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The Role of Physical Activity and Gender as Moderators for the Relationship Between Insomnia and Depression

Claire E. Wickersham
University of Massachusetts Boston

THE ROLE OF PHYSICAL ACTIVITY AND GENDER AS MODERATORS FOR THE RELATIONSHIP BETWEEN INSOMNIA AND DEPRESSION

A Dissertation Presented
by
CLAIRE E. WICKERSHAM

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Approved as to style and content by:

_____
Jan Mutchler, Professor
Chairperson of Committee

_____
Jeffrey Burr, Professor
Member

_____
Louise Parker, Professor
Member

_____
Kathrin Boerner, Program Director
Gerontology Program

_____
Edward Miller, Chairperson
Department of Gerontology

ABSTRACT

THE ROLE OF PHYSICAL ACTIVITY AND GENDER

AS MODERATORS FOR THE RELATIONSHIP BETWEEN INSOMNIA AND

DEPRESSION

May 2022

Claire E. Wickersham, B.S., SUNY Cortland
M.G.S., Miami University
M.S., University of Massachusetts Boston
Ph.D., University of Massachusetts Boston

Directed by Jan E. Mutchler, Ph.D.

Objective: The aim of this study was to examine the association between insomnia and depressive symptoms among middle-aged and older adults and to investigate whether gender or physical activity moderates this relationship. **Method:** This study used nationally representative data from the 2016 and 2018 waves of the Health and Retirement Study (HRS) and binomial logistic regression was used to estimate models. Regression models for risk of depressive symptoms (2018) were based on a longitudinal model with time-lagged indicators of insomnia, levels of physical activity, and covariates (2016). **Results:** Analyses showed that participants who reported having insomnia in 2016 were more likely to report depressive symptoms in 2018. This study did not find a statistically significant interaction between insomnia and physical activity or insomnia and gender. **Discussion:** This study showed how insomnia is associated with an increased risk of depression over a two-year period among

middle-aged and older adults. Further research is needed to explore differences in gender and physical activity in greater detail. Findings from this study have the potential to inform health professionals and policymakers about the importance of insomnia and depression and develop health promotion programs to reduce the negative and costly health consequences of depression. Moreover, results from the current study can be useful in providing a baseline for pre-and post-pandemic levels of insomnia and depression.

Keywords: Depression, Insomnia, Physical Activity, Depressive Symptoms, Older Adults, Gender, Sleep Disturbances, Sleep Disorders, Aging

DEDICATION

This dissertation is dedicated to two incredible women,

Joanne “Sue” Abbey and Grandma Loie.

Even though they are no longer with us, I will forever view them as my biggest cheerleaders and supporters.

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I would like to thank my dissertation committee Dr. Jan Mutchler, Dr. Jeffrey Burr, and Dr. Louise Parker, for their assistance throughout the dissertation process and my doctoral journey. Your encouragement and feedback have been vital and have helped shape the researcher I am today. In addition, I would like to thank the Graduate Writing Center at UMass Boston and all my virtual dissertation coworking colleagues from near and far who helped me get through dissertating during a global pandemic. Last, I would like to thank my friends and family who have supported my efforts during this chapter of my life.

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Chapter 1

INTRODUCTION

According to the World Health Organization (WHO, 2017), over 300 million (~4.4 %) individuals worldwide are estimated to suffer from depressive disorders, a number that has increased substantially over the past decade, which reflects an increase in rates of depression of nearly 20% from 2005 to 2015 alone. In the US, the percentage of adults aged 18 and over who experience regular feelings of depression is approximately 5% (Centers for Disease Control and Prevention [CDC], 2019). The percentage is even higher, about 10–20%, among older adults; in fact, depression is the most prevalent mental health condition among the older population (Federal Interagency Forum on Aging-Related Statistics, 2020).

Depression significantly impairs an individual's everyday functioning and quality of life and is associated with an increased risk of morbidity and premature mortality (Correll et al., 2017; Cuijpers et al., 2013; Gilman et al., 2017; Walker et al., 2015). According to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-V), symptoms of depression include loss of interest or motivation, lack of concentration, feelings of sadness, fatigue, irritability, and loss of appetite (American Psychiatric Association [APA], 2013; Hasin et al., 2018). Elevated depressive symptoms are associated with decreased physical, cognitive, and social functioning and contribute to adverse health outcomes, including diabetes, coronary heart disease, hypertension, and dementia (Diniz et al., 2013; Mezuk et al., 2008; Nicholson

et al., 2006). Thus, depression among older adults has potentially severe consequences for those who struggle with the condition.

A growing number of individuals will experience depression and its associated health consequences as the population continues to age rapidly. Furthermore, the coronavirus 2019 (COVID-19) pandemic has highlighted the vulnerability of older people to health problems associated with the virus and unique stressors related to living through a traumatic life event (Horesh & Brown, 2020). The pandemic will likely have long-lasting mental health effects that may contribute to rising rates of depression among the older population. Understanding the predictors of depression in later life and factors that influence its progression and management remain critical tasks for research (Cuijpers et al., 2012; Du et al., 2015). Identifying factors or behaviors that can flag those with a higher risk of depression is also vital.

Like depression, sleep disturbances and disorders are common problems many older adults face, with insomnia serving as the most prevalent sleep disorder (Bloom et al., 2009). Several studies have highlighted the close link between sleep disorders and subsequent psychiatric disorders (Christensen et al., 2016; Gold et al., 2020). An accumulating body of evidence shows that poor sleep and insomnia later in life may be an overlooked risk factor for experiencing future depression (Baglioni et al., 2011a; Chen & Saito, 2021; Fernandez-Mendoza & Vgontzas, 2013; Jackowska & Poole, 2017). Early classifications of sleep disorders, including insomnia, classified sleep issues as a symptom and consequence of depression. However, more recent evidence suggests that insomnia symptoms are more commonly observed *before* the onset of depression (Furihata et al., 2017; Murphy &

Peterson, 2015; Vargas & Perlis, 2020). Accordingly, researchers began to explore insomnia as a risk factor and precursor to depression across all ages, including in later life (Chen & Saito, 2021; Jackowska & Poole, 2017). One promising strategy proposed to prevent depression among at-risk groups targets older adults with sleep disturbances, such as insomnia (Christensen et al., 2016). This may be critical for middle-aged and older adults who become more susceptible to both insomnia and depression with age.

Physical activity is an essential determinant of healthy aging and one understudied factor that may have the potential to delay or prevent depression among middle-aged and older adults. Due to its anti-depressive relationship with mood, physical activity is considered an effective treatment for depression and is a crucial component of the rehabilitation process for various health conditions and psychiatric disorders (Schuch et al., 2018; Schuch et al., 2016; Ströhle, 2009; Rosenbaum et al., 2014). Moreover, engaging in physical activity is a preferred treatment option for many patients compared to other interventions for depression, such as medication or counseling (Busch et al., 2016; Luck-Sikorski et al., 2017). Engaging in even low physical activity levels may be a protective factor against depression (de Oliveira et al., 2019; Du et al., 2015; Teychenne et al., 2008). Researchers speculate that the positive effects of exercise on health and well-being are both short- and long-term (Ekkekakis, 2013; Kerling et al., 2017). Studies have supported this notion by documenting substantial reductions in the severity of depressive symptoms following individuals' engagement in physical activity intervention programs for depression (Ekkekakis, 2013; Murri et al., 2018; Rosenbaum et al., 2014).

In addition to physical activity, gender is another factor that may shape the relationship between insomnia and depression (Langvik et al., 2019; Stone & Xiao, 2018). Extensive research has demonstrated that women are more likely to experience insomnia and to be depressed in comparison to men across all age groups (Jackowska & Poole, 2017; Kok & Reynolds, 2017; Ozminkowski et al., 2007). Notably, one meta-analysis that examined gender differences and insomnia showed the difference in insomnia risk between genders widens with age (Zhang & Wing, 2006). Moreover, middle-aged and older women face several unique stressors that may elevate their risk of insomnia and depression compared to men. For example, research shows that insomnia and depression risk is associated with different life course stages related to hormone fluctuations, such as perimenopause and menopause (Bromberger & Epperson, 2018; Hall et al., 2015, Zhang & Wing, 2006). Therefore, the mechanisms through which insomnia contributes to depression may differ by gender.

The purpose of this dissertation is to explore how insomnia shapes the risk of depression in a large nationally representative sample of community-dwelling middle-aged and older adults over time. In addition to estimating the increased risk of depression among those with insomnia, this study explores how physical activity and gender impact the association between insomnia and depression. Based on research, this study hypothesizes that physical activity may serve as a modifiable risk factor for depression in later life that plays a buffering role between insomnia and depression. Furthermore, this study posits that the association between insomnia and depression varies by gender.

Organization of Remaining Chapters

This dissertation comprises five chapters. Chapter 2 reviews empirical research and establishes the conceptual framework for the present study. Chapter 3 describes the research methodology and plan for empirical analysis. Chapter 4 presents the results of this research. Chapter 5 discusses the research findings and implications for future research, policy, and practice.

CHAPTER 2

LITERATURE REVIEW

Depression

Among older adults with depression, approximately half experience depression as a new condition arising in old age (Fiske et al., 2009). With age, individuals experience increasing declines in health and functionality, become more vulnerable to poor health outcomes, and take longer to recover from illness, injury, and other stressors associated with physical aging processes (Miller et al., 2014). Risk factors contributing to depression in later life include chronic health-related conditions, stressful life events, and neurobiological and structural brain changes associated with aging (Blazer & Hybels, 2005). Other well-known predictors that significantly increase the risk of depression are advanced age, female gender, lower educational attainment, lower socioeconomic status, poor self-rated health, heavy alcohol consumption, smoking, and having limited social support (Areán et al., 2010; Fiske et al. 2009; Heok & Ho, 2008; Hammen, 2018; Ladin, 2008; Luppa et al., 2012; Ma et al., 2008).

Despite a growing body of literature identifying considerable risk factors for depression, preventing depression remains a significant challenge among the older population. A common misconception among older adults and health care providers alike is that depression is a normal part of the aging process (Cornwell et al., 2014; Ruppel et al.,

2010). In general, middle-aged and older adults tend to have more stigmatized attitudes about mental health than younger individuals and are less likely to seek professional mental health services (Godfrey & Denby, 2004). As physical health issues accumulate with age, it becomes more likely that depression will be overlooked by medical professionals, with comorbidities, polypharmacy, and drug interactions potentially masking indicators of depression (Fiske et al., 2009; Subedi et al., 2018). Together, these barriers lead depression to be undertreated among members of this population (Basta et al., 2021).

Insomnia

Insomnia is defined as a predominant dissatisfaction with the quantity and/or quality of sleep and involves difficulty initiating sleep, difficulty maintaining sleep, early morning awakenings with an inability to return to sleep given adequate sleep opportunity and environment, and/or nonrestorative sleep (American Academy of Sleep Medicine, 2014; APA, 2013). The condition can be either independent or comorbid, existing in conjunction with other health conditions (APA, 2013). Sleep disturbances and insomnia often have adverse effects on physical, social, behavioral, and occupational performance and are significant public health burdens (Medic et al., 2017; Tzuang et al., 2021; Varrasse et al., 2015). Sleep difficulties are related to clinically significant distress or impairment in critical areas of daily function and are often associated with negative mood, excessive daytime tiredness, and difficulty with memory and concentration (Ballesio et al., 2019; Lunde et al., 2010). Over time, poor sleep contributes to worse physical and mental health and decreased quality of life (Fernandez-Mendoza & Vgontzas, 2013). Studies show that insomnia symptoms are associated with an increased risk of developing new-onset and recurrent

depression (Baglioni et al., 2011a; Chen & Saito, 2021; Fernandez-Mendoza & Vgontzas, 2013; Langvik et al., 2019; Li et al., 2016).

Insomnia and Age

Like depression, there is an elevated risk of experiencing sleep disturbances and developing insomnia with age (Landry et al., 2015). Up to 75% of older adults have reported experiencing insomnia symptoms (Helbig et al., 2017; Hishikawa et al., 2017; Ling et al., 2016; Uchmanowicz et al., 2019). Increased insomnia among middle-aged and older adults can be attributed to several factors. Aging is associated with physical and biological changes that can negatively impact sleep structure (Lemola & Richter, 2013; Palagini et al., 2021). With age, homeostatic and circadian mechanisms decline along with sleep duration and quality (Ohayon et al., 2017). Compared to younger individuals, older adults tend to wake up more frequently and take longer to fall back asleep, which contributes to fewer hours of sleep overall and poorer sleep efficiency, which is the ratio of total sleep time to time in bed (Åkerstedt et al., 2016; André et al., 2020). Older adults generally experience increases in wake time following sleep onset and experience more early morning awakenings on average (Ohayon et al., 2017; Patel et al., 2018).

Research shows that older adults tend to nap during the day and experience greater levels of fatigue and sleepiness because of reduced sleep efficiency, which is the ratio of total sleep time to time spent in bed (Åkerstedt et al., 2016; André et al., 2020; Ohayon et al., 2017; Patel et al., 2018). Furthermore, older adults are more likely to experience situational transitions and life stressors than their younger counterparts, which may be related to and trigger the onset of sleep disturbances and disorders (Nguyen et al., 2019; Vargas & Perlis,

2020). For example, sleep schedules may become more unstructured due to retirement as individuals no longer abide by regular and fixed working hours and travel (Jing et al., 2020; Nguyen et al., 2019). When individuals are retired, they have more freedom and flexibility to rest during the day and take naps, leading to sleep becoming less consistent (Jing et al., 2020).

Other situational factors contribute to insomnia risk in later life, including caregiving responsibilities that become more prevalent with increased age, decreased social interaction overall, and the death of loved ones and bereavement (Nguyen et al., 2019; Patel et al., 2018). In addition, older adults are more likely to experience health challenges, comorbidities, limited mobility, and to take multiple medications compared to younger individuals, which can negatively impact sleep and lead to more severe conditions or disorders (Hirshkowitz et al., 2015; Vargas & Perlis, 2020). For these reasons, rates of insomnia dramatically increase with age and are expected to contribute to an increased risk of depression (Crowley, 2011). These claims are supported by research that demonstrates depression is overrepresented within populations with sleep disorders (Franzen & Buysse, 2008).

The Relationship Between Insomnia and Depression

Over the past several decades, the way researchers have explored the relationship between insomnia and depressive symptoms has changed drastically. Historically, insomnia was conceptualized, evaluated, and treated as a secondary condition and a sign of depression (Perlis et al., 2006; Vargas & Perlis, 2020). This conceptualization has been criticized, as research began showing that individuals with insomnia continued to experience insomnia

even after treatment and recovery from or improvement in depressive symptoms (Christensen et al., 2016; Manber & Chambers, 2009). Moreover, most older adults experience insomnia as a chronic condition, which the DSM-5 defined as being experienced for 3 months or longer (APA, 2013). The DSM-5 recognized insomnia as a primary and independent disorder from depression and a main diagnostic category (APA, 2013). As this viewpoint and the classification have shifted, research has pointed to a pathway in which insomnia symptoms often precede and contribute to the development of depression (Furihata et al., 2017; Murphy & Peterson, 2015; Sadler et al., 2013). Consequently, this dissertation research has focused on insomnia disorder and depression as independent disorders, with insomnia classed as a condition that precedes and elevates the risk of depression.

Ways Insomnia Acts as a Stressor With an Outcome of Depression

The exact mechanisms linking insomnia to depression remain largely unknown; however, researchers have proposed potential mechanisms. Both insomnia and depression are referred to as stress-related disorders, and several lines of research have shown that stress contributes to depression (Lotrich, 2015; Slavich & Irwin, 2014; Vargas & Perlis, 2020). There is a consensus that insomnia may result in depression by activating the body's stress system (Predatu et al., 2020; Sadler et al., 2013).

The inflammation hypothesis of depression proposes another potential mechanism affecting the relationship between insomnia and depression (Alexopoulos & Morimoto, 2011). The inflammation hypothesis holds that stressors elevate inflammatory activity and immunological responses indicative of future depression. In the case of insomnia, this hypothesis is supported by research among the general population that demonstrates that

sleep deficient individuals have higher levels of inflammatory cytokines and cellular inflammation compared to their counterparts with normal sleep (Fang et al., 2019). Moreover, researchers have speculated that insomnia contributes to depression through heightened emotional reactivity and negative affect, which may serve as precursors to depressive disorders (Fairholme & Manber, 2015; Predatu et al., 2020).

