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# Stroke impact symptoms are associated with sleep-related impairment

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## Abstract

**Background:** Sleep-related impairment is a common but under-appreciated complication after stroke and may impede stroke recovery. Yet little is known about factors associated with sleep-related impairment after stroke.

**Objective:** The purpose of this analysis was to examine the relationship between stroke impact symptoms and sleep-related impairment among stroke survivors.

**Methods:** We conducted a cross-sectional secondary analysis of a baseline (entry) data in a completed clinical trial with 100 community-dwelling stroke survivors recruited within 4 months after stroke. Sleep-related impairment and stroke impact domain symptoms after stroke were assessed with the Patient-Reported Outcomes Measurement Information System Sleep-Related Impairment scale and the Stroke Impact Scale, respectively. A multivariate regression was computed.

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**Results:** Stroke impact domain—mood ($B = -.105$, $t = -3.263$, $p = 0.002$)— and fatigue ($B = 0.346$, $t = 3.997$, $p < .001$) were associated with sleep-related impairment.

**Conclusions:** Our findings suggest that ongoing stroke impact symptoms are closely related to sleep-related impairment. An intervention targeting both stroke impact symptoms and sleep-related impairment may be useful in improving neurologic recovery and quality of life in stroke survivors.

### Keywords

stroke impact symptoms; sleep-related impairment; sleep disturbance post-stroke; wake disturbance post-stroke; secondary analysis randomized controlled trial

## Introduction

In the United States, the economic burden of stroke is more than $72 billion annually (Benjamin et al., 2017). Stroke is a leading cause of disability worldwide (Feigin et al., 2015), and approximately 40% of stroke survivors have some degree of lingering functional impairment (Young & Forster, 2007). Stroke survivors often experience stroke impact symptoms in such domains as motor function, cognition, communication, mood, activities of daily living, and social participation (P. W. Duncan, Bode, Min Lai, & Perera, 2003; Meyer et al., 2015) which limit their ability to return home or to work and improve their quality of life.

Sleep disorders, including sleep apnea, nighttime sleep disturbances, and excessive daytime sleepiness, occur commonly after stroke and may contribute to impaired functioning (Park & Choi-Kwon, 2018). The prevalence of sleep apnea after stroke has been estimated to be as high as 78% (Johnson & Johnson, 2010; Menon, Sukumaran, Varma, & Radhakrishnan, 2017) and up to 71% of stroke survivors experience other sleep disturbances that impair daytime functioning (Park & Choi-Kwon, 2018). Excessive daytime sleepiness is also common after stroke, occurring in 12% to 50% of stroke survivors, along with other sleep-related impairments during waking hours (e.g., reduced alertness upon waking, tiredness, and, functional impairments associated with sleep problems; Park & Choi-Kwon, 2018). Despite the high risk of sleep disorders following stroke, less than 10% of stroke survivors are asked about sleep disturbances or are offered sleep testing (Brown et al., 2018) and little is known about the relationship between stroke impact symptoms and sleep-related impairment in stroke.

The co-occurrence of stroke impact symptoms and sleep-related impairment can worsen quality of life among stroke survivors. For example, post-stroke fatigue, a disorder potentially intersecting with sleep-related impairment, has been shown to be an important determinant of post-stroke disability (Mandliya et al., 2016). Further, the relationship between stroke impact symptoms and sleep-related impairment may be bi-directional, with each potentially impacting the other in a positive or negative way. While sleep-disordered breathing after stroke has recently become a focus of scientific inquiry, the extent and influence of stroke impact symptoms and sleep-related impairment has not been well described in the current literature. The evaluation and treatment of sleep-related impairment

during the daytime may have important implications for post-stroke rehabilitation. The purpose of this study was to examine the association between stroke impact symptoms and sleep-related impairment in community-dwelling stroke survivors, using baseline (entry) data from a completed clinical trial for depression in stroke survivors. We hypothesized that there would be an association between stroke impact symptoms and sleep-related impairment in stroke survivors.

