THE ASSOCIATIONS BETWEEN PAIN, SLEEP, GLOBAL HEALTH, AND FUNCTIONAL OUTCOMES IN OLDER ADULTS

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Introduction: Understanding the association of sleep and pain in older adults can help improve their global health and functional outcomes. This study aimed to describe the joint associations between sleep, pain, global health, and functional outcomes in adults ages 65 or older. **Methods:** This study was a secondary analysis of data from the 2015 Sleep in America Poll by the National Sleep Foundation. Outcome measures included global health, pain intensity, sleep disturbances, and impaired sleep's interference with functional outcomes. The survey also included questions on demographics (age, sex, race, education, marital status, home Internet access), sleep (duration, efficiency, sleep debt, quality), and pain (type [no pain, acute pain, chronic pain], level of control). One-way ANOVA was conducted to compare mean scores of sleep disturbances and global health between the three pain groups. Multiple linear regression was conducted to examine the associations between pain intensity, sleep disturbances, global health, impaired sleep's interference with functional outcomes, and perceived control of pain. **Results:** The sample (N = 248) was 65 – 91 years (mean = 72.8 ± 0.4), male (46.7%), White, Non-Hispanic (78.9.%), married/partnered (66.2%), post-high-school education (48%), and had home Internet access (70.4%). Respondents had approximately 7 hours of sleep, 87% sleep efficiency, and 10 minutes of sleep debt on average. "No pain" was reported by 38.7% of the sample (n = 96), "acute pain" by 32.7% (n = 81), and "chronic pain" by 28.6% (n = 71). Respondents with acute or chronic pain had significantly more sleep disturbances and worse global health compared to

respondents with no pain (all p-value < 0.03). Higher pain intensity was associated with more sleep disturbances, worse global health, and more impaired sleep's interference with functional outcomes (all p-value < 0.01). Higher perceived control over pain was associated with lower pain intensity, less sleep disturbances, better global health, and less impaired sleep's interference with functional outcomes (all p-value < 0.02).

Conclusion: Pain has a negative impact on sleep, health, and functional outcomes in older adults. Perceived control of pain has a positive impact on pain, sleep, health, and functional outcomes in older adults.

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1.0 INTRODUCTION

Health is defined by the World Health Organization as not only the absence of disease but also physical, mental, and social well-being (World Health Organization, 1946). Sleep health is conceptualized as a multidimensional pattern of sleep and wakefulness that promotes physical and mental well-being (Buysse, 2014). Good sleep is characterized by five key dimensions: subjective satisfaction with sleep quality, appropriate timing of sleep so that one is asleep during the midpoint of the night, adequate duration of 6 to 8 hours of sleep per night, high sleep efficiency with little time awake at night, and restorative sleep that results in sustained alertness during waking hours (Buysse, 2014).

Normative age-related physiological changes contribute to alterations in sleep schedule, sleep duration, and sleep architecture in older adults (Li, Vitiello, & Gooneratne, 2018; Miner & Kryger, 2017). Compared to younger adults, older adults have changes in sleep that may include an advanced sleep schedule, a shortened nocturnal sleep duration with possible afternoon naps, and a decrease in slow-wave sleep (Li et al., 2018; Miner & Kryger, 2017). Despite these alterations, sleep quality should remain good in healthy older adults because aging, on its own, does not result in sleep disturbances (Li et al., 2018; Miner & Kryger, 2017). However, older adults have an increased prevalence of sleep disorders, chronic conditions, and pain that can negatively affect sleep (Li et al., 2018; Miner & Kryger, 2017).

Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage (Lee & Neumeister, 2020). Acute pain refers to pain that lasts less than 3 months and is associated with tissue damage (Lee & Neumeister, 2020). Acute pain is protective and acts as a warning signal to avoid further damage (Lee & Neumeister, 2020). Chronic pain

refers to pain that lasts more than 3 months (Lee & Neumeister, 2020). Chronic pain is associated with physiological alterations along the pain pathway that increase the body's sensitivity toward noxious stimuli (Lee & Neumeister, 2020). Chronic pain is independently pathological from the underlying cause and can negatively impact quality of life (Lee & Neumeister, 2020).

The prevalence of chronic pain in people aged 65 or older in the U.S. is estimated as 30% (Domenichiello & Ramsden, 2019). The most common causes of chronic pain coniditions in older adults include joint pain, back pain, and neck pain (Domenichiello & Ramsden, 2019). Chronic pain has been associated with sleep disturbances in older adults in a bidirectional relationship: pain disrupts sleep by interfering with sleep onset and sleep maintenance, while sleep deprivation worsen pain by increasing pain sensitivity (Mathias, Cant, & Burke, 2018). Polysomnography studies indicate that people with chronic pain have problems with sleep continuity, sleep architecture, and sleep fragmentation (Mathias et al., 2018). Persons with chronic pain are also showed to be significantly more likely to be diagnosed with sleep disorders compared to the general population (Mathias et al., 2018).

Nociception is a complex psychobiologic process, influenced by both sensory experience and psychosocial factors (Bandura, O'Leary, Taylor, Gauthier, & Gossard, 1987). One influencing factor is self-efficacy, defined as the conviction that one can successfully execute a behavior required to produce a desired outcome (Bandura et al., 1987). Stronger perceived coping efficacy with pain has been showed to make pain easier to control and lessen the experienced pain (Bandura et al., 1987).

2.0 BACKGROUND

2.1 SLEEP

2.1.1 Normal Sleep in Adults

Sleep is defined as a reversible state during which a person is unaware of and unresponsive to environmental stimuli, allowing the body and the mind to rest and rejuvenate (Carskadon & Dement, 2016). Adequate sleep is a requirement for actual survival and a high level of wellness (Buysse, 2014). Impaired sleep can result in excessive daytime sleepiness, decreased daytime functioning, and impaired physical, psychological, and social well-being (Dean, Weiss, Morris, & Chasens, 2017).

2.1.1.1 Circadian Regulation of Sleep

The circadian system ensures all biological processes in the body are timed appropriately by generating an internal biological clock entrained to the 24-hour light-dark cycle (Gooley & Saper, 2016). The circadian system has two major components: the suprachiasmatic nucleus (SCN) and the circadian rhythms (Gooley & Saper, 2016). Circadian rhythms are the biological processes which follow rhythmic patterns set by the aforementioned 24-hour biological clock; and the SCN is the control center which coordinates all circadian rhythms (Gooley & Saper, 2016). The SCN is located in the anterior hypothalamus, receiving input on light exposure from specialized retinal ganglion cells through the retinohypothalamic tract (Gooley & Saper, 2016). The SCN then uses this input to generate its 24-hour biological clock, which is entrained to the 24-hour light-dark

cycle defined by Earth's rotation (Gooley & Saper, 2016). Based on the timing of the biological clock, the SCN sends out inhibitory circadian output to regulate all circadian rhythms (Gooley & Saper, 2016). Major sleep-related circadian rhythms include the sleep-wake cycle, the melatonin release cycle, and the cortisol release cycle (Gooley & Saper, 2016).

The SCN controls the sleep-wake cycle by controlling the interactions between the sleep-promoting center and the wake-promoting center in the brain (Gooley & Saper, 2016). The sleep promoting center is the ventrolateral preoptic (VLPO) area in the anterior hypothalamus, containing the neurotransmitters gamma aminobutyric acid (GABA) and galanin (Gooley & Saper, 2016). The wake-promoting center is located in the lateral hypothalamus (LH) area, containing the neurotransmitters orexins (Gooley & Saper, 2016). The VLPO promotes sleep by releasing GABA and galanin to inhibit the LH; vice versa, the LH promotes wakefulness by releasing orexins to inhibit the VLPO (Gooley & Saper, 2016). The SCN has GABAergic projections to the VLPO to inhibit its activity, but glutamatergic projections to the LH to promote its activity (Gooley & Saper, 2016). During the biologic day when the SCN is highly active, it inhibits VLPO activity and promotes LH activity (which further inhibits VLPO activity), keeping the person awake (Gooley & Saper, 2016). During the biologic night when SCN activity is low, it stops inhibiting VLPO activity and stops promoting LH activity (which further enhance VLPO activity), allowing the induction of sleep (Gooley & Saper, 2016).

Cortisol and melatonin release plays a critical role in sleep regulation because cortisol induces alertness, while melatonin induces sleepiness (Gooley & Saper, 2016). The SCN promotes cortisol secretion from the adrenal gland by promoting corticotropin-releasing hormone secretion in the hypothalamus (Gooley & Saper, 2016). Because the SCN activity is highest during the biological day and lowest during the biological night; cortisol secretion peaks in the morning to

promote a general state of alertness, progressively decreasing throughout the day, and reaching its nadir in the late evening to facilitate sleep onset (Gooley & Saper, 2016). In contrast, the SCN inhibits melatonin secretion from the pineal gland by inhibiting the enzyme that converts serotonin into melatonin, serotonin *N*-acetyltransferase (Gooley & Saper, 2016). Because of the aforementioned SCN activity pattern, melatonin secretion remains low during the day, rising progressively as the day goes on, reaching its peak in the evening before bedtime to induce sleep onset, and staying elevated during bedtime to maintain sleep (Gooley & Saper, 2016).

2.1.1.2 Two-Process Model

The two-process model of sleep regulation was proposed by the Hungarian-Swiss pharmacologist Alexander A. Borbély in 1982 and it has served as an influential conceptual framework in sleep research (Borbély, Daan, Wirz-Justice, & Deboer, 2016). The model postulates that sleep timing and duration are regulated by the continuous interactions between a homeostatic process (Process S) and a circadian process (Process C) (Borbély et al., 2016). Process S represent the term sleep debt (S), which is defined as the homeostatic drive to sleep created by the interactions between the VLPO and the LH (Borbély et al., 2016). Sleep debt increases during wakefulness and decreases during sleep (Borbély et al., 2016). Process C represents the SCN output level, which is rhythmically high during the biological day and low during the biological night (Borbély et al., 2016; Gooley & Saper, 2016). Sleep propensity corresponds to the difference between S and C (Borbély et al., 2016). The difference between S and C increases during wakefulness, inducing the sensation of sleepiness as it approaches a certain threshold (Borbély et al., 2016). Vice versa, the difference between S and C decreases during sleep, triggering awakening as it approaches another threshold (Borbély et al., 2016). Because of the continuous interactions

between process S and process C, sleep onset usually starts around 8 – 10 PM, and adults on average have 7 to 8 hours of sleep a night (Borbély et al., 2016).