Although sleep disorders can still be features of depression, research indicates that insomnia often occurs before onset of depression. Specifically, insomnia can exist for months or years before the appearance of depression. Researchers have reached a consensus that sleep contributes to the development of depression, although evidence involving intermediary mechanisms remains limited (Baglioni & Riemann, 2012; Franzen & Buysse, 2008). As a result, insomnia researchers have shifted toward examining insomnia as a precursor to new-onset depression as opposed to a consequence (Chen & Saito, 2021; Franzen & Buysse, 2008).

A growing body of literature demonstrates that insomnia symptoms are risk factors for depression. For example, studies have concluded that insomnia conferred a threefold increase in the risk of future depression compared to individuals without insomnia complaints (Perlis et al., 2006; Roberts et al., 2000). One prospective study found that older women categorized as having persistent insomnia were approximately 6 times more likely to experience a first episode of depression than those with no insomnia; this finding, however, was not significant for older men (Perlis et al., 2006). Jaussent et al. (2011) found that older adults ages 65–85 who reported insomnia, defined as reporting one or more insomnia

symptoms at baseline or overall poor sleep quality, had a 23% increased risk of developing depression when assessed 2 and 4 years later.

Although studies investigating the relationship between insomnia and depression specifically among older samples are limited, studies of the general population support these findings. For example, Baglioni et al. (2011a) conducted a meta-analysis investigating whether insomnia was a significant predictor of depression among the general population. They found that nondepressed individuals with sleep difficulties at baseline, classified as having difficulty falling asleep or staying asleep, had a two-fold risk of developing depression than respondents who reported good sleep. In the 21 studies included in the analysis, researchers also found that the incidence of depression was higher among respondents with sleep difficulties in relation to the general population. Specifically, the incidence of depression at follow-up for those with insomnia was 13.1%, compared to 4% for those without insomnia.

Li et al. (2016) conducted another meta-analysis that yielded similar findings among the general population. Studies included in this meta-analysis examined insomnia as the independent variable and depression as the primary outcome variable, controlling for depression at baseline. Among the 34 prospective cohort studies included in the analyses, the researchers found that individuals with insomnia had a relative risk of developing depression that was 2.3 times greater than those without insomnia (Li et al., 2016). Although these meta-analyses provide important information about the link between sleep disturbances and depression overall and among the general population, Li et al. pointed out that the studies included did not exclusively focus on the relationship between insomnia and risk of

depression among the older population. Thus, further research on this population is warranted, given that patterns of sleep change with age and that major depression and depressive symptoms increase substantially in older individuals ages 70–85 (Alexopoulos, 2005; Crowley, 2011; Ohayon et al., 2004).

The Promise of Physical Activity

Due to its antidepressive relationship with mood, physical activity is considered an effective treatment for depressive symptoms and a crucial component of the rehabilitation process for various health conditions (Schuch et al., 2018; Schuch et al., 2016; Ströhle, 2009; Rosenbaum et al., 2014). Engaging in even low levels of exercise may serve as a protective factor against depressive symptoms (Du et al., 2015; de Oliveira et al., 2019; Teychenne et al., 2008). Individuals who are more physically active demonstrate lower levels of depressive symptoms than those who are less physically active and that individuals report experiencing higher levels of pleasant-activated feelings on the days in which they engage in greater levels of physical activity than usual (Hyde et al., 2011). Yet physical activity is mainly unexplored as a factor that has the potential to delay or prevent the onset of depression among older adults, and especially so for those demonstrating insomnia at baseline. Therefore, this study highlights the role of physical activity and its potential to disrupt the relationship between insomnia and subsequent depression via stress reduction mechanisms.

Physical activity may be critical in preventing individuals with insomnia from developing depression later in life. Specifically, engaging in exercise may serve as a buffer between insomnia and depression and may prevent the development of depression among those with insomnia. Given that physical activity may be particularly beneficial in combating

depression, it is expected that physical activity will moderate the relationship between insomnia and depression, such that physically active persons will show a weaker relationship between insomnia and depression as compared to those engaging in only light physical activity and those who report being physically inactive.

Gender and Depression

An interplay of many social, biological, and physiological factors may be linked to gender differences in depression. Empirical evidence consistently demonstrates that women experience higher rates of depression in comparison to men across the life course (Bromet et al., 2011). On average, women are twice as likely to experience depression as men, which constitutes a significant health disparity (Bromet et al., 2011; Faravelli et al., 2013).

Middle-aged and older women face several unique stressors that may elevate their risk of depression compared to men. For example, research shows that depression risk is associated with different life course stages related to hormone fluctuations, such as perimenopause and menopause (Bromberger & Epperson, 2018). Women have a higher life expectancy than men and thus unsurprisingly are more likely to outlive their spouses and become widowed. They are also more likely to be divorced, separated, and have multiple comorbid conditions. All of these factors are positively associated with depression (Afifi et al., 2006; Richardson et al., 2020). Moreover, older women enter retirement with fewer economic resources than men. In general, stressors are unequally distributed across genders and may have a cumulative effect that makes women particularly vulnerable to depression in old age.

Gender and Insomnia

Gender differences in insomnia have been widely documented across the life course and pertain to differences in origin/development, the manifestation of the disorder, impacts on health and quality of life, and management strategies (Sidani et al., 2019). Research consistently demonstrates that women experience higher rates of sleep disorders and disturbances compared to men (Hall et al., 2015; Jaussent et al., 2011; Zhang & Wing, 2006). The development of insomnia may be related to biological and psychosocial factors that differ by gender. For example, insomnia may arise in relation to hormones, hormonal events and changes that occur throughout the life course (e.g., menopause), and coexisting health conditions (Hall et al., 2015; Zhang & Wing, 2006). The development of insomnia may also be related to how gender is constructed and gender-specific roles and expectations; for instance, women tend to be responsible for more significant caregiving duties, and men are socialized to suppress emotions (Cheung et al., 2013; Hall et al., 2015).

Moreover, the way insomnia manifests and affects individuals differs by gender. For example, women are more likely to experience pre-sleep arousal, report higher fatigue levels and greater severity of insomnia than men (Jaussent et al., 2011; Sidani et al., 2019). Whereas on average women report experiencing more than one symptom of insomnia, men are more likely to report a single insomnia symptom (Jaussent et al., 2011). Sleep behaviors and strategies to manage or cope with insomnia vary by gender. For example, men are more likely, on average, to take naps compared to women, whereas women are more likely to take sleep medication compared to men and for more extended periods (Jaussent et al., 2011;

Sidani et al., 2019; Yang et al., 2020). For these reasons, insomnia may have different mechanisms through which it predicts depression.

Gaps in the Literature

There is a clear need for more well-designed studies that examine insomnia as an independent risk factor for future depression, specifically for studies that use nationally representative longitudinal data that include both men and women and explore the relationship among middle-aged and older adults (Garfield et al., 2016; Langvik et al., 2019). Most work in this area has not focused on the older population exclusively, so it remains unclear whether our current understanding of these relationships applies to the older population (Garfield et al., 2016; Langvik et al., 2019; Li et al., 2016). Studies that have included the older population in their sample have been limited by specific age ranges or excluded the oldest-old age group. For example, Jaussent et al. (2011), examining insomnia as a risk factor for depression, restricted its sample to individuals ages 43–73, whereas Suh et al. (2013) limited its selection to individuals 65–85 years old. In addition to focusing exclusively on the older population, an important contribution of this dissertation is the consideration of physical activity and gender as critical variables of interest and as potential moderators between baseline insomnia and subsequent depression. Many studies to date that examined insomnia as a predictor of depression have lacked consideration of physical activity, even as a covariate (Chen & Saito, 2021; Jaussent et al., 2011). Research has been limited by smaller sample sizes and a lack of generalizability (Jaussent et al., 2011; Suh et al., 2013). Moreover, the underlying pathways linking insomnia to subsequent mental health outcomes are poorly understood (Sadler et al., 2013; Vargas & Perlis, 2020).

To fill gaps in existing literature, this dissertation examines the relationship between insomnia, physical activity, gender, and depression using a nationally representative sample of community-dwelling middle-aged and older adults. Specifically, this dissertation aims to extend the existing literature by using longitudinal data to examine the roles of physical activity and gender as moderators between insomnia and depression. The hypotheses for this dissertation include the following:

H1: Insomnia will be positively associated with depressive symptoms 2 years later, controlling for baseline depression.

H2: Physical activity will be negatively associated with depression.

H3: Physical activity will moderate the relationship between insomnia and depression, such that the relationship between insomnia and depression will be weaker for persons who are more physically active compared to persons who are less physically active.

H4: Gender will moderate the relationship between insomnia and depression, such that the relationship between insomnia and depression will be stronger for females than males.

In previous studies, physical activity has primarily been treated as a covariate rather than a critical variable of interest. To the best of my knowledge, no research has considered physical activity as a moderating variable that may influence depression for middle-aged and older adults with insomnia, controlling for elevated depression levels at baseline using nationally representative data over time.

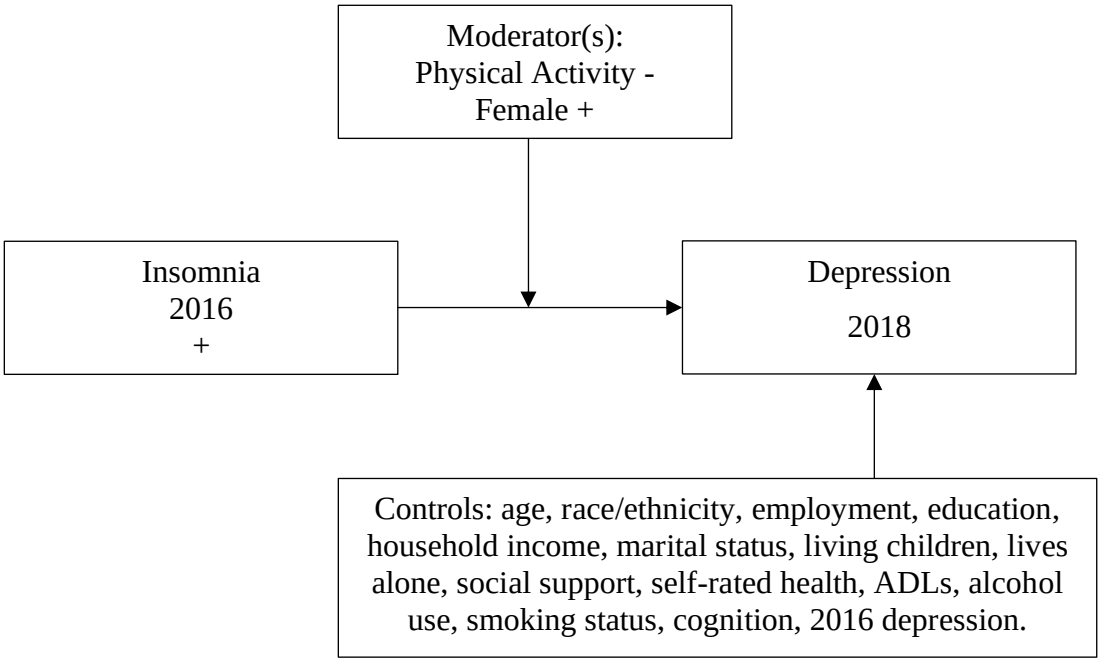
Conceptual Model

The conceptual model for this dissertation is constructed primarily from a review of empirical findings from the literature (see Figure 1). Although current studies of insomnia and depression among middle-aged and older adults lack theoretical underpinnings, this study utilizes empirical evidence related to stress processes framing insomnia as a stressor that can promote depression. Pearlin's (1989) stress process model has been used to examine how stressors accumulate over the life course and contribute to health outcomes such as depression in later life. The model specifies primary and secondary stressors and resources that shape how individuals experience and respond to stressful events. Stressors represent environmental demands that have the potential to be harmful, such as an illness or relationship loss. In particular, the model proposes that psychosocial resources, such as social support or coping mechanisms, can serve as moderators that have a buffering effect on depression as a health outcome. The stress process model provides a critical lens in examining depression in later life as older adults experience declines in resources over time and become more physically and physiologically vulnerable (Hish et al., 2019; Jeon & Dunkle, 2009). For this dissertation, physical activity is examined as a potential mechanism that can disrupt the association between insomnia and depression. Consistent with existing literature, I expected physical activity buffers the stress that insomnia can trigger, leading to depression. Furthermore, this dissertation examined whether the relationship between insomnia and depression is moderated by gender. Based on the literature, I expect the relationship to be stronger for women compared to men.

Researchers have identified a combination of risk factors for depression that serve as covariates for this study. According to the literature, depressive symptoms have been associated with increasing age, racial/ethnic minority status, lower income, lower level of education, and poor self-rated health (Alexopoulos, 2005; Aziz & Steffens, 2013; Chang-Quan et al., 2010; Choi & Kimbell, 2008; Kaji et al., 2010). On average, being separated, divorced, or widowed is associated with higher depressive symptoms (Kamiya et al., 2013). Social engagement is independently associated with reduced risk of depressive symptoms among older adults and negative health behaviors such as smoking and alcohol misuse are associated with increases in depressive symptoms (Blay et al., 2008; Weyerer et al., 2008). Moreover, it is expected that living alone is associated with depression (Barrenetxea et al., 2021).

Figure 1

Conceptual Model: The Relationship Between Insomnia, Gender, Physical Activity, and Depression



Note. ADL = activities of daily living; + = anticipated positive association; - = anticipated negative association.

CHAPTER 3

METHODS

Research Design

Data Source

This dissertation used quantitative data from the Health and Retirement Study (HRS), a nationally representative longitudinal survey of community-dwelling individuals aged 50 or older in the U.S. (Servais, 2010). This multistage area probability panel study collects information regarding health, cognition, employment status, retirement, and family structure. Data for the HRS were collected by telephone or face-to-face interview depending on the survey respondent's age and health status. Beginning with the initial wave of data collected in 1992, the HRS has collected data every 2 years. New cohorts of survey respondents continue to be added throughout subsequent waves. Respondents were selected for the HRS using a complex sampling design that involves stratification, clustering, and oversampling of Black respondents and Hispanic respondents and residents of Florida. All respondents involved in the HRS were provided with written informed consent and approved study protocols from the University of Michigan's Institutional Review Board. Since this dissertation used deidentified data available for public use, this dissertation research did not require institutional approval from the University of Massachusetts Boston, as there was no risk to human subjects.

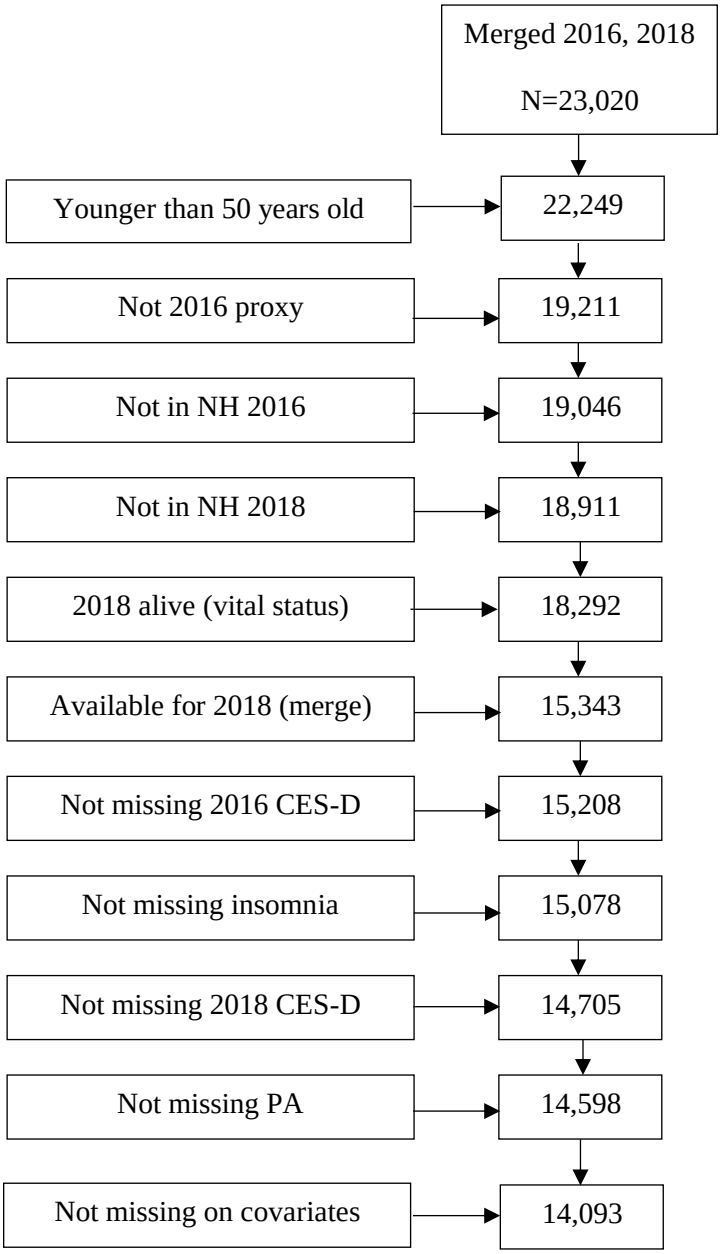
Data for this analysis came from the 2016 and 2018 waves of the HRS and were primarily obtained from data files made available to the public through the Institute for Social Research at the University of Michigan. Furthermore, additional variables made available by the RAND Corporation were used to measure household income, the number of living children, and whether respondents lived alone. The HRS is sponsored by the National Institute on Aging and the Social Security Administration. Heeringa and Connor (1995) provide additional information regarding the design of the HRS.

