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Functional Limitations and Well-Being Throughout the Adult Lifespan: The Moderating Role of Sleep

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University.

by

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Table of Contents

List of Tables

List of Figures

Abstract

FUNCTIONAL LIMITATIONS AND WELL-BEING THROUGHOUT THE ADULT LIFESPAN: THE MODERATING ROLE OF SLEEP

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Functional limitations represent individuals' difficulty with completing essential activities of daily living, such as sitting, stooping, and walking. Though functional limitations have been linked to lower well-being outcomes, less is known about potential protective factors for well-being in the experience of functional limitations. The present study used archival data from the MIDUS Refresher study to evaluate how sleep and salient aspects of identity may alter the association between the experience of functional limitations and well-being. In particular, this study had two central aims: to examine the associations between functional limitations, life satisfaction, and affect and detect how aspects of identity may alter these associations, and to examine the potential moderating effect of sleep quality and quantity on the association between functional limitations, life satisfaction, and affect. The current study revealed that functional limitations are negatively associated with life satisfaction and the positivity ratio and provided evidence for the importance of age, racial identity, perceived burden, and global sleep quality in the lived experience of functional limitations. Implications of these findings are discussed.

Keywords: functional limitations, sleep, well-being, lifespan, identity, protective factors

Introduction

Mid- to late- life is a period of salient changes for many individuals. Shifts in career, leadership, family roles, social circles, and physical ability are all commonly endorsed transitions during this time of life (Finke et al., 2005; Luong et al., 2011; Tomás et al., 2018). Although aging into elderhood is also marked by growth, positivity, and resiliency (MacLeod et al., 2016), middle-aged adults and elders face a variety of challenges as they move through these life transitions, including potentially greater susceptibility to stress, cognitive decline, and the development of mental disorders (Fässberg et al., 2016; Kremen et al., 2012; Lang et al., 2011). Middle age and elderhood are also associated with a myriad of health problems that become more common and debilitating with age. Chronic illnesses such as cardiovascular disease, cancer, osteoarthritis, diabetes, and osteoporosis are associated with aging, and around 62 percent of individuals over the age of 85 have multiple chronic condition diagnoses (Jaul & Barron, 2017). Health problems in middle to late adulthood are associated with the development of impairment in physical functioning, which can limit individuals' ability to live autonomously (Manton et al., 2008). Given the potential impact of functional limitations on psychological health and well-being, it is important to identify potential targets that may buffer these impacts (Perrig-Chiello et al., 2006). Sleep is a universal, daily biopsychosocial behavior and is strongly tied to both physical outcomes and general well-being (Buxton et al., 2012; Hamilton et al., 2007; Song et al., 2015; Walker, 2009a). Given these known links, sleep is of particular interest because it may have the potential to ameliorate or exacerbate the effects of functional limitations on well-being. Consequently, the current study has two main objectives: to clarify the associations between functional limitation and various aspects of well-being across adulthood and to explore the potential moderating effects of salient aspects of identity and sleep outcomes.

Functional Limitations

Functional limitations are the most basic indicators of disability, signifying that an individual is having difficulties performing the most fundamental tasks of daily living such as grasping, stooping, bathing, carrying groceries, or walking a short distance (Long & Pavalko, 2004). When these tasks become difficult, routine self-care can become a daily struggle and may lead to the need for full-time care or institutionalization (Luppa et al., 2010). As such, functional limitations represent some of the most pervasive and distressing concerns that individuals may face (Soer et al., 2012; Stenholm et al., 2015). Functional limitations can be conceptualized as existing as a step on a pathway from disease to disability, and are differentiated from similar terms like impairment because they affect the whole organism rather than singular aspects of performance, and from disability because they are a measure of physical performance rather than social performance (Guralnik & Ferrucci, 2003). As they may indicate a future propensity for the development of more chronic and affecting disability, understanding functional limitations and their impact on well-being may be valuable for understanding how to prevent the development of more impairing disabilities (Masala & Petretto, 2008). It is necessary to consider, however, that functional limitations are restricting largely due to ableism at both an individual and systemic level, which creates barriers to access (e.g., transportation, buildings designed for able-bodied individuals) and contributes to discriminatory laws and practices (Rabheru & Gillis, 2021).

Around 40.7 million adults report physical functioning difficulties in the United States alone (Holmes et al., 2009). As individuals age, their risk for developing functional limitations increases substantially (Holmes et al., 2009; Jaul & Barron, 2017). According to the CDC, approximately 17% of adults between 50 and 59 display functional limitations, and this percentage only grows, as over 43% of adults over the age of 80 report the presence of these limitations (Holmes et al., 2009). Indeed, individuals over the age of 80 are 2.5 times as likely to develop functional limitations compared younger adults, and many of these elders report having more than three functional limitations, or trouble with more than three essential daily tasks, at a time (Holmes et al., 2009). The population of elders is expected to increase over 20% by 2050, meaning that this group is projected to include over 2.1 billion people (United Nations, 2017). As the population becomes older, it becomes increasingly important to understand age-related functional limitations and their impact on the experience of elderhood.

A higher propensity for the development of functional limitations is also linked to identifying as a woman (Kastor & Mohanty, 2016; Tareque et al., 2017). Across age and racial identities, women are more likely than men to have one or more functional limitations, and the gap between genders increases with age (Holmes et al., 2009). In a study focusing on functional limitations in adults with type II diabetes, Chiu and Wray (2011) found that psychosocial factors such as perceived control, coping skills, self-efficacy, and depressive symptoms play a role in this gender difference. They found that women with functional limitations associated with a diagnosis of type II diabetes had lower perceived control and feelings of self-efficacy regarding their diagnosis, higher levels of depressive symptoms, and more barriers to coping with their diagnosis than men did. Though it is true that biological and psychological factors play a part in women’s susceptibility to functional limitations, it is important to note that these gender differences are also influenced by the social position that women hold in comparison to men. Women are more likely to have a lower socioeconomic status, experience more stressful life events, and engage in less physical exercise than men—all factors that are linked to limitations due to health (Gorman & Read, 2006).

Racial identity also plays a role in the development of functional limitations. Hispanic individuals are more likely to develop functional limitations relative to the general population, and Black individuals are more likely to develop these limitations than white individuals (Vasquez et al., 2016). The importance of intersectionality in these disparities is particularly accentuated when comparing non-Hispanic Black individuals and non-Hispanic white individuals, with non-Hispanic Black women in particular at more of a disadvantage for experiencing functional limitations compared to non-Hispanic white people of all gender identities (Dunlop et al., 2002). Non-Hispanic Black adults experience the rate of functional limitations equivalent to non-Hispanic white adults who are a decade older (Holmes et al., 2009). In the United States, one in four non-Hispanic Black adults experience functional limitations within an age range as young as 50 to 59, reflecting systemic inequality in functional outcomes between Black and white people in this country (Holmes et al., 2009; Kail & Taylor, 2014). Because individuals who identify as Hispanic or Latinx are the most likely to report functional limitations, followed by non-Hispanic Black individuals, identifying with a minoritized race is an important aspect for consideration when attempting to understand the pervasiveness of functional limitations (Center for Disease Control and Prevention, 2017).

Many middle aged adults and elders report that functional capacity is more important to them than the prevention of disease, highlighting the magnitude of the impact that loss of physical and mental functioning can have on individuals (Paterson & Warburton, 2010). Indeed, limitations in function are linked with several negative outcomes related to health and well-being in later life. Older individuals dealing with functional limitations are more likely to exhibit increased susceptibility to suicidal ideation, cognitive disability, anxiety, and psychological distress (Ahn & Kim, 2015; Mullen et al., 2012). One of the most prevalent complaints associated with functional limitations both cross-sectionally and longitudinally is the presence of depressive symptoms (Brown, 2017). Functional limitations are also predictors of hospital and nursing home stays, greater physician use, and greater mortality levels (Dunlop et al., 2002). Considering all of this, a greater understanding of the association between functional limitations and well-being is essential. Because functional limitations are a common transdiagnostic experience across many physical ailments and diagnoses and can be linked to physical outcomes across conditions, they are especially valuable targets for study. Though we know a considerable amount about the negative effects of functional limitations, less research is focused on the link between functional limitations and positive well-being outcomes. Despite several studies examining the association between health and disease rates with various measures of well-being, few studies have specifically investigated the association between functional limitations and subjective well-being in a non-disease-specific sample (Diener et al., 2017; Freedman et al., 2017; Steptoe et al., 2015).

It is important to note that, though racial identity, gender identity, and age seem to play a part in the development and pervasiveness of functional limitations and the subsequent effects on well-being outcomes, the disparities that exist are also rooted in larger societal issues of racism, sexism, and ageism. In this way, nominal measures of identity may be serving as proxies for systemic discrimination, negative attitudes, and reduced access to care that marginalized groups such as persons of color, women, and elders experience. In particular, racism affects access to quality healthcare, healthcare providers' perceptions of patients' pain, and both micro- and macro-experiences with discrimination in care environments and in the community that may affect the experience of functional limitations (Bastos et al., 2018). Research on sexism has also highlighted that men receive more follow-up medical appointments, more thorough medical exams, and more preventative care than women do (Chrisler et al., 2016). All of this is particularly salient in elderhood, a period of life that is itself marked by increased discrimination and negative stereotypes (Chrisler et al., 2016; Gendron et al., 2016; Levy, 2003). Elderhood stereotypes include the ideas that elders are incompetent, irritable, debilitated, and weak, all of which may be internalized by elders and contribute to a sense of helplessness and dependence (Coudin & Alexopoulos, 2010; Ramírez & Palacios-Espinosa, 2016). Thus, the internalization of these negative stereotypes may affect elders' experiences of functional limitations more significantly than their age alone. It is critical to understand that systemic discrimination and the related discriminatory environment that individuals must exist in plays a part in the way that functional limitations manifest and perpetuate, particularly in marginalized populations (Grollman, 2014; Vang et al., 2021).

Functional Limitations and the Tripartite Model of Subjective Well-Being

The experience of functional limitations is highly subjective and multi-faceted. As such, multiple facets of well-being may be affected by functional limitations. In attempting to understand the far-reaching effects of functional limitations on well-being, it is valuable to consider the larger conceptualization of subjective well-being proposed by Ed Diener, which values both cognitive and affective evaluations of individuals' lives (Diener, 2000). This model of well-being posits that pleasure and satisfaction are key to living a happy and fulfilling life, and individuals' perceptions of their lives and their affective reactions to their circumstances are good indicators of overall wellness and happiness both cross-sectionally and over time (Diener, 2000; Diener & Chan, 2011). As such, it is helpful to understand each aspect of this model of well-being – life satisfaction, positive affect, and negative affect—and how it may relate to the experience of functional limitations, an experience that is strongly associated with negative mental and physical health outcomes (Dunlop et al., 2002; Mullen et al., 2012).

Life satisfaction is the facet of the tripartite model of subjective well-being that reflects the judgements that individuals make about their satisfaction with their current life circumstances, both in general and in specific domains such as health, work, and family relationships (Prenda & Lachman, 2001). Life satisfaction is considered a cognitive evaluation of an individual's hedonic well-being, or the achievement of subjective well-being through the avoidance of pain and the attainment of pleasure (Ryan & Deci, 2001). Perceptions of life satisfaction are most significantly influenced by stable characteristics, such as personality traits, temperament, and chronically salient life events such as gradual loss of physical and mental ability or death of a loved one, but can also be influenced by immediate contextual aspects of life, such as mood or recent life changes (Pavot & Diener, 2008).