## Methods

### Design

We conducted a cross-sectional secondary analysis with a convenience sample of 100 community-dwelling stroke survivors using baseline data from the Living Well with Stroke 2 Trial. Living Well With Stroke 2 was a randomized, controlled efficacy study comparing a brief psychosocial/behavioral intervention, delivered in person or by telephone, with usual care in ischemic and hemorrhagic stroke survivors who were clinically depressed (Kirkness et al., 2017; P. H. Mitchell et al., 2008; P. H. Mitchell et al., 2009). The parent study was approved by the Institutional Review Board of the University of Washington (Human Subjects Division).

### Participants

Between May 2010 and December 2014, patients admitted with stroke were recruited from six university and community hospitals around Seattle, WA. One hundred patients within 4 months of an ischemic or hemorrhagic stroke consented to participate in the parent study while they continued to recover in the community. Stroke was verified by computerized tomography or magnetic resonance imaging. The 30-item Geriatric Depression Scale (Yesavage et al., 1982) was administered and those participants who scored > 11 were offered enrollment in the full study. Clinical depression was confirmed with the Diagnostic Interview and Structured Hamilton, which has been validated and correlated with criteria for clinical depression from the 4th edition of the *Diagnostic and Statistical Manual of Mental Disorders* (Freedland et al., 2002). All screening and full-study data obtained after the participant's discharge from the hospital was collected. All participants received standard medical care, including antidepressant treatment, as deemed appropriate by their inpatient and outpatient clinical providers.

### Measurement

**Demographic and Clinical Characteristics—**Baseline data were collected upon entry into the parent study and before randomization. The data consists of demographics, social support, medical history, stroke characteristics, functional status, and depression and fatigue scales. Social support was measured using the Enhancing Recovery in Coronary Heart Disease (ENRICHD) social support inventory (P. H. Mitchell et al., 2003). Individual items are summed for a total score ranging from 8 to 34 such that higher scores indicate better levels of perceived social support. Functional status was assessed with the Barthel Index (Collin, Wade, Davies, & Horne, 1988). Total scores range from 0 to 100, with higher scores indicating better functional status. Severity of stroke was measured by the NIH Stroke Scale (Lyden et al., 1994). Total NIH Stroke Scale scores range from 0 (not impaired) to 42 (fully

impaired). Depression was assessed using the Structured Hamilton Rating Scale for Depression (Freedland et al., 2002). Possible scores range from 0 to 52, with higher scores indicating greater severity of depression. Fatigue was assessed using the PROMIS Fatigue Scale. Scores for each item on the scale range from 1 to 5, and these raw scores are summed and converted to T scores, with higher scores indicating greater fatigue (Cella et al., 2010).

**Stroke Impact Scale—**The Stroke Impact Scale is a stroke-specific, self-reported outcome measure designed to capture the impact of stroke and health-status on areas that influence quality of life. The questionnaire includes 59 items and 8 domains: strength, hand function, activities of daily living, mobility, communication, mood, memory and thinking, and participation/role function (P. W. Duncan et al., 2003). Participants are asked to rate the difficulty for each item over the past 2 weeks on a 5-point Likert-type scale ranging from 1 (could not do it at all) to 5 (no difficultly at all). Total scores are generated for each domain ranging from 0 to 100. An extra question focuses on the overall perception of stroke recovery and is scored on a scale from 0 to100.

**Patient-Reported Outcomes Measurement Information System (PROMIS) Sleep-related Impairment Scale—**The PROMIS system is a National Institutes of Health Roadmap initiative, designed to improve the reporting of patient centered outcomes in clinical research and practice. It provides standardized and validated bank items to measure key symptoms in a variety of chronic conditions (Buysse et al., 2010; Cella et al., 2016). The PROMIS Sleep-Related Impairment Scale is an 8-item measure that assesses alertness, sleepiness, tiredness, and functional impairments associated with sleep problems during waking hours in the past 7 days (Buysse et al., 2010). The participant rates each item on a scale ranging from 0 (being bothered “not at all”) to 5 (“very much”). These raw scores are summed and converted to T scores, calibrated such that a score of 50 represents the “normal” reference population with a standard deviation of 10. Higher scores indicate more of the attribute being measured. The short forms for wake disturbance and for the Sleep-Related Impairment Scale have been tested for psychometric stability (Buysse et al., 2010).

