect of the presence of sleep apnea. For example, sleep apnea is associated with worse verbal fluency and constructional tasks (Aloia et al., 2003) and without a screen or diagnosis, it is challenging to adjust for the presence of the disorder or symptoms.

Age appear to play a role in the relationship between sleep and cognition. Blackwell et al. (2006), Lim et al. (2013), and Chang-Quan et al. (2012) all reported that participants with a mean age over 80 years old reported that the worse the sleep parameters, the worse their cognition measures. Denton and Spencer (2005) reported that in the oldest old population, the prevalence rate and the relative prevalence of chronic conditions such as dementia, stroke, and heart disease were much higher for persons over 80 years than for persons under age 80. Wolf, Starfield and Anderson (2002) also reported than adults over 80 years were more likely to have more than 4 chronic illnesses compared to their younger counterparts. A study by Kronholm et al. (2009) reported that the relationship between sleep and cognition disappeared when they accounted for participants' health status.

Some limitations must be taken into account regarding this review of literature. First, there was variation across the studies in the assessment measures for sleep and cognition. Although the measures used for cognition in the majority of studies were valid and reliable, the same measure was not consistently used by the researchers to examine the sub-domains of cognition. For example, Trail Making B, Stroop Color and Word test, Oral Word Fluency test, Porteus Maze, and Optimal Telegram were all used to assess executive function. As pointed out by Snowden et al. (2011), it would be beneficial if there was a consensus of measures, like the National Institutes of Health Toolbox or the Uniform Data Set of the Alzheimer's Disease Center, so as to allow for better comparison across studies. Another limitation within the cognitive domain involves the measures used to assess global cognition. Many of these measures, like the MMSE, may not be sensitive enough to identify small but significant changes in cognition.

Sleep parameters specific to REM and nREM sleep were not examined in this review. Since older adults report increase in sleep fragmentation and more time in lighter sleep stages (National Sleep Foundation, 2003), it is possible that these parameters are the ones that are more associated with changes in cognition. In order to determine if there is an association, PSG needs to be used on a more consistent basis. Home PSG is now an option and may be better and more convenient for the participant.

While valid and reliable measures were used to assess cognition, many of the sleep variables were collected using non-validated measures like investigator-developed sleep questionnaires. For example, one questionnaire assessed sleep latency by asking the participants to indicate the number of minutes taken to fall asleep or by asking if they usually took long to fall asleep. There was also a lack of standardization of the cut-off times for some of the sleep variables like sleep onset latency and sleep duration, which makes it challenging to compare the results. For example, Ohayon and Vecchierini (2002) used short sleep duration as < 7 hours and long sleep duration as > 8.5 hours while Loerbroks et al. (2010) defined short sleep duration as < 6 hours and long sleep duration as > 9 hours. Future studies should attempt to standardize the times used for long and short sleep duration. In addition, sleep duration should be examined as a dichotomous variable and compared since none of the studies that examined sleep duration as a continuous variable saw any relationship between that and cognition. More information could be gained by dichotomizing the variables and comparing them to the cognitive domains. The results would also enable more targeted interventions for sleep duration.

Another limitation is the use of subjective sleep measures in many studies of cognition. Subjective measures can possibly lead to differential misclassification and selective drop-out because persons with poor cognition are likely to have more difficulty accurately completing sleep questionnaires and sleep diaries.

Conclusion

The evidence is mixed concerning the relationship between sleep and cognition in older adults without sleep-related diseases. When a relationship is found across several studies, such as with sleep duration and general sleep complaints, the relationship appears to be due to the presence of depressive symptoms or some other underlying pathology. Further research which evaluates then controls for or excludes participants with depression, chronic medical illness, and sleep apnea is needed to clarify the relationship between sleep and cognition in older adults without sleep-related diseases. In addition, sleep and cognition should be consistently defined and assessed with uniform measures across studies and researchers should consider using PSG to identify the sleep phases and examine the phases of sleep in relation to cognition.

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Table 1.1. *Relationship between Sleep Parameters and Domains of and Global Cognition*

			Relationship	Cognition: Executive Function	Attention	Episodic Memory	Working Memory	Verbal Fluency	Processing Speed	Global Cognition
SLEEP	Long Sleep Latency		Sig	7,14	7		14*	14	14*	5,7,13,22
			NS	2,13	2,13,14,21	2,3,14	2,13, 14, 21	2	2,13,14	2,12,19
	Long Wake After Sleep Onset		Sig	7,18	7,18					7,18,22
			NS		21		21			12
	Low Sleep Efficiency		Sig	7,18	7,18		21			7,13,19*,22
			NS	13	13,21	13	13		13	3,18,19
	Sleep Duration	Short	Sig		17		*21	3*		1*,*3,12*,18*,19*
			NS	14,18	14,18,21	3,14,17	14,21	3,14	14	3,5,10,12,15,17,18, 19,20,23
		Long	Sig	18*	18*	14*				1*,5,10,18*,19*,20
			NS	15,18	14,17,18,21	3,14,15,17	14,17,21	3,14,17	14	1,3,12,15,17,19
		Total	Sig							7
			NS	2,7,13,23	2,7,13	2,13	2,13	2	2,13,23	2,13
	General Sleep Problems		Sig	13*,24	2,13,24	2*	2,13*,8	24	23	2*,3*,4*,5*,9,11,13, 19*,22
			NS	2,13,18,16, 23	16,18,21	2,3,8,13, 16, 24	13,16,21	2,3,16	2,13,24	2,3,4,5,6,8,12,16,18,19

References: 1. Benito-Leon et al (2013) – B; 2. St. Martin et al., (2012) – C; 3. Tworoger et al., (2006) – B; 4. Cricco et al., (2001) – B; 5. Auyeung et al., (2013) – D; 6. Foley et al., (2001) – B; 7. Blackwell et al., (2006) – C; 8. Gamaldo et al., (2008) – D; 9. Lim et al. (2013) – B; 10. Faubel et al., (2009) – D; 11. Sampaio et al., (2012) – D; 12. Keage et al., (2012) – B; 13. Nebes et al., (2009) – C; 14. Schmutte et al., (2007) – D; 15. Ohayon et al., (2002) – D; 16. Zimmerman et al., (2012) – C; 17. Loerbroks et al., (2010) – B; 18. Blackwell et al., (2011) – C; 19. Potvin et al., (2012) – A; 20. Ramos et al., (2013) – D; 21. Miyata et al., (2013) – C; 22. Chang-Quan et al., (2012) – C; 23. McCrae et al., (2012) – C; 24. Sutter et al., (2012) – C

KEY: NS – non-significant; Sig – significant

*Studies with both significant and non-significant results for the same sleep component; A – Longitudinal studies with valid sleep and cognition measures; B – Longitudinal studies with either valid sleep or valid cognition measures; C – Cross-Sectional with valid sleep and cognition measures; D – Cross-Sectional studies with either valid sleep or valid cognition measures