Long-term, gradual life changes such as decreases in income, activity level, incidence of disability, unemployment, and negative life events such as a spouse's death or becoming a caregiver for individuals with chronic conditions are associated with long-term lower levels of life satisfaction (Chen, 2001; Lucas, 2007; Pavot & Diener, 2008; Seligowski et al., 2012). The presence of functional limitations is also associated with long-term lower life satisfaction (Bourque et al., 2005; Lucas, 2007; Mehnert et al., 1990; Yang et al., 2016). This association has been explained as a function of autonomy and capability, in that individuals with less choice in how their life circumstances might play out, such as those with physical limitations or disabilities, are less satisfied with life because of a reduction in the opportunity for autonomy (Steckermeier, 2020). Accordingly, functional limitations cannot only be thought of as limitations in movement, instead being a signal of an individuals' capability of "freedom, choice, and independence," largely related to the constraints of an ableist society (Bourret et al., 2002, p. 338). Therefore, functional limitations are seen as vital to understand in relation to satisfaction with life (Åberg, 2008). Although life satisfaction typically fluctuates around an individuals' normative baseline and usually returns to "normal" after a negative life event, age- or chronic condition-related functional limitations and their progression into disability can cause long-term negative effects on life evaluations due to a reduction in adaptation behavior, which is what would usually allow individuals to return to normative level of life satisfaction after a life event (Lucas, 2007; Pavot & Diener, 2008). The ability to adapt and return to a relatively stable satisfaction with life may be different for individuals who are able to return to normative functional capacity following limitations due to illness or medical procedures, as life satisfaction may improve after recovery (Smith, 2015; van Koppenhagen et al., 2009).

After reaching the age of 65, aging has been associated with lower life satisfaction (Chen, 2001; Mroczek & Spiro III, 2005). It is hypothesized that this decrease in satisfaction may be influenced by hindered participation in enjoyable social and leisure activities, leading to loneliness, depressive symptoms, or physical inactivity (Pinto & Neri, 2013). Contradicting this finding, however, Massoudi and colleagues (2004) found that, when comparing adults older than 65 and adults younger than 65 with similar levels of functional limitations, older adults reported a higher quality of life than younger adults. These findings suggest that a contradiction in the literature exists when functional limitations are taken into consideration in examining the relationship between evaluations of life and aging. Consequently, adults younger than 65 may be more susceptible to negative perceptions of their lives when experiencing functional limitations. According to socioemotional selectivity theory, the protective factor of age may be due to a shift toward prioritizing positive information as individuals age, which in turn may positively influence adjustment and well-being in the experience of functional limitations (Carstensen, 1992; Löckenhoff & Carstensen, 2004).

However, it is still true that functional limitations are associated with reduced life satisfaction even in the oldest old. Kunzmann and colleagues (2000) found that although age has a positive effect on well-being, when functional limitations are present in individuals over the age of 65, life satisfaction declines. In fact, functional limitations become an even more significant predictor of life satisfaction than age once individuals reach the age of 65 (Kunzmann et al., 2000). In one study of older veterans, better functional health significantly predicted higher life satisfaction, suggesting that retaining ideal functional capacity in later life can act as a protective factor for life satisfaction just as the loss of functioning can serve as a risk factor for maintaining well-being (Seligowski et al., 2012). This finding is supported by another study that found better health status protected against lower life satisfaction scores (Bellis et al., 2012). In sum, functional status is a potent predictor of life satisfaction outcomes, although this association may differ depending on age (Kunzmann et al., 2000; Seligowski et al., 2012).

Life satisfaction is associated with several other critical health and well-being outcomes, making insight into this concept of particular importance. Life satisfaction is predictive of cardiovascular disease and cancer diagnoses, pain tolerance, and recovery from illness (Diener & Chan, 2011). Moreover, lower levels of life satisfaction are associated with higher risk for mortality for all causes of death, regardless of gender (Kimm et al., 2012). These far-reaching effects necessitate further study regarding the factors that affect how life satisfaction changes and fluctuates throughout the life-course. Since younger and middle-aged adults may experience functional limitations more negatively than elders, and there is conflicting evidence regarding the experience of life satisfaction in elderhood (Chen, 2001; Masoudi et al., 2004; Mroczek & Spiro

III, 2005), it is particularly important to more fully understand the effects of functional limitations on life satisfaction in both younger- and middle-aged individuals and elders.

In addition to life satisfaction, affective reactions to life circumstances are important aspects of the tripartite model of well-being (Diener & Ryan, 2009). These reactions or emotions can be both positive and negative, with positive affect encompassing pleasant emotions and reactions to life circumstances such as joy or enthusiasm and negative affect representing unpleasant emotions such as sadness or frustration (Finch et al., 2012; McMahan & Estes, 2011). Individuals are said to be experiencing higher levels of subjective well-being when they report higher levels of positive affect and lower levels of negative affect (Diener, 2000). Both of these affective states are linked with a number of health outcomes. Higher positive affect is associated with reduced biological reactions to acute stress, lower levels of indicators of inflammatory response in the body, and even a reduced risk of developing coronary heart disease (Davidson et al., 2010; Steptoe et al., 2015). Positive affect is also associated with various positive behaviors and characteristics such as self-efficacy, physical activity, higher energy levels, optimism, and better coping skills (Lyubomirsky et al., 2005). Conversely, higher levels of negative affect are associated with negative health behaviors and psychosocial outcomes such as excessive reliance on social support, greater risk for the development of mental disorders such as anxiety and depression, and lower medication adherence (Bender & Zhang, 2008; Billings et al., 2000; Leger et al., 2018). Negative affect is also associated with the experience of a number of chronic conditions such as coronary heart disease, arthritis, and diabetes (Consedine & Moskowitz, 2007).

Affect has a complex trajectory in aging populations, and many studies report seemingly contradictory results. Some seminal studies support the idea that negative affect decreases with age while positive affect remains the same (Barrick et al., 1989; Gross et al., 1997). Other studies, however, suggest that positive affect seems to decline and negative affect tends to remain stable over time as individuals age (Kunzmann, 2008). Still others report that negative affect decreases until stabilizing at age 60, and positive affect remains stable until decreasing at age 60 (Isaacowitz & Smith, 2003; Kunzmann et al., 2000). Overall, these results point to a complex, multidirectional association between aging and both negative and positive affect. The previously mentioned socioemotional selectivity theory provides a helpful framework for understanding these discrepant findings (Carstensen, 1992). Socioemotional selectivity theory posits that, as individuals age, they increasingly prioritize emotionally meaningful relationships and experiences in order to maintain emotional well-being (Alea et al., 2004). Another concept, the strength and vulnerability integration model of emotional well-being, theorizes that older adults are better at avoiding negative stimuli than younger adults but are more vulnerable to emotional disturbance if exposed to a negative emotional experience for an extended amount of time (Charles, 2010). In other words, older adults have more difficulty returning to emotional homeostasis after exposure to a negative life circumstance. So, affect in the context of aging may be dependent on life circumstances and the availability of positive social and emotional experiences.

Affect has been central in many theories of health behaviors and health outcomes for decades (Davidson et al., 2010; Kunzmann, 2008). It is widely understood that affect and health have a bi-directional association, but much research has focused on the direct causal effect that affect has on health outcomes (Consedine & Moskowitz, 2007). In particular, functional limitations are a predictor of both positive and negative affect, especially in older adults (Smith, 2001). The underlying theory behind this directional effect, the disability hypothesis, states that physical health difficulties and limitations create distress and discomfort, which in turn leads to higher levels of negative affect and lower levels of positive affect over time (Finch et al., 2012; Watson & Pennebaker, 1989). An alternative model, the psychosomatic hypothesis, posits that experiences of chronically negative affect can cause various health problems while positive affect may have implications for greater resistance to the development of physical limitations (Steptoe et al., 2009). Supporting this hypothesis, Ostir and colleagues (2000) found that individuals with higher positive affect were half as likely to report functional limitations or to have passed away after a two year follow-up. In a study of centenarians, or individuals aged over 100, positive affect was indeed related to less difficulty with functional limitations (Franke et al., 2012). Although there is substantial evidence supporting both hypotheses, a clear directional association between functional limitations and affective states has not yet been established.

The current study's focus on well-being is warranted given the historical tendency within the research community to view elderhood from a deficit perspective. Studies that include elders display tend to focus on negatively toned aspects of well-being, such as depression or other mental disorder outcomes (Smith, 2001). Especially in middle aged adults and elders who are experiencing functional limitations, it is essential to examine well-being from a strengths-based approach in addition to a deficit approach. Well-being is complex and multifaceted, and understanding both cognitive and affective aspects of well-being allows for a broader understanding of wellness and resiliency in the face of less than ideal circumstances (Delle Fave et al., 2011; McMahan & Estes, 2011). Living with functional limitations does not have to mean that an individual will have a predominantly negative experience in life (Zarzaur et al., 2017). Though individuals with functional limitations face a number of challenges and barriers, behaviors or strengths that a person possesses may make coping with functional limitations a less distressing experience. Because of this, investigating factors that may ameliorate or exacerbate the effects of functional limitations on subjective well-being is of particular importance.

Sleep Health as a Potential Protective Factor

Though several negative physical and mental health outcomes are associated with functional limitations, protective factors such as social support, exercise, and control beliefs have been shown to mitigate these negative outcomes through the improvement of functioning or the maintenance of current functional capacity (Lachman & Agrigoroaei, 2010). Therefore, it is worthwhile to identify additional factors that may ameliorate or intensify the negative effects of functional limitations in order to protect well-being in persons who experience obstacles due to their physical functioning. Because sleep is a daily, modifiable health behavior with links to executive functioning, physical health, and emotion regulation (Siegel, 2005; Steptoe et al., 2008; Teas & Friedman, 2021), it is a potentially critical protective factor for well-being in persons with functional limitations. Though sleep is impacted by functional limitations and is also associated with well-being outcomes (Luyster et al., 2011, 2012; Palmer & Alfano, 2017; Wilckens et al., 2014), less is known about sleep quality and quantity's role as a moderator of the effects of functional limitations on subjective well-being outcomes.

Sleep is a universal biopsychosocial process by which the body and mind are able to consolidate memories, regulate emotional processes, and promote healing (Adam & Oswald, 1984; Walker, 2009a). Sleep also has implications for a number of physical health outcomes in mid- to late- adulthood. Both excessive and insufficient sleep duration have been linked to diabetes, hypertension, Alzheimer's disease, and depressive disorders (Spira, 2018). Sleep problems are common in middle aged and older adults, with over 50% of community-dwelling older adults reporting symptoms of insomnia and around one third of all adults acknowledging difficulties with falling and staying asleep (Li et al., 2018; Stephan et al., 2017). Disturbed sleep is now considered a public health issue and can be thought of as a risk factor for poorer physical health, making it an important area of study in relation to aging and physical outcomes (Spira, 2018).