**PROMIS Sleep Disturbance Scale—**The PROMIS Sleep Disturbance Scale is an 8-item tool that assesses self-reported perceptions of sleep quality, sleep depth, and restoration associated with sleep in the past 7 days (Buysse et al., 2010). The participant rates each item on a 5-point Likert-type scale, ranging from 1 to 5. These raw scores are summed and converted to T scores, with higher scores indicating greater sleep disturbance. The scale is valid and reliable in people with traumatic brain injury (Carlozzi et al., 2019). The short form also has been confirmed as valid and reliable and correlated with the longer form (Yu et al., 2011).

## Statistical Analysis

We used descriptive statistics (mean, standard deviation, and frequencies) to summarize demographic and clinical characteristics, the Stroke Impact Scale (stroke impact domain symptoms), the PROMIS Sleep-Related Impairment Scale, the PROMIS Sleep Disturbance Scale, the Hamilton Rating Scale for Depression, and the PROMIS Fatigue Scale. We conducted univariate analyses (i.e., Pearson correlation, analysis of variance, and *t* tests) to

examine the relationship among stroke impact domain symptoms, demographic and clinical characteristics, fatigue, depression, sleep disturbance and sleep-related impairment. We computed multivariate regression to examine the relationship between stroke-impact domain symptoms and sleep-related impairment. In multivariate analysis, we included all factors significant in the univariate analyses. For all analyses, a *p*-value of less than .05 in a two-sided test was considered statistically significant. Analyses were completed using SPSS version 25 for Windows (IBM Corporation, Armonk, NY).

## Results

Demographic and clinical characteristics of the 100 participants who agreed to full enrollment in LWWS2 are presented in Tables 1 and 2. The average age was 60 years (youngest: 23; oldest: 88 years), and the majority of participants were White with a diagnosis of ischemic stroke. Seventy nine percent of patients had a history of one or more episodes of depression, and almost half of the patients were taking antidepressant medications.

Sleep-related impairment and stroke impact domain symptoms are described in Table 3. The mean sleep-related impairment was 56.36 ± 6.21 (minimum: 38.7; maximum: 71.9). This mean score is above the mean for the general population. The mean perceived stroke recovery was 62.25 ± 24.42. In other words, patients perceived themselves as about 62% recovered.

In the univariate analyses (Table 4), overall stroke recovery ($r = -.27$, $p = .006$) and each of the following 6 stroke impact domains were significantly associated with sleep-related impairment: activities of daily living/instrumental activities of daily living ($r = -.26$, $p = .008$), mobility ($r = -.38$, $p < .001$), communication ($r = -.37$, $p < .001$), mood ($r = -.55$ $p < .001$), memory and thinking ($r = -.45$ $p < .001$), and social participation ($r = -.28$, $p = .004$). However, strength ($r = -.19$, $p = .061$) and hand function ($r = -.12$, $p = .241$) were not significantly associated with sleep-related impairment. Sleep disturbance ($r = .25$, $p = .011$), social support ($r = -.22$, $p = .027$), fatigue ($r = .62$, $p < .001$), and depression ($r = .39$, $p < .001$) were each significantly associated with sleep-related impairment. Total scores on the PROMIS sleep-related impairment scale were higher in participants who used antidepressant, compared to those who did not use antidepressants (Table 2, $t_{(98)} = 2.05$, $p = .043$). In the multivariate analysis, all significant factors from the univariate analyses were included. In the final model (Table 5), mood domain ($B = -.105$, $t = -3.263$, $p = .002$) and fatigue ($B = 0.346$, $t = 3.997$, $p < .001$) were associated with sleep-related impairment.