Table 1.2. *Review of Literature for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
5 D	Auyeung et al., (2011) China	Cross-Sectional	N - 2945 Age - 73.9 (±5.0) % Female - 40.8 65 yrs. and older	S: Investigator developed Sleep Questionnaire (go-to-bed time, wake-up time, nocturnal sleep duration, SL > 1 hour, insomnia complaint, napping habit and frequency per week) O: None	Global Cognition: Mini-Mental Status Exam (MMSE)	Exclusion Criteria: cognitively incompetent to give informed consent, medical conditions that made them unlikely to complete the study Statistical: Age, gender, MMSE score, education, smoking, alcohol, tea and coffee consumption, habitual smoking, depression (GDS ≥ 8), use of psychotropic meds, dx of HTN, diabetes, stroke, CHD, COPD
		Findings: SL: A higher MMSE score was significantly associated with fewer reports of prolonged SL before and after analyses. TST: Longer nocturnal TST (>7hrs) was significantly associated with lower general cognition. No association between global CF and short sleep duration (4 hrs. to 7.9 hrs.) General Sleep Problems: A higher MMSE score was significantly associated with less chronic sleep complaints in the univariate but not multivariate analyses.				
1 B	Benito-Leon, Louis, & Bermejo-Pareja, (2013) Spain Neurological Disorders in Central Spain	Longitudinal (3 years)	N - 2715 Age – 72.9 (±6.1) % Female – 56.9 65 years and older	S: Question about total daily usual sleep duration (sum of daytime napping and nighttime sleep) O: None	Global Cognition: MMSE along with one attention, visual order and simple construction task each	Exclusion Criteria: Age, gender, geographical area, educational level, diabetes mellitus, chronic obstructive pulmonary disease, depressive symptoms, antidepressant use, medications with central nervous system effects
		Findings: TST: At baseline, short sleep (≤ 5hrs) global CF score was significantly different than reference (6-8 hrs.) group and long sleep (≥ 9hrs) global CF score not significantly different. Longitudinally, change in global CF associated with long sleep but not short sleep. Rate of cognitive decline not significantly different between short sleep and reference but significantly different between long sleep and reference groups. Long sleepers were 1.3 times more likely to have cognitive decline than reference group. Short sleeper's odds of having cognitive decline similar to reference group.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
7 C	Blackwell et al., (2006) USA Study of Osteoporotic Fractures	Cross-Sectional	N - 2932 Age - 83.5 (±3.7) % Female - 100 65 years and older	S: None O: Actigraphy (minimum of 3 nights)	Global Cognition: MMSE EF: Trail Making Test Part B (TMT-B) Att: TMT-B	Statistical: Age, race, depression, education, BMI, health status, Hx. of stroke, Hx. of hypertension, IADL impairments, smoking, alcohol use, caffeine intake, antidepressant use, physical activity
		Findings: SL: Longer SL was significantly associated with worse global cognition, attention, and executive function. WASO: Longer WASO was significantly associated with worse global cognition, attention, and executive function. SE: Lower SE was significantly associated with worse global cognition, attention, and executive function. TST: TST was significant associated with worse global cognition but was not associated with executive function or attention.				
18 C	Blackwell et al., (2011) USA Osteoporotic Fractures in Men	Cross-Sectional	N - 3132 Age - 76.4 (±5.6) % Female - 0% 65 years and older	S: Sleep Diary (minimum of 5 nights) Pittsburgh Sleep Quality Index (PSQI) O: Actigraphy (minimum of 5 nights)	Global Cognition: Modified MMSE EF: TMT-B Att: TMT-B Digit Vigilance Test	Statistical: Age, race, clinic, education, depression, BMI, number of IADLs, comorbidities, antidepressant use, benzodiazepine use, alcohol use, smoking, physical activity, self- reported health status
		Findings: WASO: Longer objective WASO associated with poorer global cognition, attention, and executive function. SE: Lower objective SE modeled continuously associated with poorer attention and executive functioning but not global cognition. TST: Objective long sleep duration was associated with global cognition but not attention and executive function. Objective short sleep not associated with global cognition, attention, or EF. Subjective short sleep (< 5 hrs.) and long sleep (> 8 hrs.) duration were associated with lower levels of global cognition. Long sleep, not short, was associated with poorer attention and executive function. The association between long sleep and global cognition, attention, and executive function disappeared after adjustment with WASO. General Sleep Problems: PSQI (>5) was not associated with global cognition, attention, or executive function.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
22 C	Chang-Quan, Bi-Rong, & Yan (2012) China Project of Longevity and Aging in Dijiangyan	Cross-Sectional	N - 660 Age - 93.5 (±3.4) % Female - 67.3 90 yrs and older	S: PSQI O: None	Global Cognition: MMSE	Statistical: Age, gender, education level, serum lipid/lipoprotein, BMI, blood pressure, blood glucose level, smoking habit, alcohol consumption, , tea consumption, exercise
		Findings: <u>SL</u>: Longer SL correlated with cognitive impairment <u>SE</u>: Lower SE correlated with cognitive impairment <u>General Sleep Problems</u>: Poor sleep quality increased the risk for cognitive impairment.				
4 B	Cricco Simonsick, & Foley, (2001) USA Established Populations for Epidemiologic Studies of the Elderly	Longitudinal (3 years)	N - 6444 Age - 72 % Female - 62.3 65 years and older	S: Investigator developed questionnaire about symptoms of insomnia (how often do they have trouble falling asleep or waking up too early and be unable to fall asleep again) O: None	Global Cognition: Pfeiffer's Short Portable Mental Status Questionnaire	Statistical: Age, race, educational levels, serum lipid/lipoprotein, body mass index, blood pressure, blood glucose level, smoking habit, alcohol consumption, tea consumption, exercise
		Findings: <u>General Sleep Problems</u>: For men, chronic sleep disturbances, (trouble falling asleep and waking up to early at baseline and FU) but not incident sleep disturbances (trouble falling asleep and waking up to early at FU) was associated with an increased risk of cognitive decline. For women, neither incident nor chronic sleep disturbances were associated with an increased risk of cognitive decline.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
10 D	Faubel et al., (2009) Spain Population based study	Cross-Sectional	N - 3212 Age - 71.6 (±7.8) % Female - 52.6 60 years and older	S: Investigator developed item about sleep duration for a day (include sleep during day and night) O: None	Global Cognition: Mini-Examen Cognoscitivo (Spanish version of the MMSE)	Exclusion Criteria: Diagnosis of depression, extreme sleep duration < 4 hrs. or > 17 hrs., dementia dx Statistical: age sex, physical activity, tobacco use, alcohol consumption, coffee consumption, educational level, SF -36 mental and physical summary scores, night time awakening, BMI, chronic diseases, anxiolytic and medical drug use, HTN, antihypertensive meds, number of social ties, head of family's work status
		Findings: TST: Long sleep duration (> 10 hours was associated with an increased risk for cognitive impairment. Short sleep duration (< 7 hours) was not associated with an increased risk of cognitive impairment. As TST increased from 7 hrs. to 11 hrs., cognition progressively worsened.				
6 B	Foley et al. (2001) USA Honolulu-Asia Aging Study	Longitudinal (3 year)	N - 2346 Age - 76.6 (±3.9) % Female - 0 71- 93 years Japanese-American	S: Investigator developed questionnaire about daytime sleepiness and insomnia (usually having trouble falling asleep or waking up too early and being unable to fall asleep again) O: None	Global Cognition: Cognitive Abilities Screening Instrument (CASI) Other Cognition: Clinical diagnosis of dementia	Exclusion Criteria: Diagnosis of dementia Statistical: Age, education, Apoliprotein E4 status, CASI score, depressive symptoms, hours of sleep, daytime napping, coronary heart disease, history of stroke
		Findings: General Sleep Problems: Having trouble falling asleep or waking up too early and being unable to fall asleep again at baseline was not predictive of general cognition 3 years later.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
8 D	Gamaldo, Allaire & Whitfield, (2008) USA Baltimore Study of Black Aging	Cross-Sectional	N – 174 Age – 72.7 (±5.6) % Female – 70.7 65- 90 years African-American	S: Investigator developed question about trouble falling asleep O: None	Global Cognition: MMSE Working Memory: Forward and Backward Digit Span Alpha Span task Episodic Memory: California Verbal Learning Test	Statistical: Age, gender, education, depression, health, income
		Findings: General Sleep Problems: There was a negative association between trouble falling asleep and working memory tasks. There were no significant associations between trouble falling sleep and global cognition or episodic memory. Trouble falling asleep predicted performance on the working memory task after statistical adjustment. Trouble falling asleep did not predict performance on global cognition or episodic memory.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
12 B	Keage et al., (2012) UK MRC Cognition Ageing Study	Cross-Sectional Longitudinal (2 and 10 years)	N - Baseline - 2041 2yrs - 1658 10yrs - 663 % Female - 53 65 - 94 years	S: Investigator developed sleep questionnaire (problems with sleeping, problems staying asleep or falling asleep, age sleep became a problem, snoring, sleep latency, night waking, sleep duration, napping) O: None	Global Cognition: MMSE	Statistical: MMSE ≤21at baseline, sex, age at baseline, BMI classification, education
		Findings: <ins>SL</ins>: SL was not cross-sectionally associated with cognitive impairment or predicted cognitive decline after 2 or 10 years. <ins>WASO</ins>: Night waking not cross-sectionally or longitudinally associated with cognitive impairment. <ins>TST</ins>: Both short (≤ 6.5hrs) and long (≥9hrs) sleep duration were not cross-sectionally associated with global cognitive impairment. Short sleep duration associated with incident cognitive impairment over 10 years. Long sleep duration did not predict risk for cognitive impairment at years 2 and 10. <ins>General Sleep Problems</ins>: General sleep problems were not cross-sectionally or longitudinally associated with cognitive impairment.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
9 B	Lim et al., (2013) USA Rush Memory and Aging Project	Prospective Longitudinal (6 years)	N - 737 Age - 81.6 (±7.2) % Female - 76	S: Investigator developed item about sleep duration for a day (include sleep during day and night) O: Actigraphy (up to 10 days)	Global Cognition: Composite of Word Recall, Word List Delay, Word List Recognition, Immediate Story Recall, Delayed Story Recall, Logical Memory Ia and IIa, Boston Naming, Reading Test, Verbal Fluency, Digit Span Forward, Digit Span Backward, Digit Ordering, Symbol Digit, Number Comparison, Stroop Color Naming, Stroop Word Naming, Line Orientation, Progressive Matrices	Statistical: Age, sex, education, time
		Findings: <u>General Sleep Problems</u>: Increased sleep fragmentation associated with lower baseline cognitive performance and a more rapid rate of global cognitive decline. Persons with high sleep fragmentation have an increased risk of developing Alzheimer's disease.				
17 B	Loerbroks et al., (2010) Germany HeiDE Study	Cross-Sectional Longitudinal (8.5 years)	N - 695 % Female - 59 70 years and over	S: Investigator developed sleep questionnaire (hours of nightly sleep)	Global Cognition: Telephone Interview for Cognitive Status (TICS)	Exclusion Criteria: Depression, taking mood enhancing drugs Statistical: Age, gender, educational level, physical activity, alcohol consumption, body mass index, smoking status, use of sleep medication, depressive symptoms at the time of testing
		Findings: <u>TST</u>: Short (≤ 6 hrs) and long (≥ 9 hrs) sleep duration were not cross-sectionally or longitudinally associated with global cognition. After age and multivariate adjustments, a decline in sleep duration did not predict general cognitive impairment but an increase in sleep duration was associated with a two-fold increase in general cognitive impairment after 8.5 years.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
23 C	McCrae et al. (2012) USA	Cross-Sectional	N - 72 Age - 70.18 (±7.09) 60 years and older	S: Sleep Diary (14 days) O: None	Global Cognition: Modified MMSE EF: Letter Series Task PS: Symbol Digit Modalities Test	Exclusion Criteria: Medical and neurological disorder, psychopathology, sleep disorders (sleep apnea, RLS), MMSE lower than 23, severe depressive symptoms, suspected sleep disordered breathing, missing more than 7 days of sleep data
		Findings: TST: TST didn't predict executive functioning or processing speed. General Sleep Problems: Total wake time didn't predict executive functioning but significantly predicted processing speed.				
21 C	Miyata et al., (2013) Japan	Cross-Sectional	N – 78 Age - 72.2 (±5.9) 60 years and older	S: PSQI O: Actigraphy (7 nights)	Att: Continuous Performance Test WM: N-Back Test	
		Findings: SL: SL not associated with working memory or attention performance. WASO: WASO not associated with working memory or attention performance SE: Lower SE was significantly associated with worse working memory but not associated with attention performance. TST: Accuracy of 0-back different for those with < 5 hours than those with >7 hrs. No difference between the short and long sleep duration with accuracy on the 1-back test and the attention measure. General Sleep Problems: Global sleep quality not associated with working memory and attention performance.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
13 C	Nebes et al., (2009) USA	Cross-sectional	N - 157 Age - 72.2 (±4.2) 65-80 years	S: PSQI O: None	Global Cognition: Repeatable Battery for the Assessment of Neuropsychological Status EF: Computerized version of the Stroop test Hayling test TMT-B Att: Trail Making test Part B (TMT-B) EM: Logical Memory Test from the Wechsler Memory Scale - Revised WM: N-Back test Letter - Number Sequencing subtest of the Wechsler Adult Intelligence Scale III PS: Conceptual Comparison Perceptual Comparison	Exclusion Criteria: No CNS pathology, substance abuse, taking prescription psychoactive medication, no diagnosis of major depression in last 5 years or GDS score > 15 Statistical: Total depressive score, risk of cerebrovascular disease, use of sleeping pills and anticholinergic meds
		Findings: SL: Longer sleep latency was associated with poorer global cognition but not associated with measures of attention, working memory, processing speed, executive function, and episodic memory. SE: Lower sleep efficiency was associated with poorer global cognition and working memory (N-Back) but not associated with other measures of working memory, processing speed, executive function, and episodic memory. TST: Sleep duration was not associated with any of the cognition measures. General Sleep Problems: Higher PSQI scores associated with poorer global cognition, executive function (TMT-B), attention (TMT-B), and working memory (N-Back). Higher PSQI scores not associated with executive function, processing speed, episodic memory, and working memory.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
15 D	Ohayon & Vecchierini, (2002) France	Cross-Sectional	N - 1026 % Female - 59.8 60 years and older	S: Sleep-EVAL System (sleep-wake schedule, symptoms of sleep disorders, sleep hygiene)	Global Cognition: MMSE Cognitive Difficulties Scale (McNair-R)	Statistical: Age, sex, physical activity, occupation, organic diseases, use of sleep or anxiety medications, psychological well being
		Findings: TST: Short sleep time (< 7 hours), but not long sleep duration (> 8.5 hrs.), was associated with attention-concentration deficits and difficulties in orientation for persons but not praxis, delayed recall, difficulties in temporal orientation, and prospective memory using the McNair Scale. Neither long nor short sleep duration was associated with MMSE.				
19 A	Potvin et al., (2012) Canada Surveys of Elders' Health study	Longitudinal (1 year) Prospective	N - 1664 Age- Male - 72.7(±5) Female- 73.9(±5.7) % Female - 69.7 65 years and older	S: PSQI O: None	Global Cognition: MMSE	Exclusion Criteria: Dementia, Cerebrovascular disease, Brain trauma/tumor/ infections, Parkinson's disease, Epilepsy, Schizophrenia and other forms of psychosis, Baseline MMSE score below the 15th percentile Statistical: Age, education, baseline MMSE score, anxiety, depressive episode psychotropic drug use, cardiovascular conditions score, chronic diseases
		Findings: SL: In all participants, sleep latency was not associated with incident cognitive decline. SE: In women, sleep efficiency was not associated with incident cognitive decline. In men, sleep efficiency predicted incident cognitive decline after 1year. TST: Short sleep duration (≤ 5hrs) was associated with incident cognitive decline in men and not women. In women and not men, long sleep duration (≥ 9hrs) was associated with incident cognitive impairment over 1 year. General Sleep Problems: In women but not men, PSQI sleep disturbance score was associated with general cognitive decline 1 year later. In men but not women, global sleep quality score was associated with incident cognitive decline after 1 year.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
20 D	Ramos et al. (2013) Northern Manhattan Study	Cross-Sectional	N - 927 Age - 75 (±9) % Female - 61	S: Investigator developed sleep question about average nightly sleep in the past 4 weeks.	Global Cognition: MMSE	Statistical: Demographics, vascular factors, medications, risk for SDB, depression, alcohol consumption
		Findings: TST: Long sleep (≥ 9 hrs) inversely associated with MMSE score and short sleep (< 6 hrs) not associated with MMSE score.				
2 C	St. Martin et al., (2012) France Prognostic Indicator of Cardiovascular and Cerebrovascular events Trial	Cross-Sectional	N - 272 Age - 74.8 (±1.1) % Female - 71 65 years and older	S: PSQI O: None	Global Cognition: MMSE Mac Nair Scale EF: Stroop Test TMT-B Att: TMT A and B EM: Grober and Buschke Selective Reminding Test WM: Benton Visual Retention Test VF: Alphabetic Fluency Category Fluency PS: WAIS-III Code Test	Exclusion Criteria: MI, heart failure, stroke, previous dementia, neurological D/O, initiation of CPAP for OSA, diagnosis of a new neurological D/O Statistical: Gender, AHI, anxiety, depression, use of sleep meds
		Findings: SL: SL was no associated with any of the cognition measures. TST: TST was no associated with any of the cognition measures. General Sleep Problems: Higher PSQI total scores were correlated with a poorer global cognition, shorter working memory, and worse attention span. Poorer SQ associated with shorter working memory and poorer delayed episodic memory.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
11 D	Sampaio et al. (2012) Japan	Cross-Sectional	N - 145 Age – 73 (70-77) % Female – 53.1% 65 years and older	S: Investigator developed question about sleep quality over the past month.	Global Cognition: MMSE	Exclusion Criteria: MMSE ≤21, uncontrolled cardiovascular, pulmonary, or metabolic diseases, surgery in the past 3 months, current treatment for cancer, forced bedrest in past 3 months, orthopedic condition that could restrict ADLs Statistical: Sex, education, living situation, work, financial satisfaction, smoking, alcohol, number of consultations in six months, number of medications, morbidities, comorbidities and regular physical activity categories.
		Findings: General Sleep Problems: Significant difference between good and poor sleep on performance on the MMSE.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
14 D	Schmutte et al., (2007) USA Bronx Aging Study	Cross-Sectional	N - 375 Age - 79.6(±3.15) % Female - 64.3 75 - 85 years	S: 54-item interview-based, sleep questionnaire(SL, nightly sleep duration, number of times they woke up at nights, trouble sleeping) O: None	Att: Months Backward EM: Selective Reminding task WM: Digit Span Backwards VF: Category Fluency Wechsler Adult Intelligence Scale – Vocabulary PS: Digit Symbol Substitution	Statistical: Depression, age, education, medical comorbidities , physical morbidity, hypnotic use
		Findings: <u>SL</u>: Persons with longer SL performed significantly worse on measures of attention, working memory, verbal fluency, and processing speed but SL was not associated with episodic memory. After statistical adjustment, longer SL was associated with only verbal fluency. <u>TST</u>: In univariate analyses, short sleep (<6hrs) and long sleep (> 9hrs) duration not associated with episodic memory, attention, working memory, verbal fluency, or processing speed. ANCOVA for episodic memory indicate an association with longer sleep duration (> 9hrs).				
24 C	Sutter et al. (2012) Zurich	Cross-Sectional	N - 96 Age - 72 (±5.7) % Female – 57 61 – 92 years	S: PSQI O: None	PS: Digit Symbol Substitution Test VF: Word Fluency task Animal Naming EF: German Achievement Measure Test TMT A & B Go/No-go task EM: Verbal Learning Memory Test Att: Trails A	Exclusion Criteria: Parkinson's disease, clinical significant depressive symptoms, use of antidepressants, Statistical: Age, sleep medications
		Findings: <u>General Sleep Problems</u>: Poor sleep quality negatively associated with executive function, verbal fluency, and attention at higher levels of depression. Sleep quality not associated with processing speed and episodic memory.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
3 B	Tworoger et al., (2006) USA Nurses' Health Study	Cross-Sectional Longitudinal (2 years)	N - 1844 % Female - 100 70 years and older	S: Investigator developed sleep questionnaire (sleep duration in last 24 hours, snoring, sleep difficulty over the last 4 weeks, difficulty falling or staying asleep in the past year) O: None	Global Cognition: MMSE TICS EM: Delayed Recall of TICS 10 word list East Boston Memory Test WM: Digit Span Backwards VF: Timed Animal Naming test	Exclusion Criteria: Taking antidepressants, physician-diagnosis of depression, diagnosis of stroke Statistics: Age, education, smoking status, physical activity, HTN, living status, alcohol consumption, mental health index from SF-36, use of tranquilizers
		Findings: <u>TST</u>: Cross sectionally, short sleep (≤5hrs) but not long sleep(≥ 9 hrs) duration was associated with an increased risk of global cognitive impairment, and verbal fluency but not episodic memory. Longitudinally (2 years), neither short nor long sleep duration was associated with global cognition, episodic memory, or verbal fluency. <u>General Sleep Problems</u>: Cross-sectionally but not longitudinally, persons who had regular difficulties falling or staying were at an increased risk for poorer global cognitive impairment compared to those with occasional or rare sleep difficulties. There were no cross-sectional or longitudinal associations between sleep difficulties and episodic memory or verbal fluency scores.				