2.1.1.3 Sleep Architecture

Sleep architecture is the regular pattern of sleep stages (Carskadon & Dement, 2016). Polysomnographic studies using electroencephalogram (EEG), electrooculogram (EOG), and chin electromyogram (EMG) show that there are two separate states of sleep: rapid-eye-movement (REM) sleep and non-rapid-eye-movement (NREM) sleep (Carskadon & Dement, 2016). A sleep cycle typically consists of an NREM sleep and a REM sleep, lasting 90 minutes on average (Carskadon & Dement, 2016). Sleep begins in NREM; thereafter, NREM and REM alternate cyclically throughout the night in 3 – 4 sleep cycles (Carskadon & Dement, 2016).

NREM is a relatively inactive brain in a movable body, characterized by synchronous EEG patterns, low muscle tone on EMG, and minimal mental acitivty (Carskadon & Dement, 2016). NREM sleep is subdivided into three stages based on EEG pattern, called stage N1, N2, and N3 (Carskadon & Dement, 2016). Stage N1 is considered light sleep with a low arousal threshold, characterized by the EEG pattern of both faster alpha wave (8 – 13 Hz) and slower theta wave (4 – 7 Hz) (Carskadon & Dement, 2016). Stage N2 has a higher arousal threshold, characterized by an EEG with theta activity along with sleep spindles and K complexes (Carskadon & Dement, 2016). Stage N3 is considered deep sleep with the highest arousal threshold (Carskadon & Dement, 2016). Stage N3 sleep is also known as slow wave sleep (SWS) due to a predominance of slow delta waves (0.5 – 2 Hz) on EEG (Carskadon & Dement, 2016). During the night, time spent in SWS is highest in the first sleep cycles and expotentially declines in successive cycles (Carskadon & Dement, 2016; Mander, Winer, & Walker, 2017). SWS has a strong association with the homeostatic sleep drive: the greater the sleep drive, the greater the amount of subsequent SWS

during sleep (Carskadon & Dement, 2016; Mander et al., 2017). On average, stage N1 accounts for less than 5% of sleep time, stage N2 accounts for 45 – 55% of sleep time, and SWS accounts for 10 – 20% of sleep time in a healthy young adults (Carskadon & Dement, 2016).

REM is an activated brain in a paralyzed body, characterized by episodic bursts of rapid eye movements on EOG, desynchronous EEG patterns with sawtooth waves, muscle atonia on EMG, and dreaming (Carskadon & Dement, 2016). REM sleep has a wide-ranging arousal threshold, which is hypothesized to be the result of arousal stimulus being incorporated into the ongoing dream story instead of producing an awakening (Carskadon & Dement, 2016). REM sleep episodes lengthen across the night (Carskadon & Dement, 2016). On average, REM sleep accounts for 20 to 25% of sleep time in a healthy young adults in adults (Carskadon & Dement, 2016).

2.1.2 Normal Age-Related Changes in Sleep in Healthy Older Adults

Sleep remains important for healthy aging (Li et al., 2018; Mander et al., 2017). Aging comes with normal age-related physiological changes, including decreased homeostatic sleep drive, decreased amplitude of circadian drive, and alterations in sleep architecture (Li et al., 2018; Mander et al., 2017). These physiological changes contribute to changes in sleep among older adults, with major changes include shortened nocturnal sleep duration, decreased sleep maintenance, advanced sleep schedule, longer sleep onset latency, and decreased slow-wave sleep (Li et al., 2018; Mander et al., 2017). However, none of these normal changes in sleep that accompany aging should result in excessive daytime sleepiness (Li et al., 2018; Mander et al., 2017).

2.1.2.1 Changes in the Circadian System with Aging

Changes in the circadian system occur with normal aging (Mander et al., 2017). The SCN progressively deteriorate with aging, demonstrated by degeneration in SCN neurons during post-mortem histology analyses (Mander et al., 2017).

SCN deterioration shifts the timing of the sleep-wake cycle, cortisol release, and melatonin release up one hour earlier in older adults compared to young adults (Li et al., 2018; Miner & Kryger, 2017). This advancement in circadian timing is called phase advance (Li et al., 2018; Miner & Kryger, 2017). Phase advance causes older adults to have an advanced sleep schedule, which results in earlier onset of sleepiness in the evening and earlier morning awakening (Li et al., 2018; Miner & Kryger, 2017) compared to their younger adult counterparts.

Homeostatic sleep drive decreases with aging due to degenerations of structures in the VLPO and the LH (Mander et al., 2017). Post-mortem exams reveal significant decline in galanin-expressing neurons in the VLPO, the orexin-expressing neurons in the LH, and adenosine A1 receptors (Mander et al., 2017). These changes weaken the signaling processes in the VLPO and the LH, impairing homeostatic sleep drive (Mander et al., 2017). Impaired homeostatic sleep drive causes a drop in nocturnal sleep duration and the ability to maintain sleep (Li et al., 2018). The current literature supports that nocturnal sleep duration decreases with age at the rate of 10–12 minutes per decade of age, while the decreased in sleep maintenance is demonstrated by an increased number of arousals (arousal index) and longer duration of wake after sleep onset (WASO), with a steady rate of 10 minutes increase in WASO per decade of age (Ohayon, Carskadon, Guilleminault, & Vitiello, 2004).

The pattern of cortisol and melatonin secretion also changes with age (Li et al., 2018). Older adults have elevated nocturnal cortisol secretion and decreased melatonin secretion, causing

less SWS and more frequent awakening during nocturnal sleep with a steady rate of 10 minutes increase in WASO per decade of age (Ohayon et al., 2004).

2.1.2.2 Changes in Sleep Architecture with Aging

Older adults have a higher percentage of their sleep time in "light" sleep as the proportion of stage N1 and N2 slightly increase, while the proportion of SWS and REM decrease, especially in SWS (Li et al., 2018; Mander et al., 2017; Miner & Kryger, 2017). The greatest decline in SWS is often recorded in the first and second NREM cycles, showing 75% - 80% reduction relative to younger adults (Li et al., 2018; Mander et al., 2017; Miner & Kryger, 2017). The decrease in SWS is associated with the impairment of the homeostatic sleep drive and age-related structural brain atrophy, especially in the prefrontal cortex (Li et al., 2018; Mander et al., 2017; Miner & Kryger, 2017).

2.1.3 Sleep Disturbances in Older Adults

Aging on its own does not result in sleep disturbances (Dean et al., 2017; Li et al., 2018; Miner & Kryger, 2017). However, pathological problems associated with aging can disturb sleep in older adults (Dean et al., 2017; Li et al., 2018; Miner & Kryger, 2017). Sleep disturbances are common in older adults due to increasing prevalence of sleep disorders, multimorbidity, psychosocial factors, medication and substance use, and pain (Dean et al., 2017; Li et al., 2018; Miner & Kryger, 2017).

2.1.3.1 Sleep Disorders

Common sleep disorders in older adults include insomnia, obstructive sleep apnea (OSA), restless leg syndrome (RLS), and REM behavior disorder (RBD) (Miner & Kryger, 2017). Among them, insomnia and OSA are the two most predominant sleep disorders in older adults (Li et al., 2018; Miner & Kryger, 2017).

Insomnia is characterized by difficulties falling asleep or staying asleep at least 3 times per week for more than 1 month (American Psychiatric Association, 2013). Insomnia results in shortened sleep duration, non-restorative sleep, excessive daytime sleepiness, and impaired daytime functioning (Dean et al., 2017; Miner & Kryger, 2017). Insomnia often concur with medical and psychiatric comorbidities, either as a causative agent for or result of them (Miner & Kryger, 2017). Epidemiological studies have found that the prevalence for insomnia symptoms in adults aged 65 or older is approximately 50% (Miner & Kryger, 2017).

OSA is defined as having five or more hypopneas (decreased airflow by 50% or more accompanied by an oxygen desaturation) or apneas (cessation of breathing for at least 10 seconds) per hour of sleep, resulting in sleep fragmentation due to frequent arousals from respiratory events (American Psychiatric Association, 2013). Age-related changes in upper airway such as pharyngeal muscle wasting, decrease in tissue elasticity, lengthening of soft palate, and upper airway fat pad deposition increase the tendency for oropharyngeal collapse, predisposing older adults to OSA (Miner & Kryger, 2017). Symptoms of OSA includes snoring, choking, gasping on awakening, morning headache, and excessive daytime sleepiness. OSA is also associated with worsened neurocognitive and cardiovascular health (Miner & Kryger, 2017). OSA increases with advancing age, with the prevalence of at least mild OSA in older adult estimated to be 70% in men

and 56% in women, compared to 15% in men and 5% in women in a younger adult population (Miner & Kryger, 2017).

2.1.3.2 Multimorbidity

Multimorbidity is defined as the presence of two or more chronic conditions (Li et al., 2018; Miner & Kryger, 2017). Multimorbidity is highly prevalent in older adults, reported in 62% of adults aged 65 to 74 years and 82% of adults aged 85 years or older (Li et al., 2018; Miner & Kryger, 2017). Osteoarthritis, cardiovascular disease, pulmonary disease, diabetes mellitus, cancer, and gastroesophageal reflux are some of the most common chronic conditions in older adults (Li et al., 2018; Miner & Kryger, 2017). Multimorbidity establishes a bidirectional relationship with sleep disturbances in older adults: the discomfort and emotional distress from medical conditions contribute to sleep disturbances, while sleep disturbances negatively impacts medical illnesses and their associated symptoms (Li et al., 2018; Miner & Kryger, 2017).