Though it is suggested that individuals require less sleep as they age, healthy sleep habits are still essential in middle age and elderhood (Patel et al., 2018). Individuals with better sleep health tend to perform better on cognitive tests, have less risk for poor mental health outcomes, and display better physical functioning despite the presence of chronic pain (El-Sheikh et al., 2014; Tang & Sanborn, 2014; Zhai et al., 2018). Interestingly, in a study examining subjective age and sleep complaints, individuals who reported that they felt older but were not biologically older at baseline reported greater sleeping difficulties than those who reported a younger subjective age (Stephan et al., 2017). This finding suggests that subjective experience is an important factor influencing the association between aging and sleep.

Sleep quality and quantity can be measured objectively, through polysomnography or actigraphy recording, or subjectively through self-report measures (Ibáñez et al., 2018). Polysomnography involves an overnight stay in a sleep lab or at home with a home testing kit. Polysomnography provides information on physiological factors of sleep such as sleep staging, limb movement, respiratory effort, and heart rate throughout sleep, but is usually limited to one to two nights of recording (Rundo & Downey III, 2019). Actigraphy is another objective assessment tool that uses a wristwatch-like device with built-in accelerometers to determine sleep and wake periods from activity movements (Acebo & LeBourgeois, 2006). Actigraphy is less obtrusive than polysomnography and can provide information on sleep timing, fragmentation, and efficiency (Ancoli-Israel et al., 2003). Subjective sleep measures range from self-report retrospective questionnaires to daily prospective diaries. There is inconsistency in the literature regarding the usefulness of “gold standard” objective measures of sleep relative to subjective sleep measures, as results from each type of evaluation do not always concur. Furthermore, there are concerns that the importance of subjective experience is overlooked in favor of objective measures of sleep (Ibáñez et al., 2018; Kaplan, Hardas, et al., 2017; Kaplan & Hirshman, et al., 2017). However, both subjective and objective measures are important for a fuller understanding of individual experience. In particular, subjective measures are useful for understanding how someone is feeling despite how they are objectively doing (Ocampo, 2010). Furthermore, the subjective perception of poor sleep is a clinical requirement for the diagnosis of insomnia (American Psychiatric Association, 2013). Considering all of this, it is helpful to examine both subjective and objective measures of sleep to gain a more complete understanding of sleep behaviors and characteristics.

Sleep is relevant for both the experience of functional limitations and for subjective well-being outcomes. Overall, shorter and longer objectively and subjectively measured sleep duration, worse sleep quality, more frequent nighttime awakenings, and daytime sleepiness are associated with higher levels of functional limitations (Buxton et al., 2012; Goldman et al., 2007; Song et al., 2015; Stenholm et al., 2010). In a study that examined the relationship of sleep deficiency to functional limitations in a sample of hospital workers, Buxton and colleagues (2012) found that the presence of functional limitations is significantly associated with self-reported short sleep duration, which is also referred to as sleep deficiency. These associations held even when controlling for relevant covariates such as race, ethnicity, gender, age, and BMI. These findings are supported by another study that was conducted with the aim of understanding physical performance in older women (Goldman et al., 2007). This study found that individuals who experienced worse sleep as measured by actigraphic data regarding total sleep time and time spent awake after sleep onset were also 1.8 times more likely to report difficulty associated with functional limitations. In a study examining physical functioning and both subjectively reported sleep quality and objectively collected actigraphy data in a sample of older veterans, longer nighttime sleep, more nighttime awakenings, and a greater cumulative wake time were associated with greater incidence of functional limitations, even after controlling for multiple pertinent psychosocial covariates (Song et al., 2015). Stenholm and colleagues (2010) found that, in a large sample of individuals aged 55 and older, individuals that reported both long (>9 hours) and short (<6 hours) sleep duration had a higher probability of having problems with mobility and functional limitations, and daytime consequences of poor sleep such as tiredness throughout the day were associated with functional limitations related to walking. Additionally, Stenholm et al. (2010) found that insomnia and other sleep disorders were associated with functional limitations and walking speed in men over age 55, but only with functional limitations in women over 65. Consequently, sleep seems to have important implications for the experience of functional limitations.

The factors included in the tripartite model of subjective well-being are also associated with sleep outcomes, though they have not been studied in relation to sleep as often as functional limitations or physical ability. Overall, studies indicate that higher positive affect and lower negative affect are both associated with better sleep quality and quantity (McCrae et al., 2008; Norlander et al., 2005; Paterson et al., 2011; Steptoe et al., 2008). In one study of adults aged 58 to 72, higher positive affect was related to better self-reported sleep outcomes, and these sleep outcomes were better for men than women (Steptoe et al., 2008). The authors found that participants who reported no experiences of positive affect over a full day had sleep problem scores that were 47% higher than those who did report experiencing positive affect. In a study characterizing positive and negative affect together as indicating an “affective personality,” individuals with low positive affect and high negative affect reported lower sleep quality when compared to individuals who displayed high positive affect and low negative affect (Norlander et al., 2005). Furthermore, sleep deprivation has been linked to more intense negative affect, including feelings of anger, depression, and fear (Paterson et al., 2011). In a study including elderly Chinese individuals, worse reported sleep quality and short sleep duration, but not long sleep duration, were inversely associated with life satisfaction (Zhi et al., 2016). Another study conducted to understand affect and sleep in older adulthood found that daily positive affect was related to subjective sleep quality but not to actigraphic measures of total unwanted wake time in bed (McCrae et al., 2008). This association seems to hold over time and has shown some directionality, as a longitudinal investigation of poor sleep quality and life dissatisfaction found that poor sleep quality predicted a stable pattern of life dissatisfaction but life dissatisfaction did not predict poor sleep quality in a sample of genetically similar twins (Paunio et al., 2009). Considering all of these findings, the idea that sleep has consequences for emotional processing and contentment with life circumstances seems to be supported.

The underlying reasons why sleep affects physical and mental health outcomes are important to consider in determining the merit of examining sleep as a moderator of the association between functional limitations and well-being. For example, although sleep is independently associated with functioning and well-being, sleep may also serve as a moderator of the link between these two concepts. As such, understanding how sleep affects cognitive and executive functioning, mood and emotion regulation, and physical healing and repair can highlight its potential to buffer or exacerbate the impact of functioning on well-being.

Cognition and executive functioning, especially the coordination of goal-directed behavior, mental flexibility, and task completion associated with working memory, is related to the quality and quantity of sleep (Holanda Júnior & Almondes, 2016). Walker (2009) suggested that sleep deprivation disrupts memory encoding and seems to affect encoding of positive memories more than negative memories. This negativity bias may be consequential for well-being outcomes, as negative memories may be more readily available to poor sleepers (Walker, 2009). Cognitive and executive function also affects other facets of functioning such as physical health and rehabilitation because of the self-regulation, problem solving, and memory skills that are needed in order to live a functionally independent life (Hanks et al., 1999; P. G. Williams & Thayer, 2009). Particularly in relation to functional limitations and rehabilitation, outcomes are dependent on the extent an individual is able to integrate and re-learn tasks needed to rehabilitate disorders, injuries, or disabilities that cause functional limitations (Hanks et al., 1999; Morghen et al., 2011). With all of this in mind, the links between sleep and cognition highlight the potential important role of sleep as a moderator of the functional limitations and well-being associations. If an individual sleeps well, they may exhibit better abilities to complete goal-directed behaviors, self- regulate, and remember and re-learn tasks associated with independent functioning, which may in turn affect well-being (Hanks et al., 1999; Holanda Júnior & Almondes, 2016; P. G. Williams & Thayer, 2009). Poor sleepers may have negative memories associated with their functional limitations more readily available due to increased positive memory encoding disruption, which may also affect the association between functioning and well-being (Walker, 2009).

Sleep is also theorized to play a role in emotion regulation, an important factor to consider in the rationale for examining sleep’s moderating role for functional limitations and subjective well-being (Walker & van Der Helm, 2009). Sleep can be thought of as a reset period in which neuropsychological regulation occurs through emotional brain networks and REM sleep mechanisms (Kahn et al., 2013). As such, sleep loss can create difficulties in engaging in negative emotion inhibitory control, or the ability to suppress negative thoughts and emotions (Dahl & Lewin, 2002) Sleep disruption also amplifies positive emotional reactions to pleasant stimuli, such as eating sugary or high carbohydrate foods, in reward centers of the brain, which could be problematic in the maintenance of healthy behaviors (Gujar et al., 2011). Sleep and its association with affective volatility could affect and intensify an individual's emotional reaction to negative stimuli and circumstances, such as their functional status (Walker, 2009). In addition, Shin and Kim (2018) found that poor sleepers are more likely to engage in social comparison and focus less on positive life experiences, which in turn affected their evaluation of life satisfaction. These findings suggest that poor sleepers with functional limitations might have more trouble focusing on positive aspects of life and might have more intense negative reactions to their functional status.

Sleep also has implications for physical healing and recovery (Friese, 2008). Sleep is a critical period for cell growth, protein synthesis for the repair of tissue and strengthening of bones and cartilage, and other essential metabolic processes (Evans & French, 1995). Indeed, sleep disturbance may be related to an increase in pain and fatigue in individuals who are recovering from traumatic brain injury or stroke, and poor sleep quality is associated with shorter survival time post-rehabilitation (Lowe et al., 2020; Martin et al., 2011). Hence, sleep has long been a target for intervention in hospital and acute care settings, as good sleep seems to be critical for recovery and rehabilitation (Evans & French, 1995; Friese, 2008). Thinking about the role of sleep within the association between functional limitations and well-being, good sleepers may be able to recover more quickly and with less difficulty, potentially impacting well-being outcomes positively. In light of this information, examining sleep as a potential moderator of the association between functional limitations and well-being may be particularly informative. Additionally, because sleep is a universal health behavior that is salient, highly modifiable, and essential in many aspects of optimal cognitive, emotional, and physical functioning, it is a worthwhile target for further study.

Summary and Aims of the Current Study

Functional limitations represent pervasive and distressing difficulties that many middle aged and older adults have to face (Holmes et al., 2009). These limitations can negatively affect many facets of wellness, being strongly associated with negative mental health outcomes, cognitive decline, psychological distress, institutionalization, and higher rates of mortality (Dunlop et al., 2002; Mullen et al., 2012). These detrimental effects on mental and physical health have been extensively studied, however, few studies have examined a continuum of well-being in relation to functional limitations. The three aspects of well-being comprising the tripartite model of well-being— satisfaction, positive affect, and negative affect— have important implications for an individuals' ability to recover from critical illness, pain, and mental health outcomes (Diener & Chan, 2011). It is important to note that positive and negative affect are separate constructs, in that higher positive affect does not necessarily indicate lower negative affect and vice versa (Diener & Emmons, 1984). A helpful approach to highlighting these distinctions and understanding the nuances of affect is the use of the positivity ratio. The positivity ratio reflects the proportion of positive affect to negative affect, with a higher ratio indicating better well-being (Fredrickson, 2013). The use of the positivity ratio may provide a more novel understanding of well-being that still reflects the unique contributions of both positive and negative affect.