Table 1.2. Cont'd *Review of Literature Table for Sleep and Cognition in Older Adults*

#	Author, Year Country	Design	Sample Characteristics	Instruments used to measure sleep	Instrument used to measure Cognition	Exclusion Criteria/Statistical Adjustment
16 C	Zimmerman et al., (2012) USA Einstein Aging Study	Cross-Sectional	N – 549 Age - 79.7 (±5.0) % Female - 62.1 7o years and over	S: Medical Outcomes Study Sleep Scale O: None	Global Cognition: Blessed Information Memory Concentration Test EF: TMT-B Att: Weschler Adult Intelligence Scale-3rd ed. (WAIS-III) Digit Span Subtest TMT A & B EM: Free and Cued Selective Reminding test WM: WAIS-III Digit Span Backwards Subtest VF: Category Fluency Letter Fluency	Exclusion Criteria: Visual and auditory impairment, active psychiatric symptoms, dementia, amnestic MCI Statistical: Age, gender, ethnicity, depression, cardiovascular history
		Findings: General Sleep Problems: General sleep onset/maintenance difficulties were not associated with any of the cognition measures.				

KEY: Att.-Attention; BMI-Body Mass Index; CHD- Coronary Heart Disease; COPD-Chronic Obstructive Pulmonary Disease; EF-Executive Function; EM-Episodic Memory; HTN-Hypertension; IADL-Instrumental Activities of Daily Living; PS-Processing Speed; SE-Sleep Efficiency; SL-Sleep Onset Latency; VF-Verbal Fluency; WASO-Wake After Sleep Onset; WM-Working Memory; S-Subjective; O-Objective

Section Two: Assessing the Factor Structure of the Center for Epidemiologic Studies – Depression Scale in Older Adults: The Influence of Ethnicity

Abstract

The Center for Epidemiologic Studies Depression Scale (CES-D) is a widely used instrument to measure depression. While the four-factor structure is validated in many samples, the scale is not validated in Afro-Caribbean Americans. In adults 60 years and older, this secondary data analysis aims to replicate Radloff's postulated 4-factor structure in Afro-Caribbean Americans, European-Americans, Hispanic-Americans, and African-Americans and determine whether there is any measurement invariance across the four ethnic groups in their responses to the CES-D statements. The fit statistics for the participants for Radloff's 4-factor model was consistent with those of an adequately fit model; χ^2 =1131.86, *df*=656, *RMSEA*=.089, *CFI*=.935. Based on the analyses, there is support for configural invariance and partial metric invariance across the four ethnic groups. This study provides support for the use of the four factor CES-D model in older Americans of European, Afro-Caribbean, African-American and Hispanic descent. While there is configural invariance, the partial metric invariance suggests that some of the items in the instrument are non-invariant across the groups and researchers need to be aware of this when comparing groups.