2.1.3.3 Psychosocial Factors

Psychosocial factors can negatively impact sleep in older adults including psychiatric conditions, social isolation, loss of physical function, and bereavement (Miner & Kryger, 2017). Many psychiatric disorders have been linked with sleep disturbances, including depression and anxiety which are common in older adults (Miner & Kryger, 2017). Social isolation may impact sleep by decreasing exposure to zeitgebers, which are external cues that entrain the circadian rhythms to a 24-hour light-dark cycle, promoting regular sleep-wake cycles (Miner & Kryger, 2017). Major zeitgebers include light, temperature, social interactions, eating schedule, and exercise (Miner & Kryger, 2017). A socially isolated individual may have reduced social

interactions, irregular eating schedule, and inactivity (Miner & Kryger, 2017). This lack of adequate exposure to zeitgebers may results in irregular sleep-wake patterns (Miner & Kryger, 2017).

Many older adults experience loss of physical function and independence in activities of daily life, making them depend on a caretaker and may have to transition from their homes to long-term care facilities (Miner & Kryger, 2017). Such major changes in later life may contribute to physical and psychosocial stressors, causing or worsening sleep problems (Miner & Kryger, 2017). The loss of loved ones is more common in this age group and has been associated with emotional distress and loneliness (Miner & Kryger, 2017). This worsens sleep by increasing risk for mood disorders, social isolation, and impaired functionality (Li et al., 2018; Miner & Kryger, 2017).

2.1.3.4 Medication and Substance Use

Use of medications is highly prevalent in older adults, with 90% of adults aged 65 or older taking prescription drugs to treat chronic medical conditions (Li et al., 2018). Different classes of common medications in older adults can alter sleep (Carskadon & Dement, 2016; Miner & Kryger, 2017). For example, beta blockers, have been shown to suppress melatonin secretion, impairing sleep onset and sleep maintenance (Miner & Kryger, 2017). Opioids and benzodiazepines result in SWS suppression, which is associated with sleep apnea syndromes, and worsens OSA (Carskadon & Dement, 2016). Antidepressants, including tricyclic antidepressants, monoamine oxidase inhibitor (MAOI), and selective serotonin uptake inhibitor (SSRI), have been shown to suppress REM sleep and increase motor activity during all sleep stages, worsening RLS (Carskadon & Dement, 2016). The use of over-the-counter medications and dietary supplements besides prescription medication, as well as the increasing prevalence of polypharmacy, which is

defined as taking five medications or more concurrently, result in even more interactions among drugs, diseases, and food; consequently, aggravating the impact of medications on sleep (Li et al., 2018; Miner & Kryger, 2017).

Lifestyle habits may promote substance use in older adults, including the consumption of caffeine, tobacco, and alcohol (Miner & Kryger, 2017). As a stimulant, caffeine can increase both sleep onset latency and the number of arousals during the night, shortening sleep duration and impairing sleep maintenance (Miner & Kryger, 2017). Nicotine, which is found in cigarettes and other tobacco delivery devices, has been shown to promote wakefulness by effecting acetylcholine transmission in the central nervous system, resulting in a strong association between tobacco consumption and insomnia (Miner & Kryger, 2017). Alcohol intake before bed increases SWS and suppresses REM sleep early in the night; however, REM sleep rebounds in the latter portion of the night as the alcohol is metabolized (Carskadon & Dement, 2016). Chronic alcohol consumption is associated with suppression of SWS, which is problematic because SWS is already declined as a normal age-related change in sleep architecture in older adults (Miner & Kryger, 2017).

2.1.3.5 Pain

Pain, especially chronic pain, is prevalent in older adults, with 30% of adults aged 65 or older reporting chronic pain symptoms (Domenichiello & Ramsden, 2019). The most frequent chronic pain conditions in older adults are joint pain, back pain, and neck pain (Domenichiello & Ramsden, 2019). Chronic pain has been associated with sleep disturbances in older adults in a bidirectional relationship: pain disrupts sleep by interfering with sleep onset and sleep maintenance, while sleep deprivation worsens pain by increasing pain sensitivity (Mathias et al., 2018).

2.2 PAIN

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2.2.1 Pathophysiology of Pain

Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage (Lee & Neumeister, 2020).

2.2.1.1 Pain Pathway

The transmission of painful stimuli from the periphery to the brain is called the pain pathway (Lee & Neumeister, 2020). Painful stimuli are picked up by nociceptors on the afferent nerve fibers (1st order neuron) in the periphery and turned into electrical impulses (Lee & Neumeister, 2020). Afferent nerve fibers have two types: Aδ fibers, which are myelinated with fast and well-localized signaling, and C fibers, which are unmyelinated with slow and poorly localized signaling (Lee & Neumeister, 2020). The afferent nerve fibers transmit the electrical impulses to the 2nd order neuron in the dorsal horn of the spinal cord (Lee & Neumeister, 2020). The 2nd order neurons transmit the electrical impulses to the 3rd order neuron in the thalamus

through two tracks: the lateral spinothalamic tract, which carries information regarding duration, location, and intensity of pain, and the medial spinothalamic tract, which carries information regarding the autonomic and unpleasant emotional perception of pain (Lee & Neumeister, 2020). From the thalamus, 3rd order neurons project to other cortical regions for pain perception and localization (Lee & Neumeister, 2020).

2.2.1.2 Acute Pain versus Chronic Pain

Acute pain refers to pain that lasts less than 3 months (Lee & Neumeister, 2020). Acute pain is caused by tissue damage and is mediated by Aδ fibers (Lee & Neumeister, 2020). Acute pain is protective because it warns the individual of possible damage to engage in behaviors that avoid further damage (Lee & Neumeister, 2020). Chronic pain refers to pain that lasts more than 3 months (Lee & Neumeister, 2020). Chronic pain is mediated by C fibers and is caused by physiological changes along the pain pathway, including but not limited to overstimulation of nociceptors on C fibers and decreased depolarization threshold of nociceptors due to altered distribution of ectopic Na+ channels (Lee & Neumeister, 2020). Such changes increase the body's sensitivity toward noxious stimuli, result in persistent pain (Lee & Neumeister, 2020). Chronic pain is considered pathological and may severely impact quality of life (Lee & Neumeister, 2020).

2.2.2 Chronic Pain in Older Adults

Chronic pain is highly prevalent in older adults with the prevalence of chronic pain in people aged 65 or older in the U.S. is estimated as 30% (Domenichiello & Ramsden, 2019). The most frequent chronic pain conditions in older adults are chronic joint pain, chronic back pain, and chronic neck pain (Domenichiello & Ramsden, 2019). Chronic pain has negative effects in older

adults, impairing physical, psychological, and social functioning (Domenichiello & Ramsden, 2019). Physically, chronic pain results in significant discomfort, limited mobility, and increased adverse drug events from frequent analgesic consumption (Domenichiello & Ramsden, 2019). Psychologically, chronic pain is associated with increased risk for mood disorders such as depression (Domenichiello & Ramsden, 2019). Socially, chronic pain is linked with decreased participation in leisure activity and increased social isolation (Domenichiello & Ramsden, 2019).

2.2.3 Effects of Chronic Pain on Sleep

Polysomnography studies indicate that people with chronic pain have problems with sleep continuity, sleep architecture, and sleep fragmentation (Mathias et al., 2018). Sleep continuity was most affected as patients with chronic pain experienced less total sleep time, longer sleep onset latency, lower sleep efficiency, and higher time awake after sleep onset compared to patients without chronic pain (Mathias et al., 2018). Regarding sleep architecture, N1 duration was longer in people with chronic pain (Mathias et al., 2018). As the lightest stage of sleep with a low arousal threshold, N1 is prone to awakening due to noxious stimuli (Mathias et al., 2018). Patients with chronic pain also experienced greater sleep fragmentation with significantly more awakening and movement-related disruption to sleep compared to patients without chronic pain (Mathias et al., 2018). The prevalence of sleep disorders was significantly higher in people with chronic pain compared to the general population (Mathias et al., 2018). Studies have shown that people with chronic pain were thirteen times more likely to be diagnosed with insomnia than the general population (72% vs. 5.6%), and sixteen times more likely to be diagnosed with OSA compared to the general population (32% vs. 2%) (Mathias et al., 2018).

2.3 SELF EFFICACY OF PAIN CONTROL

The concept of self-efficacy was developed by the American-Canadian psychologist, Albert Bandura (Bandura, 1977). Self-efficacy is defined as the conviction that one can successfully execute a behavior required to produce a desired outcome (Bandura, 1977). The strength of perceived self-efficacy plays a prominent role in both initiation and persistence of the behavior (Bandura, 1977). The stronger the perceived self-efficacy, the more likely the behavior will be initiated, the more effort will be expended, and the longer the behavior will persist when facing aversities (Bandura, 1977). One's perceived self-efficacy is created using information from four major sources: performance accomplishment, vicarious experience, verbal persuasion, and physiological states (Bandura, 1977). Several contextual factors affect the perception of self-efficacy, including the difficulty of the behavior, the amount of effort needed to accomplish the behavior, and whether the accomplishment is attributed to internal factors (ability, skills) or external factors (situational circumstances, external aid) (Bandura, 1977).

The concept of self-efficacy is closely associated with the concept of locus of control, which was developed by the American psychologist, Julian B. Rotter (Bandura, 1977). Locus of control is defined as the degree to which people perceive an event is dependent upon their own behaviors or is controlled by external forces (e.g. fate, chance, powerful others) (Rotter, 1966). Locus of control are classified as internal and external (Rotter, 1966). People who believe in an internal locus of control perceive that events are results of their own characteristics and behaviors, while people who believe in an external locus of control perceive that events are controlled by forces outside of themselves and may occur regardless of their own actions (Rotter, 1966). Many studies provided strong support for the hypotheses that individuals with a belief in an internal locus of control are more likely to value their skills and abilities, take steps to improve their life

condition, pay attention to useful information for their future behaviors, and more resistant to subtle attempts to manipulate them (Rotter, 1966).