Sleep is an essential biopsychosocial process by which individuals are able to regulate cognitive and emotional functioning and physically heal and repair (Friese, 2008; Holanda Júnior & Almondes, 2016; Walker & van Der Helm, 2009). Research supports the idea that physical status affects sleep outcomes in individuals dealing with pain, limited mobility, and critical illness (Bihari et al., 2012; Costa & Ceolim, 2013; Zhang et al., 2013), which suggests that a bi-directional relationship may exist between sleep and functioning. Though a bi-directional association exists, I am interested in specifically probing sleep's role as a moderator versus a correlate of functional limitations to identify the potential of sleep to alter the association between functional limitations and well-being.

Sleep is also a highly modifiable universal concept, making it of particular interest for the development and improvement of interventions purposed for protecting well-being in individuals with functional limitations (Kyle & Henry, 2017). Given these factors, the current study broadly aims to clarify the associations that exist between functional limitations and subjective well-being in mid- to late- life, with consideration of potential buffering effects of sleep. Additionally, because gender and racial identity are associated with the prevalence of functional limitations, sleep outcomes, and well-being, these aspects of identity were included as both covariates and as moderators in the current study (Åberg, 2008; Holmes et al., 2009; Vasquez et al., 2016). Because of the robust associations of age with both the presence of functional limitations and subjective well-being outcomes, age was included as an additional moderator for all moderation analyses (Chen, 2001; Kunzmann, 2008; Paterson & Warburton, 2010). This study specifically aims to understand the association between functional limitations and life satisfaction, positive affect, and negative affect, which are the three aspects of the tripartite model of subjective well-being, and explore the moderating effects of sleep and identity on these associations. Though age, racial identity, and gender identity are used as moderators in the present study, it is important to recognize that systemic factors such as ableism, ageism, racism, and sexism may play a larger role in the association between functional limitations and well-being.

Aim 1. The first aim of this study is to examine whether functional limitations predict the three aspects of the tripartite model of subjective well-being—life satisfaction, positive affect, and negative affect. Based on the literature, I predict that:

(1) Higher functional limitations will be associated with lower life satisfaction after adjusting for relevant covariates.

(2) Higher functional limitations will be associated with a lower positivity ratio.

Aim 1.1. Additionally, the current study aims to understand the moderating roles of identity, specifically, the effects of age (i.e., young adult, middle aged adult, elder), gender (i.e., female, male), racial identity, and perceived burdensomeness on the association between functional limitations and subjective well-being. Based on a review of existing literature, I predict that:

(3) Older age will buffer the negative impact of functional limitations on life satisfaction and positivity ratios.

(4) White racial identity will buffer the negative impact of functional limitations on life satisfaction and positivity ratios, particularly for white younger and middle-aged adults.

(5) Male gender identity will buffer the negative impact of functional limitations on life satisfaction and positivity ratios, particularly for male younger and middle-aged adults.

(6) Lower perceived burdensomeness will buffer the negative impact of functional limitations on life satisfaction and positivity ratios, particularly for younger and middle-aged adults with lower levels of burden.

Aim 2. The second aim of this study is to examine whether sleep quality and quantity has a moderating effect on the associations between functional limitations, life satisfaction, positive affect, and negative affect after accounting for the moderating effects of age. Based on previous studies, I predict that:

(1) Higher global sleep quality (retrospective self-report questionnaire), higher daily sleep quality (daily diary), and shorter onset sleep latency (daily diary) will buffer the detrimental effects of functional limitations on life satisfaction and the positivity ratio, particularly for younger and middle-aged adults.

(2) Longer total sleep time and shorter wake after sleep onset assessed objectively by actigraphy will buffer the detrimental effects of functional limitations on life satisfaction and the positivity ratio, particularly for younger and middle-aged adults.

Method

Participants

The Midlife in the United States (MIDUS) study was first conducted with support from the John D. and Catherine T. MacArthur Foundation Research Network from 1995-1996 and has since been funded by the National Institute on Aging for several follow-up studies. The intended purpose of these studies is to facilitate better understanding of the interactions of biological, social, and psychological factors throughout adulthood (Ryff et al., 2019). Data for the present study were taken from the survey and biomarker projects of the MIDUS Refresher study, which was conducted between 2011-2014 in order to collect data on an updated sample of U.S. adults as compared to the previous MIDUS samples. There were 3,577 participants overall who participated in the MIDUS Refresher study, which represents the initial sample for Aim 1 of the present study. Out of the full sample, 793 participants completed the PSQI assessment, and 276 participants completed the objective sleep measures and the sleep diary assignment of the biomarker project. These two samples will be used for the assessments of sleep for Aim 2 of the present study.

Procedure

A national probability sample of U.S. adults aged 23 to 76 were recruited in order to refresh the original MIDUS sample. These participants completed a 30-minute phone interview along with two self-report questionnaires that collected information on participant demographics, psychosocial factors, and health. After completing these initial surveys, participants were asked to complete tasks associated with other projects in the study, namely, cognitive, biomarker, daily diary, and neurological assessments. Biomarker assessments consisted of taking blood and urine samples, gait analyses, general physical exams, sleep monitoring, and self-reported health measures. The assessments were completed in person at one of three clinical research centers across the United States (University of California at Los Angeles, University of Wisconsin, and Georgetown University). Objective sleep assessments through the use of Actiwatch® activity monitors were conducted only in the sample of participants that completed the biomarker assessments at the University of Wisconsin.

Measures

A subset of psychological, behavioral, and biomarker measures included in the MIDUS Refresher study was selected for analysis in the current study. The following sections detail the measures used in the current study.

Demographic Factors. The participants in this study completed a phone interview in which information about their general background was collected. During this interview, participants reported their age, gender identity, and racial identity. Options available for describing participants’ gender identity were female and male. Options available for describing racial identity were white, Black and/or African American, Native American or Alaska Native Aleutian/Eskimo, Asian, Native Hawaiian or Pacific Islander, or other. Racial identity and gender were used as covariates in the present study. See Table 1 for more information regarding the demographic characteristics of the samples used in the present study.

Perceived Burden. Participants’ perceptions of the burden they place on others was assessed using a single item from a MIDUS created measure that assesses individuals’ perceptions of their own self-control, or ability to exert control over ones’ cognitions, emotional state, and burden consciousness. The item from this scale that was used reads, “I worry I am a burden on others.” Responses range from 1 to 7, with 1 being “strongly disagree” and 7 being “strongly agree.”

Functional Limitations. Functional limitations were evaluated using items from the Instrumental Activities of Daily Living portion of the Functional Status Questionnaire (FSQ) developed by Jette and Cleary (1987). Items in this questionnaire ask participants to rate limitations that their health imposes on instrumental activities of daily living, namely, the ability to walk up a flight of stairs; walk up several flights of stairs; bathe or dress themselves; carry groceries; walk a block; walk several blocks; walk more than a mile; bend, kneel, or stoop; and partake in moderate or vigorous physical activity. Responses can range from 1 to 4, with one being “a lot” and 4 being “not at all.” Responses to each item were summed and averaged to form a single composite score that represented an average level of perceived functional limitation. The IADL portion of the FSQ displays high construct and criterion validity, as well as high reliability ($\alpha > .80$) (Cleary & Jette, 2000).

Life Satisfaction. Participants were asked, “At present, how satisfied are you with your life?” Responses are made on a scale of 1 to 4, with 1 being “very” and 4 being “not at all.” Single item assessments of life satisfaction are commonly used in psychological research, and have been found to be congruent with multidimensional assessments of wellbeing such as the Satisfaction with Life Scale developed by Ed Diener and colleagues (Diener et al., 1985; Fonberg & Smith, 2019).

Positive and Negative Affect. Positive and negative affect were both assessed with 5 items each from the Midlife Development Inventory (MDI), which was specifically created for the MIDUS project, as well as 5 items each from the Positive and Negative Affect Schedule (PANAS) (Crawford & Henry, 2004). The MDI scales were developed using items from other well-established measures of affect such as the Affect Balance Scale and the General Well-Being Schedule (Mroczek & Kolarz, 1998). Positive and negative affect were assessed separately via two ten item self-report questionnaires formed from these two measures that asked about the participants’ experiences with different feelings over the past 30 days. Scores ranged from 1 “very satisfied” to 4 “not at all.” The negative affect scale asked about feelings such as feeling “so sad nothing could cheer you up,” “that everything was an effort,” and “hopeless.” The positive affect scale asked about feeling “in good spirits,” “calm and peaceful,” and “cheerful.” Both scales display high reliability (positive scale: $\alpha = .87$, negative scale: $\alpha =.91$) (Mroczek & Kolarz, 1998).

The PANAS scale included one extra affect descriptor of negative affect as compared to positive affect. As such, one descriptor within the negative affect PANAS scale was removed in order to ensure that positive and negative affect scales each had 10 items total for comparison. The PANAS negative affect scale had two descriptors that were similar— “jittery” and “restless.” Because of this similarity, “jittery” was removed, and “restless” was retained.

The positivity ratio for positive and negative affect was calculated by summing the positive affect scores and the negative affect scores, then dividing the sum of the number of positive affect scores over the established cutoff of ≥3 by the number of negative affect scores that aligned with the established cutoff of ≥ 2. This is aligned with previous studies that have used the positivity ratio (Diehl et al., 2011; Fredrickson & Losada, 2005), which uses these cutoffs to account for the positivity offset theory. This theory states that individuals will typically report more positive affect even if no stimuli are present (Ito & Cacioppo, 2005). Higher scores indicate more positive affect ratios.

Objective Sleep. Objective sleep quality and quantity were evaluated through Actiwatch® activity data. Actigraphy is a wristwatch-like device that uses a built-in accelerometer to monitor wrist movements which are then converted into wake or sleep periods. Participants wore the Actiwatch for 24-hour periods for seven consecutive days. Although several characteristics of sleep can be measured using actigraphy, given the smaller sample size of participants with actigraphy, two measures will be examined in the current study – total sleep time and wake after sleep onset. Total sleep time refers to the total amount of time spent asleep while in bed, and wake after sleep onset refers to the amount of time spent awake between falling asleep and waking for the day. For the purposes of this study, the weekly mean of participants’ total sleep time and wake after sleep onset will be used. These two measures will provide an assessment of sleep duration as well as wakefulness during the night and will complement variables assessed via subjective measures. Actigraphy plays a central role in sleep medicine and assessment, and literature suggests that it sufficiently sensitive to subtle sleep behaviors and changes throughout the night (Sadeh, 2011).

Subjective Sleep. Subjective sleep quality was assessed using items from the Pittsburgh Sleep Quality Inventory (PSQI) and daily diary surveys. The PSQI asks participants to rate their sleep quality overall over the period of one month, with responses ranging from very good to very bad, as well as asking about sleep timing, duration, medication, sleeping environment, and daytime behavior. The total questionnaire includes 19 items, which form 7 component scores of sleep—sleep latency, subjective sleep quality, habitual sleep efficiency, sleep duration, sleep disturbances, daytime dysfunction, and use of sleeping medication (Buysse et al., 1989). These component scores are summed to create one global score, which will be used in the current study. Similarly, participants report their overall sleep quality and their sleep onset latency each morning after waking up for seven days in the MIDUS daily diary survey, which is subsequently averaged to create a weekly mean. These two assessments of sleep quality have been used commonly in sleep research and demonstrate an important facet of sleep behavior—how well one thinks they are sleeping, despite how they are objectively doing (Carney et al., 2012).