## Discussion

Our findings indicate that certain domains of stroke impact symptoms in the early months following stroke are importantly related to sleep-related impairment. This important relationship was overlooked in earlier reports using self-report stroke quality of life measures, probably because the most commonly used measures do not include any sleep dimension (Chou, Ou, & Chiang, 2015). One stroke impact domain—mood—and fatigue were most strongly related to sleep-related impairment. Stroke recovery, other stroke impact

domains (activities of daily living/instrumental activities of daily living, mobility, communication, memory and thinking, and social participation), sleep disturbance, social support, depression, and the use of antidepressant medication were also associated with sleep-related impairment.

The degree of sleep-related impairment in this cohort was higher than that of other populations with neurologic disease or injury. The average reported values for sleep-related impairment, using the 8-item PROMIS Sleep-Related Impairment Scale, were 52.55 (*SD* ± 9.24) in people with multiple sclerosis (n = 461, mean age, 52.8 ± 10.9) and 50.27 (*SD* ± 10.05) in people with spinal cord injury (n = 239, mean age, 47.4 ± 14.1; Fogelberg, Vitiello, Hoffman, Bamer, & Amtmann, 2015), compared to 56.36 (*SD* ± 6.21) in this study. Our cohort was slightly older, with a mean age of 60.3 (*SD* ± 12.73), than the cohort reported in the study by Fogelberg et al. (2015). The proportion of female participants (83%) with multiple sclerosis (Fogelberg et al., 2015) was also higher than the proportion in our study (50%). However, in this study, neither age nor gender was associated with sleep-related impairment. Other differences in the sample characteristics between this study and the study by Fogelberg et al. (2015) may also have influenced the degree of sleep-related impairment. Whereas our cohort was in the subacute phase after stroke (i.e., within 4 months post-stroke), participants in the study by Fogelberg et al. (2015) had chronic conditions with an average time since diagnosis/injury of over a decade. Despite some difficulty comparing the degree of sleep-related impairment between studies due to heterogenous sample characteristics, the average score of 56.36 (*SD* ± 6.21) in our study was higher than the reported normative values for adults with score of 50 (*SD* ± 10; HealthMeasures, 2019). Our results suggest stroke survivors may experience relatively high sleep-related impairment. Further studies focusing on sleep-related impairment in a range of diseases and sample characteristics (e.g., age and gender) are required to confirm our findings.

One stroke impact domain, mood, was strongly associated with sleep-related impairment. Depression was associated with sleep-related impairment in the univariate analysis. Our findings may be due to the fact that participants in our study were selected for the presence of depression, which are associated with sleep problems even in the absence of stroke. Mood disorder in stroke is common. A meta-analysis study reported that prevalence of post-stroke major depression, anxiety, and adjustment disorder are 17.7%, 9.8%, and 6.9%, respectively (A. J. Mitchell et al., 2017). Among stroke survivors, 33.5% of the population experiences a depressive disorder (A. J. Mitchell et al., 2017). Mood disorders have been related to pathophysiological mechanisms such as neurochemical changes due to brain injury, as well as psychological disturbances (Kim, 2017). A bidirectional relationship between sleep and mood has been reported in patients with mood disorders in the general population (Cousins et al., 2011; Krystal, Thakur, & Roth, 2008). In one study of stroke patients with self-reported sleep disturbance during hospitalization, depression was the most powerful predictor of night-time sleep disturbance (Suh, Choi-Kwon, & Kim, 2014). In another study of patients with sleep-disordered breathing, higher scores on a depression scale were associated with reduced daytime alertness, a potentially important determinant of mood (Sforza, de Saint Hilaire, Pelissolo, Rochat, & Ibanez, 2002). Depression, mood and sleep-related impairment may directly and indirectly influence each other and may erode stroke recovery in this study population. Further research is needed to reveal any potential

mechanisms underlying the relationship between mood, depression and sleep-related impairment in stroke survivors.