Keywords: depression, Radloff's 4-factor structure, Afro-Caribbeans, measurement invariance, metric invariance

Introduction

By 2030, depression will be the leading contributor to the global burden of disease (World Health Organization, 2011). The Center for Epidemiologic Depression Scale (CES-D; Radloff, 1977) is an instrument that is widely used in epidemiological and population-based studies to measure depression in cross-sectional and longitudinal studies (Kim, DeCoster, Huang, & Chiriboga, 2011; Saczynski et al., 2010; Shafer, 2006) and with older adults (Haringsma, Engels, Beekman, & Spinhoven, 2004; Lewinsohn, Seeley, Roberts, & Allen, 1997; Ros et al., 2011). It has also been used in different ethnic and immigrant populations (Blazer, Landerman, Hays, Simonsick, & Saunders, 1998; Cheng & Chan, 2005; Ghubash, Daradkeh, Al Naseri, Al Bloushi, & Al Daheri, 2000; Hertzog, Van Alstine, Usala, Hultsch, & Dixon, 1990; Kazarian, 2009; Leykin, Torres, Aguilera, & Muñoz, 2011; Roberts; Spijker et al., 2004). Numerous studies use a single, summated score to measure depression; however, Radloff initially identified a four-factor structure in Caucasian participants: depressive affect, somatic and retarded activity, positive affect and interpersonal. In most cases, the instrument functions as intended (Golding & Aneshensel, 1989; Nguyen, Kitner-Triolo, Evans, & Zonderman, 2004; Shafer, 2006); however, in other cases, different factor structures (Crockett, Randall, Shen, Russell, & Driscoll, 2005; Ghubash et al., 2000; Guarnaccia, Angel, & Worobey, 1989; Long Foley, Reed, Mutran, & DeVellis, 2002; Posner, Stewart, Marin, & Perez-Stable, 2001) may contribute to inaccurate findings and conclusions. Therefore, some research on ethnic differences in depression may be inconsistent partially due to measurement invariance in depressive surveys among the sub-groups in the population and social and cultural differences in how depression is conceptualized (Nguyen et al., 2004). For instance, African-Americans and Hispanics tend to incorporate physical complaints into their responses to the affective symptom statements compared to

Caucasians (Brown, Schulberg, & Madonia, 1996; Guarnaccia et al., 1989). The possibility of measurement non-invariance suggests that the meaning of the CES-D may vary and thus current research may not accurately reflect the prevalence of depression in these populations.

In the USA, there are approximately 3.5 million Caribbean immigrants (McCabe, 2011). In research with black populations, researchers tend to include Afro-Caribbean individuals with African-Americans; however, these two groups differ based on national heritage, social and economic status, ethnicity, environmental exposure, educational attainment, and immigration status (Gibbs et al., 2013; Woodward, Taylor, Abelson, & Matusko, 2013). Woodward et al. mentioned that older Americans of Afro-Caribbean and African descent have similar rates of depressive symptoms while older Caucasians have higher rates of depressive symptoms. However, Gibbs et al. stated that persons from the Caribbean report lower levels of depression compared to African-Americans and Caucasians, but that that the persistence of depression is higher among Americans of Afro-Caribbean and African descent than Caucasians. Therefore, it is important to understand whether the differences in group responses to the statements on the CES-D are real or whether they are due to instrumentation.

Structural equation modelling assesses cross-cultural validity of an instrument by testing the invariance of the factor structure, factor loadings, and factor variances and covariances across samples (Sörbom, 1974). Confirmatory factor analyses are useful for examining the factorial validity of multi-item, multi-factor instruments by testing whether the covariances or correlations among the variables are consistent with a theorized model (Beckstead, 2002; Beckstead, Yang, & Lengacher, 2008). Factorial invariance evaluates whether items on an instrument which represents underlying factors function the same across groups that are being compared (Beckstead et al., 2008). Factorial invariance involves many types of invariances. The weakest type of invariance is configural invariance which is the extent to which the pattern of factor loadings occurs across groups meaning that the items in the instrument should have the same factor loading configuration across the groups being compared (Beckstead et al., 2008; Gregorich, 2006). Metric invariance suggests that the items are appraised according to the same scale units meaning that it examines whether the factors have the same meaning across the groups (Beckstead et al., 2008; Gregorich, 2006). Scalar invariance suggests that the differences across groups on the item means are as a result of differences in the underlying constructs, and tests whether the comparisons of group means are meaningful (Gregorich, 2006). Factor-covariance invariance refers to the similarity of the relationships among the latent variables which implies that the inter-relationships among the constructs are the same across the groups. Error-variance invariance implies that the item reliabilities are the same across groups. Partial invariance suggest that it is possible for some of the items on an instrument to display metric, scalar and error-variance invariance across groups, while other items do not. When measurement invariance is not met, comparing the groups cross-culturally will be pointless since the measurement scales are essentially different across the cultures (Beckstead et al., 2008; Little, 1997; Steenkamp & Baumgartner, 1998).

Williams et al. (2007) confirmed the four-factor structure of the CES-D in more than 40,000 African-American women. They reported that the factor loadings for the factors varied with age. Nguyen et al. (2004) and Blazer et al. (1998) substantiated the four-factor model in a sample of African-Americans and Caucasians. However, Nguyen et al. (2004) noted that there were differences between both races among the loadings for the statements that represented each of the four factors. Boutin-Foster (2008) found that the four-factor structure replicated across the Caucasian, Latino, and African-American participants but that there was a significant difference in the response between Latinos and Caucasians on the somatic, depressive, and interpersonal items and between Caucasians and African-Americans on their responses to the items on the depressive affect factor. Liang, Van Tran, Krause, and Markides (1989) also replicated the four-factor model in a three-generational sample of Mexican-Americans. And while, Long Foley, Reed, Mutran, & DeVellis (2002) replicated a four-factor structure in older African-Americans, they found no distinction between the social and depressed affect factors in the sample.

While the CES-D has been validated in many races, it has never been validated in Afro-Caribbean Americans. The present study will ascertain whether in adults 60 years and older, the postulated 4-factor structure replicates across Afro-Caribbean Americans, African-Americans, Hispanic-Americans, and European-Americans and determine whether there is evidence for measurement invariance across the four racial/ethnic groups in their responses to the CES-D statements.

Methods

Design

This is a secondary data analysis of the baseline data from the Healthy Aging Research Initiative (HARI), a prospective, longitudinal study of group differences among ethnically diverse community-living older adults (age 60+ years) in three communities in south Florida (Palm Beach, Broward and Miami-Dade counties).

Sample

Participants were recruited from health fairs, senior centers, adult communities, and by referral. Inclusion criteria included being able to ambulate independently or with the help of a device (e.g., cane, walker) and having an age- and education-adjusted Mini-Mental State Examination score greater than 23. The study over-sampled the minority sub-groups (African

Americans, Afro-Caribbeans, and Hispanic Americans). The study protocol was approved by the Florida Atlantic University Institutional Review Board and all respondents provided informed consent prior to providing any information.

Data were collected from participants during three or four visits. They provided information on their health and well-being and completed tests of memory, quality of life, mood and physical function, and a detailed health history. The measures were administered in English, Spanish, or Creole.

The HARI sample included 591 participants but the analyzed sample was reduced to 489 participants due to missing CES-D scores. The CES-D score was missing for 25, 31, 19, and 27 participants from the African-American, European-American, Hispanic-American, and Afro-Caribbean Americans, respectively. Of the 489 participants in the analyzable sample, 96 were African-American, 205 were European-American, 95 were Hispanic-Americans and 93 were African-Caribbean Americans.

Measures

Depressive Symptoms. The CES-D is a 20-item self- report measure that asks participants to rate on a scale between 0 and 3 how frequently they experience certain feelings (Radloff, 1977). In this study, they were asked to rate their feelings over the past week. Of the 20 items, 4 of them are reversed scored (Items 4, 8, 12, and16). Examples of items on the scale are “I felt fearful”, “I felt lonely”, “I enjoyed life”, and “I was happy”. Summed scores range from 0 to 60 and higher scores represent more depressive symptomatology. The CES-D also had a postulated four-factor structure (Radloff, 1977).

Data Analyses

Descriptive statistics, correlations, and Cronbach's alpha for reliability were calculated. We then conducted confirmatory factor analyses with maximum likelihood estimation to examine the factor structure of the CES-D across the four groups. LISREL 9.1 was used to replicate Radloff's four-factor model (Scientific Software International, Inc., Skokie, IL) (Joreskog & Sorbom, 2007). We assessed the fit of each of the races/ethnicities separately then ran a "stacked" model with all the parameters freely estimated. We used the overall chi square test of model fit, then supplemented with Comparative Fit Index (Byrne, 1994), Standardized Root Mean Square Residual (Bentler, 2007), Root Mean Square Error of Approximation (Steiger, 1990) and Goodness of Fit Index (Byrne, 1994) to better characterize model fit. We then conducted follow-up analyses by constraining the factor loadings matrix to be equal across all the groups. The $\chi 2$ difference test (Steiger, Shapiro, & Browne, 1985) was used to determine if fit significantly improved as a result of freeing one or more parameters in a model. Modification indices which correspond to the improvement in model fit, measured by the amount the overall $\chi 2$ value would decrease if a constrained parameter was freed, were examined. The point in the factor loading matrix with the most stress was freed and the model re-run. A threshold of 6.64 was used as a standard for significant improvement in fit, which corresponds to p=.05 for a $\chi 2$ with 1 degree of freedom change. Under partial metric invariance, we constrained the factor-covariance matrix across the groups.

Results

The mean age of the sample was 74.5 years, *SD* (±8.6 years) and age ranged between 60 to 96 years. Approximately 72% of the sample was female with African-Americans having the largest percent of females and European-Americans having the lowest percentage. The sample had about 13.4 years, *SD* (±4.7years) of education and more than half of the sample had more than 13 years of education. More than one-third of the sample was married with African-Americans reporting the lowest rate of marriage (20.2%) and European-Americans having the highest rate (43.9%). Table 1 presents the demographics of the participants. The Cronbach's α for the sample was .9 with the specific group reliability indices being .88, .86, .92, and .9 for African-Americans, European-Americans, Hispanic-Americans and Afro-Caribbean Americans, respectively.