Data Analytic Plan

Preliminary data analyses were conducted to assess chosen covariates' relation to the variables of interest. The covariates of racial identity and gender identity were chosen to include in analyses given their significant associations with sleep outcomes. Pearson correlations are presented for all variables (Please see Table 2). Moderated moderation analyses using Hayes' (2013) SPSS PROCESS macro were conducted to assess the effects[1] of sleep quality and quantity on the associations between functional limitations and life satisfaction or the positivity

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[1] For PROCESS model results, the terminology of 'effect' is standard for describing associations. This terminology does not signify a causal association and will be limited to the presentation of the results.

ratio. PROCESS is a tool which allows for the examination of OLS regression coefficients in a model as well as the conditional effects of a moderation using a bootstrapping process. This process includes resampling 5,000 times in order to estimate the bias-corrected sampling distribution of the conditional effects identified in the model. For continuous moderators, the Johnson-Neyman technique was used to identify the intervals at which the predictor slope went from nonsignificant to significant relative to moderator values.

To assess Aim 1, two multiple regressions were conducted with functional limitations predicting (1) life satisfaction and (2) the positivity ratio and controlling for age (continuous), gender (man-identifying, woman-identifying), and race (white, Black/African American, Native American/Aleutian/Eskimo, Asian, Native Hawaiian/Pacific Islander, or other). For Aim 1.1, two simple moderations and six moderated moderations were run with functional limitations predicting (1) life satisfaction and (2) the positivity ratio moderated by age (continuous), gender (man-identifying, woman-identifying), racial identity (white. Black/African American), self-reported perceived burden (see Figure 1). Only white and Black/African American individuals were included in the moderation analyses due to the small sample size of other racial identities in the present study. The latter three moderation analyses (gender identity, racial identity, and perceived burden) included age as an additional moderating factor, given the hypothesized salience of age in the interaction between functional limitations and well-being.

Ten moderated-moderations were completed for Aim 2 (see Figure 2): four with functional limitations predicting life satisfaction and the positivity ratio moderated by actigraphic total sleep and wake after sleep onset (covariates not included due to small sample size); four with functional limitations predicting life satisfaction and the positivity ratio moderated by sleep diary overall sleep quality and sleep onset latency (covariates not included due to small sample size); and two with functional limitations predicting life satisfaction and the positivity ratio moderated by PSQI global sleep quality score controlling for gender and racial identity. Age was included as an additional moderating factor in all analyses for Aim 2. Models were run separately for each moderator given the PROCESS limitation of one moderator for moderated moderation models.

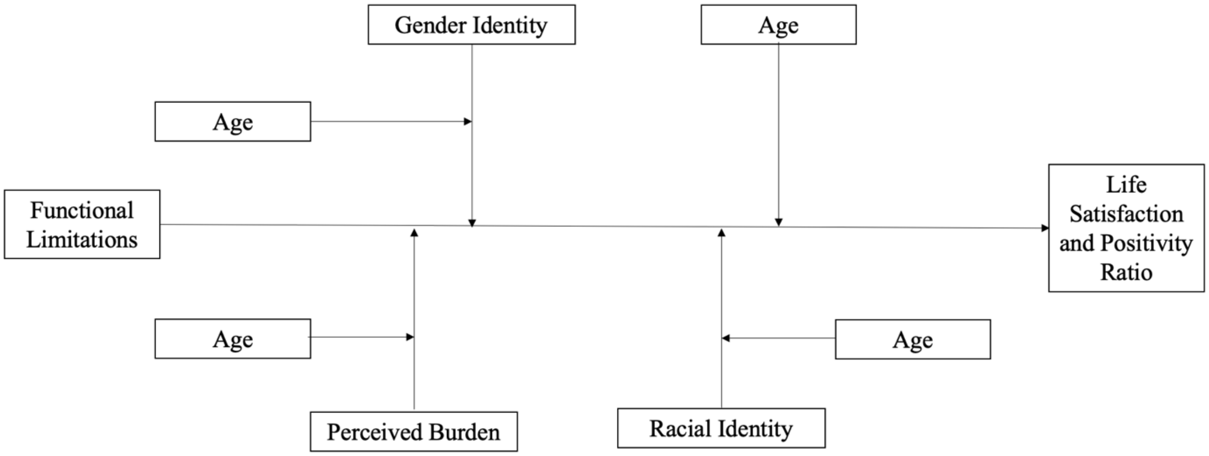

Figure 1. Sample of moderated moderation models for Aim 1.1. Note: models were run separately for age, gender identity, racial identity, and perceived burden for each outcome.

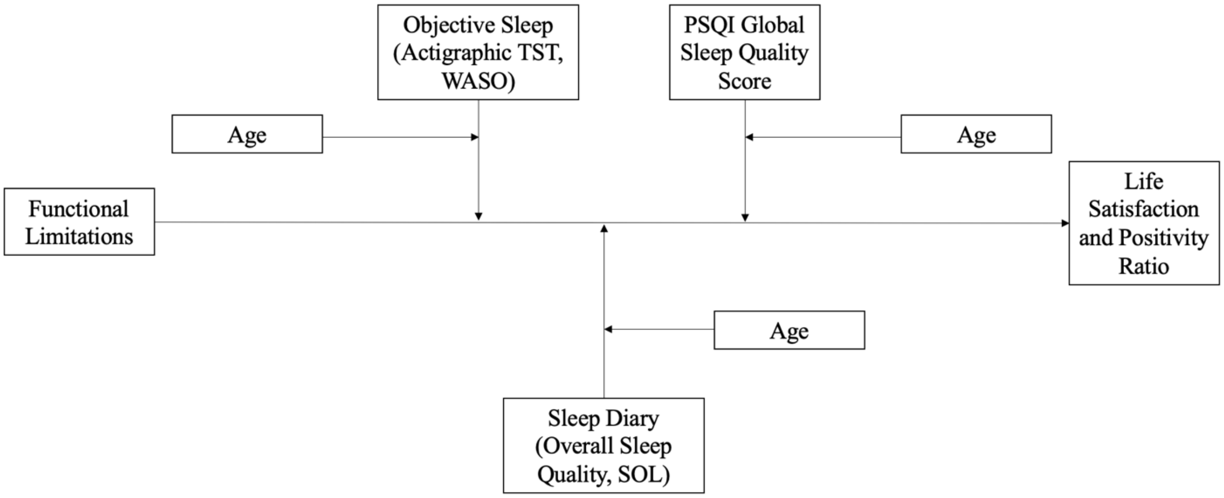

Figure 2. Moderated moderation models for Aim 2. Note: models were run separately for each sleep outcome variable and each outcome.

Results

Data Preparation

SPSS 27.0 was used for all data analyses. A data quality check was conducted to ensure that all main variables and covariates complied with assumptions of univariate and multivariate normality before running further analyses. Data was also checked for skewness, kurtosis, homoscedasticity, linearity, and other relevant assumptions. After winsorizing univariate and multivariate outliers, the data met assumptions of normality.

Power analyses were run to determine whether the three sample sizes used for the aims of the current study are sufficient. Using G*Power, it was determined that 602 participants are needed to detect a small effect size with an alpha level of .05 and a power level of .80 in the model for Aim 1 of the current study. The sample size for this aim is 696, which is sufficient. Furthermore, this sample size is sufficient for the model that includes self-report PSQI sleep measures, with a sample of 647 participants needed to detect a small effect size using an alpha level of .05 and a power level of .80. The use of G*Power also determined that a sample size of 77 was needed to determine a medium effect using an alpha level of .05 and power level of .80 for models with actigraphic data and daily sleep diary assessments. The respective sample sizes of 157 and 609 for these models are adequate. Therefore, the analyses used in this study were sufficiently powered.

Descriptives and Preliminary Correlations

First, sociodemographic and sleep characteristics were examined (Table 1). Participants in Sample 1 (Global Sleep Score/Identity Sample) had an average age of 51.58 years old *(SD = 13.61).* This sample was primarily white (80.6%) and woman-identifying (50.6%). In Sample 2 (Actigraphy Sample), the average age was 50.36 *(SD = 14.30),* and the gender and racial makeup was primarily woman-identifying (52.4%) and white (82.3%). Similarly, Sample 3 (Daily Sleep Diary Sample) consisted of primarily white (84.9%) and woman-identifying (56.8%) participants. The average age for Sample 3 was 50.78 *(SD = 13.46)*. The mean life satisfaction for each sample skewed positively (1 = "very satisfied"), and positivity ratios fell near or above the "critical" positivity ratio of 2.9 (Diehl et al., 2011). Pearson correlations were conducted to examine bivariate associations between all main variables and covariates. This information can be found in Table 2.

Table 1 *Participant Demographics*

	GSS/Identity Sample	Actigraphy Sample	Daily Sleep Diary Sample
Variable		Statistic	
N	696	157	609
M (*SD*) age (years)	51.58 (*13.61*)	50.36 (*14.30*)	50.78 (*13.46*)
Age range	25 - 76	23 - 76	25 - 75
Gender, % female	50.6%	52.4%	56.8%
Race, %			
White	80.6%	82.3%	84.9%
African American	7.9%	7.7%	4.9%
Native American or Alaska Native	2.2%	1.6%	1.0%
Asian	1.7%	1.3%	2.0%
Native Hawaiian/Pacific Islander	0.3%	0.1%	0.0%
Other	7.3%	6.8%	5.9%
M (*SD*) Life Satisfaction	1.49 (.66)	1.50 (*.67)*	1.48 (.66)
M (*SD*) Positivity Ratio	3.23 (*3.01)*	3.23 (*3.01)*	2.58 (*2.70*)
M (*SD*) Functional Limitations	3.47 (0*.71)*	3.45 (*.73)*	3.45 (*.73*)
M (*SD*) Global Sleep Score	5.65 (3.12)	5.92 (3.31)	6.05 (*3.36*)
Actigraphy *(minutes)*			
M (*SD*) Total Sleep Time	--	369.84 *(67.97)*	--
M (*SD*) Wake After Sleep Onset	--	44.27 *(23.24)*	--
Daily Sleep Diary			
M (*SD*) Self Rated Sleep Quality	--	--	2.05 (*0.65*)
M (*SD*) SOL (min)	--	--	20.74 *(17.87)*

Note. SOL = sleep onset latency, WASO = wake after sleep onset, TST = total sleep time

Table 2 *Pearson Correlation Coefficients among Key Study Variables*

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. FL	-											
2. LS	-.15**	-										
3. PR	.24**	-.35**	-									
4. Age	-.25**	-.17**	.12**	-								
5. Race	-.004	.09*	-.05*	-.12**	-							
6. Gender	-.12**	.06	-.06**	-.11**	.06	-						
7. Burden	-.19**	.24**	-.21**	-.17**	.04	.10**	-					
8. GSS *(P)*	-.29**	.30**	-.26**	-.07*	.26**	.20**	.26**	-				
9. SQ *(D)*	-.16**	.25**	-.19**	-.15**	.15**	.09**	.15**	.65**	-			
10. SOL *(D)*	-.21**	.15**	-.16**	-.07*	.08*	.10**	.08**	.62**	.33**	-		
11. TST *(A)*	-.002	-.11	.19**	-.04	.04	.06	.04	-.32**	-.20**	-.20**	-	
12. WASO *(A)*	-.11	.15*	-.19**	-.06	.14*	-.06	.14**	.26**	.18**	.22**	-.15*	-

Note. (P) denotes PSQI data, (A) denotes actigraphy, and (D) denotes daily sleep diary data.
Note. FL = functional limitations. LS = life satisfaction. PR = positivity ratio. GSS = global sleep score. SQ = sleep quality. SOL = sleep onset latency. TST = total sleep time. WASO = wake after sleep onset.
* $p < .05$. ** $p < .01$.