Study Sample

The sample for this research consisted of community-dwelling survey respondents from the 2016 and 2018 waves of the HRS. The sample was restricted to respondents age 50 and older in 2016, who participated in the 2016 and 2018 waves and had complete data for the variables included in the models (final N = 14,093). Data from 2016 were used as baseline because indicators of insomnia were first introduced to respondents during that wave. For additional inclusion and exclusion criteria for the final study sample, which includes 14,093 individuals, see Figure 2.

Figure 2

Flowchart of Respondents 2016 and 2018 Data From the Health and Retirement Study



Note. NH = nursing home; PA = physical activity; CES-D = Center for Epidemiological Studies-Depression Scale.

Excluded and Missing Data

Individuals less than 50 years old, respondents living in a nursing home at baseline, and those who relocated to a nursing home by the 2018 wave of data collection were excluded from the sample. Proxy respondents, who completed the survey on behalf of the respondent, were excluded because they were not administered the relevant survey measures of interest for this study. Specifically, the HRS does not ask proxy respondents to answer questions for the depression scale on behalf of the original self-respondent because there may be errors in proxy reporting regarding the symptomatic experiences of depression. Finally, the sample excluded respondents who were deceased by 2018.

After applying exclusion criteria for age, proxy respondents, nursing home relocation, and mortality, the working sample was 15,343. However, some respondents were missing responses for some variables in the HRS. Respondents with missing data on the independent variable (insomnia markers), the dependent variable (depressive symptoms), and the moderator variables (physical activity and gender) were excluded from the study. A small number of individuals were missing valid information on covariates included in the model, so the decision was made to exclude those respondents, as well. After listwise deletion was used to identify valid cases, 1,250 cases were excluded due to missing data (approximately 9% of the working sample), which reduced the total sample for this research to 14,093 respondents. Sensitivity analyses of missing data revealed no remarkable patterns, indicating that a complete case analysis of HRS data is appropriate for this dissertation analysis.

Measures

The coding of variables for this dissertation can be found in Table 1. In addition, Table 1 demonstrates the expected direction of effects in relation to depressive symptoms in 2018, the dependent variable (i.e., I expect that insomnia is positively associated with depression, whereas physical activity is negatively associated with depression). The expected direction of effects were based on research findings, as indicated in the literature review.

Table 1

Variable Descriptions and Expectations

	Description/coding	Expected Sign
Dependent variable (2018)		
Depression	1=yes (≥ 3 CES-D); 0=no (< 3 CES-D)	---
Independent variables (2016)		
Insomnia	1=yes; 0=no	+
Physical activity	1=yes; 0=no	-
Covariates		
Age	Age in years (50 and older)	+
Female	1=yes; 0=no	+
Race		
Non-Hispanic White*	1=yes; 0=no	Ref.
Non-Hispanic Black	1=yes; 0=no	+
Non-Hispanic other race	1=yes; 0=no	+
Hispanic	1=yes; 0=no	+
Employed	1=yes; 0=no	-
Education	Education in years	-
Household income	Household income in dollars ($)	-
Social network characteristics		
Marital status		
Married	1=yes; 0=no	Ref.
Divorced/separated	1=yes; 0=no	+
Widowed	1=yes; 0=no	+
Never married	1=yes; 0=no	+
Any living children	1=yes; 0=no	-
Lives alone	1=yes; 0=no	+
Perceived support	1=yes; 0=no	-
Health variables		

Self-rated health		
Excellent/very good/good*	1=yes; 0=no	Ref.
Fair/poor	1=yes; 0=no	+
ADL limitations (1+)	1=yes; 0=no	+
Heavy alcohol use	1=yes; 0=no	+
Smoking status		
Current smoker	1=yes; 0=no	+
Not a smoker	1=yes; 0=no	-
Cognition (TICS)	Score (from 0–10)	-
Depression in 2016	1=yes (≥ 3 CES-D); 0=no (< 3 CES-D)	+

Note. + = Positive expectation; - = negative expectation; *reference group; ADL = activities of daily living; TICS = Telephone Interview for Cognitive Status; CES-D = Center for Epidemiological Studies-Depression Scale.

Dependent Variable

Depression

The HRS uses the eight-item Center for Epidemiologic Studies Depression (CES-D) Scale to assess depressive symptoms (Steffick, 2000; Turvey et al., 1999). Specifically, respondents were asked to rate the frequency of experiencing different depressive symptoms within the previous week, including whether they experienced several feelings "much of the time during the past week" as indicated by the following prompts: "you felt depressed," "you felt everything you did was an effort," "your sleep was restless," "you could not get going," "you were happy," "you felt lonely," "you enjoyed life," "you felt sad." Response options for these questions were "yes" and "no." The two positive emotions included in the scale (enjoying life and feeling happy) were reverse coded so that higher scores indicated a higher number of depressive symptoms or greater possible severity of depression. A modified version of the CES-D Scale was used to examine depressive symptoms. The restless sleep item was removed from the depression scale to minimize operational confounding of insomnia markers with depression, following studies that have examined insomnia and

depression, including studies that have used the HRS dataset (Chen & Saito, 2021; Kalmbach et al., 2018). The remaining seven items of the CES-D were summed for a count of recent depressive symptoms, which ranged from 0 to 7 (Chen & Saito, 2021; Jackowska & Poole, 2017; Kalmbach et al., 2018; Leggett et al., 2018). Three or more symptoms indicated a higher likelihood of clinical depression (Steffick, 2000). Thus, depression was recoded into a new dichotomous variable, with respondents who reported three or more CES-D symptoms (out of possible seven) categorized as depressed (1 = *three or more symptoms* and 0 = *less than three symptoms*).

Due to the measurement decision to exclude the sleep item from the eight-item CES-D index, a sensitivity analysis was performed to test a different cutoff point for categorizing a depression threshold based on two or more symptoms. This coding method has also been supported by existing literature on this topic (Jackowska & Poole, 2017; Leggett et al., 2018). In the sensitivity analysis, respondents who reported two or more symptoms (out of possible seven) were categorized as depressed (1 = *two or more symptoms* and 0 = *less than two symptoms*). Results of the sensitivity analysis are reported in Chapter 4.

Independent Variables

The primary independent variable of interest for this dissertation was insomnia. Physical activity and gender were the other critical, independent variables of interest. A range of demographic and health-related covariates associated with depressive symptoms was also examined.

Insomnia

The HRS assesses insomnia using a modified version of the Jenkins Sleep Questionnaire. This valid and widely used screening tool measures self-reported sleep complaints, which comprise the four primary symptoms of insomnia. Specifically, respondents were asked four questions related to sleep: (a) how often they had trouble falling asleep, (b) how often they had trouble with waking up during the night, (c) how often they had trouble with waking up too early and not being able to fall asleep again, and (d) how often they felt really rested when they woke up in the morning (Gao et al., 2013; Jani et al., 2016; Kretchy et al., 2014; Li et al., 2015). Respondents answered these questions with regards to their experiences over the past month. Response items for these questions included "*most of the time*," "*sometimes*," and "*rarely or never*." Subjects were defined as having insomnia if they answered "*most of the time*" or "*sometimes*" to any of the first three questions or "*rarely or never*" or "*sometimes*" to the fourth question. Binary indicators were created for each insomnia symptom. Specifically, responses of "*most of the time*" or "*sometimes*" were coded as 1 for the first three questions, with other responses coded as 0. For the fourth question regarding how often respondents felt really rested when they woke up in the morning, "*rarely or never*" or "*sometimes*" was coded as 1, with other response items coded as 0. This item was reverse coded to establish consistency with the meaning of the other insomnia markers. This coding method has been used in research surrounding this topic area and for studies that have used the HRS (Canham et al., 2015; Chen-Edinboro et al., 2015; Dong & Yang; 2019; Kaufmann et al., 2013). For this dissertation, scores across the four insomnia indicators were summed, and composite scores greater or equal to 1

represented the presence of insomnia. Composite scores of 0 represented the absence of insomnia at baseline.

Physical Activity

In the section of the HRS that asks survey respondents about their physical health, individuals are asked about the type and amount of physical activity they are involved with in daily life, including what the HRS categorizes as "vigorous," "moderate," and "light" physical activity. To assess vigorous physical activity, respondents were asked the question, "How often do you take part in sports or activities that are vigorous, such as running or jogging, swimming, cycling, aerobics or gym workout, tennis, or digging with a spade or shovel?" Respondents were then asked, "and how often do you take part in sports or activities that are moderately energetic such as gardening, cleaning the car, walking at a moderate pace, dancing, floor or stretching exercises?" Finally, respondents were then asked, "and how often do you take part in sports or activities that are mildly energetic, such as vacuuming, laundry, home repairs?" Response options for each of the questions included "more than once a week," "once a week," "one to three times a month," and "hardly ever or never."

Physical activity was categorized hierarchically into four groups (a) vigorous physical activity, (b) moderate physical activity, (c) light physical activity, and (d) physical inactivity. To code the variable into mutually exclusive categories, physical activity was determined using a hierarchical scale with vigorous physical activity determined by engagement in any vigorous activity at least once a week; then, for those who did not report at least weekly vigorous exercise, moderate physical activity was determined by engagement in at least

moderate activity once a week or more; for those who did not report at least weekly vigorous or moderate exercise, light activity was determined by engagement in at least light activity once a week or more; and physical inactivity was defined by the absence of physical activity reported on at least a weekly basis for each categorization (less than weekly vigorous, moderate, and light activity). Next, a dummy variable was created that collapsed mild physical activity with physical inactivity and moderate with vigorous physical activity (1= *vigorous or moderate physical activity,* 0 = *mild physical activity or physical inactivity)*. The decision to use the cutoff point of "at least once a week" for the classification of mild, moderate, and vigorous physical activity engagement is based on literature utilizing the HRS (Germain et al., 2016). Similarly, the decision to create a dummy variable and collapse moderate and vigorous physical activity to represent being physically active was based on measurement decisions from prior research (Whibley et al., 2020).

Gender

Gender served as the other critical variable of interest for this research and was used to examine gender differences in the relationship between insomnia and depression. Specifically, gender was assessed as a moderator variable. The HRS relies on self-reported data for respondents' gender. Based on this data, a dichotomous variable was created for gender (1 = female and 0 = male).

Covariates

The following covariates were included in this study based on research. Demographic variables include age, race/ethnicity, marital status, level of educational attainment, and income. All covariates were from 2016, the initial wave of data used for this study. Survey

respondents' age was measured in years (range = 50–99). Race/ethnicity was coded as a series of mutually exclusive dichotomous dummy variables—non-Hispanic White, non-Hispanic Black, Hispanic (any race), and non-Hispanic other race. Respondents who identified being non-Hispanic White served as the reference group. Marital status was measured as married, divorced/separated, widowed, and never married. Respondents who were married served as the reference group. To capture socioeconomic status, educational attainment, and income measures were included in the analysis. Education was measured in years as a continuous variable. As measured by the HRS, the number of years of education ranged from 0 to 17. Finally, annual income was estimated at the household level (in dollars) and presented in quintiles.

Health-Related Behaviors

Several health-related behaviors and statuses were included as covariates, including self-reported health status, ADL limitations, heavy alcohol use, current smoking status, and cognitive functioning. A series of dichotomous variables were included to measure self-reported health (excellent/very good [reference group], good, and fair/poor). Activity limitations were determined from responses to six activities of daily living (dressing, walking, bathing, eating, getting in/out of bed, and using the toilet). Individuals who reported difficulty performing one or more ADL were classified as having an ADL limitation (1 = ADL limitation), whereas individuals who reported no activity limitations were coded as 0. The HRS asks respondents about the number of drinks they consume on the days they drink, reflecting over the previous 3 months. Following existing research, if respondents were female and reported consuming more than two drinks per occasion or male and reported

consuming more than three drinks per occasion, these individuals were identified as heavy alcohol consumers (Satre et al., 2007). Current smoking status was assessed and included in the analyses (1 = current smoker, 0 = not a smoker). The HRS assesses cognitive functioning using the Telephone Interview for Cognitive Status (TICS). The score ranges from 0 to 35. However, due to significant missingness, an abbreviated TICS score was used for this current research ranging from 0 to 10, with higher scores representing better cognitive functioning.

Social Network Variables

Current employment status, living alone, having living children, and perceived support were measured as social network characteristics and support indicators. Current employment status was measured as paid work (1 = employed, 0 = not currently employed). Living alone was measured by the self-reported number of people living in the respondent's household (1 = living alone, 0 = living with others). Having living children was measured by the number of living children of the respondent and spouse/partner, with children of the respondent's spouse/partner being counted as a child of their own (1 = has living children, 0 = no living children). Social support was measured by combining respondents who received support for ADL limitations and those who did not have an ADL limitation but believed they could get help in the future if needed (1 = has current assistance for ADL limitations or has perceived future support, 0 = no support for current ADL limitations or has no perceived future support if needed).

Analytic Strategy

Descriptive statistics were calculated for all variables employed in the analyses using STATA16. Multivariate analyses were performed using binomial logistic regression to

examine the association between insomnia, physical activity, gender, and depression, controlling for other baseline factors and depression in the previous wave. Regression models for risk of depression (2018 wave) were based on a longitudinal model with time-lagged indicators of insomnia, physical activity, gender, and covariates (2016 wave). The first model examined the association between insomnia and depression. The second model examined the association between physical activity with depression 2 years later. The third model included insomnia, physical activity, and depression. The fourth model had insomnia, physical activity, depression at follow-up, and all other covariates identified above.

To examine the extent to which insomnia shapes the risk of depression among middle-aged and older community-dwelling adults, an analysis was conducted to evaluate whether respondents were more likely to develop depression 2 years later if they experienced insomnia at baseline (2016 wave). Studies have demonstrated that baseline depression accounts for a large proportion of variance in the association between insomnia and depression at follow-up, so the decision was made to control for depression in the previous wave by including baseline depression as a covariate (Chen & Saito, 2021; Paudel et al., 2013). Accounting for baseline depression minimized the influence of multicollinearity and confounding bias, which can result in the overestimation or underestimation of the impact of the independent variable on the dependent variable, in this case, the effect of insomnia on subsequent depression.

I carried out several sensitivity analyses, and the results are reported in Chapter 4. First, a logistic regression was estimated with a different threshold of depression (2+ CES-D symptoms) measured at baseline and follow-up to assess the impact of alternative outcome

definitions. Next, a linear regression was estimated to determine the stability of the results when analyzing depression as a continuous rather than a dichotomous outcome. In addition, logistic regression models were estimated without controlling for baseline depression to assess the similarity of results. Finally, a logistic regression model was estimated with a different threshold of insomnia (2+ symptoms) at baseline instead of one or more symptoms.

CHAPTER 4

RESULTS

This chapter presents results from analyses of how insomnia is associated with the risk of depression among middle-aged and older community-dwelling adults. The chapter begins with presenting descriptive results for the entire study sample. Next, logistic regression results demonstrate how insomnia is related to the risk of future depression, including moderation analyses involving physical activity and gender. These analyses focus on the dichotomous outcome of depression (1=yes, 0=no), composed of indicators using the CES-D scale, collected in the HRS to capture the number of depressive symptoms. Last, the chapter presents sensitivity analyses using different cut-off measures for the main variables of interest.