The fit statistics for the baseline Radloff's four factor model was consistent with those of an adequately fit model χ^2 =1131.86 *df*=656, *RMSEA*=.089, *CFI*=.935. Within the stacked model, the four groups fit the model reasonably well (see table 2). The similarity of the fit indices across the groups offers support for configural invariance of the CES-D. The fit statistics of the constrained model had acceptable fit χ^2 =1274.683, *df*=716, *RMSEA*= .092, *CFI*=.924, *p*=.05. However, this constrained model had a significantly worse fit than the unconstrained model, $\Delta\chi^2$ =142.827, Δdf=60, p=.05 suggesting that some of the factor loadings were non-invariant. This process continued until eight items (crying spells, happy, enjoyed life, depressed, sad, blues, talked less and dislike) were freed and until the change in χ^2 between the unconstrained and unconstrained models was no longer significant. These results suggest that there is partial metric invariance across the groups. Model 3h is the final model demonstrating partial invariance.

With partial metric invariance supported, we looked at whether the subscales correlated in the same way across the races/ethnicities. Therefore, under partial metric invariance, I constrained the factor-covariance matrix and compared the 4 correlation tables. This allowed me to examine reasons why the groups are different and not due to an artifact of measurement. This constrained model had a significantly worse fit than the unconstrained model $\Delta\chi^2$ =47.849, Δ*df*=18, *p*=.05 suggesting that there was factor-covariance invariance (See Table 2). We terminated our analyses at this point.

Factor-covariance invariance suggests that there are differences among the groups in the subscales of the CES-D. Comparing the groups to European-Americans, Hispanic-Americans had the highest correlation (*r*=.974) between the depressed affect and the somatic and retarded activity sub-scales and Afro-Caribbean Americans had the lowest correlation (*r*=.139) between the interpersonal and the positive affect sub-scales.

Discussion

Often in research one construct is compared across multiple groups but it is important that these constructs are invariant so that the conclusions made are meaningful and correct. The purpose of the paper was to test the measurement invariance of the CES-D in European-Americans, African-Americans and Hispanic-Americans and Afro-Caribbean Americans. While other researchers have examined measurement invariance in immigrant populations, to our knowledge, this is the first study that examined measurement properties of the CES-D in the Afro-Caribbean American population. Based on the analyses, there is evidence for the use of the CES-D to measure depression, but partial metric invariance suggests that it is not completely comparable across the four ethnicities.

Radloff's four-factor model fit each of the samples adequately well. Thus, the CES-D can be explained by the four factors: depressed affect, positive affect, somatic and retarded activity, and interpersonal factor. Our findings are similar to the studies that supported the four-factor structure as the best fit in African-Americans, Hispanics, and Caucasians (Blazer et al., 1998; Boutin-Foster, 2008; Liang et al., 1989; Long Foley et al., 2002; Nguyen et al., 2004; Williams et al., 2004). Similar to Boutin-Foster, and Nguyen et al., this study found that there were ethnic differences among the parameter loadings for the statements that represented each of the four factors. However, our findings are different from those reported by Guarnaccia et al. (1989), Ying (1988) and Yen, Robins, and Lin (2000) who instead proposed a three-factor models for the CES-D.

The factor-covariance structure across the groups was different suggesting that the subscales are non-invariant across the ethnicities. For example, compared to European-Americans, there is a strong positive correlation between somatic and retarded activity and depressive affect in Hispanic Americans. Guarnaccia et al. (1989) suggested the integration of the depressed and the somatic items into a single subscale. Guarnaccia et al. suggest that in the Hispanic culture, there is little differentiation between the mind and the body compared to the U.S. and that there is also a high level of stigma associated with mental illness. Thus, Hispanics would likely report more somatic symptoms compared to other cultures. On the other hand, the correlation between the positive affect and the interpersonal factor was low in Afro-Caribbean Americans compared to European Americans. The perception of being disliked and people being unfriendly appeared to have a small impact on the positive affect of Afro-Caribbean Americans. It is possible that older Afro-Caribbean Americans do not internalize the views of others around them. Thus, experiences with other people are less likely to influence their mood. MacIntosh and Strickland (2010) suggested that if a person's culture does not support the display of certain emotions then that persons might be less likely to endorse any item related to the emotional component of depression. Further, Gregorich (2006) suggests that the items could have different meanings across the population groups and cultural norms can contribute to one group valuing an item more than another group.

Four statements (cry, depressed, sad, blues) from the depressed affect factor, two (happy, enjoy) from the positive affect factor, and one each from the somatic and retarded activity (talk) and interpersonal factors (dislike) were non-invariant. Other researchers have also reported that some of these items have been shown to be problematic (Carleton et al., 2013; Mogos et al., 2014; Williams et al., 2007).

This study examined and validated Radloff's four-factor model in four groups of Americans from African-American, Hispanic, European, and Afro-Caribbean descent. However, the study used cross-sectional data, thus is it not possible to identify changes in the factors with time causal associations among the factors. Also, the CES-D was administered in multiple languages, although all the language versions were delivered in the same format using the same medium. Finally, this was a study of older adults so is not generalizable to the younger adult population.

Future studies should focus on validating the CES-D in a younger Afro-Caribbean population and also examine whether the recommend cut-off is the same in the Afro-Caribbean population as the Caucasian population. In addition, some studies should be conducted comparing the measurement invariance between Afro-Caribbean Americans and Caribbean natives and examine measurement invariance of the scale among the different generations of Afro-Caribbean Americans. Longitudinal studies should be conducted with larger samples to observe the stability of the relationship among the factors and the statements in the groups over time. It may be also useful to consider measuring acculturation and marginalization and test whether or not these variables would affect measurement invariance (MacIntosh & Strickland, 2010).

Woodward et al. (2013) reported that Afro-Caribbean persons have similar lifetime prevalence rates of depression as Caucasians and African-Americans so it is important to have tools that are invariant across races/ethnicities to allow for meaningful comparisons. The CES-D has never been validated in the Afro-Caribbean population and this study has supported the partial metric invariance of the four-factor structure, which is validated in other races/ethnicities, in Afro-Caribbean persons. This study provides support for the use of the four factor CES-D model in older Americans of European, Afro-Caribbean, African American and Hispanic descent. While there is configural invariance, the partial metric invariance suggests that some of the items in the instrument are non-invariant across the groups and researchers need to be aware of this when comparing groups. In addition, this supports the use of the CES-D by healthcare practitioners in this population. However, caution should still be exercised when making diagnoses about depression and screens should be coupled with clinical assessment since depressive symptoms may present differently by persons in different racial/ethnic groups (Kim et al., 2011).

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Table 2.1. *Demographics for the sample and each ethnicity*

	Sample	African-American	European-American	Hispanic-American	Afro-Caribbean	p-value
Age m(sd)	74.4(8.6)	71.8(7.6)	76.9(9.1)	72.6(7.75)	73.5(7.8)	<.001
Female (%)	71.5	82.3	61.2	75.8	78.5	<.001
Education m(sd)	13.4(4.7)	12.9(3.9)	15.5(3.7)	11.2(5.2)	11.6(4.9)	<.001
0-11years (%)	23.7	30.4	6.1	39.1	40	
12 years (%)	17.6	14.1	21.7	18.5	11.1	
13 or more years (%)	58.7	55.4	72.2	42.4	48.9	
Married (%)	35.8	20.2	43.9	32.3	37.6	<.001

Table 2.2. *Summary of Model Fit Statistics*

Model		χ^2	df	$\Delta\ \chi^2$	Δ df	RMSEA	CFI	SRMR	GFI
	European-American	352.329	164			.077	.932	.068	.850
Radloff 4-Factor	Hispanic-American	290.072	164			.091	.952	.076	.776
	African-American	383.289	164			.119	.858	.093	.754
	Afro-Caribbean American	301.445	164			.095	.928	.079	.758
	All Groups	1131.856	656			.089	.935		
	European-American							.068	.850
Model 1	Hispanic-American							.076	.776
	African-American							.094	.754
	Afro-Caribbean							.079	.758
	All Groups	1274.683	716	142.827	60	.092	.924		
	European-American							.184	.826
Model 2	Hispanic-American							.246	.748
	African-American							.121	.738
	Afro-Caribbean							.129	.740
	17 freed	1259.205	713	15.478	3	.092	.925		
	European-American							.162	.830
Model 3a	Hispanic-American							.243	.748
	African-American							.120	.739
	Afro-Caribbean							.130	.742
	17, 12 freed	1248.775	710	10.43	3	.091	.926		
	European-American							.163	.832
Model 3b	Hispanic-American							.243	.747
	African-American							.120	.739
	Afro-Caribbean							.118	.746
	17, 12,16 freed	1239.473	707	9.302	3	.090	.927		
	European-American							.162	.832
Model 3c	Hispanic-American							.228	.751
	African-American							.113	.742
	Afro-Caribbean							.117	.746

Table 2.2. Cont'd *Summary of Model Fit Statistics*

Model		χ^2	df	$\Delta\ \chi^2$	Δ df	RMSEA	CFI	SRMR	GFI
	17,12,16,6 freed	1229.493	704	9.98	3	.090	.928		
	European-American							.158	.832
Model 3d	Hispanic-American							.230	.751
	African-American							.117	.746
	Afro-Caribbean							.112	.749
	17,12,16,6,18 freed	1218.830	701	10.663	3	.090	.929		
	European-American							.157	.832
Model 3e	Hispanic-American							.219	.752
	African-American							.121	.747
	Afro-Caribbean							.104	.751
	17,12,16,6,18,3 freed	1210.966	698	7.864	3	.089	.930		
	European-American							.151	.833
Model 3f	Hispanic-American							.198	.752
	African-American							.117	.747
	Afro-Caribbean							.105	.753
	17,12,16,6,18,3,13 freed	1200.859	695	9.840	3	.089	.931		
	European-American							.136	.835
Model 3g	Hispanic-American							.184	.756
	African-American							.115	.745
	Afro-Caribbean							.108	.754
	17,12,16,6,18,3,13,19 freed	1192.118	692	8.741	3	.089	.932		
	European-American							.122	.838
Model 3h	Hispanic-American							.175	.760
	African-American							.116	.745
	Afro-Caribbean							.107	.754
	All Groups	1239.967	710	47.849	18	.090	.928		
	European American							.134	.832
Model 4	Hispanic-American							.193	.760
	African-American							.129	.735
	Afro-Caribbean							.122	.739

Note: Model 1-Unconstrained Model; Model 2- Complete Metric Invariance; Model 3a-h-Partial Metric Invariance; Model 4- Factor-Covariance Invariance. *-p=.01