3.0 SPECIFIC AIMS

Although previous studies have examined the association between pain, sleep, subjective health, functional outcomes, and perceived control of pain separately, their joint associations remain unclear especially in the older adult population. The purpose of this study is to gain greater insight into the assocation between pain, sleep, health, functional outcomes, and perceived self-efficacy of pain control. Data from participants ages 65 years or older in a nationwide representative sample from the 2015 Sleep in America Poll – Sleep and Pain will be used in this study to explore the association between these factors.

This study has three specific aims.

Aim 1: Describe the association between pain (type and intensity), sleep disturbances, and global health in older adults.

Hypothesis 1a: Older adults with chronic pain have more sleep disturbances and lower global health compared to older adults with either no pain or acute pain.

Hypothesis 1b: Increased pain intensity is associated with more sleep disturbances and lower global health in older adults.

Aim 2: Describe the association between pain intensity and functional outcomes in older adults with sleep disturbances.

Hypothesis 2: Increased pain intensity is associated with worse functional outcomes in older adults with sleep disturbances.

Aim 3: Explore the role of perceived pain control level on pain intensity, sleep disturbances, global health, and functional outcomes in older adults.

Hypothesis 3: Higher perception of being able to control pain is associated with lower pain intensity, less sleep disturbances, better global health, and higher functional outcomes in older adults.

4.0 METHODS

4.1 SLEEP IN AMERICA POLL

The National Sleep Foundation (NSF) is a non-profit organization dedicated to improving health and well-being through sleep education, research, and advocacy (National Sleep Foundation, n.d.). Since 1991, the NSF has conducted its annual Sleep in America Poll to focus on aspects of sleep health that are of high interest (Knutson, 2015). The purpose of the NSF's 2015 Sleep in America Poll was to look at the relationship between sleep and pain through a cross-sectional online survey of a representative sample of 1,029 non-institutionalized American adults aged 18 years or older. A large market research organization was contracted to conduct the 2015 Sleep in America Poll on behalf of the NSF with data collection commencing in December 2014. The survey was developed by a panel of experts in sleep, pain, neurology, and clinical psychology and focused on sleep practices and beliefs and their relationship to pain in adults. The online survey took approximately 11 minutes to complete. If needed, respondents were provided a laptop and Internet connection at no additional cost. De-identified data and details about the study methodology for the National Sleep Foundation 2015 poll were acquired from the NSF (National Sleep Foundation, 2015). The institutional review board at the University of Pittsburgh approved this secondary analysis of the NSF data.

4.2 SAMPLING

The 2015 Sleep in America Poll's sampling methodology was designed to recruit a representative, nationwide sample. Respondents were obtained by random address-based sampling based on the United States Postal Service's Delivery Sequence File. All data collection was accomplished with a web survey instrument. The study completion rate was 60% (1,740 potential persons identified, N = 1,044 respondents in final sample). Twenty-five persons were excluded due to "speeding" (i.e. completing the survey in less than 4 minutes) or refusing to answer more than one-third of the eligible questions. The estimated maximum sampling error of the entire sample was ± 3.3% (99% CI). The subsample studied in this analysis, respondents aged 65 years or older (n = 248), yielded an estimated maximum sampling error of ± 6.2% (95% CI).

4.3 SURVEY

4.3.1 Outcome Measures

4.3.1.1 Global Health

The survey included four questions where respondents were asked to rate their general health, quality of life, physical health, and mental health. Potential responses to each question were based on a 5-point Likert scale ranging from 1 "excellent", 2 "very good", 3 "good", 4 "fair", to 5 "poor". Global health was calculated as the composite score of the four health questions with potential scores ranging from 4 to 20, with higher scores indicating worse overall health.

4.3.1.2 Pain Intensity

A composite score of three questions on physical pain was calculated. Respondents were asked to rate what in the previous seven days was their worse pain, average pain, their current pain level on a 5-point Likert scale, ranging from 1 “no pain”, 2 “mild”, 3 “moderate”, 4 “severe”, to 5 “very severe”. Potential scores range from 3 to 15, with higher scores indicative of more severe pain.

4.3.1.3 Sleep Disturbances

Sleep difficulty was evaluated with 8 questions from the National Institutes of Health (NIH) PROMIS Sleep Disturbance instrument. The questions asked about the frequency during the last 7 days of: 1) feeling satisfied with sleep, 2) refreshing sleep, 3) experiencing restless sleep, 4) difficulty falling asleep, 5) having adequate sleep duration, 6) trouble sleeping, 7) trouble staying asleep, and 8) sleep quality. All responses were rated on a 5-point Likert scale, ranging from 1 to 5, with positively worded answers reverse coded. Potential scores ranged from 8 to 40, with higher scores indicative of more severe sleep difficulty. Each question was also dichotomized: respondents were categorized as having “sleep difficulty” if they reported one of the two worse possible responses in any of the 8 questions.

4.3.1.4 Functional Outcomes

Respondents who indicated that they had “sleep difficulty” were asked the degree to which impaired sleep interfered with their: 1) mood, 2) day-to-day activities, 3) enjoyment of life, 4) relationships with other people, and 5) ability to do work, chores, childcare, and other duties. Each question used a 4-point Likert scales ranging from 1 “a great deal”, 2 “quite a bit”, 3 “not that much”, to 4 “not at all” so that lower scores indicated worse function.

4.3.2 Demographic Information

Demographic questions used to describe the sample included self-reported age, gender, race/ethnicity, education, marital status, and household Internet access. Gender was dichotomized as “male” or “female.” Race/ethnicity’s original categories included “White, Non-Hispanic”, “Black, Non-Hispanic”, “Other, Non-Hispanic”, “2+ Races, Non-Hispanic”, and “Hispanic”. Race/ethnicity was re-coded as “White, Non-Hispanic”, “Non-White, Non-Hispanic”, and “Hispanic”. Education level original categories included “less than high school”, “high school”, “some college”, and “bachelor’s degree or higher”. Education was re-coded as “high school or less” and “post-high-school graduates”. Marital status was originally coded as “married”, “widowed”, “divorced”, “separated”, “never married”, and “living with partner”. Marital status was re-coded as “married/partnered” or “single.” Respondents were queried if they or anyone in their household had Internet access from home.

4.3.3 Sleep Questions

General sleep questions included time in bed, sleep duration, sleep efficiency, preferred sleep duration, sleep debt, and diagnosis of sleep disorders. Additional questions queried respondents on whether they had sleep difficulties, if impaired sleep affected their functional outcomes, and diagnosis of sleep disorders.

4.3.3.1 Time in Bed and Sleep Duration

Time in bed was determined by questions asking bedtime and wake-up time on weekdays and weekends. Sleep duration was determined by questions asking estimated actual sleep time on weekdays and weekends. A formula was used to calculate average time in bed and sleep duration ([*weekday value * 5*] + [*weekend value * 2*]) */ 7*.

4.3.3.2 Sleep Efficiency

Sleep efficiency was calculated by dividing the average sleep duration by the average time in bed. Normal sleep efficiency is when persons are asleep 85% or more of the time they are in bed.

4.3.3.3 Preferred Sleep Duration and Sleep Debt

Preferred sleep duration was determined by a question asking how much sleep they need at the minimum to feel their best during the day. Sleep debt was calculated by subtracting average sleep duration from preferred sleep duration.

4.3.3.4 Sleep Disorders

Respondents were asked whether they were diagnosed by a healthcare provider with insomnia, OSA, or “other” sleep disorders.

4.3.4 Pain Questions

Information on pain included presence, type, intensity, effect of pain on functional outcomes, and perceived control level in pain management.

4.3.4.1 Presence and Type of Pain

Respondents were asked to classify their type of pain as either no pain, “only fleeting and minor pain”, or “chronic pain”. Fleeting and minor pain was classified as “acute pain.” If respondents had chronic pain, they were asked to specify how long had the pain been experienced and the pain location (e.g., head, neck, shoulders, back, arms, legs, chest, abdomen, and hip).

4.3.4.2 Perceived Control Level in Pain Management

Respondents were asked to rate how much control they think they have on the pain using 4-point Likert scales ranging from 1 “a lot of control”, 2 “some control”, 3 “not much control”, to 4 “no control at all”.

4.4 STATISTICAL APPROACH

Data was analyzed with IBM SPSS version 27 using functionality for complex survey sampling incorporating the post-stratification weight provided by the 2015 Sleep in America survey. Significance level was set at 0.05.

4.4.1 Use of Weighted Data

The original data from the 2015 Sleep in America Poll was weighted in two stages to be representative of the U.S. population (National Sleep Foundation, 2015). The recruited panel was weighted using demographic distributions from the most recent Current Population Survey (National Sleep Foundation, 2015; United States Census Bureau, 2015). The final sample was weighted again to adjust for survey nonresponse and under-coverage/over-coverage imposed by the study's specific sample design using demographic distributions from the most recent Current Population Survey (National Sleep Foundation, 2015; United States Census Bureau, 2015). The estimated maximum sampling error of the total sample was ± 3.3% (99% CI) (National Sleep Foundation, 2015).

For the subsample of older adults aged 65 years or older used in this study, post-stratified weights were used to ensure representativeness and generalizability. The subsample (n = 248) yielded an estimated maximum sampling error of ± 6.2% (95% CI).

4.4.2 Sample Description

Categorical variables were described using frequency distribution. For each categorical variable, chi-square analysis was conducted to compare between three pain groups (no pain, acute pain, and chronic pain). Because the sample was weighted, SPSS's chi-square analysis included the adjusted F as a variant of the second-order Rao-Scott adjusted chi-square statistic (Rao & Scott, 1987). Significance is based on this adjusted F and its degree of freedom.