Direct Associations Between Functional Limitations, Life Satisfaction, and Positivity Ratio

Functional limitation status was a significant predictor of life satisfaction $F(3, 692) = 29.09$, $p < .001$, $R^2 = .28$) and the positivity ratio $F(4, 2059) = 186.07$, $p < .001$, $R^2 = .31$) after accounting for covariates of age, gender identity, and racial identity. Lower reported difficulty regarding functional status was associated with both higher satisfaction with life and a higher positivity ratio.

Moderating Effects of Identity

To investigate how age, racial identity, gender identity, and perceived burden may alter the association between functional limitations and well-being measures, a series of moderation analyses were run. Results can be found in Table 3 and Table 4.

Life Satisfaction

Age. After controlling for gender identity and racial identity, age was a significant moderator of the relationship between functional limitation status and reported life satisfaction ($\beta = .01$, $\Delta R^2 = .01$, $F(1, 690) = 8.75$, $p = .0032$) such that the negative association between functional limitations and life satisfaction was strongest in younger adults as compared to middle-aged adults and elders. The negative association of functional limitations with life satisfaction was significant for younger adults (B = -0.35, $p < .001$) and middle-aged adults (B = -0.22, $p < .001$), but had a smaller effect for elders (B = -0.10, $p = .045$).

Gender Identity. After controlling for racial identity, gender identity did not emerge as a significant moderator in the association between life satisfaction and functional limitation status

(B = -0.31, p = .5178). Adding age to this model to assess a potential three-way interaction did not affect the moderating effects of gender identity (β = -0.01, ΔR^2 = .001, F(1, 687) = 1.32, p = .2512).

Racial Identity. Race significantly moderated the association between functional limitation status and life satisfaction (B = -0.39, p = 0.0082) after controlling for gender identity (B = 0.01, p = 0.8155). The addition of age as a moderating-moderator also produced a significant three-way effect (β = -0.002, ΔR^2 = .01, F(1, 687) = 6.89, p = .0089). The moderating effect of racial identity on the association between functional limitation status and life satisfaction was significant for younger adults (B = -0.15, p = .0138), but not for middle aged adults (B = -0.03, p = .3191) or elders (B = 0.07, p = .1051). So, the negative association between functional limitations and life satisfaction was stronger in Black individuals, particularly within younger adults.

Burden. Participants' perceived burden significantly moderated the association between functional limitation status and life satisfaction (B = 0.18, p = .0486) after controlling for gender identity (B = 0.003, p = 0.9461) and racial identity. (B = 0.03, p = 0.0724). The negative association between functional limitations and life satisfaction was stronger for those with a higher degree of perceived burden. A three way interaction including age, perceived burden, and functional limitation status was not significant (β = -0.003, ΔR^2 = .004, F(1, 686) = 3.07, p = .08).

Positivity Ratio

Age. Controlling for gender identity and racial identity, age was not a significant moderator of the relationship between functional limitation status and the positivity ratio (β = -0.003, ΔR^2 = 0.0001, F(1, 2058) = 0.21, p = .6467).

Gender Identity. Gender identity did not emerge as a significant moderator in the association between life satisfaction and functional limitation status (B = 0.15, $p = .9089$). Adding age to this model to assess a potential three-way interaction did not affect the moderating effects of gender identity ($\beta = -0.008$, $\Delta R^2 = .0002$, $F(1, 2055) = 0.35$, $p = .5560$).

Racial Identity. Race did not significantly moderate the association between functional limitation status and life satisfaction (B = -0.34, $p = 0.2109$) after controlling for gender identity. There was not a significant three-way effect between age, racial identity, and functional limitation status ($\beta = 0.004$, $\Delta R^2 = 0.0003$, $F(1, 2055) = .58$, $p = .4483$).

Burden. Participants' perceived burden did not significantly moderate the association between functional limitation status and life satisfaction (B = -0.09, $p = .8842$) after controlling for gender identity and racial identity. A three way interaction including age, perceived burden, and functional limitation status was not significant ($\beta = -0.002$, $\Delta R^2 = .0001$, $F(1, 600) = 0.06$, $p = .8004$).

Moderating Effects of Sleep

The moderating effects of a series of sleep variables on the association between functional limitations and well-being measures were evaluated. Results can be found in Table 5 and Table 6.

Life Satisfaction

PSQI Global Sleep. Participants' global sleep score was a significant moderator of the association between functional limitation status and life satisfaction (B = 0.16, $p < .001$). Within this model, the interaction between the global sleep score and age was significant (B = 0.009, $p < 0.001$), and the interaction between functional limitation status and age was significant (B = 0.03, $p < 0.001$). Overall better global sleep quality buffered the association between higher functional limitations and worse life satisfaction. A significant three-way interaction between age, global sleep, and functional limitations was detected (β = -0.003, $\Delta R^2 = .02$, $F(1, 686) = 12.25$, $p < .001$). The effect of global sleep on the association between life satisfaction and functional limitation status was significant for younger adults (B = 0.07, $p < .001$) and middle-aged adults (B = 0.02, $p = .0224$), but not for elders (B = -0.02, $p = .2223$). Better global sleep quality buffered the association between higher functional limitations and lower life satisfaction for younger and middle-aged adults.

Sleep Diary Sleep Quality. Sleep quality did not significantly moderate the association between functional limitation status and life satisfaction (B = -0.34, $p = 0.2109$). Additionally, no significant three-way effect between age, sleep quality, and functional limitation status was found (β = 0.004, $\Delta R^2 = 0.0003$, $F(1, 2055) = .58$, $p = .4483$).

Sleep Diary Sleep Onset Latency. Sleep onset latency did not significantly moderate the association between functional limitation status and life satisfaction (B = 0.01, $p = 0.0790$). No significant three-way effect between age, sleep onset latency, and functional limitation status was found (β = 0.0002, $\Delta R^2 = 0.003$, $F(1, 733) = 2.10$, $p = .1475$).

Actigraphic Total Sleep Time. Total sleep time did not emerge as a significant moderator in the association between life satisfaction and functional limitation status (B = -0.00, $p = .5444$). Age was added to this model to assess a potential three-way interaction, but it did not significantly affect the moderation (β = 0.0001, $\Delta R^2 = .003$, $F(1, 196) = 0.52$, $p = .47$).

Actigraphic Wake After Sleep Onset. Wake after sleep onset did not significantly moderate the association between functional limitation status and life satisfaction (B = 0.002, $p = 0.8886$). There was not a significant three-way effect between age, wake after sleep onset, and functional limitation status (β = 0.0005, $\Delta R^2 = 0.000$, $F(1, 196) = 0.006$, $p = .9368$).

Positivity Ratio

PSQI Global Sleep. Global sleep did not significantly moderate the association between functional limitation status and the positivity ratio (B = 0.02, $p = 0.9309$). No significant three-way effect between age, global sleep, and functional limitation status was found ($\beta = -0.002$, $\Delta R^2 = 0.0003$, $F(1, 567) = 0.21$, $p = .6489$).

Sleep Diary Sleep Quality. Sleep quality did not significantly moderate the association between functional limitation status and the positivity ratio (B = -1.11, $p = 0.4222$). Additionally, no significant three-way effect between age, sleep quality, and functional limitation status was found ($\beta = 0.009$, $\Delta R^2 = 0.0002$, $F(1, 599) = 0.15$, $p = .6957$).

Sleep Diary Sleep Onset Latency. Sleep onset latency did not significantly moderate the association between functional limitation status and the positivity ratio (B = 0.03, $p = 0.2904$). There was not a significant three-way effect between age, sleep onset latency, and functional limitation status ($\beta = -0.001$, $\Delta R^2 = 0.003$, $F(1, 599) = 2.09$, $p = .1483$).

Actigraphic Total Sleep Time. Total sleep time did not emerge as a significant moderator in the association between the positivity ratio and functional limitation status (B = 0.01, $p = 0.5410$). Age was added to this model to assess a potential three-way interaction, but it did not significantly affect the moderation ($\beta = -0.0003$, $\Delta R^2 = .005$, $F(1, 147) = 0.80$, $p = .3720$).

Actigraphic Wake After Sleep Onset. Wake after sleep onset did not significantly moderate the association between functional limitation status and the positivity ratio (B = 0.02, $p = 0.7644$). No significant three-way effect between age, wake after sleep onset, and functional limitation status was found ($\beta = -0.001$, $\Delta R^2 = 0.001$, $F(1, 147) = 0.16$, $p = .6930$).

Table 3 *Identity Moderations for Life Satisfaction (Aim 1.1)*

	Age		**Race**		**Gender**		**Perceived Burden**	
	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI
Functional Limitations *(X)*	-0.63 (0.153)***	-0.933, -.332	-0.08 (0.261)	-0.595, 0.430	-0.16 (0.575)	-1.294, 0.965	-1.40 (0.429)***	-2.246, -0.559
Age	-0.04 (0.009)***	-0.183, 1.321	-0.001 (0.017)	-0.035, 0.031	-0.01 (0.036)	-0.084, .057	-0.09 (0.027)**	-0.138, -0.033
Racial Identity	0.03 (0.018)	-0.001, 0.068	1.53 (.548)**	0.451, 2.602	0.034 (0.018)	-0.001, 0.069	0.03 (0.017)	-0.003, 0.066
Gender Identity	0.01 (0.049)	-0.089, 0.105	0.01 (0.049)	-0.085, 0.108	0.793 (1.23)	-1.613, 3.200	0.003 (0.049)	-0.092, 0.099
Burden							-0.62 (0.330)	-1.266, 0.031
FL x Age	0.01 (.002)**	0.003, 0.013						
FL x Racial Identity			-0.39 (0.147)**	-0.679, -0.101				
FL x Racial Identity x Age			0.01 (0.003)**	0.002, 0.012				
FL x Gender Identity					-0.31 (.331)	-0.966, 0.337		
FL x Gender Identity x Age					0.01 (.006)	-0.005, 0.020		
FL x Burden							0.18 (0.089)*	0.001, 0.352
FL x Burden x Age							-0.002 (.002)	-0.006, 0.0003)
Model Summary	$R^2 = 0.09$		$R^2 = 0.10$		$R^2 = 0.09$		$R^2 = 0.12$	
	F (5, 690) = 13.17, *p* < .001		*F* (8, 687) = 9.27, *p* < .001		*F* (8, 687) = 8.84, *p* < .001		*F* (9, 686) = 10.47, *p* < .001	

Notes. *p < .05, **p < .01, ***p < .001.