Table 2.3. *Correlations among the factors for each of the ethnicities*

European-American

	DEP	SOM	POS	INP
DEP	1.000			
SOM	.774	1.000		
POS	.714	.549	1.000	
INP	.798	.563	.579	1.000

Hispanic-American

	DEP	SOM	POS	INP
DEP	1.000			
SOM	.944	1.000		
POS	.774	.770	1.000	
INP	.777	.833	.588	1.000

African-American

	DEP	SOM	POS	INP
DEP	1.000			
SOM	.816	1.000		
POS	.622	.461	1.000	
INP	.891	.719	.295	1.000

Afro-Caribbean American

	DEP	SOM	POS	INP
DEP	1.000			
SOM	.841	1.000		
POS	.905	.829	1.000	
INP	.314	.404	.139	1.000

DEP- Depressive Affect, SOM-Somatic and Retarded Activity, POS-Positive Affect, INP-Interpersonal

Section Three: Sleep, Depressive Symptoms, and Cognition in Caregivers of Persons with Dementia

Abstract

Caregivers of persons with dementia report sleep disturbance, high rates of depressive symptoms and may be at risk for impaired cognition. This study examined the cross-sectional relationships between sleep parameters, depressive symptoms, and crystallized, fluid, and total cognition in caregivers of persons with dementia. Participants were 28 caregivers (82% female) with a mean age 65.14 years (SD=10.08). Caregivers completed a 14-day sleep diary, the Center for Epidemiologic Studies Depression Scale and the cognitive battery of tests from the National Institutes of Health Toolbox. Caregivers slept less than seven hours nightly, had long sleep onset latency and wake after sleep onset, and had significantly worse fluid cognition than the population norms. While some of the sleep parameters were correlated with each other, they did not correlate with depressive symptoms or crystallized, fluid, or total cognition. It is possible that the small sample size prevented any associations among the variables from being revealed. Sleep problems and lower fluid cognition scores in the caregivers suggest that there are issues in the caregiving population where interventions are possible. Healthcare providers should assess these variables at baseline and on an on-going basis.

Keywords: fluid cognition, crystallized cognition, sleep onset latency, sleep duration, caregiver sleep

Introduction

Almost 15 million persons care for someone with Alzheimer's disease (AD) or other dementias (Family Caregiving Alliance, 2012). With the population of older adults expected to double over the next 15 years and age being the highest risk factor for the development of dementia, it is anticipated that the population of caregivers will also increase as family members and spouses start to care for their aging loved ones (Family Caregiver Alliance, 2004; Levine, Halper, Peist, & Gould, 2010).

Up to 66% of family caregivers of persons with dementia report sleep disturbances (Creese, Bédard, Brazil, & Chambers, 2008; McCurry, Logsdon, Teri, & Vitiello, 2007; McCurry & Teri, 1996; Wilcox & King, 1999) possibly related to the changes in the sleep-wake pattern and the night-time activity exhibited by care recipients (Rowe et al., 2009). Caregivers took a significantly longer time to fall asleep (Beaudreau et al., 2008; Castro et al., 2009; Fonareva, Amen, Zajdel, Ellingson, & Oken, 2011; McCurry et al., 2007; Rowe, McCrae, Campbell, Benito, & Cheng, 2008), experienced frequent awakenings (Beaudreau et al., 2008), had a longer wake after sleep onset (Beaudreau et al., 2008; Mills et al., 2009; Rowe et al., 2008), shorter sleep duration (Beaudreau et al., 2008; McKibbin et al., 2005; Rowe et al., 2008), shorter sleep efficiency (Beaudreau et al., 2008; Castro et al., 2009; McCurry et al., 2007; Mills et al., 2009; Rowe et al., 2008), and poor sleep quality (Fonareva et al., 2011; Rowe et al., 2008). Rowe et al. also concluded that there was an irregular pattern of caregiver sleep demonstrated by a significantly greater variability in caregivers' night to night sleep and suggested that this irregularity in the sleep pattern may promote the perception of poor sleep.

Sleep problems mediated the difference in scores on a measure of cognitive decline, between caregivers of persons with dementia and non-caregivers (Caswell et al., 2003; de Vugt et al., 2006) with recent research revealing that in a population-based longitudinal study over 9.2 ± 3.1 years, former AD caregivers had a six times greater risk of incident dementia (Norton et al., 2010). Cognition was theorized to consist of two types, fluid and crystallized, (Cattell, 1943) but it can also be calculated as a total score. Fluid abilities are used in problem solving, creating memories and allowing individual to adapt to new situations in daily life; these abilities peak in early adulthood, then decline with age (Flanagan & Dixon, 2013; Nisbett et al., 2012). Crystallized abilities are more dependent on experience and represent an accumulation of verbal knowledge and skills; these abilities develop throughout childhood and continue to improve with age then stabilizes in middle adulthood (Flanagan & Dixon, 2013; Nisbett et al., 2012). Executive function, attention, memory, and processing speed are sub-domains of fluid abilities and language is one subdomain of crystallized cognition.

Caregivers were at higher risk for performing poorly on cognition functions tests including tests of processing speed (Caswell et al., 2003; de Vugt et al., 2006; Vitaliano et al., 2009), attention (Caswell et al., 2003; Mackenzie, Smith, Hasher, Leach, & Behl, 2007), executive function (de Vugt et al., 2006), memory (de Vugt et al., 2006; Mackenzie, Wiprzycka, Hasher, & Goldstein, 2009), and global cognition (de Vugt et al., 2006; Herrera et al., 2013). What is unclear, however, is how sleep disturbances affect cognition. One factor may be a high rate of depressive symptoms reported by caregivers of persons with dementia. Caregivers of persons with dementia report higher levels of depressive symptoms than non-caregivers (Beaudreau et al., 2008; Epstein-Lubow, Davis, Miller, & Tremont, 2008; Fonareva et al., 2011; Joling et al., 2010; McCurry, Pike, Vitiello, Logsdon, & Teri, 2008; Schoenmakers, Buntinx, & Delepeleire, 2010; Vitaliano et al., 2009) with one in three caregivers of persons with dementia reporting depressive symptoms (Schoenmakers et al., 2010). Estimates show that between 46%

and 83% of dementia caregivers experience depression (Alspaugh, Stephens, Townsend, Zarit, & Greene, 1999). Depressive symptoms mediated the difference in scores on a measure of cognitive decline, between caregivers of persons with dementia and non-caregivers (Köhler et al., 2010; Vitaliano et al., 2009).

There are few studies directly examining the effect of sleep parameters and fluid, crystallized and total cognitive abilities in caregivers. Given the potential social and economic savings as a result of persons accepting the caregiving role (Levine et al., 2010), it is important to identify mechanisms that influence the relationships between sleep and cognition so that targeted interventions can be developed. Moreover, since caregivers use these abilities to manage the care of their loved ones, it is even more vital to understand how these variables interact in the caregivers. The aim and hypotheses of the current study are:

Aim: To understand the relationships among sleep, depressive symptoms and, crystallized, fluid and total cognition in caregivers of persons with dementia.

H1: Poor sleep will be associated with lower crystallized, fluid and total cognition.

H2: Higher depressive symptoms will be associated with lower crystallized, fluid and total cognition.

H3: Depressive symptoms will mediate the association between poor sleep and lower crystallized, fluid and total cognition.

H4: Depressive symptoms have a moderating effect between poor sleep and cognition such that caregivers with poor sleep and high depressive symptoms will have worse crystallized, fluid and total cognition.

Methods

Design

A cross-sectional, correlational study was conducted using baseline data from a larger parent study of a randomized, prospective study of caregivers of persons with dementia (Improving Dementia Caregiver Sleep & the Effect of Heart Disease Biomarkers, 1R01AG039495-01).

Participants

Participants were 28 in-home caregivers of persons with dementia. The caregivers were recruited from the community in the Eastern to Mid-Florida area and all data collection was done in the homes of the participants. To be included in the study, the participants had to have met the standard criteria for insomnia (reported time to fall asleep and/or time awake during the night is more than 30 minutes on at least 3 nights/week over a 6-month period of time), speak and understand English, deny the presence of chronic illness that requires frequent treatment/ assessment, not have a diagnosed sleep disorder such as sleep apnea or restless leg syndrome, not require aids to walk in the home at night, and have a cognitive status score of more than 25 based on a the Telephone Interview for Cognitive Status.

The study protocol was approved by the University of South Florida Institutional Review Board and all respondents provided informed consent prior to data collection.

Measures

Sleep. All measures were collected over a period of 14 days using a sleep diary. The sleep diary asked the participants to complete the number of minutes they napped the previous day, bedtime, time taken to fall asleep, number of awakening for themselves and the care recipients, the minutes awake during the night for themselves and the care recipient, their final wake-up time, their out-of-bed time, their sleep quality and the medications they took for sleep. From the data collected, the variables used were sleep onset latency, wake after sleep onset, time in bed, total sleep time, sleep efficiency, and sleep quality. According to Schutte-Rodin, Broch, Buysse, Dorsey, and Sateia (2008), sleep onset latency is the time from intention to fall asleep to actually falling asleep; wake after sleep onset is the sum of minutes awake from sleep onset to the final awakening; time in bed is the time from bed time to getting out of bed; total sleep time is the time in bed that the individual was actually asleep; sleep efficiency is the percentage of time the individual is asleep during time in bed; and sleep quality which has a range from 1 to 5 represents how the caregiver felt when they awoke.

Depressive Symptoms. Depressive Symptoms were assessed using the Center for Epidemiologic Studies Depression (CES-D) Scale. The CES-D is a 20-item, self-report questionnaire about depressive symptoms that was developed to measure symptoms of depression in community populations. It is rated on a 4-point scale from “rarely or none of the time” to “most of the time” (Radloff, 1977). CES-D scores range from 0 to 60; higher scores indicate more severe depressive symptoms. It has a very good reliability and validity (Beekman et al., 1997; Black, Markides, & Miller, 1998; Farran, Miller, Kaufman, Donner, & Fogg, 1999; Lee & Farran, 2004; Roberts, 1980). The CES-D has also been used successfully to assess prevalence of symptoms in caregivers (Lee & Farran, 2004). The Cronbach’s alpha for this study was .923.

Cognition. The cognitive battery of the National Institutes of Health (NIH) Toolbox was used to test cognition. The test was administered on the computer and had a computer adaptive format.