Continuous variables were described using mean and standard deviation. For each continuous variable, one-way analysis of variance (ANOVA) was conducted to compare the means

between the three pain groups (no pain, acute pain, and chronic pain). Test of homogeneity of variances were done to check for equal variances across groups. Post-hoc comparison was conducted to determine exactly which groups had a difference in means. Bonferroni correction was used with post hoc test to minimize false positives from multiple comparisons.

4.4.3 Analysis Plan for the Specific Aims

Aim 1a is focused on describing the association between pain type, sleep disturbances, and global health in older adults. Hypothesis 1a stated that older adults with chronic pain have higher mean sleep disturbances and lower mean global health compared to older adults with either no pain or acute pain. One-way ANOVA was conducted to compare the means of sleep disturbances and global health between the three pain groups (no pain, acute pain, and chronic pain)

Aim 1b is focused on examining the association between pain intensity, sleep disturbances, and global health in older adults. Hypothesis 1b stated that increased pain intensity is associated with more sleep disturbances and lower global health in older adults. Multiple linear regression was used to analyze the association between pain intensity and each of sleep disturbances and global health. Pain intensity was the focal predictor. Six demographic variables (age, sex, education, race, marital status, home Internet access) were controlled for by inclusion in the regression model as covariates. R^2 is reported at the model level, with unstandardized coefficient (B) and standardized coefficient (β) presented for predictors. The standardized coefficients were obtained by using z-score transformation on continuous outcomes and predictors and re-running the analyses.

Aim 2 is focused on examining the association between pain intensity and functional outcomes in older adults with sleep disturbances. Aim 2 stated that increased pain intensity is

associated with worse functional outcomes in older adults with sleep disturbances. Multiple linear regression was used to analyze the association between pain intensity and each of the five functional outcomes (mood, day-to-day activity, enjoyment of life, relationships with other people, and ability to do work, chores, childcare, or other duties).

Aim 3 is focused on exploring the role of perceived pain control level on pain intensity, sleep disturbances, global health, and functional outcomes in older adults. Hypothesis 3 stated that higher perception of being able to control pain is associated with lower pain intensity, less sleep disturbances, better global health, and higher functional outcomes in older adults. Multiple linear regression was used to analyze the association between perceived control of pain and each of pain intensity, sleep disturbances, global health, and the five functional outcomes (mood, day-to-day activity, enjoyment of life, relationships with other people, and ability to do work, chores, childcare, or other duties).

5.0 RESULTS

5.1 DESCRIPTION OF SAMPLE

Table 1 depicts the demographic characteristics of the sample. A total of 248 participants were included in the subsample for this study. The age range was 65 to 91 years old with the mean age of 72.79 ± 0.405 years, in which 65.7% of participants were between 65 and 74 years old and 34.3% were 75 or older. Sex was evenly distributed with 46.7% male and 53.3% female. The sample was predominantly White, Non-Hispanic (78.9%) with Non-White, non-Hispanic (14.6%) and Hispanic (6.4%). Education was evenly distributed, with 52% had high school or less education and 48% had post-high-school education. For marital status, 66.2% were married/partnered and 33.8% were single. For home Internet access, 70.4% of participants had home Internet access and 29.6% did not. There were no differences in demographic variables between the three pain groups.

Participants averaged 7 hours of sleep each night; 87% of the time they reported being in bed was spent asleep. There were no significant differences between groups of pain for sleep duration and sleep efficiency. Mean sleep debt was 9.713 ± 4.590 minutes. There were statistically significant differences between pain groups regarding sleep debt ($p = 0.002$), ranging from the mean of – 9.624 ± 5.882 minutes in no pain group, to 8.726 ± 8.046. minutes in acute pain group, to 30.038 ± 9.503 minutes in chronic pain group (See Table 2).

5.2 AIM 1A

5.2.1 Sleep Disturbances

One-way ANOVA showed statistically significant differences in means of sleep disturbances score among the three pain groups with $F(2, 246) = 9.824$, $p < 0.001$. The no pain group had the mean sleep disturbances score of 16.149 ± 0.674, the acute pain group had the mean sleep disturbances score of 19.303 ± 0.668, and the chronic pain group had the mean sleep disturbances score of 20.670 ± 0.874. Post hoc comparison showed a significant difference between the no pain group vs. acute pain group ($p = 0.001$) and no pain group vs. chronic pain group ($p < 0.001$) (See Table 3).

5.2.2 Global Health

One-way ANOVA showed statistically significant differences in means of global health score among the three pain groups with $F(2, 246) = 6.713$, $p = 0.001$. The no pain group had a mean global health score of 9.194 ± 0.285, the acute pain group had a mean global health score of 10.158 ± 0.331, and the chronic pain group had a mean global health score of 10.788 ± 0.340. Post hoc comparison showed statistically significant differences in means between the no pain group vs. acute pain group ($p = 0.028$) and no pain group vs. chronic pain group ($p < 0.001$). Since a higher global health score indicated worse global health, participants in the acute pain group and chronic pain group had significantly worse global health compared to participants with no pain (See Table 3).

5.3 AIM 1B

5.3.1 Sleep Disturbances

Multiple linear regression model found that 13.1% of the variation in sleep disturbances was explained by pain intensity and included covariates ($R^2 = 0.131$). There was a statistically significant positive association between pain intensity and sleep disturbances ($B = 0.654 \pm 0.170$, $p < 0.001$), indicating that higher pain intensity was associated with more sleep disturbances (See Table 4).

5.3.2 Global Health

Multiple linear regression model found that 23.4% of the variation in global health was explained by pain intensity and included covariates ($R^2 = 0.234$). There was a statistically significant positive association between pain intensity and global health ($B = 0.352 \pm 0.065$, $p < 0.001$), indicating that higher pain intensity was associated with a higher global health score (which signals worse health). Three other covariates also showed positive association with global health, including sex ($B = 0.784 \pm 0.335$, $p = 0.020$), education ($B = 1.478 \pm 0.335$, $p < 0.001$), and home Internet access ($B = 1.053 \pm 0.421$, $p = 0.013$) (See Table 5).

5.4 AIM 2

5.4.1 Mood

Multiple linear regression model found that 9.5% of the variation in mood was explained by pain intensity and included covariates ($R^2 = 0.095$). There was a statistically significant negative association between pain intensity and mood ($B = -0.071 \pm 0.021$, $p < 0.001$), indicating that higher pain intensity was associated with a lower score on this metric, meaning impaired sleep had more interference with mood (See Table 6).

5.4.2 Day-to-Day Activities

Multiple linear regression model found that 11.1% of the variation in interference with day-to-day activities was explained by pain intensity and included covariates ($R^2 = 0.111$). There was a statistically significant negative association between pain intensity and day-to-day activities ($B = -0.070 \pm 0.023$, $p = 0.003$), indicating that higher pain intensity was associated with a lower score on this metric, meaning impaired sleep had more interference with day-to-day activities (See Table 7).

5.4.3 Enjoyment of Life

Multiple linear regression model found that 12.3% of the variation in enjoyment of life was explained by pain intensity and included covariates ($R^2 = 0.123$). There was a statistically

significant negative association between pain intensity and mood (B = – 0.072 ± 0.024, p = 0.003), indicating that higher pain intensity was associated with a lower score on this metric, meaning impaired sleep had more interference with enjoyment of life. Among the covariates, education showed a negative association against the score for enjoyment of life (B = – 0.214 ± 0.098, p = 0.031) (See Table 8).

5.4.4 Relationships with Other People

Multiple linear regression model found that 10.2% of the variation in interference on relationships with other people was explained by pain intensity and included covariates (R^2 = 0.102). There was a statistically significant negative association between pain intensity and mood (B = – 0.067 ± 0.024, p = 0.006), indicating that higher pain intensity was associated with a lower score on this metric, meaning impaired sleep had more interference with relationships with other people (See Table 9).

5.4.5 Ability to Do Work, Chores, Childcare, or Other Duties

Multiple linear regression model found that 10.8% of the variation in ability to do work, chores, childcare, or other duties was explained by pain intensity and included covariates (R^2 = 0.108). There was a statistically significant negative association between pain intensity and mood (B = – 0.070 ± 0.023, p = 0.002), indicating that higher pain intensity was associated with a lower

score on this metric, meaning impaired sleep had more interference with ability to do work, chores, childcare, or other duties (See Table 10).

5.5 AIM 3

5.5.1 Pain Intensity

Multiple linear regression model found that 12.4% of the variation in pain intensity was explained by perceived control of pain and included covariates ($R^2 = 0.124$). There was a statistically significant positive association between perceived control of pain and pain intensity ($B = 1.153 \pm 0.229$, $p < 0.001$), indicating that greater lack of perceived control of pain was associated with a higher level of pain intensity (See Table 11).

5.5.2 Sleep Disturbances

Multiple linear regression model found that 14.6% of the variation in sleep disturbances was explained by perceived control of pain and included covariates ($R^2 = 0.146$). There was a statistically significant positive association between perceived control of pain and pain sleep disturbances ($B = 2.641 \pm 0.627$, $p < 0.001$), indicating that greater lack of perceived control of pain was associated with higher level of sleep disturbances (See Table 12).

5.5.3 Global Health

Multiple linear regression model found that 26.7% of the variation in global health was explained by perceived control of pain and included covariates (R^2 = 0.267). There was a statistically significant positive association between perceived control of pain and global health (B = 1.483 ± 0.263, p < 0.001), indicating that greater lack of perceived control of pain was associated with a higher score on global health (which signals worse health). Three other covariates also showed positive association with global health, including sex (B = 0.829 ± 0.311, p = 0.020), education (B = 0.189 ± 0.359, p < 0.001), and home Internet access (B = 0.989 ± 0.424, p = 0.013) (See Table 13).