Table 4 *Identity Moderations for Positivity Ratio (Aim 1.1)*

	Age		**Race**		**Gender**		**Perceived Burden**	
	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI
Functional Limitations *(X)*	1.32 (0.365)***	0.600, 2.034	1.93 (0.560)***	0.827, 3.025	1.12 (1.33)	-1.491, 3.740	2.27 (2.03)	-1.717, 6.255
Age	0.056 (0.022)*	0.012, 0.100	0.09 (0.035)*	0.022, 0.160	0.022 (0.082)	-.139, 0.183	0.08 (0.125)	-0.167, 0.325
Racial Identity	-0.05 (0.050)	-0.149, 0.049	1.44 (0.998)	-0.552, 3.392	-0.05 (0.050)	-0.153, 0.044	-0.17 (0.082)*	-0.003, 0.066
Gender Identity	-0.038 (0.130)	-0.293, 0.049	-0.053 (0.130)	-0.307, 0.202	-0.32 (2.84)	-5.891, 5.241	0.40 (0.232)	-0.054, 0.858
Burden							0.05 (1.608)	-3.108, 3.209
FL x Age	-0.003 (0.006)	-0.015, 0.010						
FL x Racial Identity			-0.34 (0.276)	-0.885, 0.196				
FL x Racial Identity x Age			0.004 (0.005)	-0.006, 0.014				
FL x Gender Identity					0.15 (0.775)	-1.376, 1.665		
FL x Gender Identity x Age					-0.01 (0.013)	-0.034, 0.018		
FL x Burden							-0.09 (0.437)	-0.945, 0.773
FL x Burden x Age							-0.001 (0.008)	-0.017, 0.013
Model Summary	$R^2 = 0.10$		$R^2 = 0.10$		$R^2 = 0.10$		$R^2 = 0.13$	
	F (5,2058) = 44.68, *p* < .001		*F* (8, 2055) = 28.75, *p* < .001		*F* (8, 2055) = 28.34, *p* < .001		*F* (9, 600) = 9.78, *p* < .001	

Notes. *p < .05, **p < .01, ***p < .001.

Table 5 *Sleep Outcome Moderations for Life Satisfaction (Aim 2)*

Aim 2: Life Satisfaction	**PSQI Global Sleep Score**		**Daily Diary Sleep Quality**		**Daily Diary Sleep Onset Latency**		**Actigraphic Total Sleep Time**		**Actigraphic Wake After Sleep Onset**	
	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI
Functional Limitations *(X)*	-1.71 (0.356)***	-2.409, -1.011	-1.27 (0.507)*	-2.260, -0.270	-0.86 (0.217)***	-1.289, -0.436	0.65 (1.610)	-2.525, 3.828	-0.35 (0.692)	-1.715, 1.014
Age	-0.10 (0.023)***	-0.146, -0.058	-0.08 (0.032)*	-0.144, -0.016	-0.05 (0.014)***	-0.081, 0.027	0.04 (.106)	-0.171, 0.245	-0.02 (0.045)	-0.104, 0.073
FL x GSS	0.16 (0.043)***	0.081, 0.249								
FL x GSS x Age	-0.003 (0.001)***	-0.004, -0.001								
FL x SQ			0.34 (0.231)	-0.100, 0.807						
FL x SQ x Age			-0.01 (.004)	-0.015, 0.002						
FL x SOL					0.01 (0.007)	-0.001, 0.025				
FL x SOL x Age					-0.000 (0.0001)	-0.0004, 0.0001				
FL x TST							-0.002 (0.004)	-0.010, 0.005		
FL x TST x Age							0.00 (0.0001)	-0.0001, 0.0002		
FL x WASO									0.002 (0.013)	-0.024, 0.028
FL x WASO x Age									0.00 (0.0003)	-0.0005, 0.0005
Model Summary	R^2 = 0.16 *F* (9, 686) = 14.39, *p* < .001		R^2 = 0.13 *F* (7, 733) = 14.98, *p* < .001		R^2 = 0.10 *F* (7, 733) = 11.92, *p* < .001		R^2 = 0.062 *F* (7, 196) = 1.84, *p* = .0813		R^2 = 0.061 *F* (7, 196) = 1.81, *p* = .0878	

Notes. *p < .05, **p < .01, ***p < .001.

Table 6 *Sleep Outcome Moderations for Positivity Ratio (Aim 2)*

Aim 2: Positivity Ratio	**PSQI Global Sleep Score**		**Daily Diary Sleep Quality**		**Daily Diary Sleep Onset Latency**		**Actigraphic Total Sleep Time**		**Actigraphic Wake After Sleep Onset**	
	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI	Coefficient (*SE*)	0.95% CI
Functional Limitations *(X)*	1.67 (1.792)	-1.855, 5.1857	4.53 (2.968)	-1.295, 10.364	1.26 (1.147)	-0.992, 3.513	-3.18 (7.879)	-18.755, 12.386	0.28 (3.685)	-7.001, 7.562
Age	0.07 (0.113)	-0.153, 0.292	0.24 (0.185)	-0.118, 0.610	0.05 (0.072)	-0.086, 0.196	-0.15 (0.509)	-1.161, 0.851	-0.02 (0.236)	-0.489, 0.441
FL x GSS	0.02 (0.223)	-0.418, 0.457								
FL x GSS x Age	-0.002 (0.004)	-0.010, 0.006								
FL x SQ			-1.11 (1.385)	-3.832, 1.608						
FL x SQ x Age			0.01 (0.024)	-0.038, 0.056						
FL x SOL					0.03 (0.033)	-0.029, 0.099				
FL x SOL x Age					-0.001 (0.001)	-0.002, 0.000				
FL x TST							0.01 (0.018)	-0.024, 0.046		
FL x TST x Age							-0.0003 (0.0003)	-0.001, 0.0004		
FL x WASO									0.019 (0.065)	-0.109, 0.148
FL x WASO x Age									-0.001 (0.001)	-0.003, 0.002
Model Summary	$R^2 = 0.12$		$R^2 = .11$		$R^2 = 0.10$		$R^2 = 0.14$		$R^2 = 0.12$	
	F (9, 567) = 8.43, $p < .001$		F (9, 599) = 8.54, $p < .001$		F (9, 599) = 7.69, $p < .001$		F (9, 147) = 2.68, $p < .01$		F (9, 147) = 2.18, $p < .05$	

Notes. *p < .05, **p < .01, ***p < .001.

Discussion

The overall objective of the present study was to evaluate how sleep and aspects of identity may alter the association between the experience of functional limitations and well-being. In particular, this study had two central aims: 1) to examine the associations between functional limitations, life satisfaction, and affect and detect how aspects of identity may alter these associations, and 2) to examine the potential moderating effect of sleep quality and quantity on the association between functional limitations, life satisfaction, and affect. In particular, this study identified the importance of age, racial identity, perceived burden, and sleep quality in the experience of functional limitations and associated life satisfaction. However, no significant moderations were detected for the positivity ratio. As such, results of the present study supported some of the present hypotheses and did not provide significant findings for others.

The current study identified a significant negative association between functional limitations and the factors that represent salient components of the tripartite model of well-being—life satisfaction and the positivity ratio. In other words, greater difficulty with functional limitations was associated with lower life satisfaction and a lower positivity ratio (e.g., a greater proportion of negative as compared to positive affect). These findings contribute to a growing body of literature that points to the critical role of the experience of functional limitations and related feelings of dependence and loss of autonomy in subjective well-being (Franke et al., 2012; Kunzmann, 2008; Masoudi et al., 2004; Smith, 2001). This study was also the first to examine the positivity ratio, a novel measure of affect, as an indicator of well-being relative to functional limitations. Understanding the experience of functional limitations is critical, given that they are a transdiagnostic experience that occur across many different physical conditions and can be linked to physical health outcomes and mortality (Ahn & Kim, 2015; Dunlop et al., 2002; Mullen et al., 2012). Most functional limitation research has focused on risk factors and negative outcomes. The present study highlighted the importance of examining positive, protective factors in relation to functional limitations.

Along with examining the association between functional limitations and well-being, another aim of the present study was to investigate the way that this association may change based on salient aspects of identity. It was hypothesized that older age, identifying as a woman, white racial identity, and lower levels of perceived burden would buffer the negative association between functional limitations and life satisfaction. Age, racial identity, and perceived burden emerged as significant moderators in the current study, while gender identity did not.

Age significantly moderated the negative association between functional limitations and life satisfaction such that, when younger (<35), middle-aged (36-52) and elders (>52) were compared, this negative association was strongest for younger adults. In other words, elders report the smallest decreases in life satisfaction in relation to functional limitations compared to younger and middle-aged adults. Previous literature has noted that functional limitations tend to increase as individuals age (Jaul & Barron, 2017; Masoudi et al., 2004; Mroczek & Kolarz, 1998; Seligowski et al., 2012), although there is conflicting evidence for the trajectory of life satisfaction, particularly throughout middle age and elderhood (Baird et al., 2010; Gaymu & Springer, 2010; Gerstorf et al., 2008; Stone et al., 2010). However, few studies link these two concepts together in relation to age. The current findings clarify the trajectory of life satisfaction across the adult lifespan, specifically in relation to the development of functional limitations.

Functional limitations may have a more negative impact on younger adults' life satisfaction for a few reasons. In one study investigating the effects of pain on the psychological stress of younger and older cancer patients, Krok and colleagues (2013) found that younger cancer patients that reported more difficulty with functional limitations reported higher pain, worse sleep disturbance, and more frequent feelings of worry, stress, and anxiety than older participants. In another study, younger adults experiencing neurological injury-related pain reported a more constricted range of coping skills and resources as well as less social support than older adults (Molton et al., 2008). These findings may indicate that younger adults that are experiencing functional limitations are less equipped to cope with the various changes that may come along with a change in functional status. Additionally, younger adults might experience functional limitations more negatively due to ageism. This ageism might cause more distress for younger adults, as they may desire to create distance between themselves and functional limitations that they may perceive as being related to older age (Barrett et al., 2021; Bodner, 2009; Chrisler et al., 2016). Additionally, as functional limitations may be stereotyped as more characteristic of elderhood, younger adults may receive less social support relative to their functional limitations because their experience is not seen as pervasive or affecting. Indeed, younger adults who report disabilities are more lonely than elders (Emerson et al., 2021).

Elders, on the other hand, may have a greater ability to manage distress and cope with negative evaluations related to their functional limitation status. This concept is central to the previously mentioned socioemotional selectivity theory, which can provide a helpful framework for understanding elderhood as a protective factor for well-being when experiencing functional limitations. Elders may also tend to underreport negative evaluations of pain and functional limitations, as it is more likely to be seen as a part of the aging process (Caltagirone et al., 2010; Ferrer et al., 1999; Krok et al., 2013).

Racial identity also emerged as a significant moderator. As hypothesized, white racial identity served as a buffer for the negative association between functional limitations and life satisfaction. This negative association was more pronounced in Black individuals than in white individuals. This was especially true in younger adults, and was not significant for middle aged adults or elders. Black individuals face greater levels of stressors throughout both childhood and adulthood, which has been linked to a greater presence of functional limitations as well as lower life satisfaction in Black populations (Barger et al., 2009; Sauerteig et al., 2021). Disparities between Black-identifying and white-identifying individuals also exist in access to care and quality of care, which may undermine the management of functional limitations and subsequent effects on well-being for Black individuals (Rhee et al., 2021). As such, systemic factors may play a large part in the racial disparities within the association between life satisfaction and functional limitations. Importantly, given the moderated moderation of race by age, younger adulthood for Black-identifying individuals may be a particularly vulnerable time for well-being when experiencing functional limitations.