Fluid cognition was computed using the following tests: Flanker Inhibitory Control and Attention Test, Dimensional Change Card Sort Test, Picture Sequence Memory Test, List Sorting Working Memory Test and Pattern Comparison Processing Speed Test. The NIH Toolbox Flanker Inhibitory Control and Attention Test required the participant to focus on a given stimulus while inhibiting attention to stimuli flanking it. Sometimes the middle stimulus pointed in the same direction as the “flankers” and sometimes it pointed in the opposite direction. Scoring was based on a combination of accuracy and reaction time (Slotkin, Kallen, et al., 2012). For the NIH Toolbox Dimensional Change Card Sort Test, participants were asked to match a series of test pictures that were presented varying along two dimensions (e.g., shape and color). Scoring is based on a combination of accuracy and reaction time (Slotkin, Kallen, et al., 2012). For the NIH Toolbox Picture Sequence Memory Test, the participant recalled an increasingly lengthy series of illustrated objects and activities that were presented in a particular order. The participants were asked to recall the sequence of pictures that were demonstrated over two learning trials. Participants were given credit for each adjacent pair of pictures they placed correctly (Slotkin, Kallen, et al., 2012). The NIH Toolbox List Sorting Working Memory Test required the participants to sequence different visually- and orally-presented stimuli food or animal), first in size order from smallest to largest, and second food in size order, followed by animals in size order (Slotkin, Kallen, et al., 2012). For the NIH Toolbox Pattern Comparison Processing Speed Test, participants had to decide whether two side-by-side pictures were the same or different. Participants’ raw score was the number of items correct in a 90-second period (Slotkin, Kallen, et al., 2012).

Crystallized cognition was computed using the following tests: Picture Vocabulary Test and the Oral Reading Recognition Test. In the NIH Toolbox Picture Vocabulary Test, the participants heard a word and saw four photographs on the computer screen and asked to select the picture that most closely matched the meaning of the word (Slotkin, Kallen, et al., 2012). In the NIH Toolbox Reading Recognition Test, the participants were asked to read and pronounce letters and words displayed on the computer screen as accurately as possible. The test administrator scored them as right or wrong (Slotkin, Kallen, et al., 2012).

Total cognition was computed using the fluid and crystallized cognition tests. All the test scores were fully adjusted for age, gender, race, ethnicity, and educational attainment (Slotkin, Nowinski, et al., 2012).

Demographics. Baseline data included gender, race, age, marital status, years of education, employment status, and relationship to person with dementia.

Data Analyses

Data were analyzed with SPSS (version 22; SPSS, Chicago, IL, USA). Descriptive statistics were used to describe the sample characteristics and the study variables. Cronbach's Alpha was calculated on the CES-D. One sample t-tests were used to compare the sample means with the general population on the cognition variables. Bivariate correlations were used to examine the relationships among the sleep variables, depressive symptoms, and cognitive performance. Multiple regressions were used to conduct mediation and moderation analyses. For mediation analyses, we conducted simple regressions between the sleep parameters and depressive symptoms, sleep parameters and cognition, and depressive symptoms and cognition. We then conducted hierarchical regression with sleep parameters, depressive symptoms and cognition. For the moderation analyses, we centered the sleep parameters and depressive symptoms then computed an interaction term by multiplying the centered sleep parameter with the centered depressive symptoms variable. We then ran a multiple hierarchical regression with the sleep parameters, depressive symptoms and the computed centered term.

Results

The sample included 28 caregivers. The mean age of the sample was 65.14 years, *SD* (±10.08 years; range 44 – 83 years) with a mean of 15.14 years, *SD* (±2.53 years) of education. Eighty-two percent of the participants were women. Seventy-nine percent were Caucasian. Twenty-nine percent of the participants were employed and the majority of the caregivers were the wives (46%) and the adult daughters (36%) of the care recipients.

Caregiver Sleep, Depressive Symptoms, and Cognition characteristics

On average, caregiver sleep onset latency was 34.93 minutes, *SD* (±20.56 minutes). Caregivers also experienced fragmented sleep seen by a wake after sleep onset mean of 43.77 minutes, *SD* (±25.13 minutes). Caregivers spent an average of 500.35 minutes, *SD* (±45.24 minutes) in bed and obtained an average total sleep time of 395.94 minutes, *SD* (±44.66 minutes). Self-reported mean sleep quality score was 3.04, *SD* (±.51). The average sleep efficiency was 79.12%, *SD* (±6.78%). Approximately 41% of the caregivers reported depressive symptoms suggestive of a diagnosis of depression (scores of 16 or greater on the CES-D) but the average CES-D score was 14.36, *SD* (±9.25, range 1.50 to 31). The average crystallized ability score was 112.81, *SD* (±18.38) which was significantly less than the general population norm of 141.13, $t(1,27)$=.000 and the average fluid cognition score was 93.21, *SD* (±8.28) which was significantly less than the general population norm of 116.68, $t(1,27)$=.000. The average total cognition score was 102.05, *SD* (±16.56) which was less than but not significantly different from the general population norm of 99.21, $t(1,27)$=.373 (See Table 1).

Relationships among the study variables

Age was significantly positively correlated with race and being a caregiver spouse and was negatively correlated with education and employment meaning that the older the participant, the more likely to be Caucasian, a spousal caregiver, have less years of education and not be currently employed. Gender was negatively correlated with time in bed (r=.399, p=.032) suggesting that females were likely to spend a longer time in bed. Employment was significantly negatively correlated with being a caregiver spouse and depressive symptoms scores and was positively correlated with sleep efficiency.

Among the sleep variables, sleep onset latency was significantly correlated with time in bed (r=.470, p=.012) and sleep efficiency (r= -.560, p=.002); the longer the sleep onset latency, the longer the time in bed and the lower the sleep efficiency. Wake after sleep onset was significantly correlated with sleep efficiency (r=-.653, p<.001) and sleep quality (r=-.405, p=.033); the longer the wake after sleep onset, the lower the sleep efficiency and the worse the sleep quality. Time in bed was significantly correlated with total sleep time (r=.618, p<.001) suggesting that the longer the time spent in bed the longer the total sleep time. Total sleep time was significantly correlated with sleep efficiency (r=.624, p<.001) meaning that the longer the total sleep duration, the higher the sleep efficiency. Sleep efficiency was significantly correlated with sleep quality (r=.386, p=.042); the higher the sleep efficiency, the higher the sleep quality.

There were no significant correlations between the sleep variables, depressive symptoms, and crystallized, fluid, and total cognition. The fluid and crystallized cognition domains were not significantly correlated with each other suggesting that they measured different constructs.

Mediation and Moderation Analyses

Neither the sleep variables nor depressive symptoms predicted the cognition variables; therefore, we did not conduct any mediation analyses.

The intent for moderation was to show the unique contribution of the sleep parameters, depressive symptoms and the interaction of both; however, due to the inter-correlations among the predictors (including the interaction term) leading to suppressor effects, the results are difficult to interpret. For example, for total cognition, the predictors explained 27% of the variance and the overall regression equation was significant, $F(3,24)=3.00$, $p=.05$. Sleep efficiency and depressive symptoms were not significant; however, the interaction between sleep efficiency and depressive symptoms reached significance, $t(27)=2.849$, $p=.009$. Upon closer examination, the part correlations for the predictors which should be less than then zero-order correlations increased suggesting that there are suppressor effects.

Discussion

The present study explored the relationships between sleep, depressive symptoms and cognitive performance in caregivers of persons with dementia. Sleep onset latency, wake after sleep onset, time in bed, total sleep duration sleep efficiency, and sleep quality were not correlated with and did not predict performance on the crystallized, fluid, or total cognition tasks. While caregivers spent at least 8 hours in bed, they had less than 7 hours total sleep duration and they experienced fragmented sleep similar to caregivers in other studies (Beaudreau et al., 2008; Castro et al., 2009; Fonareva et al., 2011; Rowe, Kairalla, & McCrae, 2010; Rowe et al., 2008). Depressive symptoms also did not mediate or moderate the ability of the sleep parameters to predict cognitive performance. It is possible that due to the small sample size, any associations among the variables were not revealed.

In this study, caregivers performed significantly better when compared to normalized scores in the crystallized cognition tasks. Crystallized cognition is associated with learning and knowledge over the lifetime, and continues to improve into late adulthood (Cattell, 1943; Flanagan & Dixon, 2013); the higher crystallized scores in this sample could be due to the highly educated sample with an average of more than 15 years of education. While Vitaliano et al. (2005) found that caregivers' scores were lower than non-caregivers scores on a test of crystallized cognition, the scores between the groups were not significantly different.

Caregivers performed significantly worse when compared to the normalized scores in the fluid cognition tasks. Similar to other studies, caregivers also performed worse on tests of fluid cognition (Caswell et al., 2003; de Vugt et al., 2006; Mackenzie et al., 2009; Vitaliano et al., 2009). Mackenzie et al. suggested that burden could be contributing to the caregivers' pooerer scores. However, Bertrand et al. (2012) reported that compared to non-caregivers and former caregivers, current caregivers did better on fluid cognition tests. However the caregivers were younger and more educated than the comparison sample. Sleep problems are thought to affect the frontal cortex which is where the activities of fluid cognition are processed (Bugg, Zook, DeLosh, Davalos, & Davis, 2006; Parkin & Java, 1999). Fluid cognition represents one's ability to think and reason and peaks then starts to decline in the late 20s (Cattell, 1943; Flanagan & Dixon, 2013). Fluid cognition tasks occur in the prefrontal cortex which is thought to be affected by sleep problems (McGrew, 2005). It is possible that the chronic sleep problems in these caregivers are associated with the poorer performance in this domain compared to the norms. Also, there may be a floor effect and thus no effect observed between sleep parameters and fluid cognition in the poor-sleeping caregivers. It would be interesting to study the relationship among the variables in caregivers who have no sleep problems at the start of the caregiving experience.

Researchers can also examine whether a relationship between the variables emerges when the sleep in the caregivers has improved after a sleep intervention.

Employment was correlated with lower depressive symptoms scores. Pawl, Lee, Clark, & Sherwood, (2013) suggests that persons who are employed may have a better sleep-wake schedule due to their work schedules. They also suggested that employment may lead to more fatigue so the caregivers may have a higher propensity to sleep (Pawl et al., 2013). They suggested that more research exploring sleep, employment, and caregiving is warranted. In terms of employment and depressive symptoms, it is likely that employment may provide respite from the caregiving role and the stressors associated with caregiving.