5.5.4 Mood

Multiple linear regression model found that 5.4% of the variation in mood was explained by perceived control of pain and included covariates (R^2 = 0.054). There was a statistically significant negative association between perceived control of pain and mood score (B = – 0.171 ± 0.067, p = 0.011), indicating that greater lack of perceived control of pain was associated with a lower score on this metric, meaning impaired sleep had more interference with mood (See Table 14).

5.5.5 Day-to-Day Activities

Multiple linear regression model found that 7.5% of the variation in day-to-day activities was explained by perceived control of pain and included covariates ($R^2 = 0.075$). There was a statistically significant negative association between perceived control of pain and day-to-day activities score ($B = – 0.172 \pm 0.074$, $p = 0.020$), indicating that greater lack of perceived control of pain was associated with a lower score on this metrics, meaning impaired sleep had more interference with day-to-day activities (See Table 15).

5.5.6 Enjoyment of Life

Multiple linear regression model found that 9.3% of the variation in enjoyment of life was explained by perceived control of pain and included covariates ($R^2 = 0.093$). There was a statistically significant negative association between perceived control of pain and enjoyment of life score ($B = – 0.188 \pm 0.075$, $p = 0.012$), indicating that greater lack of perceived control of pain was associated with a lower score on this metric, meaning impaired sleep had more interference with enjoyment of life. Among the covariates, education showed a negative association against the score for enjoyment of life ($B = – 0.227 \pm 0.099$, $p = 0.023$) (See Table 16).

5.5.7 Relationships with Other People

Multiple linear regression model found that 11.4% of the variation in relationships with other people was explained by perceived control of pain and included covariates ($R^2 = 0.114$). There was a statistically significant negative association between perceived control of pain and interference of relationships with other people score ($B = – 0.256 \pm 0.073$, $p < 0.001$), indicating that greater lack of perceived control of pain was associated with a lower score on this metrics, meaning impaired sleep had more interference with relationships with other people (See Table 17).

5.5.8 Ability to Do Work, Chores, Childcare, or Other Duties

Multiple linear regression model found that 6.7% of the variation in ability to do work, chores, childcare, or other duties was explained by perceived control of pain and included covariates ($R^2 = 0.067$). There was a statistically significant negative association between perceived control of pain and ability to do work, chores, childcare, or other duties score ($B = – 0.158 \pm 0.064$, $p = 0.015$), indicating that greater lack of perceived control of pain was associated with a lower score on this metric, meaning impaired sleep had more interference with ability to do work, chores, childcare, or other duties (See Table 18).

6.0 DISCUSSION

Our study found that both acute or chronic pain have a negative impact on sleep and global health in older adults, as participants with pain had significantly higher mean of sleep disturbances scores and global health scores (which signals worse health) compared to participants without pain. Higher level of pain intensity was associated with worse health outcomes and functional outcomes of more sleep disturbances, worse global health, and higher level of impaired sleep interference with mood, day-to-day activities, enjoyment of life, relationships with other people, and ability to do work, chores, childcare, or other duties. On the other hand, higher level of perceived control over pain was associated with better health outcomes and functional outcomes of lower pain intensity, less sleep disturbances, better global health, and lower degree of impaired sleep's interference with mood, day-to-day activities, enjoyment of life, relationships with other people, and ability to do work, chores, childcare, or other duties.

This study showed consistent results compared to previous studies. Pain has been shown to be associated with sleep disturbances (Mathias et al., 2018), have negative impacts on older adults' physical, psychological, and social functioning (Domenichiello & Ramsden, 2019), and perceived self-efficacy has been linked with more life-improving behaviors (Rotter, 1966). This study increased the knowledge base by providing a more detailed description of the relationship between pain, sleep, subjective health, and functional outcomes in the older adult population, which had been unclear in the literature. This study also provided insights on the role of perceived control on pain on pain intensity, sleep disturbances, global health, and functional outcomes in older adults, which is a relatively unexplored topic.

This study has limitations. The study design was descriptive and cross-sectional, which prevents it from having any causal conclusions. The study used self-reported data from surveys, which is inherently biased because there might be deviation between the self-report data and the true values of the same measure. Use of objective measures of sleep such as actigraphy would have improved the measurement of sleep variables because it minimizes the self-report bias. The study was a secondary analysis; hence, lacking detailed information regarding variables such as health conditions or comorbidities. The survey was conducted online, which raises concerns about who was able to participate (i.e., potential for decreased accessibility and unfamiliarity with filling online survey for some participants). Fortunately, to expand access and increase generalizability, the 2015 Sleep in America study provided laptops and internet connections to participants at no cost.

This study has strengths that include a robust sample size as well as use of a questionnaire with multiple language versions (i.e., Spanish version). The sample that was analyzed originated from a nationally representative study of the U.S. and was weighted with post-stratified weights to increase representativeness and generalizability to the general population. The original questionnaire had a Spanish version, which reduces language barriers for Spanish-speaking participants.

7.0 DISCUSSION

Pain was shown to have a negative impact on sleep, health, and functional outcomes in adults aged 65 or older, whereas perceived control of pain was shown to have a positive impact on pain, sleep, health, and functional outcomes. This study supports the need to explore sleep in the context of pain management to optimize health related quality of life in older adults.

Table 1

Description of the Sample and Comparison by the Type of Pain Using Chi-square Analysis

Weighted %	All (100%)	No pain (39.6%)	Acute pain (27.9%)	Chronic pain (32.5%)	X^2 statistics				p-value
					Value	Adjusted F	df1	df2	
Age (years)					0.384	0.173	1.999	493.825	0.841
65 – 74	65.7%	25.7%	17.9%	22.2%					
75 or older	34.3%	14.0%	10.1%	10.3%					
Sex					1.753	0.805	1.996	493.090	0.448
Male	46.7%	20.4%	11.6%	14.7%					
Female	53.3%	19.2%	16.3%	17.8%					
Race/Ethnicity					9.435	1.654	3.862	953.904	0.161
White, Non-Hispanic	78.9%	31.0%	24.5%	23.5%					
Non-White, Non-Hispanic	14.6%	4.7%	2.7%	7.2%					
Hispanic	6.4%	3.9%	0.8%	0.7%					
Education					0.118	0.054	1.998	493.559	0.947
High school or less	52%	20.7%	14.9%	16.4%					
Post high school graduates	48%	18.9%	13.0%	16.0%					
Marital Status					0.958	0.418	1.999	493.845	0.658
Married/Partnered	66.2%	27.7%	17.8%	20.7%					
Single	33.8%	11.9%	10.1%	11.7%					
Home Internet Access					1.945	0.730	1.999	493.739	0.483
No	29.6%	13.6%	7.0%	9.0%					
Yes	70.4%	26.0%	20.9%	23.5%					

Note. The adjusted F is a variant of the second-order Rao-Scott adjusted chi-square statistic. Significance is based on the adjusted F and its degree of freedom.

Table 2

Description of the Sample and Comparison by the Type of Pain Using ANOVA

Variables	All	No pain	Acute pain	Chronic pain	Wald-F test statistics			p-value
	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Value	*df1*	*df2*	
Age (years)	72.79	72.64	73.03	72.71	0.086	2.000	246.000	0.917
	(0.405)	(0.634)	(0.724)	(0.739)				
Sleep duration (mins)	423.971	432.821	412.762	426.332	1.726	2.000	244.000	0.180
	(5.331)	(8.017)	(7.455)	(11.658)				
Sleep efficiency (%)	0.868	0.904	0.860	0.841	2.715	2.000	242.000	0.068
	(0.010)	(0.023)	(0.013)	(0.014)				
Sleep debt (mins)	9.713	– 9.624	8.726	30.038	6.572	2.000	244.000	**0.002**
	(4.590)	(5.882)	(8.046)	(9.503)				
Pain intensity	5.880	3.102	6.577	7.961	325.922	2.000	246.000	**< 0.001**
	(0.104)	(0.545)	(0.193)	(0.239)				
Sleep disturbances	18.707	16.149	19.303	20.670	9.824	2.000	246.000	**< 0.001**
	(0.430)	(0.674)	(0.668)	(0.874)				
Global health	10.047	9.194	10.158	10.788	6.713	2.000	246.000	**0.001**
	(0.185)	(0.286)	(0.331)	(0.340)				
Mood	3.10	3.25	3.17	2.88	4.225	2.000	171.000	**0.016**
	(0.049)	(0.085)	(0.066)	(0.101)				
Day-to-day activities	3.08	3.24	3.15	2.87	4.486	2.000	171.000	**0.013**
	(0.050)	(0.079)	(0.082)	(0.098)				
Enjoyment of life	3.13	3.31	3.22	2.85	6.467	2.000	171.000	**0.002**
	(0.051)	(0.084)	(0.077)	(0.103)				
Relationships with other people	3.24	3.41	3.34	2.99	4.415	2.000	171.000	**0.014**

	(0.054)	(0.088)	(0.074)	(0.117)				
Ability to do work, chores,	3.15	3.32	3.22	2.92	4.852	2.000	171.000	**0.012**
childcare, or other duties	(0.050)	(0.080)	(0.069)	(0.105)				

Table 3

Comparisons of Sleep Disturbances and Global Health Between the Types of Pain

Mean (SE)	No pain	Acute pain	Chronic pain	Wald-F test statistics			p-value	Post hoc comparison p-value		
				Value	*df1*	*df2*		No pain vs. Acute pain	No pain vs. Chronic pain	Acute pain vs. Chronic pain
Sleep Disturbance	16.149	19.303	20.670	9.824	2.000	246.000	**< 0.001**	**0.001**	**< 0.001**	0.215
	(0.674)	(0.668)	(0.874)							
Global Health	9.194	10.158	10.788	6.713	2.000	246.000	**0.001**	**0.028**	**< 0.001**	0.186
	(0.285)	(0.331)	(0.340)							