Fatigue, defined as a “feeling of early exhaustion developing during mental activity, with weariness, lack of energy, and aversion to effort,” (Staub & Bogousslavsky, 2001, p. 75) is common after stroke (F. Duncan, Wu, & Mead, 2012). Prior studies have noted a significant effect of fatigue on sleep-related impairment in stroke survivors. In a study of hospitalized stroke patients, Suh et al. (2014) reported an association between daytime sleepiness and fatigue. Fatigue has also been related with a lower health-related quality of life after stroke (Alguren, Fridlund, Cieza, Sunnerhagen, & Christensson, 2012), and been shown to impact work performance and employability (Andersen, Christensen, Kirkevold, & Johnsen, 2012). Our findings further support the association between fatigue and sleep-related impairment after stroke, and point towards an important target for additional support among stroke survivors.

With the exception of hand function and strength, the other stroke impact symptoms and perceived stroke recovery were associated with sleep-related impairment. A bidirectional relationship between sleep disorders and stroke also has been suggested with potential implications for both stroke risk and outcome (Bassetti, 2019; Gottlieb et al., 2019). The effects of stroke on brain function can trigger changes in sleep EEG and circadian rhythm, which in turn relate to poor functional outcome and worsened stroke severity (Bassetti, 2019; Gottlieb et al., 2019). Given the impact of stroke on sleep architecture and quality, stroke survivors can experience reduced sleep efficiency and significant reductions to non-rapid-eye-movement stage 1 sleep (NREM-1), NREM-2, Slow-wave-sleep (NREM3) and rapid eye movement (REM) sleep (Gottlieb et al., 2019). This fragmentation of normal sleep may contribute to our findings where certain aspects of stroke impact symptoms were associated with the development of sleep-related impairment during wake hours.

Sleep disturbance was associated with sleep-related impairment in the univariate analysis, although the relationship was attenuated in the multivariate analysis. In a previous study with patients at 3 months post-stroke, sleep disturbance was partially associated with excessive daytime sleepiness (Suh et al., 2014). Sleep deprivation is a risk factor for daytime sleepiness in the general population (Jaussent, Morin, Ivers, & Dauvilliers, 2017), whereas stroke survivors with sleep duration longer than 8 hours when compared to average sleepers (7–8 hours) reported more problems in their instrumental activities of daily living (Seixas et al., 2019). It is not clear whether sleep duration influenced stroke impact symptoms in this study population. After stroke, obstructive sleep apnea has been associated with impaired cognition and poorer functional status (Aaronson et al., 2015). Long sleep duration has also been associated with an increased risk for stroke related to frequent snoring and sleepiness (Chen et al., 2008; Song et al., 2016). Stroke survivors who experience sleep disturbance, sleep-related impairment and stroke impact symptoms may need to be closely monitored for recurrent stroke. Future studies that include self-reported sleep duration or objective sleep measures, such as actigraphy or polysomnography, are required to understand the relationship between sleep disturbance and sleep-related impairment.

## Clinical Implications

While stroke-specific quality of life and impact measures are being measured more commonly, the absence of sleep-wake measures in these patient-reported outcomes indicates a need for timely attention to both stroke impact symptoms and sleep-wake impairment. The goal towards the development of targeted interventions may improve sleep and stroke recovery in stroke survivors. A recent review article (Khot & Morgenstern, 2019) indicated that stroke survivors experience not only sleep apnea (Johnson & Johnson, 2010; Menon et al., 2017) but also other types of sleep-wake cycle disorders such as longer sleep latencies or worse sleep efficiency compared to healthy controls (Sterr et al., 2018) and insomnia (Palomaki et al., 2003; Sterr et al., 2018). In stroke survivors, cognitive-behavioral therapy has improved sleep quality, insomnia, daytime sleepiness, and other sleep parameters such as sleep duration and sleep onset latency (Herron, Farquharson, Wroe, & Sterr, 2018; Nguyen et al., 2019). Other interventions (e.g., promoting health practices such as regular exercise or relaxation) designed to improve sleep quality (Ahn, Jiang, Smith, & Ory, 2014; Schmutte, Davidson, & O'Connell, 2018) may be helpful for stroke survivors.