Individuals' perceived level of burden placed on others also significantly moderated the association of interest, such that individuals with higher levels of reported burden displayed a stronger negative association between functional limitations and life satisfaction. Age, however, did not emerge as a significant secondary moderator in this model. Therefore, it seems that the buffering effect of a low level of perceived burden may be salient across age groups. Individuals with a higher sense of burden may experience a sense of guilt, distress, and a reduced sense of self (Libert et al., 2017). Experiencing feelings of burden can also have implications for treatment seeking and choices made regarding life-extending procedures (Libert et al., 2017; Zweibel & Cassel, 1989). These behaviors may also arise due to an internalized sense of ableism, in that the subjective experience of functional limitations may be rooted in societal value placed on independence and productivity, particularly in the United States (Campbell, 2009; Menec, 2003). Individuals with a lower sense of burden may be better able to manage negative emotions that surface with the development of functional limitations.

Gender identity did not emerge as a significant moderator in the present study. Although post hoc t-tests revealed that woman-identifying individuals experience higher levels of functional limitations than man-identifying individuals, these differences were not significant. Prior research has shown that women report higher levels of functional limitations (Chiu & Wray, 2011; Dunlop et al., 2002). It is possible that the lack of gender differences in functional limitations in the present sample contributed to the nonsignificant moderation. As such, the association between functional limitations and life satisfaction appears to be similar between man-identifying and woman-identifying individuals in the current sample.

The results from aim 1 call greater attention to systemic factors that may be affecting the lived experience of functional limitations, particularly for groups that have historically experienced discrimination and marginalization. In particular, the realities of an ableist society may increase distress in individuals who are not able to care for themselves (Menec, 2003). Racism and discrimination also contribute to undue stress in individuals with minoritized racial identities, perhaps making the already distressing experience of the loss of functioning even more distressing (Rhee et al., 2021; Sauerteig et al., 2021). The present study, though it centers individual-level factors of age, racial identity, and gender identity as moderating factors rather than systemic issues such as ageism, ableism, racism, and sexism, highlights a crucial difference in well-being for individuals of marginalized racial identities and younger age in the face of functional limitations.

Given that systemic factors may play a role in exacerbating the negative experience of functional limitations, the second main aim of the present study was to explore the role of a universal, daily process—sleep—as a potentially modifiable target. Previous research has indicated that minoritized groups also experience worse sleep quality. Indeed, racial and ethnic minorities tend to experience shorter sleep duration, poorer sleep quality, more inconsistent sleep timing, and more sleepiness (Johnson et al., 2019; Unruh et al., 2008; Williams et al., 2015). This is important context to keep in mind when interpreting the significant moderation of the global sleep score, which reflects general sleep quality, in the association between functional limitations and life satisfaction.

The negative association between functional limitations and life satisfaction was stronger for individuals who had worse global sleep quality. Additionally, this moderation was significant for younger adults and middle-aged adults, but not for elders. So, poorer sleep quality exacerbated the negative experience of functional limitations for younger and middle-aged adults, but not for elders. Prior research has focused on negative associations between functional limitations and general well-being (Bourque et al., 2005; Kunzmann, 2008; Yang et al., 2016). Previous research has also found that worse sleep quality is associated with poorer physical health outcomes and negatively impacts well-being (Buxton et al., 2012; Song et al., 2015; Zhi et al., 2016). The present study’s finding extends existing literature by, for the first time, examining sleep as a potential protective factor in the experience of functional limitations. Poor sleep has been linked to increased inflammation responses in the body, increased stress and anxiety, and diminished cognitive and motor performance (Buysse et al., 1989; Luyster et al., 2012). As such, those who experience poorer sleep may be more susceptible to distress surrounding their functional status, as well as other health problems that may exacerbate negative experiences associated with their functional status. The interaction with age suggests that sleep is particularly important for younger and middle-aged adults with functional limitations. Assessing and targeting sleep at an earlier time in the lifespan may be crucial for promoting life satisfaction among these groups. This is especially true as younger adults are more susceptible to chronic sleep deficiency and disruption of the circadian rhythm (Zitting et al., 2018). Additionally, middle aged adults may be experiencing disrupted sleep and increased stress due to caregiving roles for both parents and children, changes in social and financial status, and physical changes (e.g., the effects of menopause) (Hume et al., 1998; Leger et al., 2021; Willis & Reid, 1998). The lack of significant findings for elders is less clear. Follow-up analyses revealed no significant differences in global sleep quality among younger adults, middle-aged adults, and elders. Perhaps a clue can be found within the interaction between functional limitations, age, and sleep. First, the association between functional limitations and life satisfaction is less robust for elders, as shown in the moderation that only includes age in the present study. Therefore, it may have been more difficult to detect the moderating effect of sleep within the older adult sample. In other words, there was less of an association between functional limitations and life satisfaction to predict with sleep in elders.

Other sleep outcomes examined in the current study included daily diary sleep quality, daily diary sleep onset latency, actigraphic total sleep time, and actigraphic wake after sleep onset. A wide array of sleep measures, both subjective and objective, were used in order to gain a broader view of sleep outcomes and how different aspects of sleep may relate to the subjective experience of functional limitations. However, only the global sleep score of the PSQI, a measure that encompasses 7 domains of sleep (sleep latency, subjective sleep quality, habitual sleep efficiency, sleep duration, sleep disturbances, daytime dysfunction, and use of sleeping medication), emerged as a significant predictor. The significance of global sleep quality may reflect the importance of subjective sleep, or how one feels that they are sleeping, over objective measures of sleep, such as actigraphic measures. The importance of global sleep may also reflect the significance of subjective sleep across several domains, as the subjective measures of individual aspects of sleep, such as the daily diary sleep quality measure, were not significant. Given that life satisfaction and global sleep quality were both retrospective, global measures, there may also be a degree of measurement concordance present in this analysis. Additionally, analyses including actigraphic and daily diary data included smaller sample sizes, and were less powered to detect small effects.

Two well-being outcomes were examined in the present study: life satisfaction and the positivity ratio. The positivity ratio is a novel way to examine affect, in that it allows for a better understanding of an individuals' affective experience through the calculation of the *ratio* of positive to negative affect. This was the first study to examine the positivity ratio in relation to functional limitations. Although higher levels of functional limitations were significantly associated with a lower positivity ratio, no significant moderations were found relative to the association between functional limitations and the positivity ratio. The significance of the life satisfaction outcome versus the positivity ratio may reflect the importance of long-term evaluations of one's life in relation to the experience of functional limitations, as the positivity ratio asked participants to rate affect for the past 30 days while the life satisfaction measure did not limit the time frame of the evaluation. Additionally, the positivity ratio was created using a mixture of two separate scales—one created specifically for the MIDUS Refresher study, and one that included items from the Positive and Negative Affect Schedule (PANAS). In past research, the positivity ratio was created using the full PANAS scale (Diehl et al., 2011;

Fredrickson & Losada, 2005). This difference may have contributed to the nonsignificance of positivity ratio analyses in the present study.

Limitations

It is important to acknowledge the limitations that are present within the current study. Through the use of a cross-sectional design, I could not analyze the associations of interest over time. Future studies may benefit from prioritizing a longitudinal design to examine functional limitations and well-being trajectories across the lifespan. This study also lacked racial and ethnic diversity, which affects the generalizability of the results. To better understand how functional limitations affect well-being outcomes, future work should take place in more diverse samples.

Additionally, gender identity in this study was limited to only man-identifying and woman-identifying, which is not representative of all gender identities. Future research should expand this definition and include individuals who have other gender identities, such as nonbinary individuals. The study is also limited because of its sole use of self-report data, specifically related to functional limitation status. Future research should seek to include objective data to supplement subjective measures, such as gait and grip strength tests.

Sleep measurement in the present study may also represent a limitation. The sample size for the sleep diary and actigraphy outcomes was small, and these analyses were only powered to detect medium effects. It is also possible that other aspects of sleep that were not included in this study, such as sleep environment, could play a differential role in this association.

Implications and Future Directions

Despite these limitations, the present study’s results have several implications for future research endeavors as well as clinical practice. One particularly important implication for future research is the need for consideration of systemic factors, such as ageism, ableism, and racism, as they relate to the experience of functional limitations. Including measures such as the Expectations Regarding Aging Scale, the Symbolic Ableism Scale, or the Perceived Discrimination Scale may be helpful for future understanding of these impacts (Ayalon et al., 2019; Friedman & Awsumb, 2019; Sims et al., 2009). As the current study was limited to measures used in the MIDUS Refresher project, these measures were not available for inclusion.

Clinicians may benefit from prioritizing preventative, education-based intervention regarding the impact of functional limitations and potential coping skills. Additionally, the identification of Black racial identity and younger age as important factors in the experience of functional limitations may help target individuals who need additional support, and may help clinicians provide additional resources to those more at risk for negative impacts to well-being. In particular, the present study highlights the need for mental health support for younger adults and adults with minoritized racial identities who are dealing with functional limitations that may impact their mobility, independence, and self-perceptions. It would be potentially valuable to include mental health screening measures in inpatient, outpatient, in-home care, and other rehabilitation or assisted living contexts that work with adults with functional limitations. Additionally, social interventions that target negative perceptions and stereotypes regarding ability status and ableism may be beneficial in reducing the negative impact of functional limitations on well-being.

Additionally, sleep quality and perceived burden both represent a salient, malleable modifiers of the negative experience of functional limitations. Consequently, targeting the sleep quality of individuals with functional limitations may be crucial in preventing negative impacts to subjective well-being. This approach may mean implementing screening tools for sleep outcomes and perceived burden in medical and mental health care settings, as well as implementing interventions that improve sleep quality and improve sense of self or self-efficacy to target perceived burden. Cognitive behavioral therapy for insomnia (CBTi) is a highly effective, first line approach for addressing insomnia in adults (Qaseem et al., 2016). CBTi has been adapted for use for various populations including for individuals in pain, cancer survivors, individuals with traumatic brain injury, and racial and ethnic minorities (Nowakowski et al., 2021). Less is known about specific adaptations for functional limitations. However, this is promising area of future research. In instances when functional limitations may not be malleable, the current findings provide preliminary support for addressing perceived global sleep quality as a way to buffer the impact of these limitations.

Conclusion

The current study provided evidence for the importance of age, racial identity, perceived burden, and global sleep quality in the lived experience of functional limitations. This study contributes to a rapidly growing body of literature that seeks to identify protective factors for individuals experiencing lower functioning and can help expand upon conceptualizations of a broader view of physicality and multi-faceted health and well-being in adulthood. Future research may benefit from examining systemic factors, such as racism, ableism, and ageism within the association between functional limitations and well-being. In the future, clinicians should integrate sleep quality and mental health screeners in medical and mental health care settings in order to identify at-risk individuals who are experiencing functional limitations, and potentially consider establishing preventative, education-based interventions concerning the experience of functional limitations.

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