The study was a cross-sectional study with a small sample size. Cross-sectional studies cannot demonstrate causality; thus, longitudinal studies are important to examine the relationships over time. It is challenging to interpret results with small sample sizes since the lack of significance could be because of the small sample size instead of the absence of an effect (Hackshaw, 2008). While the cognitive battery of the National Institutes of Health Toolbox is brief and does not test all the domains of cognition, it allows for the efficient assessment of the main aspects of cognition (Bauer & Zelazo, 2014). The cognitive battery also provides scores on the individual domains along with a total cognitive score. The test is a computer adaptive test and caregivers who may not be adept at using the computer may be intimidated which may adversely affect their performance. However, there are practice sections before the actual test so that the participant will understand how to perform the test. Finally, the caregivers in this sample were highly educated and mostly Caucasian; thus, generalizability to other samples and populations is challenging. Future studies should seek to recruit a more heterogeneous sample.

Objective and subjective sleep are not often congruent (Rowe et al., 2008); therefore, it may be may be useful to examine whether the findings would be similar or different using actigraphic, objective data. Caregiver sleep is also variable; this study collected data over a 14-day period to account for night-to-night variability in caregiver's sleep (Rowe et al., 2008).

This is one of the first studies to examine the associations among sleep parameters, depressive symptoms, and cognition in caregivers of persons with dementia. Poor sleeping caregivers are at risk for having low fluid cognition. Performance in fluid cognition measures can predict everyday function. For example, performance in tests of processing speed can predict execution of cognitively complex tasks like managing medications, problem-solving, completing independent activities of daily living, and the ability to take care of one's self and the care recipient (Bertrand et al., 2012; Vitaliano et al., 2009). With the negative impact that a change in cognition can have on the caregiver and the care recipient, healthcare practitioners should assess caregivers for sleep problems and changes in cognition on an ongoing basis (Vitaliano et al., 2009) in order to provide interventions and support for the caregivers and minimize outcomes like more depressive symptoms and early institutionalization of the care recipient.

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Table 3.1. *Descriptives Statistics for Sleep, Depressive Symptoms, and Cognition*

Variables	Mean (SD)	N (%)	Norms	t- test	p-value
Sex					
Male		5 (17.9)			
Female		23 (82.1)			
Race					
Caucasian		22 (78.6)			
African-American		4 (14.3)			
Hispanic		2 (7.1)			
Relation to care recipient					
Spouse		14 (50)			
Child		13 (46.4)			
Other		1 (3.6)			
Employment status					
Currently Employed		8 (28.6)			
Not currently employed		20 (71.4)			
Age	65.14 (10.08)				
Years of education	15.14 (2.53)				
Sleep					
Sleep Onset Latency	34.93 (20.56)				
Wake After Sleep Onset	43.77 (25.13)				
Time in Bed	500.35 (45.24)				
Total Sleep Time	395.94 (44.66)				
Sleep Efficiency	79.13 (6.78)				
Sleep Quality	3.03 (.51)				
Depressive Symptoms	14.36 (9.25)				
Cognition					
Crystallized Cognition	112.81 (18.38)		98.21 (17.90)	4.20	P<.001
Fluid Cognition	93.21 (8.28)		100.40 (16.45)	-4.591	P<.001
Total Cognition	102.05 (16.56)		99.21 (17.40)	.906	P=.373

Table 3.2. *Correlations among Sleep, Depressive Symptoms, and Cognition*

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Age	1															
2	Gender(Female=0)	.069	1														
3	Race(Caucasian=1)	.438*	.016	1													
4	Relationship (Spouse=1)	.577**	-.093	.348	1												
5	Education	-.399*	-.252	.100	-.230	1											
6	Employment (Yes=1)	-.672**	-.088	-.248	-.474*	.345	1										
7	SOL	.130	-.147	.015	-.131	-.160	-.200	1									
8	WASO	-.054	-.162	.075	-.337	.225	-.210	.080	1								
9	TIB	.095	-.393*	.255	.063	.109	-.121	.470*	.300	1							
10	TST	-.019	-.230	.215	.255	.152	.213	-.115	-.292	.618**	1						
11	SE	-.158	.109	-.003	.182	.076	.413*	-.560**	-.653**	-.207	.624**	1					
12	SQ	-.344	-.089	-.160	-.109	-.098	.370	.039	-.405*	-.140	.172	.386*	1				
13	CESD	.172	-.239	.097	.362	.079	-.460*	.150	.139	.227	.113	-.111	-.247	1			
14	Crystallized Cognition	.045	-.012	.322	.009	.170	.193	-.110	-.117	-.164	-.082	.122	-.037	.062	1		
15	Fluid Cognition	.097	-.117	.116	-.183	.002	.290	.069	.014	.003	.002	.043	.049	-.107	.359	1	
16	Total Cognition	-.014	-.050	.301	-.075	.177	.287	-.107	-.095	-.138	-.040	.158	.037	.027	.953**	.601**	1

**p* < .05, ***p* < .001, SOL-Sleep Onset Latency, WASO-Wake After Sleep Onset, TIB-Time in Bed, TST-Total Sleep Time, SE- Sleep Efficiency, SQ-Sleep Quality, CES-D-Center for Epidemiologic Studies Depression Scale

Summary of Dissertation

Discussion

This dissertation used the theory by Vitaliano et al. (2011) which attempts to explain how mediators of caregiver stress can increase the risk of cognitive impairment in spousal caregivers of persons with dementia to guide my dissertation which aimed to understand the relationships among sleep, depressive symptoms and cognition in caregivers of persons with dementia. Using adults 60 years and older as a comparative population for caregivers, I concluded that in the first section of the dissertation, the current literature is inconclusive about the association between subjective sleep parameters and cognition in older adults and there is insufficient literature to determine whether a relationship exists between objective sleep parameters and cognition. Therefore, more research studies incorporating measures to capture sleep variability and similar cognitive measures, are needed to clarify the relationships both in older adults and caregivers of persons with dementia.

One in three caregivers report depressive symptoms (Schoenmakers et al., 2010). If the instrument used to evaluate depression among different groups is measurement non-invariant and comparisons are then made across these groups, the conclusions will be incorrect. An instrument widely used to measure depression is the Center for Epidemiologic Studies Depression Scale (Radloff, 1977). The second section of the dissertation demonstrated evidence for configural and partial measurement invariance in Afro-Caribbean Americans, African-Americans, Hispanic Americans, and European-Americans. While being aware that some of the items are non-invariant, researchers and healthcare providers can use a composite score for the CES-D to make comparisons across the four groups of older adults.

Finally, caregivers report sleep problems, higher depressive symptoms and are at risk for impaired cognition (Alspaugh, Stephens, Townsend, Zarit, & Greene, 1999; McCurry, Logsdon, Teri, & Vitiello, 2007; Norton et al., 2010; Schoenmakers et al., 2010). In the third section of the dissertation, in caregivers of persons with dementia, subjective sleep parameters did not predict depressive symptoms or cognition. There is a possibility that depressive symptoms can moderate some sleep parameters but the suppression effects make it challenging to interpret the moderating influence. With the knowledge that there are potential associations among sleep parameters, depressive symptoms and cognition in caregivers, healthcare providers should collect baseline assessments on sleep, depressive symptoms and cognition from caregivers and monitor them on an ongoing basis to identify changes and intervene in a timely manner.

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Appendices

Appendix 1: Institutional Review Board Approval for Section Two

USF
UNIVERSITY OF
SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

January 13, 2015

Glenna Brewster
College of Nursing
12901 Bruce B Downs Blvd,
MDC22
Tampa, , FL 33612-4766

RE: **NOT Human Research Activities Determination**

IRB#: Pro00018551

Title: Assessing the factor structure of the Center for Epidemiological Studies – Depression Scale in older adults: The influence of race/ethnicity

Dear Ms. Brewster:

The Institutional Review Board (IRB) has reviewed the information you provided regarding the above referenced project and has determined the activities do not meet the definition of human subjects research. Therefore, IRB approval is not required. If, in the future, you change this activity such that it becomes human subjects research, IRB approval will be required. If you wish to obtain a determination about whether the activity, with the proposed changes, will be human subjects research, please contact the IRB for further guidance.

All research activities, regardless of the level of IRB oversight, must be conducted in a manner that is consistent with the ethical principles of your profession and the ethical guidelines for the protection of human subjects. As principal investigator, it is your responsibility to ensure subjects' rights and welfare are protected during the execution of this project

Also, please note that there may be requirements under the HIPAA Privacy Rule that apply to the information/data you will use in your activities. For further information about any existing HIPAA requirements for this project, please contact a HIPAA Program administrator at 813-974-5638.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

John A Schinka, Ph.D.

John Schinka, Ph.D., Chairperson
USF Institutional Review Board

Appendix 2: Institutional Review Board Approval for Section Three

USF
UNIVERSITY OF
SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

2/25/2015

Meredeth Rowe, Ph.D.
College of Nursing
12901 Bruce B. Downs Blvd.
MDC22
Tampa, FL 33612

RE: **Expedited Approval for Amendment**
IRB#: Ame23_Pro00003931
Title: Improving Dementia Caregiver Sleep & The Effect on Heart Disease Biomarkers

Dear Dr. Rowe:

On 2/24/2015, the Institutional Review Board (IRB) reviewed and **APPROVED** your Amendment. The submitted request has been approved for the following:

Addition of protocol for dissertation that uses study data
Addition of grant application for dissertation in parent study (1.5.4)

Approved Item(s):
Protocol Document(s):
Glenna Brewster - Protocol for dissertation

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

VJorgensen MD

E. Verena Jorgensen, M.D., Chairperson
USF Institutional Review Board

About the Author

Glenna Brewster grew up in St. Vincent and the Grenadines and migrated to Florida in 2003. She earned an A.S. and A.A. in Nursing from Broward College, a B.S. and M.S. in Nursing from the University of South Florida, College of Nursing, and a M.A. in Gerontology from the University of South Florida, School of Aging Studies. She actively participates in extracurricular activities; she has served as the President of the Doctoral Nursing Student Organization and is the current secretary of the Emerging Scholars and Professional Organization of the Gerontological Society of America.

Glenna has worked as a Registered Nurse on a medical-surgical unit caring for older adults. She developed an interest in research while taking her first undergraduate research methods course. Her research interests are sleep, depressive symptoms and cognition in older adults and caregivers on persons with dementia. During her doctoral studies, Glenna co-authored one peer-reviewed publication. She has collaborated on many posters and oral presentations. She was awarded a National Institutes of Health/National Institutes on Aging diversity supplement award and a National Hartford Centers of Gerontological Nursing Excellence Patricia G. Archbold Scholar award. She was one of sixteen chosen to attend the inaugural Global Social Initiative on Aging Masterclass in Dublin, Ireland in April, 2015.

Glenna enjoys travelling and exploring new cultures. She sees herself collaborating with and visiting her global collaborators to assist with performing and implementing the findings of her research.