Descriptive Statistics

Table 2 presents results from a descriptive analysis of the entire study sample. Nearly 17% of the sample reported three or more depressive symptoms in 2018. Similarly, almost 17% of the sample reported three or more depressive symptoms at baseline. The alternative measure of depression used in the sensitivity analysis indicates that 26% of the sample reported two or more symptoms of depression at baseline and follow-up. These estimates are consistent with previous estimates among the older population, which ranged from 10–20% (Federal Interagency Forum on Aging-Related Statistics, 2020). In line with other studies,

approximately 82% of respondents reported baseline insomnia. The alternative measure of insomnia used in the sensitivity analysis indicates that 39% of the sample reported 2 or more symptoms of insomnia. Due to differences in measurement and definition of insomnia, rates reported in the literature have ranged from 50 to 75% (Helbig et al., 2017; Hishikawa et al., 2017; Ling et al., 2016, Uchmanowicz et al., 2019).

Nearly 72% of the sample reported regular moderate to vigorous physical activity, whereas 28% were inactive or only engaged in light physical activity. These results were also in line with other studies utilizing this dataset and method of coding. Respondents in the sample were, on average, 65 years old (*SD* = 10.3, range 50–99). Overall, the sample was about 59% female (*n* = 8,267) and 41% male (*n* = 5,826). Most of the sample was non-Hispanic white (58.1%), followed by non-Hispanic blacks (21.7%), Hispanic (15.7%), and non-Hispanic other races (4.7%). On average, 44% of the sample worked for pay. Respondents reported nearly 13 years of education on average (*SD* = 3.2). The median household income was $45,104.

Approximately 63% of the study sample was married, 16% were divorced or separated, 14% were widowed, and nearly 7% were never married. Most of the sample had living children (91.5%). Although 22% of respondents lived alone, almost 66% either currently received social support or reporting that they expect to have social support if they developed difficulties with ADL limitations in the future.

Regarding self-rated health, 38% reported excellent or very good health, 34% reported having good health, and 28% reported having fair or poor health. On average, about 15% of the sample had at least one ADL limitation at baseline. Approximately 8% of the

sample reported heavy alcohol use, and 14% were current smokers. On average, respondents answered 6.8 out of 10 memory-related items correctly (*SD* = 3.6, range 1–10).

Table 2

Summary Characteristics of the Health and Retirement Study Sample

Measure	*M*	*SD*
Dependent variable (2018)		
Depressive symptoms (3+)	16.6%	
Independent variables & covariates (2016)		
Depressive symptoms (3+)	16.6%	
Insomnia (1+)	82.0%	
Physical activity		
Vigorous/moderate	71.9%	
Light/inactive	28.1%	
Covariates		
Age	65.3	10.3
Female	58.7%	
Race		
Non-Hispanic White	58.1%	
Non-Hispanic Black	21.7%	
Non-Hispanic Other Race	4.6%	
Hispanic	15.7%	
Employed	44.2%	
Education (in years)	13.0	3.2
Household income ($)	77,944	158,000
Household income median ($)	45,104	
Social network characteristics		
Marital status		
Married	63.0%	
Divorced/separated	16.4%	
Widowed	13.9%	
Never married	6.8%	
Any living children	91.5%	
Lives alone	22.3%	
Perceived support	65.5%	
Health variables		
Self-rated health		
Excellent/very good	38.2%	
Good	34.0%	
Fair/poor	27.8%	
ADL limitations	14.7%	
Heavy alcohol use (drinks/occasion)		
Female three+; male four+	7.6%	
Current smoker	14.2%	
Cognition	6.8	3.6

Note. *N*=14,093; ADL = activities of daily living. TICS = Telephone Interview for Cognitive Status. Age 50+.

The Relationship Between Insomnia and Depression

The following section presents bivariate descriptive analyses of hypothesized relationships to examine the relationship between insomnia and depression. Next, results from the binomial logistic regression models estimate the change in depressive symptoms over a 2-year period. Research questions and hypotheses regarding the relationship between insomnia and depression are as follows: Is insomnia associated with an increase in the risk of depression among a nationally representative sample of middle-aged and older adults over 2 years? It is hypothesized that insomnia will be positively associated with depression 2 years later, controlling for baseline depression.

Table 3 illustrates the bivariate relationship between insomnia status in 2016 and depression 2 years later. Respondents with insomnia had higher rates of depression at follow-up in comparison to their counterparts without insomnia. Approximately 19% of respondents with insomnia were depressed at follow-up compared to 5% of respondents without baseline insomnia. This finding is in line with the hypothesis that insomnia would be associated with an increase in the risk of depression. The Pearson chi-square test for independence suggests that the association between insomnia and depression at follow-up was statistically significant ($x^2 = 302.41$, $p < 0.001$).

Table 3

Distribution of Independent and Dependent Variable

		Not depressed 2018 (< 3 CES-D)	Depressed 2018 (≥ 3 CES-D)	Total	*n*
Insomnia 2016?	No	95.0%	5.0%	100.0%	2,533
	Yes	80.8%	19.2%	100.0%	11,560

Note. N = 14,093. x^2 = 302.41; CES-D = Center for Epidemiological Studies-Depression Scale.
$p < 0.001$.

Table 4 presents binomial logistic regression results examining the relationship between insomnia and depression. In the model, effects were net of the strong positive relationship between depression in 2018 and depression 2 years earlier. As hypothesized, Model 1 demonstrated a positive association between baseline insomnia and subsequent depression. Specifically, respondents who had insomnia in 2016 were nearly 3 times as likely to be depressed in 2018 compared to people without insomnia when controlling for baseline depression (*OR* = 2.91, 95% CI = [2.40, 3.52], $p < 0.001$). The pseudo R^2 for Model 1 was 0.19. The Likelihood Ratio chi-square test was $\chi^2(2) = 2{,}390.09$, ($p < 0.001$), which serves as an alternative goodness-of-fit test to the pseudo R^2.

Adjustments for the covariates described in Table 2 are included in Table 4, Model 2. Results demonstrated that net of 2016 depression, and despite a substantial positive effect of 2016 depression, insomnia was positively associated with depression 2 years later and that relationship retained statistical significance when covariates were included in the model (*OR* = 2.19, 95% CI = [1.80, 2.67, $p < 0.001$]. Specifically, respondents who had insomnia in

2016 were 2.19 times as likely to be depressed in 2018 than those without insomnia when controlling for baseline depression. This finding supported the hypothesis that individuals with insomnia have an increased risk of depression.

As hypothesized, results from Model 2 demonstrated a negative and statistically significant association between physical activity and depression (*OR* = 0.87, 95% CI = [0.78, 0.97]). This finding provided support that individuals who are more physically active are less likely to develop depression in comparison to their less physically active counterparts. Results showed that the odds of depression were approximately 13% lower for respondents who were more physically active than their counterparts who were less physically active.

As hypothesized, Model 2 provided support that there is a gender difference in the risk of depression. Compared to their male counterparts, results from Model 2 demonstrated that women had an increased risk of depression (*OR* = 1.26, 95% CI = [1.13, 1.41], $p < 0.001$). Specifically, females were 1.26 times as likely to report depression in 2018 compared to males.

Table 4, Model 2 presents factors that were positively associated with risk of depression. Respondents who were in the "other" race category had an increased risk of depression at follow-up, compared to non-Hispanic Whites (*OR* = 1.32, 95% CI = [1.04, 1.68], $p < 0.05$). Similarly, respondents with low household income—specifically, those in Quantiles 1 and 2—had an increased risk of depression in 2018 (*OR* = 1.29, 95% CI = [1.09, 1.54], $p < 0.01$; *OR* = 1.24, 95% CI = [1.06, 1.46], $p < 0.01$, respectively), using the median value of Quantile 3 as a reference group. Compared to married respondents, those who were divorced/separated or never married had an increased risk of depression in 2018 (*OR* = 1.26,

95% CI = [1.06, 1.49], $p < 0.01$; *OR* = 1.31, 95% CI = [1.04, 1.65], $p < 0.05$, respectively). Compared to respondents who reported very good or excellent self-rated health, individuals who rated their health as good and those who rated their health as fair/poor had an increased risk of depression at follow-up (*OR* = 1.50, 95% CI = [1.29, 1.74], $p < 0.001$; *OR* = 2.59, 95% CI = [2.33, 3.02], $p < 0.001$, respectively). Results indicated that the likelihood of depression was higher among those with limitations to ADLs (*OR* = 1.52, 95% CI = [1.33, 1.73], $p < 0.001$). Individuals who were current smokers had an increased risk of depression (*OR* = 1.31, 95% CI = [1.14, 1.51], $p < 0.001$) compared to those who did not smoke at baseline.

Several factors were negatively associated with the risk of depression in 2018, including age (*OR* = 0.99, 95% CI = [0.99, 0.99], $p < 0.05$), employment (*OR* = 0.87, 95% CI = [0.77, 0.99], $p < 0.05$), having a household income that falls into the highest quantile (Q5) (*OR* = 0.81, 95% CI = [0.66, 0.98], $p < 0.05$), and having social support for ADL needs (*OR* = 0.77, 95% CI = [0.69, 0.86], $p < 0.001$). Moreover, factors with no statistically significant association with depression at Time 2, net of other variables in the model, included Hispanic or non-Hispanic Black race/ethnicity, education (in years), having a household income that falls into the fourth quantile, being widowed, having living children, living alone, heavy alcohol use, and cognition (TICS). The pseudo R^2 for the fully adjusted model (Model 2) was 0.24. The Likelihood Ratio chi-square test $\chi^2(26) = 2987.46$, ($p < 0.001$) demonstrated that the full model predicts significantly better than the null model, which had a Likelihood Ratio chi-square test $\chi^2(2) = 2{,}390.09$, ($p < 0.001$).

Table 4

Logistic Regression Results for Depression and Insomnia

	Model 1 *OR* [95% CI]	Model 2 *OR* [95% CI]
Insomnia	2.91 [2.40, 3.53]***	2.19 [1.80, 2.67]***
Depression in 2016	10.11 [9.11, 11.21]***	6.05 [5.40, 6.77]***
Physical activity		
Vigorous/moderate		0.87 [0.78, 0.97]*
Light/inactive		Ref
Gender		
Female		1.26 [1.13, 1.41]***
Male		Ref
Age		0.99 [0.99, 0.99]*
Race		
Hispanic		0.91 [0.77, 1.06]
Non-Hispanic Black		0.96 [0.83, 1.09]
Other		1.32 [1.05, 1.68]*
Non-Hispanic White		Ref
Employed		0.87 [0.77, 0.99]*
Education		0.99 [0.97, 1.01]
Household Income [$]		
Quantile 1		1.29 [1.09, 1.54]**
Quantile 2		1.24 [1.06, 1.46]**
Quantile 3		Ref
Quantile 4		0.94 [0.80, 1.13]
Quantile 5		0.81 [0.66, 0.98]*
Marital Status		
Married		Ref
Divorced/separated		1.26 [1.06, 1.49]**
Widowed		1.08 [0.89, 1.30]
Never married		1.31 [1.04, 1.65]*
Living children		0.92 [0.76, 1.12]
Lives alone		0.92 [0.79, 1.07]
Perceived social support		0.77 [0.69, 0.86]***
Self-rated health		
Excellent/very good		Ref
Good		1.50 [1.29, 1.74]***
Fair/poor		2.59 [2.22, 3.01]***
ADL limitations (1+)		1.52 [1.33, 1.73]***
Heavy alcohol use		1.01 [0.83, 1.22]
Current smoker		1.31 [1.14, 1.51]***
Cognition (TICS)		0.99 [0.98, 1.01]
Pseudo R^2	0.19	0.24
LR chi2	2,458.40	2,987.46

Note. *N*=14,093; ADL = activities of daily living; TICS = Telephone Interview for Cognitive Status. Covariates and baseline depression controlled for.
*$p < .05$. **p < .01. ***p < .001.

Does Physical Activity Moderate the Relationship Between Insomnia and Depression?

Research questions and hypotheses regarding the relationship between insomnia, physical activity, and depression are as follows: Does physical activity moderate the relationship between insomnia and depression, controlling for baseline depression? I hypothesized that there would be a negative association between physical activity and depression and that the association between insomnia and depression would be stronger for individuals who are less physically active. The following section presents analyses of hypothesized relationships to examine differences in the relationship between insomnia and depression by physical activity.

Table 5 highlights the distribution of 2018 depression by baseline physical activity status. Respondents who were less physically active had higher rates of depression than their counterparts who reported regular engagement in moderate to vigorous physical activity. Specifically, nearly 25% of respondents who were not physically active were depressed at Time 2, compared to 13.5% of physically active people at baseline. The Pearson chi-square test for independence showed that the association between physical activity and depression at follow-up was statistically significant ($\chi^2 = 257.64$, $p < 0.001$).

Table 5

Distribution of Physical Activity and 2018 Depression

		Not depressed 2018 (< 3 CES-D)	Depressed 2018 (≥ 3 CES-D)	Total	*N*
Physical Activity	No	75.3%	24.7%	100.0%	3,964
	Yes	86.5%	13.5%	100.0%	10,129

Note. N = 14,093; x^2 = 257.64; CES-D = Center for Epidemiological Studies-Depression Scale.
$p < 0.001$.

Similarly, results from Table 6 depicted how the relationship between baseline insomnia and depression differs by physical activity. Specifically, among those who engaged in moderate to vigorous physical activity at Time 1, nearly 16% of respondents with insomnia were depressed at Time 2, compared to 4.5% of respondents without insomnia. Among those who were not physically active or only engaged in light physical activity, 27% of respondents with insomnia were depressed in 2018 compared to 7.2% of their counterparts who did not have insomnia. Examining the ratio of the percentage depressed across insomnia categories, a slightly higher ratio is observed among those who were physically inactive, compared to those who engaged in moderate to vigorous physical activity (3.8 in comparison to 3.5 respectively). Yet, the difference in ratios was small and may not represent a meaningful clinical difference.

Table 6

Distribution of Independent and Dependent Variable

Physical activity	Insomnia	Not depressed 2018 (< 3 CES-D)	Depressed 2018 (≥ 3 CES-D)	Total	*n*
Moderate/vigorous	Yes	84.2%	15.8%	100.0%	2,061
	No	95.5%	4.5%	100.0%	472
Light or no PA	Yes	73.0%	27.0%	100.0%	8,068
	No	92.8%	7.2%	100.0%	3,492

Note. Moderate to vigorous physical activity (n = 10,129); light or no physical activity (n = 3,964); $x^2 = 180.24$; $p < 0.001$ for moderate to vigorous PA; $x^2 = 87.98$; $p < 0.001$ for light or no PA; PA = physical activity; CES-D = Center for Epidemiological Studies-Depression Scale.

Table 7 presents logistic regression results examining the relationship between insomnia, depression, and physical activity. Model 1 included baseline depression, insomnia, and physical activity but no other variables. Moderate to vigorous physical activity was negatively associated with depression. The likelihood of depression was approximately 35% lower for respondents who were more physically active in comparison to their counterparts who were less physically active, net of insomnia status (*OR* = 0.65, 95% CI = [0.58, 0.72], $p < 0.001$). The pseudo R^2 for Model 1 was 0.19.

All covariates in the main effects model are included in Table 7, Model 2. The relationship between insomnia and depression was reduced when covariates were added to the model but the coefficient for insomnia retained statistical significance (*OR* = 0.87, 95% CI = [0.78, 0.97]). The likelihood of depression was approximately 13% lower for

respondents who were more physically active than their counterparts who were less physically active, net of insomnia status. The pseudo R^2 for Model 2 was 0.24.

Table 7, Model 3 included the interaction term for insomnia and physical activity. The interaction between insomnia and physical activity did not reach statistical significance, which indicated that the effect of insomnia on depression did not vary by level of physical activity. Thus, the hypothesis that physical activity moderates the association between insomnia and depression was not supported.

Table 7

Logistic Regression Results for Depression, Physical Activity, and Insomnia

	Model 1	Model 2	Model 3
	OR [95% CI]	*OR* [95% CI]	*OR* [95% CI]
Insomnia	2.85 [2.36, 3.44]***	2.19 [1.80, 2.67]***	2.28 [1.55, 3.33]***
Depression in 2016	9.69 [8.75, 10.73]***	6.05 [5.40, 6.77]***	6.05 [5.40, 6.77]***
Physical activity			
Vigorous/moderate	0.65 [0.58, 0.72]***	0.87 [0.78, 0.97]*	0.91 [0.59, 1.40]
Light/inactive	Ref	Ref	Ref
Interaction			
Insomnia*PA	---	---	0.95 [0.61, 1.48]
Pseudo R^2	0.19	0.24	0.24

Note. N=14,093; PA = physical activity. Covariates included in Model 2 and Model 3 above include gender, age, race, employment, education, household income, marital status, living children, lives alone, perceived social support, self-rated health, ADL limitation, heavy alcohol use, smoking status, and cognition. Baseline depression controlled for.
*$p < .05$. **$p < .01$. ***$p < .001$.