Table 4

The Association between Pain Intensity and Sleep Disturbance in Older Adults

Variables	B	95% CI for B		β	p-value	R^2
	(SE B)	LL	UL	(SE β)		
Sleep Disturbances						0.131
Constant	3.138	– 7.718	13.995	– 0.386	0.492	
	(5.512)			(0.348)		
Pain intensity	0.654	0.319	0.988	0.257	< **0.001**	
	(0.170)			(0.067)		
Age	0.127	– 0.020	0.274	0.117	0.089	
	(0.075)			(0.069)		
Sex	– 1.538	– 3.305	0.229	– 0.240	0.088	
Ref. "Female"	(0.897)			(0.140)		
Race/ethnicity					0.210	
Ref. "Hispanic"						
"White, Non-Hispanic"	2.913	– 0.613	6.439	0.455		
	(1.790)			(0.280)		
"Non-White, Non-Hispanic"	3.118	– 1.102	7.339	0.487		
	(2.143)			(0.335)		
Education	0.968	– 0.695	2.632	0.151	0.253	
Ref. "Post high school graduates"	(0.845)			(0.132)		
Marital status	0.126	– 1.564	1.816	0.020	0.883	
Ref. "Single"	(0.858)			(0.134)		
Home Internet access	– 0.835	– 2.942	1.273	– 0.130	0.436	
Ref. "Yes"	(1.070)			(0.167)		

Table 5

The Association between Pain Intensity and Global Health in Older Adults

Variables	B	95% CI for B		β	p-value	R^2
	(SE B)	LL	UL	(SE β)		
Global Health						0.234
Constant	5.209	0.678	9.740	– 0.366	0.002	
	(2.300)			(0.279)		
Pain intensity	0.352	0.224	0.479	0.305	**< 0.001**	
	(0.065)			(0.056)		
Age	0.022	– 0.035	0.079	0.044	0.453	
	(0.029)			(0.059)		
Sex	0.784	0.125	1.443	0.270	**0.020**	
Ref. "Female"	(0.335)			(0.115)		
Race/ethnicity					0.703	
Ref. "Hispanic"						
"White, Non-Hispanic"	0.024	– 1.424	1.473	0.008		
	(0.736)			(0.254)		
"Non-White, Non-Hispanic"						
	0.347	– 1.197	1.890	0.120		
	(0.784)			(0.270)		
Education	1.478	0.779	2.176	0.510	**< 0.001**	
Ref. "Post high school graduates"	(0.335)			(0.122)		
Marital status	– 0.481	– 1.196	0.235	– 0.166	0.187	
Ref. "Single"	(0.363)			(0.125)		
Home Internet access	1.053	0.224	1.882	0.363	**0.013**	
Ref. "Yes"	(0.421)			(0.145)		

Table 6

The Association between Pain Intensity and Impaired Sleep's Interference with Mood in Older Adults

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Mood						0.095
Constant	3.772 (0.612)	2.565	4.980	– 0.015 (0.364)	< 0.001	
Pain intensity	– 0.071 (0.021)	– 0.113	– 0.030	– 0.288 (0.078)	**< 0.001**	
Age	– 0.004 (0.008)	– 0.020	0.013	– 0.035 (0.078)	0.650	
Sex	– 0.049	– 0.248	0.149	– 0.079	0.624	
Ref. "Female"	(0.100)			(0.161)		
Race/ethnicity					0.610	
Ref. "Hispanic"						
"White, Non-Hispanic"	0.062 (0.216)	– 0.363	0.488	0.100 (0.346)		
"Non-White, Non-Hispanic"	0.213 (0.258)	– 0.297	0.723	0.341 (0.414)		
Education	– 0.098	– 0.296	0.100	– 0.157	0.330	
Ref. "Post high school graduates"	(0.100)			(0.161)		
Marital status	0.030	– 0.175	0.236	0.049	0.770	
Ref. "Single"	(0.104)			(0.167)		
Home Internet access	0.006	– 0.231	0.244	0.010	0.957	
Ref. "Yes"	(0.120)			(0.193)		

Table 7

The Association between Pain Intensity and Impaired Sleep's Interference with Day-to-day Activities in Older Adults

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Day-to-day Activities						0.111
Constant	4.647 (0.754)	3.159	6.134	0.193 (0.290)	< 0.001	
Pain intensity	– 0.070 (0.023)	– 0.116	– 0.025	– 0.276 (0.091)	**0.003**	
Age	– 0.014 (0.010)	– 0.034	0.005	– 0.131 (0.091)	0.149	
Sex Ref. "Female"	0.035 (0.101)	– 0.165	0.235	0.055 (0.158)	0.728	
Race/ethnicity Ref. "Hispanic"					0.399	
"White, Non-Hispanic"	– 0.123 (0.155)	– 0.430	0.183	– 0.193 (0.242)		
"Non-White, Non-Hispanic"	0.062 (0.202)	– 0.338	0.462	0.097 (0.316)		
Education Ref. "Post high school graduates"	– 0.101 (0.095)	– 0.289	0.088	– 0.157 (0.149)	0.293	
Marital status Ref. "Single"	0.038 (0.109)	– 0.176	0.253	0.060 (0.170)	0.725	
Home Internet access Ref. "Yes"	0.015 (0.124)	– 0.229	0.260	0.024 (0.193)	0.902	

Table 8

The Association between Pain Intensity and Impaired Sleep's Interference with Enjoyment of Life in Older Adults

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Enjoyment of Life						0.123
Constant	4.529 (0.757)	3.036	6.023	0.460 (0.268)	< 0.001	
Pain intensity	– 0.072 (0.024)	– 0.119	– 0.025	– 0.267 (0.088)	**0.003**	
Age	0.009 (0.010)	– 0.029	0.011	– 0.082 (0.088)	0.352	
Sex	– 0.153	– 0.372	0.066	– 0.226	0.170	
Ref. "Female"	(0.111)			(0.164)		
Race/ethnicity					0.257	
Ref. "Hispanic"						
"White, Non-Hispanic"	– 0.138 (0.137)	– 0.408	0.133	– 0.203 (0.202)		
"Non-White, Non-Hispanic"	0.050 (0.165)	– 0.276	0.376	0.074 (0.243)		
Education	– 0.214	– 0.049	– 0.020	– 0.316	**0.031**	
Ref. "Post high school graduates"	(0.098)			(0.145)		
Marital status	– 0.028	– 0.243	0.187	– 0.041	0.798	
Ref. "Single"	(0.109)			(0.161)		
Home Internet access	0.071	– 0.174	0.317	0.105	0.568	
Ref. "Yes"	(0.125)			(0.184)		

Table 9

The Association between Pain Intensity and Impaired Sleep's Interference with Relationships with Other People in Older Adults

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Relationships with Other People						0.102
Constant	4.361 (0.803)	2.775	5.947	0.086 (0.367)	< 0.001	
Pain intensity	– 0.067 (0.024)	– 0.115	– 0.020	– 0.251 (0.090)	**0.006**	
Age	– 0.009 (0.011)	– 0.030	0.012	– 0.080 (0.092)	0.389	
Sex Ref. "Female"	– 0.009 (0.111)	– 0.227	0.210	– 0.013 (0.165)	0.939	
Race/ethnicity Ref. "Hispanic"					0.631	
"White, Non-Hispanic"	0.128 (0.226)	– 0.318	0.574	0.190 (0.336)		
"Non-White, Non-Hispanic"	0.230 (0.253)	– 0.279	0.730	0.341 (0.377)		
Education Ref. "Post high school graduates"	– 0.190 (0.102)	– 0.391	0.011	– 0.282 (0.151)	0.064	
Marital status Ref. "Single"	– 0.126 (0.114)	– 0.350	0.099	– 0.187 (0.169)	0.271	
Home Internet access Ref. "Yes"	0.016 (0.137)	– 0.254	0.287	0.024 (0.204)	0.905	

Table 10

The Association between Pain Intensity and Impaired Sleep's Interference with Ability to Do Work, Chores, Childcare, or Other Duties in Older Adults

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Ability to Do Work, Chores, Childcare, or Other Duties						0.108
Constant	4.552	3.047	6.056	0.276	< 0.001	
	(0.762)			(0.322)		
Pain intensity	– 0.070	– 0.114	– 0.025	– 0.273	**0.002**	
	(0.023)			(0.089)		
Age	– 0.011	– 0.031	0.009	– 0.102	0.264	
	(0.010)			(0.091)		
Sex	0.071	– 0.139	0.282	0.111	0.503	
Ref. "Female"	(0.106)			(0.166)		
Race/ethnicity					0.361	
Ref. "Hispanic"						
"White, Non-Hispanic"	– 0.215	– 0.566	0.135	– 0.335		
	(0.178)			(0.277)		
"Non-White, Non-Hispanic"						
	– 0.090	– 0.501	0.320	– 0.141		
	(0.208)			(0.324)		
Education	– 0.091	– 0.282	0.100	– 0.142	0.349	
Ref. "Post high school graduates"	(0.097)			(0.151)		
Marital status	0.055	– 0.164	0.273	0.085	0.622	
Ref. "Single"	(0.111)			(0.172)		
Home Internet access	0.013	– 0.233	0.258	0.020	0.919	
Ref. "Yes"	(0.124)			(0.194)		

Table 11

The Association between Perceived Pain Control Efficacy and Pain Intensity in Older Adults