Factors related to sleep-wake impairment revealed in our study, including fatigue and mood, also may help with the development of tailored interventions focusing on areas that need to be addressed to improve health in stroke survivors. In this study population, social support was associated with sleep-related impairment. Lack of social support has been associated with depression (Grav, Hellzen, Romild, & Stordal, 2012) and sleep disturbance (Chung, 2017) in the general population. Further, a recent meta-analysis suggests that sleep is improved by all types of social support (Kent de Grey, Uchino, Trettevik, Cronan, & Hogan, 2018). Thus, health care providers may be influential in reducing stroke impact symptoms and improving sleep-related impairment through the assistance of stroke survivors in accessing potential sources of both emotional and tangible support.

## Strengths and Limitations

We acknowledge some limitations in this study. Importantly, this sample of stroke survivors included only people with clinical depression, prior to their treatment for that condition; however, we did control for depression and the use of antidepressant in the multivariate analysis. In addition, sleep disturbance is a component of depression and the majority of depression scales include items related to sleep. For example, the Structured Hamilton Rating Scale for Depression used in this study includes three insomnia-related items. The association between depression and sleep-related impairment in this study may be due to overlapping components between the scales. The PROMIS scales used in this study assess sleep-related impairment and sleep disturbance in the past 7 days. In this study, we did not assess sleep problems in the acute phase post-stroke, which may limit our capacity to compare changes in sleep over time. Other limitations are convenience sampling from a single geographic region, cross-sectional analysis and the use of only self-reported sleep measures. Further research with objective sleep measures, such as actigraphy and polysomnography, that assesses daytime activity, daytime sleepiness as well as sleep duration or disruption are warranted to better explain the precise nature of sleep–wake impairment during wake hours. Stroke survivors with severe cognitive impairment or aphasia were excluded since they were not sufficiently able to complete self-reported sleep

questionnaires. These stroke survivors may have severe stroke impact symptoms and greater sleep-related impairment, mood disorder, and fatigue than the population in our study. Finally, the study findings reflect associations rather than causality or consequences of sleep-related impairment. The strengths of this study include the association between stroke impact symptoms and sleep-related impairment in a varied sample of stroke survivors and the use of the PROMIS scale, a standardized measure for patient-reported health outcome.

## Conclusions

Our findings suggest that people with stroke impact symptoms may also experience sleep-related impairment at higher rates compared with other populations and this co-occurrence may influence stroke recovery. Clinicians should assess and ameliorate factors affecting sleep-related impairment which, in turn, may also improve health in stroke survivors at risk for additional morbidity. Our findings underscore the need to recognize the overlap between stroke impact symptoms and sleep-related impairment and provide appropriate support and intervention in stroke survivors.

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## Highlights

- Stroke impact symptoms are associated with daytime sleep-related impairment.
- Mood and fatigue are strongly associated with sleep-related impairment.
- An intervention targeting both stroke impact symptoms and sleep-related impairment may improve health in stroke survivors at risk for additional morbidity.

**Table 1.**

Baseline Demographics and Relationships with Sleep-related Impairment (N=100)