Gender Differences in the Relationship Between Insomnia and Depression

The final question in this dissertation was as follows: Does gender moderate the relationship between insomnia and depression among middle-aged and older adults over 2 years controlling for baseline depression? The association between baseline insomnia and depression was anticipated to be stronger for females than their male counterparts. The following section presents analyses of hypothesized relationships to examine gender differences in the relationship between insomnia and depression.

Table 8 depicted the distribution of 2018 depression by gender. As hypothesized, women had higher rates of depression in comparison to men. Specifically, 19.2% of women were depressed at Time 2, whereas 13.4% of men were depressed.

Table 8

Distribution of Gender and 2018 Depression

		Not Depressed 2018 (< 3 CES-D)	Depressed 2018 (≥ 3 CES-D)	Total	*n*
Gender	Male	86.8%	13.2%	100.0%	5,826
	Female	80.9%	19.1%	100.0%	8,267

Note. N = 14,093; x^2 = 84.94; CES-D = Center for Epidemiological Studies-Depression Scale.
$p < 0.001$.

Table 9 presents gender differences in the relationship between baseline insomnia and depression. A higher proportion of women had depression, among those with baseline insomnia and those who did not have insomnia. However, the coupling of female gender with insomnia was associated with a notably high risk of depression. Specifically, 21.6% of

women with baseline insomnia were depressed. This finding demonstrates that women with insomnia had the highest risk of depression across these groups.

Table 9

Distribution of Independent and Dependent Variable

			Not depressed 2018 (< 3 CES-D)	Depressed 2018 (≥ 3 CES-D)	Total	*N*
Insomnia 2016?	No	Males	95.8%	4.2%	100.0%	1,268
		Females	94.2%	5.8%	100.0%	1,265
	Yes	Males	84.0%	16.0%	100.0%	4,558
		Females	78.4%	21.6%	100.0%	7,002

Note. Males (*n* = 5,826); females (*n* = 8,267); x^2 = 116.79; x^2 = 168.79; CES-D = Center for Epidemiological Studies-Depression Scale.
p < 0.001 for male. *p* < 0.001 for females.

Table 10

Logistic Regression Results for Depression, Gender, and Insomnia

	Model 1 *OR* [95% CI]	Model 2 *OR* [95% CI]	Model 3 *OR* [95% CI]
Insomnia	2.91 [2.41, 3.52]***	2.19 [1.80, 2.67]***	2.25 [1.66, 3.04]***
Depression in 2016	10.04 [9.07,11.11]***	6.05 [5.40, 6.77]***	6.05 [5.40, 6.77]***
Gender			
Female	1.28 [1.15, 1.41]***	1.26 [1.13, 1.41]***	1.32 [0.90, 1.93]
Male	Ref	Ref	Ref
Interaction			
Insomnia*female			0.95 [0.64, 1.41]
Pseudo R^2	0.19	0.24	0.24

Note. N=14,093. Covariates included in Model 2 and Model 3 but not shown above include physical activity, age, race, employment, education, household income, marital status, living children, lives alone, perceived social support, self-rated health, ADLs, heavy alcohol use, smoking status, and cognition.
*p < .05. **p < .01. ***p < .001.

Table 10 presents the binomial logistic regression results for the relationship between insomnia, gender, and depression. Model 1 shows that women were 1.28 times as likely to report depression in 2018 compared to men, controlling for baseline depression (*OR* = 1.28, 95% CI = [1.15, 1.41], $p < 0.001$). The pseudo R^2 for Model 1 was 0.19.

When covariates were added in Model 2, the likelihood of depression among women decreased slightly. However, a statistically significant association remained between female gender and depression in 2018 (*OR* = 1.26, 95% CI = [1.12, 1.41], $p < 0.001$). The likelihood of depression was approximately 1.26 times as high for females compared to males.

Table 10, Model 3 included the interaction between insomnia and female gender. The interaction term (insomnia*female) did not reach statistical significance, which indicated that the effect of insomnia on depression did not vary by gender. Therefore, the hypothesis that gender moderates the association between insomnia and depression was not supported.

Sensitivity Analyses

I conducted a sensitivity analysis to determine whether the results would hold when the limits for having depression changed from three or more CES-D symptoms to two or more CES-D symptoms. Depression in 2016 was coded the same way as the dependent variable in each model. As demonstrated in Table 11 (Model 2 of Table 11), the association between baseline insomnia and 2018 depression decreased slightly but retained statistical significance ($p < 0.001$), in comparison to Model 1 of Table 11, which utilized three or more depressive symptoms. The model fit also decreased slightly, as indicated by the pseudo R^2 value. In conclusion, despite a change in measurement of the dependent variable, no significant differences were observed in comparison to the final model.

Table 11

Logistic Regression Results for Depression and Insomnia

	Model 1 (≥ 3 CES-D) *OR* [95% CI]	Model 2 (≥ 2 CES-D) *OR* [95% CI]
Insomnia	2.19 [1.80, 2.67]***	1.93 [1.66, 2.41]***
Depression in 2016	6.05 [5.40, 6.77]***	5.45 [4.97, 5.99]***
Physical activity		
Vigorous/moderate	0.87 [0.78, 0.97]*	0.88 [0.80, 0.97]*
Light/inactive	Ref	Ref
Gender		
Female	1.26 [1.13, 1.41]***	1.23 [1.12, 1.36]***
Male	Ref	Ref
Age	0.99 [0.99, 0.99]*	0.99 [0.99, 1.00]
Race		
Hispanic	0.91 [0.77, 1.06]	0.92 [0.79, 1.04]
Non-Hispanic Black	0.96 [0.83, 1.09]	1.01 [0.90, 1.14]
Other	1.32 [1.05, 1.68]*	1.25 [1.02, 1.54]*
Non-Hispanic White	Ref	Ref
Employed	0.87 [0.77, 0.99]*	0.95 [0.85, 1.06]
Education	0.99 [0.97, 1.01]	0.99 [0.97, 1.00]
Household income [$]		
Quantile 1	1.29 [1.09, 1.54]**	1.26 [1.09, 1.45]**
Quantile 2	1.24 [1.06, 1.46]**	1.11 [0.96, 1.27]
Quantile 3	Ref	Ref
Quantile 4	0.94 [0.80, 1.13]	0.91 [0.79, 1.05]
Quantile 5	0.81 [0.66, 0.98]*	0.84 [0.72, 0.99]*
Marital status		
Married	Ref	Ref
Divorced/separated	1.26 [1.06, 1.49]**	1.17 [1.01, 1.36]*
Widowed	1.08 [0.89, 1.30]	1.17 [1.00, 1.38]
Never married	1.31 [1.04, 1.65]*	1.26 [1.02, 1.55]*
Living children	0.92 [0.76, 1.12]	0.90 [0.76, 1.07]
Lives alone	0.92 [0.79, 1.07]	0.95 [0.83, 1.08]
Perceived social support	0.77 [0.69, 0.86]***	0.78 [0.71, 0.86]***
Self-rated health		
Excellent/very good	Ref	Ref
Good	1.50 [1.29, 1.74]***	1.39 [1.24, 1.56]***
Fair/poor	2.59 [2.22, 3.01]***	2.27 [2.00, 2.57]***
ADL limitations (1+)	1.52 [1.33, 1.73]***	1.80 [1.59, 2.03]***
Heavy alcohol use	1.01 [0.83, 1.22]	0.99 [0.83, 0.17]
Current smoker	1.31 [1.14, 1.51]***	1.40 [1.24, 1.56]***
Cognition (TICS)	0.99 [0.98, 1.01]	0.99 [0.99, 1.01]
Pseudo R^2	0.24	0.23
LR chi2	2,987.46	3,733.50

Note. N=14,093; TICS = Telephone Interview for Cognitive Status; CES-D = Center for Epidemiological Studies-Depression Scale; ADL = activities of daily living; PA = physical activity. In Model 1 depression is measured by 3+ symptoms in comparison to Model 2, which uses 2+ symptoms. Covariates and baseline depression controlled for.
*$p < .05$. **$p < .01$. ***$p < .001$.

Results of the alternate threshold for depression with respect to the moderation effect of gender are presented in Table 12. Model 1 presents results from the original interaction analysis using three or more symptoms of depression for reference. Table 12, Model 2 includes the interaction term between gender and insomnia using two symptoms of depression at baseline and follow-up. The model shows that the interaction term (insomnia*female) did not reach statistical significance in either model.

Table 12

Sensitivity Analysis: Logistic Regression Results for Depression, Gender, and Insomnia

	Model 1 (≥ 3 CES-D) *OR* [95% CI]	Model 2 (≥ 2 CES-D) *OR* [95% CI]
Insomnia	2.25 [1.66, 3.05]***	1.81 [1.45, 2.25]***
Depression in 2016	6.05 [5.40, 6.77]***	5.46 [4.97, 5.99]***
Gender		
Female	1.32 [0.90, 1.93]	1.11 [0.84, 1.52]
Male	Ref	Ref
Interaction		
Insomnia*female	0.95 [0.64, 1.41]	1.13 [0.84, 1.52]
Pseudo R^2	*0.24*	*0.23*
LRchi2	*2,987.51*	*3,734.15*

Note. N=14,093; CES-D = Center for Epidemiological Studies-Depression Scale. Covariates included in Model 1 and Model 2 but not shown above include physical activity, age, race, employment, education, household income, marital status, living children, lives alone, perceived social support, self-rated health, ADLs, heavy alcohol use, smoking status, and cognition. Baseline depression controlled for.
*p < .05. **p < .01. ***p < .001.

Results of the alternate threshold for depression with respect to the moderation effect of physical activity are presented in Table 13. Model 1 presents results from the original interaction analysis using three or more symptoms of depression for reference. Similarly,

Table 13, Model 2, included the interaction between insomnia and physical activity using two symptoms of depression at baseline and follow-up. Results showed that the interaction term (insomnia*moderate/vigorous physical activity) did not reach statistical significance in either model.

Table 13

Sensitivity Analysis: Logistic Regression Results for Depression, Physical Activity, and Insomnia

	Model 1 (≥ 3 CES-D) *OR* [95% CI]	Model 2 (≥ 2 CES-D) *OR* [95% CI]
Insomnia	2.28 [1.55, 3.33]***	1.96 [1.46, 2.62]***
Depression in 2016	6.05 [5.40, 6.77]***	5.46 [4.97, 5.99]***
Physical activity		
Vigorous/moderate	0.91 [0.59, 1.40]	0.89 [0.65, 1.24]
light/inactive	Ref	Ref
Interaction		
Insomnia*PA	0.95 [0.61, 1.48]	0.98 [0.70, 1.38]
Pseudo R^2	0.24	0.23
LRchi2	2,987.51	3,733.51

Note. N=14,093; PA = physical activity; Covariates included in Model 1 and Model 2 are gender, age, race, employment, education, household income, marital status, living children, lives alone, perceived social support, self-rated health, ADLs, heavy alcohol use, current smoking status, and cognition. Baseline depression controlled for.
*$p < .05$. **$p < .01$. ***$p < .001$.

Another sensitivity analysis was conducted to assess how results would change when the decision was made to exclude baseline depression as a covariate in the model. Table 14, Model 2 presented results from that analysis in relation to the original model in Model 1. The association between baseline insomnia and 2018 depression increased and maintained statistical significance ($p < 0.001$). The model fit decreased to 0.16, as indicated by the

pseudo R^2 value. Interestingly, the key variables were not heavily impacted by controlling for 2016 depression.

Table 14

Sensitivity Analysis Logistic Regression Results

	Model 1	Model 2
	OR [95% CI]	*OR* [95% CI]
Insomnia	2.19 [1.80, 2.67]***	2.67 [2.20, 3.24]***
Depression in 2016	6.05 [5.40, 6.77]***	-
Physical activity		
Vigorous/moderate	0.87 [0.78, 0.97]*	0.84 [0.75, 0.93]**
Light/inactive	Ref	Ref
Gender		
Female	1.26 [1.13, 1.41]***	1.36 [1.22, 1.51]***
Male	Ref	Ref
Pseudo R^2	0.24	0.16
LRchi2	2,987.46	2,017.36

Note. N=14,093; Model 1 controls for depression in 2016. Model 2 does not control for depression in 2016. Covariates included in Model 1 and Model 2 include gender, age, race, employment, education, household income, marital status, living children, lives alone, perceived social support, self-rated health, ADLs, heavy alcohol use, smoking status, and cognition. 2016 depression not controlled for.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 15 presents a sensitivity analysis using depression as a continuous variable both at baseline and follow-up. For this analysis, CES-D scores ranged from 0–7. In the model, insomnia, baseline depression, and insomnia retained statistical significance. The relationship between physical activity and depression became stronger and increased in statistical significance ($p < 0.01$).

Table 15

Sensitivity Analysis: Linear Regression Results With Depression as a Continuous Variable

	β	SE	[95% CI]
Insomnia	0.20***	0.03	[0.14, 0.26]
Depression in 2016 (continuous)	0.48***	0.01	[0.46, 0.50]
Physical activity			
Vigorous/moderate	-0.09**	0.03	[-0.14, -0.04]
Light/inactive	Ref	Ref	Ref
Gender			
Female	0.10***	0.25	[0.05, 0.15]
Male	Ref	Ref	Ref

Note. N=14,093. This model controls for depression in 2016 and 2018 as measured by the CES-D scale (0–7). Covariates included in both models include gender, age, race, employment, education, household income, marital status, living children, lives alone, perceived social support, self-rated health, ADLs, heavy alcohol use, smoking status, and cognition.
*$p < .05$. **$p < .01$. ***$p < .001$.

Finally, a sensitivity analysis was conducted to determine whether results would hold when the limits for having insomnia changed from one or more symptoms to two or more symptoms. Table 16, Model 2 presents results from this analysis in relation to the original main effects model to its left. Results show that the association between baseline insomnia and 2018 depression decreased yet retained statistical significance ($p < 0.001$). As indicated by the pseudo R^2 value, the model fit remained the same.

Table 16

Sensitivity Analysis: Logistic Regression Results With Insomnia ≥ 2 Symptoms

	Main Effects Model	Model 2
	Insomnia ≥ 1 symptom	Insomnia ≥ 2 symptoms
	OR [95% CI]	*OR* [95% CI]
Insomnia	2.19 [1.80, 2.67]***	1.91 [1.68, 2.17]***
Depression in 2016	6.05 [5.40, 6.77]***	5.86 [5.23, 6.56]***
Physical activity		
Vigorous/moderate PA	0.87 [0.78, 0.97]*	0.87 [0.77, 0.97]**
Light/inactive	Ref	Ref
Gender		
Female	1.26 [1.13, 1.41]***	1.24 [1.11, 1.39]***
Male	Ref	Ref
Pseudo R^2	0.24	0.24
LRchi2	2,987.46	3,021.41

Note. N=14,093; PA = physical activity; The main effects model and Model 2 controlled for depression in 2016. Covariates included in the above models include gender, age, race, employment, education, household income, marital status, living children, lives alone, perceived social support, self-rated health, ADLs, heavy alcohol use, smoking status, and cognition.
*$p < .05$. **$p < .01$. ***$p < .001$.

CHAPTER 5

DISCUSSION

Depression is one of the most prevalent and debilitating public health issues globally (Alexopoulos, 2005). Population aging will only further compound this problem. According to the WHO, the proportion of adults over 60 years of age will nearly double by 2050 (WHO, 2016). Among older adults, depression has been associated with several negative consequences, including reduced quality of life, exacerbation of chronic illnesses, cognitive decline, dementia, and suicide (Cuijpers et al., 2013; Diniz et al., 2013; Taylor, 2014). Due to the growing segment of the population at risk for experiencing depression and its associated health consequences, prevention strategies and interventions are urgently needed (Hoare et al., 2020).

The relationship between insomnia and depression is a burgeoning area of research due to growing evidence that sleep disturbances often precede psychiatric disorders. This research investigated the relationship between insomnia and depression over 2 years among a large sample of community-dwelling middle-aged and older men and women. Consistent with the study's main hypothesis, the central finding was that insomnia was positively associated with an increased risk of depression 2 years later, and the relationship was statistically significant. Respondents with insomnia were nearly 3 times more likely to be depressed at follow-up than those without insomnia, controlling for baseline depression.