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Pain Intensity						0.124
Constant	4.112 (2.051)	0.072	8.152	– 0.220 (0.332)	0.026	
Pain intensity	1.153 (0.229)	0.702	1.604	0.321 (0.064)	< **0.001**	
Age	– 0.016 (0.027)	– 0.070	0.038	– 0.037 (0.064)	0.568	
Sex Ref. "Female"	– 0.259 (0.328)	– 0.905	0.387	– 0.103 (0.130)	0.430	
Race/ethnicity					0.490	
Ref. "Hispanic"						
"White, Non-Hispanic"	0.655 (0.740)	– 0.802	2.113	0.261 (0.294)		
"Non-White, Non-Hispanic"	1.018 (0.856)	– 0.669	2.705	0.405 (0.341)		
Education Ref. "Post high school graduates"	0.152 (0.338)	– 0.514	0.817	0.060 (0.134)	0.654	
Marital status Ref. "Single"	0.013 (0.347)	– 0.671	0.697	0.005 (0.138)	0.969	
Home Internet access Ref. "Yes"	– 0.315 (0.419)	– 1.140	0.510	– 0.125 (0.166)	0.452	

Table 12

The Association between Perceived Pain Control Efficacy and Sleep Disturbances in Older Adults

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Sleep Disturbances						0.146
Constant	4.325 (5.482)	– 6.474	15.213	– 0.464 (0.336)	0.295	
Pain intensity	2.641 (0.627)	1.406	3.875	0.289 (0.069)	< **0.001**	
Age	0.089 (0.077)	– 0.062	0.241	0.082 (0.071)	0.246	
Sex Ref. "Female"	– 1.469 (0.893)	– 3.227	0.289	– 0.229 (0.139)	0.101	
Race/ethnicity					0.114	
Ref. "Hispanic"						
"White, Non-Hispanic"	3.563 (1.709)	0.197	6.930	0.557 (0.267)		
"Non-White, Non-Hispanic"	3.655 (2.058)	– 0.398	7.709	0.571 (0.321)		
Education Ref. "Post high school graduates"	0.819 (0.850)	– 0.856	2.493	0.128 (0.133)	0.337	
Marital status Ref. "Single"	0.057 (0.847)	– 1.612	1.726	0.009 (0.132)	0.946	
Home Internet access Ref. "Yes"	0.089 (0.077)	– 0.062	0.241	– 0.150 (0.165)	0.364	

Table 13

The Association between Perceived Pain Control Efficacy and Global Health in Older Adults

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Global Health						0.267
Constant	5.799 (2.243)	1.381	10.216	– 0.460 (0.283)	<0.001	
Pain intensity	1.483 (0.263)	0.966	2.000	0.358 (0.063)	**< 0.001**	
Age	0.000 (0.030)	– 0.058	0.059	0.001 (0.060)	0.990	
Sex	0.829	0.215	1.442	0.286	**0.008**	
Ref. "Female"	(0.311)			(0.107)		
Race/ethnicity					0.706	
Ref. "Hispanic"						
"White, Non-Hispanic"	0.382 (0.736)	– 1.067	1.831	0.132 (0.254)		
"Non-White, Non-Hispanic"	0.632 (0.810)	– 0.965	2.228	0.218 (0.280)		
Education	1.389	0.681	2.097	0.479	**< 0.001**	
Ref. "Post high school graduates"	(0.359)			(0.124)		
Marital status	– 0.520	– 1.230	0.190	– 0.179	0.150	
Ref. "Single"	(0.361)			(0.124)		
Home Internet access	0.989	0.155	1.824	0.341	**0.020**	
Ref. "Yes"	(0.424)			(0.146)		

Table 14

The Association between Perceived Pain Control Efficacy and Impaired Sleep's Interference with Mood

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Mood						0.054
Constant	3.479	2.190	4.768	0.025	< 0.001	
	(0.653)			(0.399)		
Pain intensity	– 0.171	– 0.303	– 0.040	– 0.192	**0.011**	
	(0.067)			(0.075)		
Age	– 0.001	– 0.018	0.016	– 0.006	0.940	
	(0.009)			(0.082)		
Sex	– 0.044	– 0.243	0.155	– 0.070	0.665	
Ref. "Female"	(0.101)			(0.162)		
Race/ethnicity					0.759	
Ref. "Hispanic"						
"White, Non-Hispanic"	0.050	– 0.430	0.530	0.080		
	(0.243)			(0.390)		
"Non-White, Non-Hispanic"						
	0.165	– 0.389	0.719	0.265		
	(0.280)			(0.450)		
Education	– 0.113	– 0.318	0.093	– 0.181	0.280	
Ref. "Post high school graduates"	(0.104)			(0.167)		
Marital status	0.017	– 0.196	0.231	0.028	0.872	
Ref. "Single"	(0.108)			(0.173)		
Home Internet access	0.020	– 0.217	0.256	0.032	0.868	
Ref. "Yes"	(0.120)			(0.192)		

Table 15

The Association between Perceived Pain Control Efficacy and Impaired Sleep's Interference with Day-to-day Activities

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Day-to-day Activities						0.075
Constant	4.363 (0.736)	2.911	5.816	0.232 (0.261)	< 0.001	
Pain intensity	– 0.172 (0.074)	– 0.317	– 0.027	– 0.188 (0.080)	**0.020**	
Age	– 0.011 (0.010)	– 0.031	0.008	– 0.103 (0.091)	0.261	
Sex Ref. "Female"	0.040 (0.102)	– 0.162	0.242	0.063 (0.160)	0.694	
Race/ethnicity					0.650	
Ref. "Hispanic"						
"White, Non-Hispanic"	– 0.136 (0.138)	– 0.409	0.137	– 0.213 (0.216)		
"Non-White, Non-Hispanic"	0.015 (0.182)	– 0.345	0.374	0.023 (0.284)		
Education Ref. "Post high school graduates"	– 0.115 (0.095)	– 0.302	0.073	– 0.179 (0.148)	0.229	
Marital status Ref. "Single"	0.026 (0.109)	– 0.189	0.240	0.040 (0.170)	0.814	
Home Internet access Ref. "Yes"	0.029 (0.120)	– 0.208	0.265	0.045 (0.187)	0.812	

Table 16

The Association between Perceived Pain Control Efficacy and Impaired Sleep's Interference with Enjoyment of Life

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Enjoyment of Life						0.093
Constant	4.252 (0.730)	2.811	5.692	0.501 (0.229)	< 0.001	
Pain intensity	– 0.188 (0.075)	– 0.336	– 0.041	– 0.194 (0.077)	**0.012**	
Age	– 0.006 (0.010)	– 0.026	0.014	– 0.053 (0.089)	0.549	
Sex Ref. "Female"	– 0.149 (0.112)	– 0.369	0.072	– 0.219 (0.165)	0.186	
Race/ethnicity					0.347	
Ref. "Hispanic"						
"White, Non-Hispanic"	– 0.153 (0.112)	– 0.373	0.068	– 0.225 (0.165)		
"Non-White, Non-Hispanic"	0.001 (0.140)	– 0.276	0.278	0.001 (0.207)		
Education Ref. "Post high school graduates"	– 0.227 (0.099)	– 0.422	– 0.032	– 0.335 (0.146)	**0.023**	
Marital status Ref. "Single"	– 0.041 (0.110)	– 0.258	0.176	– 0.060 (0.162)	0.710	
Home Internet access Ref. "Yes"	0.085 (0.121)	– 0.153	0.324	0.126 (0.178)	0.481	

Table 17

The Association between Perceived Pain Control Efficacy and Impaired Sleep's Interference with Relationships with Other People

Variables	B (SE B)	95% CI for B LL	95% CI for B UL	β (SE β)	p-value	R^2
Interference with Relationships with Other People						0.114
Constant	4.190	2.639	5.741	0.145	< 0.001	
	(0.786)			(0.380)		
Pain intensity	– 0.256	– 0.400	– 0.113	– 0.267	**< 0.001**	
	(0.073)			(0.076)		
Age	– 0.005	– 0.026	0.016	– 0.044	0.641	
	(0.011)			(0.095)		
Sex	– 0.010	– 0.223	0.203	– 0.015	0.926	
Ref. "Female"	(0.108)			(0.160)		
Race/ethnicity					0.768	
Ref. "Hispanic"						
"White, Non-Hispanic"	0.103	– 0.379	0.586	0.153		
	(0.245)			(0.364)		
"Non-White, Non-Hispanic"						
	0.178	– 0.347	0.703	0.265		
	(0.266)			(0.395)		
Education	– 0.192	– 0.393	0.009	– 0.286	0.061	
Ref. "Post high school graduates"	(0.102)			(0.151)		
Marital status	– 0.137	– 0.361	0.086	– 0.204	0.226	
Ref. "Single"	(0.113)			(0.168)		
Home Internet access	0.032	– 0.227	0.291	0.047	0.641	
Ref. "Yes"	(0.131)			(0.195)		

Table 18

The Association between Perceived Pain Control Efficacy and Impaired Sleep's Interference with Ability to Do Work, Chores, Childcare, or Other Duties

Variables	B	95% CI for B		β	p-value	R^2
	(SE B)	LL	UL	(SE β)		
Interference with R						0.114
Constant	4.190	2.639	5.741	0.145	< 0.001	
	(0.786)			(0.380)		
Pain intensity	– 0.256	– 0.400	– 0.113	– 0.267	**< 0.001**	
	(0.073)			(0.076)		
Age	– 0.005	– 0.026	0.016	– 0.044	0.641	
	(0.011)			(0.095)		
Sex	– 0.010	– 0.223	0.203	– 0.015	0.926	
Ref. "Female"	(0.108)			(0.160)		
Race/ethnicity					0.768	
Ref. "Hispanic"						
"White, Non-Hispanic"	0.103	– 0.379	0.586	0.153		
	(0.245)			(0.364)		
"Non-White, Non-Hispanic"						
	0.178	– 0.347	0.703	0.265		
	(0.266)			(0.395)		
Education	– 0.192	– 0.393	0.009	– 0.286	0.061	
Ref. "Post high school graduates"	(0.102)			(0.151)		
Marital status	– 0.137	– 0.361	0.086	– 0.204	0.226	
Ref. "Single"	(0.113)			(0.168)		
Home Internet access	0.032	– 0.227	0.291	0.047	0.641	
Ref. "Yes"	(0.131)			(0.195)		

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