| Characteristic | *N (%) or* Mean ± *SD* [Minimum - Maximum] | Statistics with Sleep-related Impairment |
|---|---|---|
| Gender | | |
| Male | 50 (50%) | $t_{(98)} = 0.68$, $p = .498$ |
| Female | 50 (50%) | |
| Age, years | 60.3 ± 12.73 [23–88] | $r = 0.009$, $p = .930$ |
| Marital Status | | |
| Single | 13 (13%) | $F_{(2, 97)} = .562$, $p = .572$ |
| Married, partnered | 51 (51%) | |
| Widowed, divorced, separated | 36 (36%) | |
| Current Living Arrangement | | |
| Homeless | 1 (1%) | $F_{(4,95)} = 1.477$, $p = .215$ |
| Alone | 23 (23%) | |
| With spouse, partner | 51 (51%) | |
| With relatives, others | 16 (16%) | |
| Group housing | 9 (9%) | |
| Race, Ethnicity | | |
| Hispanic ethnicity | 5 (5 %) | $t_{(98)} = 0.104$, $p = .917$ |
| More than one race | 14 (14%) | $F_{(4,95)} = .541$, $p = .706$ |
| White only | 79 (79%) | |
| Black only | 4 (4%) | |
| Asian only | 2 (2%) | |
| Pacific only | 1 (1%) | |
| Social Support (ENRICHD) | 25.4 ± 6.81 [8–34] | $r = -.221$, $p = .027$ |

*Note*. ENRICHD = Enhancing Recovery in Coronary Heart Disease; Associations of demographics with sleep-related impairment were evaluated using Pearson correlations; Differences in sleep-related impairment by categories of demographics were evaluated using independent sample t-tests or analyses of variance.

**Table 2.**

Clinical Characteristics and Relationships with Sleep-related Impairment (N=100)

| Characteristic | *N (%) or* Mean ± *SD* [Minimum-Maximum] | Statistics with Sleep-related Impairment |
|---|---|---|
| Stroke Type | | |
| Ischemic stroke | 85 (85 %) | $F_{(2, 97)} = .351$, $p = .705$ |
| Intraparenchymal hemorrhage | 11 (11%) | |
| Subarachnoid hemorrhage | 4 (4%) | |
| Current Antihypertensive Medication | 70 (7%) | $t_{(90)} = 0.569$, $p = .571$ |
| Heart Failure | 8 (8%) | $t_{(98)} = 0.960$, $p = .340$ |
| Diabetes | 28 (28%) | $t_{(98)} = 0.278$, $p = .781$ |
| Depression (HRSD) | 18.48 ± 3.12 [12.0–27.0] | $r = 0.393$, $p = < .001$ |
| Currently Taking Antidepressant Medication | 47 (47%) | $t_{(98)} = 2.05$, $p = .043$ |
| Severity of Stroke (NIHSS score) | 3.43 ± 3.50 [0.0–15.0] | $r = 0.021$, $p = .836$ |
| Functional Status (Barthel Index) | 89.80 ± 19.89 [10.0–100.0] | $r = -0.151$, $p = .133$ |
| Fatigue (PROMIS Fatigue Scale) | 56.22 ± 6.25 [41.9–72.9] | $r = 0.618$, $p = < .001$ |

*Note*. HRSD = Hamilton Rating Scale for Depression; NIHSS = National Institutes of Health Stroke Scale; PROMIS = Patient-Reported Outcomes Measurement Information System; Associations of clinical characteristics with sleep-related impairment were evaluated using Pearson correlations; Differences in sleep-related impairment by categories of clinical characteristics were evaluated using independent sample t-tests or analyses of variance.