When covariates were added to the model, the relationship retained statistical significance. Moreover, the risk for depression was about 2.19 times greater in respondents with insomnia at baseline compared to those without insomnia when controlling for baseline depression and factors significantly associated with depression. In a fully adjusted model, depression in 2018 remained significantly associated with having insomnia, being female, being in the "other" race category, having a low household income, being divorced, never married, reporting good or fair/poor health as opposed to excellent or very good health, having an ADL limitation, and being a smoker. The likelihood of depression was approximately 13% lower for respondents who were more physically active than their counterparts who were less physically active, net of insomnia status.

As hypothesized, women had significantly higher rates of depression in comparison to men. Specifically, 19.2% of women were depressed at Time 2, whereas 13.4% of men were depressed. This study found that compared to men, a higher proportion of women had depression, both among those with baseline insomnia and those without insomnia at baseline. The coupling of female gender with insomnia was associated with a notably high risk of depression. Specifically, 21.6% of women with baseline insomnia were depressed. This finding demonstrates that women with insomnia had the highest risk of depression across these groups. Compared to their male counterparts, a fully adjusted model shows that women had an increased risk of depression. Specifically, females were 1.26 times as likely to report depression in 2018 compared to males.

Moreover, this study explored a possible moderation effect of gender on the relationship between insomnia and depression. Although the interaction term did not reach statistical significance, the results provide important considerations for future research. Whereas women were significantly more likely to be depressed and have insomnia, the relationship between insomnia and depression is similar for men and women. Therefore, despite the higher risk women have, interventions may not need to be gender specific but rather target both genders.

Last, the results indicate that more physically active individuals were less likely to develop depression than their less physically active counterparts. The odds of depression were approximately 35% lower for respondents who were more physically active than their peers who were less physically active, net of insomnia status. The effect of physical activity on the relationship between insomnia and depression was reduced when covariates were added to the model but retained statistical significance. The odds of depression were approximately 13% lower for respondents who were more active than their counterparts who were less physically active, net of insomnia status.

Despite these findings, interaction analyses determined that physical activity differences in the relationship between insomnia and depression were not statistically significant. Therefore, even though more physically active individuals were less likely to be depressed, the relationship between insomnia and depression was similar for people regardless of differences in physical activity engagement. Because the relationship is the same for those who are more and less physically active, interventions to prevent or alleviate

depressive symptoms by treating insomnia may be equally effective among those with and without physical activity engagement.

Results from this study are generally consistent with studies that have examined insomnia as an independent risk factor for depression (Chen & Saito, 2021; Jackowska & Poole, 2017; Jaussent et al., 2011; Li et al., 2016; Suh et al., 2013). The results of this study align with and further complement the findings of other studies in several important aspects.

Contributions

To date, few studies have examined the relationship between insomnia and depressive symptoms among older adults. Most research on the relationship between insomnia and health has focused on younger adults, with limited attention directed to middle-aged and older adults (Garfield et al., 2016; Langvik et al., 2019; Li et al., 2016). This study extended the age continuum by showing the effects of insomnia on depression among middle-aged and older adults. Further, this study included participants with and without insomnia and depression as opposed to studies that only examined the development of depression among people with insomnia at baseline and studies that excluded people who were depressed at Time 1.

Another strength of the current study is the direction of association in which insomnia precedes depression. As previously mentioned, early classifications of sleep disorders and insomnia held that sleep issues were a symptom and consequence of depression. However, more recent evidence has demonstrated that insomnia symptoms are more commonly observed before depression (Furihata et al., 2017; Murphy & Peterson, 2015; Vargas & Perlis, 2020). Accordingly, researchers began to explore insomnia as a risk factor and

precursor to depression among all age groups and later life (Chen & Saito, 2021; Jackowska & Poole, 2017). Moreover, the current study considered each of the four insomnia symptoms as indicators of insomnia, consistent with an updated definition of insomnia given by the DSM-5. Last, the current research conducted several sensitivity analyses to verify the robustness of the results.

Possible Explanations for How Insomnia Shapes Depression

There are several possible interpretations of my findings. Experimental studies have demonstrated that lack of sleep may result in cognitive and affective alterations that contribute to increased depression risk (Jackson et al., 2014; Li et al., 2016). However, the pathways through which insomnia contributes to future depression remain poorly understood. Other hypothesized pathways include neurotransmitter imbalance, heightened emotional reactivity, stress and inflammation, impairments in executive functioning systems, and overactivity of the hypothalamic-pituitary-adrenal axis (Gruber & Cassoff, 2014; Gujar et al., 2011; O'Leary et al., 2017; Predatu et al., 2020; Rumble et al., 2015). Moreover, insomnia and depression may be related to common background factors such as chronic stressors or medical conditions that have not yet been considered (Furihata et al., 2017). The interaction of several such mechanisms may likely play a role. Further research is needed to explain how insomnia contributes to depressive symptoms.

Study Limitations

Although the HRS provides many advantages for the current study, limitations in methodology should be acknowledged. First, insomnia, physical activity, and depression were all measured using respondents' self-reported data, which may be subject to

inaccuracies in reporting. Even though the study assessed possible insomnia and depression based on a cutoff of symptoms, the findings should be replicated for those with formal clinical diagnoses. In terms of physical activity, the HRS is limited in capturing frequency, duration, and type of physical activity. More extensive measures of physical activity are warranted to make more reliable and accurate examinations of variables and their relationship to one another. In addition, the HRS collects data biannually, so the current study was limited to points of data that were obtained 2 years apart.

Further, due to sample size limitations, this study only includes two waves of data from the HRS. Due to attrition, this study was subject to the possibility of sample selection bias because people who participated in both waves were likely to be healthier than those who were not available for the 2018 wave. In conducting comparisons between the selected study sample and those who experienced attrition or had missing information on variables in the model, the missingness group reported higher levels of ADL limitations, were more likely to rate their health as fair/poor, had less income, were older on average, and were more likely to live alone. Thus, each of these points demonstrates the increased vulnerability of those who were not included in the final sample.

Moreover, the current study did not account for changes in critical variables over time. For example, measures of physical activity and insomnia were only obtained at baseline, meaning that the present study does not take into consideration changes in physical activity engagement or insomnia status from 2016 to 2018. In addition, only community-dwelling individuals were included in the sample. Therefore, study results cannot be generalized to other specific middle-aged and older adult samples such as those residing in

nursing homes or residential care facilities. Despite these limitations, the HRS provides a rich data source for investigating the association between insomnia and depression using a large national sample of community-dwelling middle-aged and older individuals.

Implications for Policy and Practice

Findings from this study have the potential to inform health professionals and policymakers about the importance of insomnia for depression, and develop health promotion strategies and programs to reduce the negative and costly health consequences of depression. In addition, this research can inform and guide experts on insomnia and depression as our population ages. One suggestion for policy would be to develop interventions that specifically target individuals with insomnia to delay or prevent depression onset or recurrence. With insomnia being an independent risk factor for depression, it is also important to raise awareness of the importance of sleep and develop early interventions to promote sleep health and hygiene within the general population. For example, health education and counseling for sleep disturbances have the potential to prevent or alleviate depressive symptoms. Similarly, results from this study can inform clinical practice and contribute to improvements in the screening, diagnosis, and management of both insomnia and depression.

Implications of COVID-19

Although the data used in this study precede the COVID-19 pandemic, the importance of this current research is further heightened by the pandemic, as experts have documented extreme surges in insomnia, anxiety, and depression rates. According to the US Census Bureau, more than 42% of people reported symptoms of anxiety or depression in

December 2020, an increase from 11% the previous year. Such changes may be attributed to pandemic-related stress, increased emotional distress, fear, loneliness, social isolation, job uncertainty, unemployment, loss, and bereavement (Le Couteur et al., 2020).

The COVID-19 pandemic has highlighted the vulnerability of the older population to health problems associated with the virus and stressors related to living through a traumatic life event (Horesh & Brown, 2020). For example, older adults' more significant need for health care increases their vulnerability to contracting the virus, experiencing adverse health outcomes, hospitalization, and death. Moreover, during the height of the pandemic, many people did not have access to adequate medical assistance due to closures of medical facilities and fear of contracting the virus.

According to recent research, adequate sleep is critical to coping with crises and future uncertainty or fear (Morin & Carrier, 2021). Major stressful life events are likely to impair sleep and circadian rhythms. Moreover, results from the current study can be useful in providing a baseline for pre- and post-pandemic levels of insomnia and depression, and physical activity levels.

Future Research

Future research should account for changes in insomnia and depression over time to better understand how sleep disturbances contribute to the development of depression in middle and older adulthood. Obtaining data from shorter intervals (less than 2 years apart) or from additional points in time is also warranted. Although physical activity did not act as a moderator for insomnia and depression in this study, future research should differentiate by frequency, duration, and type of activity and examine different thresholds of physical activity

engagement to confirm these findings. Intervention studies may contribute to a deeper understanding of how physical activity affects depression for individuals with and without insomnia. Identifying factors that enable or inhibit people with and without insomnia from engaging in physical activity is another vital area of focus for future research. Finally, in the coming years, it will be important to examine cohort differences regarding the role of physical activity and gender on the relationship between insomnia and the risk of depression.

Conclusion

The current study contributed to the existing literature by examining insomnia as an independent risk factor for depression among a nationally representative sample of middle-aged and older men and women. Even with multiple variables held constant, insomnia increased the odds of experiencing depression at follow-up. This research adds to the evidence establishing insomnia, physical activity, and gender as independent risk factors for experiencing depression.

REFERENCES

Afifi, T., Cox, B., & Enns, M. (2006). Mental health profiles among married, never-married, and separated/divorced mothers in a nationally representative sample. *Social Psychiatry and Psychiatric Epidemiology*, *41*(2), 122–129. https://doi.org/10.1007/s00127-005-0005-3

Åkerstedt, T., Schwarz, J., Gruber, G., Lindberg, E., & Theorell-Haglöw, J. (2016). The relation between polysomnography and subjective sleep and its dependence on age–poor sleep may become good sleep. *Journal of Sleep Research*, *25*(5), 565–570. https://doi.org/10.1111/jsr.12407

Alexopoulos, G. S. (2005). Depression in the elderly. *The Lancet, 365*, 1961–1970. https://doi.org/10.1016/S0140-6736(05)66665-2

Alexopoulos, G. S., & Morimoto, S. S. (2011). The inflammation hypothesis in geriatric depression. *International Journal of Geriatric Psychiatry*, *26*(11), 1109–1118. https://doi.org/10.1002/gps.2672

American Academy of Sleep Medicine. (2014). *International classification of sleep disorders*. https://learn.aasm.org/Public/Catalog/Details.aspx?id=%2FgqQVDMQIT%2FEDy86PWgqgQ%3D%3D&returnurl=%2FUsers%2FUserOnlineCourse.aspx%3FLearningActivityID%3D%252fgqQVDMQIT%252fEDy86PWgqgQ%253d%253d

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

André, C., Rehel, S., Kuhn, E., Landeau, B., Moulinet, I., Touron, E., Ourry, V., Le Du, G., Mezenge, F., Tomadesso, C., de Flores, R., Benjanin, A., Sherif, S., Delcroix, N., Manrique, A., Abbas, A., Marchant, N. G., Lutz, A., Klimecki, O., . . . Rauchs, G. (2020). Association of sleep-disordered breathing with Alzheimer disease biomarkers in community-dwelling older adults: A secondary analysis of a randomized clinical trial. *JAMA Neurology*, *77*(6), 716–724. https://doi.org/10.1001/jamaneurol.2020.0311

Aziz, R., & Steffens, D. (2013). What are the causes of late-life depression? *Psychiatric Clinics*, *36*, 497–516. https://doi.org/10.1016/j.psc.2013.08.001

Baglioni, C., Battagliese, G., Feige, B., Spiegelhalder, K., Nissen, C., Voderholzer, U., Lombardo, C., & Riemann, D. (2011a). Insomnia as a predictor of depression: A meta-analytic evaluation of longitudinal epidemiological studies. *Journal of Affective Disorders*, *135*, 10–19. https://doi.org/10.1016/j.jad.2011.01.011

Baglioni, C., & Riemann, D. (2012). Is chronic insomnia a precursor to major depression? Epidemiological and biological findings. *Current Psychiatry Reports*, *14*, 511–518. https://doi.org/10.1007/s11920-012-0308-5

Ballesio, A., Aquino, M., Kyle, S., Ferlazzo, F., & Lombardo, C. (2019). Executive functions in insomnia disorder: A systematic review and exploratory meta-analysis. *Frontiers in Psychology*, *10*, 101. https://doi.org/10.3389/fpsyg.2019.00101

Barrenetxea, J., Pan, A., Feng, Q., & Koh, W. (2021). Factors associated with depression across age groups of older adults: The Singapore Chinese health study. *International Journal of Geriatric Psychiatry*, *37*(2). https://doi.org/10.1002/gps.5666

Basta, M., Micheli, K., Simos, P., Zaganas, I., Panagiotakis, S., Koutra, K., Krasanaki, C., Lionis, C., & Vgontzas, A. (2021). Frequency and risk factors associated with depression in elderly visiting primary health care (PHC) settings: Findings from the Cretan aging cohort. *Journal of Affective Disorders Reports*, *4*, 100109. https://doi.org/10.1016/j.jadr.2021.100109

Blay, S., Batista, A., Andreoli, S., & Gastal, F. (2008). The relationship between religiosity and tobacco, alcohol use, and depression in an elderly community population. *The American Journal of Geriatric Psychiatry*, *16*, 934–943. https://doi.org/10.1097/JGP.0b013e3181871392

Blazer, D., & Hybels, C. (2005). Origins of depression in later life. *Psychological Medicine*, *35*, 1241–1252. https://doi.org/10.1017/S0033291705004411

Bloom, H., Ahmed, I., Alessi, C., Ancoli-Israel, S., Buysse, D. J., Kryger, M., Phillips, B., Thorpy, M., & Vitiello, M. V. (2009). Evidence-based recommendations for the assessment and management of sleep disorders in older persons. *Journal of American Geriatrics Society, 57*(5), 761–789. https://doi.org/10.1111/j.1532-5415.2009.02220.x

Bromberger, J. T., & Epperson, C. N. (2018). Depression during and after the perimenopause: Impact of hormones, genetics, and environmental determinants of disease. *Obstetrics and Gynecology Clinics of North America*, *45*(4), 663–678. https://doi.org/10.1016/j.ogc.2018.07.007

Bromet, E., Andrade, L. H., Hwang, I., Sampson, N. A., Alonso, J., de Girolamo, G., de Graaf, R., Demyttenaere, K., Hu, C., Iwata, N., Karam, A., Kaur, J., Kostyuchenko, S., Lepine, J.-P., Levinson, D., Matschinger, H., Medina Mora, M. E., Oakley Browne, M. O., . . . & Kessler, R. C. (2011). Cross-national epidemiology of DSM-IV major depressive episode. *BMC Medicine*, *9*(1), 1–16. https://doi.org/10.1186/1741-7015-9-90

Bull, F. C., Al-Ansari, S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, J., Katzmarzyk, P. T., Lambert, E., . . . Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*, 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Busch, A., Ciccolo, J., Puspitasari, A., Nosrat, S., Whitworth, J., & Stults-Kolehmainen, M. A. (2016). Preferences for exercise as a treatment for depression. *Mental Health and Physical Activity*, *10*, 68–72. https://doi.org/10.1016/j.mhpa.2015.12.004

Canham, S., Kaufmann, C., Mauro, P., Mojtabai, R., & Spira, A. (2015). Binge drinking and insomnia in middle-aged and older adults: The health and retirement study. *International Journal of Geriatric Psychiatry*, *30*, 284–291. https://doi.org/10.1002/gps.4139

Centers for Disease Control and Prevention. (2021). *NHIS early release program.* https://www.cdc.gov/nchs/nhis/releases.htm

Chang-Quan, H., Zheng-Rong, W., Yong-Hong, L., Yi-Zhou, X., & Qing-Xiu, L. (2010). Education and risk for late-life depression: A meta-analysis of published literature. *The International Journal of Psychiatry in Medicine*, *40*, 109–124. https://doi.org/10.2190/PM.40.1.i

Chen-Edinboro, L., Kaufmann, C., Augustinavicius, J., Mojtabai, R., Parisi, J., Wennberg, A., Smith, M. T., & Spira, A. (2015). Neighborhood physical disorder, social cohesion, and insomnia: Results from participants over age 50 in the Health and Retirement Study. *International Psychogeriatrics*, *27*, 289–296. https://doi.org/10.1017/S1041610214001823

Chen, T., & Saito, Y. (2021). Longitudinal effects of nocturnal insomnia symptom subtypes and nonrestorative sleep on the incidence of depression among community-dwelling older adults: Results from the Health and Retirement Study. *Sleep Medicine, 79*, 155–163. https://doi.org/10.1016/j.sleep.2021.01.003

Cheung, J., Bartlett, D., Armour, C., & Saini, B. (2013). The insomnia patient perspective, a narrative review. *Behavioral Sleep Medicine*, *11*(5), 369–389. https://doi.org/10.1080/15402002.2012.694382

Choi, N., & Kimbell, K. (2008). Depression care needs among low-income older adults: Views from aging service providers and family caregivers. *Clinical Gerontologist, 32*, 60–76. https://doi.org/10.1080/07317110802474742

Christensen, H., Batterham, P., Gosling, J., Ritterband, L., Griffiths, K., Thorndike, F., Glozier, N., O'Dea, B. D., Hickie, I. B., & Mackinnon, A. (2016). Effectiveness of an online insomnia program (SHUTi) for prevention of depressive episodes: A randomised controlled trial. *The Lancet Psychiatry, 3*, 333–341. https://doi.org/10.1016/S2215-0366(15)00536-2

Cornwell, B., Schumm, L., Laumann, E., Kim, J., & Kim, Y. (2014). Assessment of social network change in a national longitudinal survey. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *69*, S75–S82. https://doi.org/10.1093/geronb/gbu037

Correll, C. U., Solmi, M., Veronese, N., Bortolato, B., Rosson, S., Santonastaso, P., Thapa-Chhetri, N., Fornaro, M., Gallicchio, D., Collantoni, E., Pigato, G., Favaro, A., Monaco, F., Kohler, C., Vancampfort, D., Ward, P. B., Gaughran, F., Carvalho, A. F., & Stubbs, B. (2017). Prevalence, incidence and mortality from cardiovascular disease in patients with pooled and specific severe mental illness: A large-scale meta-analysis of 3,211,768 patients and 113,383,368 controls. *World Psychiatry, 16*, 163–180. https://doi.org/10.1002/wps.20420

Crowley, K. (2011). Sleep and sleep disorders in older adults. *Neuropsychology Review, 21* 41–53. https://doi.org/10.1007/s11065-010-9154-6

Cuijpers, P., Beekman, A. T., & Reynolds, C. F. (2012). Preventing depression: A global priority. *Journal of the American Medical Association*, *307*(10), 1033–1034. https://doi.org/10.1192/bjp.bp.112.112169

Cuijpers, P., Vogelzangs, N., Twisk, J., Kleiboer, A., Li, J., & Penninx, B. W. (2013). Differential mortality rates in major and subthreshold depression: Meta-analysis of studies that measured both. *The British Journal of Psychiatry*, *202*(1), 22–27. https://doi.org/10.1192/bjp.bp.112.112169

De Oliveira, L., Souza, E., Rodrigues, R., Fett, C., & Piva, A. (2019). The effects of physical activity on anxiety, depression, and quality of life in elderly people living in the community. *Trends in Psychiatry and Psychotherapy*, *41*, 36–42. https://doi.org/10.1590/2237-6089-2017-0129

Diniz, B., Butters, M., Albert, S., Dew, M., & Reynolds, C. (2013). Late-life depression and risk of vascular dementia and Alzheimer's disease: Systematic review and meta-analysis of community-based cohort studies. *British Journal of Psychiatry*, *202*, 329–335. https://doi.org/10.1192/bjp.bp.112.118307

Dong, Y., & Yang, F. (2019). Insomnia symptoms predict both future hypertension and depression. *Preventive Medicine*, *123*, 41–47. https://doi.org/10.1016/j.ypmed.2019.02.001

Du, W., Tan, J., Yi, F., Zou, Y., Gao, Y., Zhao, Y., & Wang, L. (2015). Physical activity as a protective factor against depressive symptoms in older Chinese veterans in the community: results from a national cross-sectional study. *Neuropsychiatric Disease and Treatment*, *11*, 803–813. https://doi.org/10.2147/NDT.S80295

Ekkekakis, P. (Ed.). (2013). *Routledge handbook of physical activity and mental health*. Routledge. https://doi.org/10.4324/9780203132678

Fairholme, C., & Manber, R. (2015). Sleep, emotions, and emotion regulation: An overview. *Sleep and Affect, 2015,* 45–61. https://doi.org/10.1016/B978-0-12-417188-6.00003-7

Fang, H., Tu, S., Sheng, J., & Shao, A. (2019). Depression in sleep disturbance: A review on a bidirectional relationship, mechanisms and treatment. *Journal of Cellular and Molecular Medicine, 23,* 2324–2332. https://doi.org/10.1111/jcmm.14170

Faravelli, C., Scarpato, M. A., Castellini, G., & Sauro, C. L. (2013). Gender differences in depression and anxiety: The role of age. *Psychiatry Research, 210,* 1301–1303. https://doi.org/10.1016/j.psychres.2013.09.027

Federal Interagency Forum on Aging-Related Statistics. (2020). *Older Americans 2020: Key indicators of well-being.* U.S. Government Printing Office.

Fernandez-Mendoza, J., & Vgontzas, A. (2013). Insomnia and its impact on physical and mental health. *Current Psychiatry Reports, 15,* a418. https://doi.org/10.1007/s11920-013-0418-8

Fiske, A., Wetherell, J., & Gatz, M. (2009). Depression in older adults. *Annual Review of Clinical Psychology, 5,* 363–389. https://doi.org/10.1146/annurev.clinpsy.032408.153621

Franzen, P., & Buysse, D. (2008). Sleep disturbances and depression: Risk relationships for subsequent depression and therapeutic implications. *Dialogues in Clinical Neuroscience, 10,* 473–481. https://doi.org/10.31887/DCNS.2008.10.4/plfranzen

Furihata, R., Hall, M., Stone, K., Ancoli-Israel, S., Smagula, S., Cauley, J., Furihata, R., Hall, M. H., Stone, K. L., Ancoli-Israel, S., Smagula, S. F., Cauley, J. A., Kaneita, Y., Uchiyama, M., & Buysse, D. (2017). An aggregate measure of sleep health is associated with prevalent and incident clinically significant depression symptoms among community-dwelling older women. *Sleep*, *40*(3), zsac015. https://doi.org/10.1093/sleep/zsw075

Gao, S., Hendrie, H., Yang, L., Stump, T., Stewart, J., Kesterson, J., Clark, D. O., & Callahan, C. (2013). Increase in blood pressure precedes clinical depression in elderly primary care patients. *International Journal of Geriatric Psychiatry*, *28*, 1099-1100. https://doi.org/10.1002/gps.3957

Garfield, V., Llewellyn, C., & Kumari, M. (2016). The relationship between physical activity, sleep duration and depressive symptoms in older adults: The English longitudinal study of ageing (ELSA). *Preventive Medicine Reports*, *4*, 512–516. https://doi.org/10.1016/j.pmedr.2016.09.006

Germain, C., Vasquez, E., & Batsis, J. (2016). Physical activity, central adiposity, and functional limitations in community-dwelling older adults. *Journal of Geriatric Physical Therapy*, *39*(2), 71–76. https://doi.org/10.1519/JPT.0000000000000051

Gilman, S., Sucha, E., Kingsbury, M., Horton, N., Murphy, J., & Colman, I. (2017). Depression and mortality in a longitudinal study: 1952–2011. *Canadian Medical Association Journal*, *189*(42), E1304–E1310. https://doi.org/10.1503/cmaj.170125

Girgus, J. S., Yang, K., & Ferri, C. V. (2017). The gender difference in depression: Are elderly women at greater risk for depression than elderly men? *Geriatrics,* 2(4), a35. https://doi.org/10.3390/geriatrics2040035

Godfrey, M., & Denby, T. (2004). Depression and older people: Towards securing well-being in later life. Policy Press.

Gold, S., Köhler-Forsberg, O., Moss-Morris, R., Mehnert, A., Miranda, J., Bullinger, M., Steptoe, A., Whooley, M. A., & Otte, C. (2020). Comorbid depression in medical diseases. *Nature Reviews Disease Primers*, *6*, 1–22. https://doi.org/10.1038/s41572-020-0200-2

Gruber, R., & Cassoff, J. (2014). The interplay between sleep and emotion regulation: conceptual framework empirical evidence and future directions. *Current Psychiatry Reports*, *16*(11), a500. https://doi.org/10.1007/s11920-014-0500-x

Gujar, N., Yoo, S., Hu, P., & Walker, M. (2011). Sleep deprivation amplifies reactivity of brain reward networks, biasing the appraisal of positive emotional experiences. *Journal of Neuroscience*, *31*, 4466–4474. https://doi.org/10.1523/JNEUROSCI.3220-10.2011

Hall, M. H., Kline, C. E., & Nowakowski, S. (2015). Insomnia and sleep apnea in midlife women: Prevalence and consequences to health and functioning. *F1000 Prime Reports*, *7*, 63. https://doi.org/10.12703/P7-63

Hammen, C. (2018). Risk factors for depression: An autobiographical review. *Annual Review of Clinical Psychology, 14*, 1–28. https://doi.org/10.1146/annurev-clinpsy-050817-084811

Hasin, D., Sarvet, A., Meyers, J., Saha, T., Ruan, W., Stohl, M., & Grant, B. (2018). Epidemiology of adult DSM-5 major depressive disorder and its specifiers in the United States. *JAMA Psychiatry, 75*, 336–346. https://doi.org/10.1001/jamapsychiatry.2017.4602

Heeringa, S., & Connor, J. (1995). *Technical description of the Health and Retirement Survey sample design.* University of Michigan Press. https://doi.org/10.7826/ISR-UM.06.585031.001.05.0001.1995

Helbig, A. K., Stöckl, D., Heier, M., Thorand, B., Schulz, H., Peters, A., Ladwig, K.-H., & Meisinger, C. (2017). Relationship between sleep disturbances and multimorbidity among community-dwelling men and women aged 65–93 years: Results from the KORA Age Study. *Sleep Medicine*, *33*, 151–159. https://doi.org/10.1016/j.sleep.2017.01.016

Heok, K., & Ho, R. (2008). The many faces of geriatric depression. *Current Opinion in Psychiatry, 21*, 540–545. https://doi.org/10.1097/YCO.0b013e328311cdae

Hirshkowitz, M., Whiton, K., Albert, S., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Katz, E. S., Kheirandish-Gozal, L., Neubauer, D. N., O'Donnell, A. E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R. C., Setters, B., Vitiello, M. V., Ware, C., Hillard, P. J., & Neubauer, D. (2015). National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. *Sleep Health*, *1*, 40–43. https://doi.org/10.1016/j.sleh.2014.12.010

Hishikawa, N., Fukui, Y., Sato, K., Ohta, Y., Yamashita, T., & Abe, K. (2017). Cognitive and affective functions associated with insomnia: A population-based study. *Neurological Research*, *39*(4), 331–336. https://doi.org/10.1080/01616412.2017.1281200

Hoare, E., Callaly, E., & Berk, M. (2020). Can depression be prevented? If so, how? *JAMA Psychiatry*, 77(11), 1095–1096. https://doi.org/10.1001/jamapsychiatry.2020.1273

Horesh, D., & Brown, A. (2020). Traumatic stress in the age of COVID-19: A call to close critical gaps and adapt to new realities. *Psychological Trauma: Theory, Research, Practice, and Policy*, *12*(4), 331–335. https://doi.org/10.1037/tra0000592

Hyde, A., Conroy, D., Pincus, A., & Ram, N. (2011). Unpacking the feel-good effect of free-time physical activity: Between-and within-person associations with pleasant–activated feeling states. *Journal of Sport and Exercise Psychology*, *33*, 884–902. https://doi.org/10.1123/jsep.33.6.884

Jackowska, M., & Poole, L. (2017). Sleep problems, short sleep and a combination of both increase the risk of depressive symptoms in older people: A 6-year follow-up investigation from the English Longitudinal Study of Ageing. *Sleep Medicine*, *37*, 60–65. https://doi.org/10.1016/j.sleep.2017.02.004

Jackson, M., Banks, S., & Belenky, G. (2014). Investigation of the effectiveness of a split sleep schedule in sustaining sleep and maintaining performance. *Chronobiology International*, *31*, 1218–1230. https://doi.org/10.3109/07420528.2014.957305

Jani, B., Cavanagh, J., Barry, S., Der, G., Sattar, N., & Mair, F. (2016). Relationship between blood pressure values, depressive symptoms, and cardiovascular outcomes in patients with cardiometabolic disease. *The Journal of Clinical Hypertension*, *18*, 1027–1035. https://doi.org/10.1111/jch.12813

Jaussent, I., Bouyer, J., Ancelin, M., Akbaraly, T., Peres, K., Ritchie, K., Besset, A., & Dauvilliers, Y. (2011). Insomnia and daytime sleepiness are risk factors for depressive symptoms in the elderly. *Sleep*, *34*(8), 1103–1110. https://doi.org/10.5665/SLEEP.1170

Jeon, H.-S., & Dunkle, R. E. (2009). Stress and depression among the oldest-old: A longitudinal analysis. *Research on Aging*, *31*(6), 661–687. https://doi.org/10.1177/0164027509343541

Jing, R., Barath, D., Zhang, H., Chen, J., & Fang, H. (2020). Changes in sleep duration associated with retirement transitions: The role of naps. *Journal of Sleep Research*, *29*(6), e12975. https://doi.org/10.1111/jsr.12975

Kaji, T., Mishima, K., Kitamura, S., Enomoto, M., Nagase, Y., Li, L., Kaneita, Y., Ohida, T., Nishikawa, T., & Uchiyama, M. (2010). Relationship between late-life depression and life stressors: Large-scale cross-sectional study of a representative sample of the Japanese general population. *Psychiatry and Clinical Neurosciences*, *64*, 426–434. https://doi.org/10.1111/j.1440-1819.2010.02097.x

Kalmbach, D., Cuamatzi-Castelan, A., Tonnu, C., Tran, K., Anderson, J., Roth, T., & Drake, C. (2018). Hyperarousal and sleep reactivity in insomnia: Current insights. *Nature and Science of Sleep*, *10*, 193–201. https://doi.org/10.2147/NSS.S138823

Kamiya, Y., Doyle, M., Henretta, J. C., & Timonen, V. (2013). Depressive symptoms among older adults: The impact of early and later life circumstances and marital status. *Aging & Mental Health, 17*(3), 349–357. https://doi.org/10.1080/13607863.2012.747078

Kaufmann, C., Canham, S., Mojtabai, R., Gum, A., Dautovich, N., Kohn, R., & Spira, A. (2013). Insomnia and health services utilization in middle-aged and older adults: Results from the Health and Retirement Study. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences*, *68*, 1512–1517. https://doi.org/10.1093/gerona/glt050

Kerling, A., Kück, M., Tegtbur, U., Grams, L., Weber-Spickschen, S., Hanke, A., Stubbs, B., & Kahl, K. G. (2017). Exercise increases serum brain-derived neurotrophic factor in patients with major depressive disorder. *Journal of Affective Disorders*, *215*, 152–155. https://doi.org/10.1016/j.jad.2017.03.034

Kok, R., & Reynolds, C. (2017). Management of depression in older adults: A review. *Journal of the American Medical Association, 317*, 2114–2122. https://doi.org/10.1001/jama.2017.5706

Kretchy, I., Owusu-Daaku, F., & Danquah, S. (2014). Mental health in hypertension: Assessing symptoms of anxiety, depression and stress on antihypertensive medication adherence. *International Journal of Mental Health Systems*, *8*, a25. https://doi.org/10.1186/1752-4458-8-25

Ladin, K. (2008). Risk of late-life depression across 10 European Union countries: Deconstructing the education effect. *Journal of Aging and Health, 20*, 653–670. https://doi.org/10.1177/0898264308321002

Landry, G., Best, J., & Liu-Ambrose, T. (2015). Measuring sleep quality in older adults: A comparison using subjective and objective methods. *Frontiers in Aging Neuroscience, 7*, 166. https://doi.org/10.3389/fnagi.2015.00166

Langvik, E., Saksvik-Lehouillier, I., Kennair, L., Sørengaard, T., & Bendixen, M. (2019). Gender differences in factors associated with symptoms of depression among high school students: An examination of the direct and indirect effects of insomnia symptoms and physical activity. *Health Psychology and Behavioral Medicine, 7*, 179–192. https://doi.org/10.1080/21642850.2019.1615926

Le Couteur, D., Anderson, R., & Newman, A. (2020). COVID-19 through the lens of gerontology. *The Journals of Gerontology: Series A, 75*(9), e119–e120. https://doi.org/10.1093/gerona/glaa077

Leggett, A., Sonnega, A., & Lohman, M. (2018). The association of insomnia and depressive symptoms with all-cause mortality among middle-aged and old adults. *International Journal of Geriatric Psychiatry*, *33*, 1265–1270. https://doi.org/10.1002/gps.4923

Lemola, S., & Richter, D. (2013). The course of subjective sleep quality in middle and old adulthood and its relation to physical health. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *68*, 721–729. https://doi.org/10.1093/geronb/gbs113

Li, L., Wu, C., Gan, Y., Qu, X., & Lu, Z. (2016). Insomnia and the risk of depression: a meta-analysis of prospective cohort studies. *BMC Psychiatry*, *16*, a375. https://doi.org/10.1186/s12888-016-1075-3

Li, Z., Li, Y., Chen, L., Chen, P., & Hu, Y. (2015). Prevalence of depression in patients with hypertension: a systematic review and meta-analysis. *Medicine, 94*(3), 1317. https://doi.org/10.1097/MD.0000000000001317.