**Table 3.**

Sleep-related Impairment, Sleep Disturbance and Stroke Impact Symptoms

| | N (%) or Mean *SD* [Minimum-Maximum] | Associations with Sleep-related Impairment |
|---|---|---|
| Sleep-related Impairment (PROMIS Sleep-related Impairment) | 56.36 ± 6.21 [38.70–71.90] | |
| Sleep Disturbance (PROMIS Sleep Disturbance) | 53.30 ± 3.49 [44.20–62.6] | $r = 0.253$, $p = .011$ |
| Stroke Impact Domain Symptoms (Stroke Impact Scale) | | |
| Strength | 64.31 ± 24.89 [0.00–100.00] | $r = -0.188$, $p = .061$ |
| Memory and thinking | 69.36 ± 17.80 [28.57–100.00] | $r = -0.453$, $p = < .001$ |
| Mood | 61.58 ± 18.94 [2.78–100.00] | $r = -0.554$, $p = < .001$ |
| Communication | 83.57 ± 16.76 [28.57–100.00] | $r = -0.367$, $p = < .001$ |
| Activity of daily living/Instrumental activities of daily living | 76.08 ± 23.99 [0.00–100.00] | $r = -0.262$, $p = .008$ |
| Mobility | 72.08 ± 25.10 [5.56–100.00] | $r = -.381$, $p = < .001$ |
| Hand function | 65.95 ± 34.98 [0.00–100.00] | $r = -.118$, $p = .241$ |
| Participation/role function | 51.56 ± 23.78 [0.00–100.00] | $r = -.284$, $p = .004$ |
| Stroke Recovery (Stroke Impact Scale) | 62.25 ± 24.42 [0.00–95.00] | $r = -.274$, $p = .006$ |

*Note*. PROMIS = Patient-Reported Outcomes Measurement Information System; Associations of sleep disturbance and stroke impact symptoms were evaluated using Pearson correlations.

**Table 4.**

Pearson Correlation Matrix

| | Sleep-related impairment |
|---|---|
| Stroke Impact Domain Symptoms (Stroke Impact Scale) | |
| Strength | −.19 |
| Memory and thinking | −.45** |
| Mood | −.55** |
| Communication | −.37** |
| Activity of daily living/Instrumental activities of daily living | −.26** |
| Mobility | −.38** |
| Hand function | −.12 |
| Participation/role function | −.28** |
| Stroke Recovery (Stroke Impact Scale) | −.27** |
| Sleep Disturbance (PROMIS Sleep Disturbance) | .25* |
| Depression (HRSD) | .39** |
| Fatigue (PROMIS Fatigue Scale) | .62** |
| Age | .01 |
| Social Support (ENRICHD) | −.22* |
| Severity of Stroke (NIHSS score) | .02 |
| Functional Status (Barthel Index) | −.15 |

*Note*.

**. Correlation is significant at the 0.01 level (2-tailed);

*. Correlation is significant at the 0.05 level (2-tailed);

ENRICHD = Enhancing Recovery in Coronary Heart Disease; HRSD = Hamilton Rating Scale for Depression; NIHSS = National Institutes of Health Stroke Scale; PROMIS = Patient-Reported Outcomes Measurement Information System.

**Table 5.**

Predictors of Sleep-related Impairment

| Predictors | *B* | *SE* | *t* statistic | *p* value |
|---|---|---|---|---|
| Stroke Impact Domain Symptoms (Stroke Impact Scale) | | | | |
| Memory and thinking | −0.043 | 0.032 | −1.373 | .173 |
| Mood | −0.105 | 0.032 | −3.263 | .002 |
| Communication | −0.032 | 0.033 | −0.978 | .331 |
| Activity of daily living/Instrumental activities of daily living | 0.001 | 0.031 | 0.028 | .978 |
| Mobility | −0.041 | 0.031 | −1.324 | .189 |
| Participation/role function | 0.038 | 0.026 | 1.495 | .139 |
| Stroke Recovery (Stroke Impact Scale) | −0.001 | 0.025 | −0.023 | .982 |
| Sleep Disturbance (PROMIS Sleep Disturbance) | 0.169 | 0.131 | 1.288 | .201 |
| Depression (HRSD) | 0.171 | 0.179 | 0.955 | .342 |
| Antidepressant | 0.606 | 0.950 | 0.638 | .525 |
| Fatigue (PROMIS Fatigue Scale) | 0.346 | 0.087 | 3.997 | <.001 |
| Social Support (ENRICHD) | 0.008 | 0.075 | 0.109 | .914 |

*Note*. B = unstandardized; SE = standard error; F (9.516, p < .001) $R^2$ = .568; ENRICHD = Enhancing Recovery in Coronary Heart Disease; HRSD = Hamilton Rating Scale for Depression; PROMIS = Patient-Reported Outcomes Measurement Information System