Ling, A., Lim, M. L., Gwee, X., Ho, R. C., Collinson, S. L., & Ng, T. P. (2016). Insomnia and daytime neuropsychological test performance in older adults. *Sleep Medicine, 17*, 7–12. https://doi.org/10.1016/j.sleep.2015.07.037

Lotrich, F. (2015). Inflammatory cytokine-associated depression. *Brain Research, 1617*, 113–125. https://doi.org/10.1016/j.brainres.2014.06.032

Luck-Sikorski, C., Stein, J., Heilmann, K., Maier, W., Kaduszkiewicz, H., Scherer, M., Weyerer, S., Werle, J., Wiese, B., Moor, L., Bock, J.-O., König, H.-H., & Riedel-Heller, S. G. (2017). Treatment preferences for depression in the elderly. *International Psychogeriatrics*, *29*(3), 389–398. https://doi.org/10.1017/S1041610216001885

Lunde, L., Pallesen, S., Krangnes, L., & Nordhus, I. (2010). Characteristics of sleep in older persons with chronic pain: A study based on actigraphy and self-reporting. *The Clinical Journal of Pain, 26,* 132–137. https://doi.org/10.1097/AJP.0b013e3181b61923

Luppa, M., Sikorski, C., Luck, T., Ehreke, L., Konnopka, A., Wiese, B., Weyerer, S., König, H.-H., Riedel-Heller, S. G., & Riedel-Heller, S. (2012). Age-and gender-specific prevalence of depression in latest-life–systematic review and meta-analysis. *Journal of Affective Disorders, 136,* 212–221. https://doi.org/10.1016/j.jad.2010.11.033

Ma, X., Xiang, Y., Li, S., Xiang, Y., Guo, H., Hou, Y., Cai, Z.-J., Li, Z.-B., Li, Z.-J., Tao, Y.-F., Dang, W.-M., Wu, X.-M., Deng, J., Ungvari, G. S., & Chiu, H. F. K., (2008). Prevalence and sociodemographic correlates of depression in an elderly population living with family members in Beijing, China. *Psychological Medicine*, *38*, 1723–1730. https://doi.org/10.1017/S0033291708003164

Manber, R., & Chambers, A. (2009). Insomnia and depression: A multifaceted interplay. *Current Psychiatry Reports*, *11*, 437–442. https://doi.org/10.1007/s11920-009-0066-1

Medic, G., Wille, M., & Hemels, M. E. (2017). Short-and long-term health consequences of sleep disruption. *Nature and Science of Sleep*, *9*, 151–161. https://doi.org/10.2147/NSS.S134864

Mezuk, B., Eaton, W., Albrecht, S., & Golden, S. (2008). Depression and type 2 diabetes over the lifespan: A meta-analysis. *Diabetes Care*, *31*, 2383–2390. https://doi.org/10.2337/dc08-0985

Miller, L., Dieckmann, N., Mattek, N., Lyons, K., & Kaye, J. (2014). Social activity decreases risk of placement in a long-term care facility for a prospective sample of community-dwelling older adults. *Research in Gerontological Nursing*, *7*, 106–112. https://doi.org/10.3928/19404921-20140110-02

Morin, C., & Carrier, J. (2021). The acute effects of the COVID-19 pandemic on insomnia and psychological symptoms. *Sleep Medicine*, *77*, 346–347. https://doi.org/10.1016/j.sleep.2020.06.005

Murphy, M., & Peterson, M. (2015). Sleep disturbances in depression. *Sleep Medicine Clinics*, *10*, 17–23. https://doi.org/10.1016/j.jsmc.2014.11.009

Murri, M., Ekkekakis, P., Menchetti, M., Neviani, F., Trevisani, F., Tedeschi, S., Latessa, P. M., Nerozzi, E., Ermini, G., Zocchi, D., Squatrito, S., Toni G., Cabassi, A., Neri, M., Zanetidou, S., & Amore, M. (2018). Physical exercise for late-life depression: Effects on symptom dimensions and time course. *Journal of Affective Disorders*, *230*, 65–70. https://doi.org/10.1016/j.jad.2018.01.004

Nguyen, V., George, T., & Brewster, G. (2019). Insomnia in older adults. *Current Geriatrics Reports*, *8*, 271–290. https://doi.org/10.1007/s13670-019-00300-x

Nicholson, A., Kuper, H., & Hemingway, H. (2006). Depression as an aetiologic and prognostic factor in coronary heart disease: A meta-analysis of 6362 events among 146,538 participants in 54 observational studies. *European Heart Journal*, *27*, 2763–2774. https://doi.org/10.1093/eurheartj/ehl338

Ohayon, M., Carskadon, M., Guilleminault, C., & Vitiello, M. (2004). Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep*, *27*, 1255–1273. https://doi.org/10.1093/sleep/27.7.1255

Ohayon, M., Wickwire, E., Hirshkowitz, M., Albert, S., Avidan, A., Daly, F., Dauvilliers, Y., Ferri, R., Fung, C., Gozal, D., Hazen, N., Krystal, A., Lichstein, K., Mallampalli, M., Plazzi, G., Rawding, R., Scheer, F. A., Somers, V., & Vitiello, M. (2017). National Sleep Foundation's sleep quality recommendations: First report. *Sleep Health*, *3*, 6–19. https://doi.org/10.1016/j.sleh.2016.11.006

O'Leary, K., Bylsma, L., & Rottenberg, J. (2017). Why might poor sleep quality lead to depression? A role for emotion regulation. *Cognition and Emotion*, *31*(8), 1698–1706. https://doi.org/10.1080/02699931.2016.1247035

Ozminkowski, R., Wang, S., & Walsh, J. (2007). The direct and indirect costs of untreated insomnia in adults in the United States. *Sleep*, *30*, 263–273. https://doi.org/10.1093/sleep/30.3.263

Palagini, L., Geoffroy, P., Miniati, M., Perugi, G., Biggio, G., Marazziti, D., & Riemann, D. (2021). Insomnia, sleep loss, and circadian sleep disturbances in mood disorders: A pathway toward neurodegeneration and neuroprogression? A theoretical review. *CNS Spectrums*, *2021,* 1–11. https://doi.org/10.1017/S1092852921000018

Patel, D., Steinberg, J., & Patel, P. (2018). Insomnia in the elderly: A review. *Journal of Clinical Sleep Medicine*, *14*, 1017–1024. https://doi.org/10.5664/jcsm.7172

Paudel, M., Taylor, B., & Ancoli-Israel, S. (2013). Sleep disturbances and risk of depression in older men. *Sleep*, *36*, 1033e40. https://doi.org/10.5665/sleep.2804

Pearlin, L. (1989). The sociological study of stress. *Journal of Health and Social Behavior*, 241–256. https://doi.org/10.2307/2136956

Perlis, R., Ostacher, M., Patel, J., Marangell, L., Zhang, H., Wisniewski, S., Terence A. Ketter, T. A., Miklowitz, D. J., Otto, M. W., Gyulai, L., Reilly-Harrington, N. A., Nierenberg, A. A., Sachs, G. S., Thase, M. & Reilly-Harrington, N. (2006). Predictors of recurrence in bipolar disorder: Primary outcomes from the Systematic Treatment Enhancement Program for Bipolar Disorder (STEP-BD). *American Journal of Psychiatry*, *163*, 217–224. https://doi.org/10.1176/appi.ajp.163.2.217

Predatu, R., Voinescu, B., & David, D. (2020). The Role of emotion regulation difficulties in the relation between insomnia and depressive symptoms. *International Journal of Behavioral Medicine*, *27*, 615–622. https://doi.org/10.1007/s12529-020-09903-7

Richardson, R. A., Keyes, K. M., Medina, J. T., & Calvo, E. (2020). Sociodemographic inequalities in depression among older adults: cross-sectional evidence from 18 countries. *The Lancet, Psychiatry*, *7*(8), 673–681. https://doi.org/10.1016/S2215-0366(20)30151-6

Roberts, R., Shema, S., Kaplan, G., & Strawbridge, W. (2000). Sleep complaints and depression in an aging cohort: A prospective perspective. *American Journal of Psychiatry*, *157*, 81–88. https://doi.org/10.1176/ajp.157.1.81

Rosenbaum, S., Tiedemann, A., Sherrington, C., Curtis, J., & Ward, P. (2014). Physical activity interventions for people with mental illness: A systematic review and meta-analysis. *The Journal of Clinical Psychiatry*, *75*(9). https://doi.org/10.4088/JCP.13r08765

Rumble, M., White, K., & Benca, R. (2015). Sleep disturbances in mood disorders. *Psychiatric Clinics*, *38*, 743–759. https://doi.org/10.1016/j.psc.2015.07.006

Ruppel, S., Jenkins, W., Griffin, J., & Kizer, J. (2010). Are they depressed or just old? A study of perceptions about the elderly suffering from depression. *North American Journal of Psychology*, *12*(1), 31–42. http://najp.us/

Sadler, P., McLaren, S., & Jenkins, M. (2013). A psychological pathway from insomnia to depression among older adults. *International Psychogeriatrics*, *25*, 1375–1383. https://doi.org/10.1017/S1041610213000616

Satre, D., Gordon, N., & Weisner, C. (2007). Alcohol consumption, medical conditions, and health behavior in older adults. *American Journal of Health Behavior*, *31*, 238–248. https://doi.org/10.5993/AJHB.31.3.2

Schuch, F. B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P. B., Silva, E. S., Hallgren, M., Ponce De Leon, A., Dunn, A. L., Deslandes, A. C., Fleck, M. P., Carvalho, A. F. & Stubbs, B. (2018). Physical activity and incident depression: A meta-analysis of prospective cohort studies. *American Journal of Psychiatry*, *175*(7), 631–648. https://doi.org/10.1176/appi.ajp.2018.17111194

Schuch, F., Vancampfort, D., Richards, J., Rosenbaum, S., Ward, P., & Stubbs, B. (2016). Exercise as a treatment for depression: a meta-analysis adjusting for publication bias. *Journal of Psychiatric Research*, *77*, 42–51. https://doi.org/10.1016/j.jpsychires.2016.02.023

Servais, M. (2010). *Overview of HRS public data files for cross-sectional and longitudinal analysis*. Institute for Social Research, University of Michigan. https://doi.org/10.7826/ISR-UM.06.585031.001.05.0023.2010

Sidani, S., Guruge, S., Fox, M., & Collins, L. (2019). Gender differences in perpetuating factors, experience and management of chronic insomnia. *Journal of Gender Studies*, *28*(4), 402–413. https://doi.org/10.1080/09589236.2018.1491394

Slavich, G., & Irwin, M. (2014). From stress to inflammation and major depressive disorder: a social signal transduction theory of depression. *Psychological Bulletin*, *140*, 774–815. https://doi.org/10.1037/a0035302

Steffick, D. (2000). Documentation of affective functioning measures in the Health and Retirement Study. https://doi.org/10.7826/ISR-UM.06.585031.001.05.0005.2000

Stone, K., & Xiao, Q. (2018). Impact of poor sleep on physical and mental health in older women. *Sleep Medicine Clinics*, *13*, 457–465. https://doi.org/10.1016/j.jsmc.2018.04.012

Ströhle, A. (2009). Physical activity, exercise, depression and anxiety disorders. *Journal of Neural Transmission*, *116*, 777–784. https://doi.org/10.1007/s00702-008-0092-x

Subedi, S., Shrestha, P., & Thapa, D. (2018). Study of depression in elderly: Prevalence and factors associated. *Journal of Psychiatrists' Association of Nepal, 7*, 16–23. https://doi.org/10.3126/jpan.v7i2.24609

Suh, S., Kim, H., Yang, H., Cho, E., Lee, S., & Shin, C. (2013). Longitudinal course of depression scores with and without insomnia in non-depressed individuals: A 6-year follow-up longitudinal study in a Korean cohort. *Sleep*, *36*(3), 369–376. https://doi.org/10.5665/sleep.2452

Taylor, W. (2014). Depression in the elderly. *New England Journal of Medicine, 371*(13), 1228–1236. https://doi.org/10.1056/NEJMcp1402180

Teychenne, M., Ball, K., & Salmon, J. (2008). Physical activity and likelihood of depression in adults: A review. *Preventive Medicine*, *46*, 397–411. https://doi.org/10.1016/j.ypmed.2008.01.009

Turvey, C., Wallace, R., & Herzog, R. (1999). A revised CES-D measure of depressive symptoms and a DSM-based measure of major depressive episodes in the elderly. *International Psychogeriatrics*, *11*, 139–148. https://doi.org/10.1017/S1041610299005694

Tzuang, M., Owusu, J., Huang, J., Sheehan, O., Rebok, G., Paudel, M., Wickwire, E. M., Kasper, J. D., & Spira, A. (2021). Associations of insomnia symptoms with subsequent health services use among community-dwelling US older adults. *Sleep, 44*(5), zsaa251. https://doi.org/10.1093/sleep/zsaa251

Uchmanowicz, I., Markiewicz, K., Uchmanowicz, B., Kołtuniuk, A., & Rosińczuk, J. (2019). The relationship between sleep disturbances and quality of life in elderly patients with hypertension. *Clinical Interventions in Aging*, *14*, 155–165. https://doi.org/10.2147/CIA.S188499

Vargas, I., & Perlis, M. (2020). Insomnia and depression: clinical associations and possible mechanistic links. *Current Opinion in Psychology*, *34*, 95–99. https://doi.org/10.1016/j.copsyc.2019.11.004

Varrasse, M., Li, J., & Gooneratne, N. (2015). Exercise and sleep in community-dwelling older adults. *Current Sleep Medicine Reports*, *1*, 232–240. https://doi.org/10.1007/s40675-015-0028-6

Walker, E. R., McGee, R. E., & Druss, B. G. (2015). Mortality in mental disorders and global disease burden implications: A systematic review and meta-analysis. *JAMA Psychiatry*, *72*(4), 334–341. https://doi.org/10.1001/jamapsychiatry.2014.2502

Weyerer, S., Eifflaender-Gorfer, S., Köhler, L., Jessen, F., Maier, W., Fuchs, A., & Pentzek, M., Kaduszkiewicz, H., Bachmann, C., AngermeyeR, M. C. Luppa, M., Wiese, B., Mösch, E., HorstBickel, H. (2008). Prevalence and risk factors for depression in non-demented primary care attenders aged 75 years and older. *Journal of Affective Disorders*, *111*, 153–163. https://doi.org/10.1016/j.jad.2008.02.008

Whibley, D., Guyer, H. M., Swanson, L. M., Braley, T. J., Kratz, A. L., & Dunietz, G. L. (2020). Sleep disturbance as a moderator of the association between physical activity and later pain onset among American adults aged 50 and over: Evidence from the Health and Retirement Study. *BMJ Open*, *10*(6), e036219. https://doi.org/10.1136/bmjopen-2019-036219

World Health Organization. (2016). *Ageing and life-course.* http://www.who.int/ageing/features/yearsahead-campaign/en/

World Health Organization. (2017). *Depression and other common mental disorders: Global health estimates* (No. WHO/MSD/MER/2017.2). https://apps.who.int/iris/bitstream/handle/10665/254610/WHO-MSD-MER-2017.2-eng.pdf

Yang, Y., Liu, W., Ji, X., Ma, C., Wang, X., Li, K., & Li, J. (2020). Extended afternoon naps are associated with hypertension in women but not in men. *Heart & Lung*, *49*(1), 2–9. https://doi.org/10.1016/j.hrtlng.2019.09.002

Zhang, B., & Wing, Y. (2006). Sex differences in insomnia: A meta-analysis. *Sleep*, *29*, 85–93. https://doi.org/10.1093/sleep/29.1.85