# Sleep and Quality of Life in Stable Heart Failure

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**ABSTRACT**

**Background:** Functional performance and mental health are significant quality of life concerns for heart failure (HF) patients. Poor sleep also appears to be common. We examined the extent to which sleep was associated with functional performance and mental health among persons who had stable systolic HF.

**Methods and Results:** Sixty-one patients with stable systolic HF wore wrist actigraphs to record nocturnal sleep and daily activity for 3 days while living at home, performed 6-minute walks (6MWT), and completed the Pittsburgh Sleep Quality Index and the Medical Outcomes Study SF-36 questionnaire. Self-reported sleep quality and actigraph-recorded wake time and wake bout time explained 9% to 20% of the variance in the functional performance variables (daytime activity level, 6MWT, self-reported physical function), and mental health, after controlling for age, gender, comorbidity, and New York Heart Association class. Time in bed was negatively associated with functional performance. There were no statistically significant relationships between sleep duration and functional performance.

**Conclusions:** Self-reported sleep quality and sleep continuity (sleep that is undisturbed by nocturnal awakenings) are associated with functional performance and mental health in stable systolic HF patients. Effective treatment of sleep problems may contribute to improvement in quality of life.

**Key Words:** Heart failure, Sleep disorders, Sleep, Actigraphy, Quality of life.

Anecdotal and self-reported data indicate that poor sleep quality and sleep continuity (restless sleep, difficulty falling asleep, frequent nocturnal awakenings, and early morning awakenings) are common among patients with heart failure (HF),[1–5] and these problems appear to be more prevalent among HF patients than in the general population.[1,5] However, a limitation of past studies is reliance on self-report measures that are typically poorly correlated with objective measures of disturbed sleep.[6,7] Sleep-disordered breathing, including Cheyne-Stokes breathing, central sleep apnea, and obstructive sleep apnea are also common in HF patients, have been the focus of increasing clinical and scientific interest,[8,9] and may be among the contributors to observed and self-reported differences in sleep quality.[9,10] However, there has been little focus on the nature of sleep itself in HF patients or on sleep occurring in naturalistic settings, such as the home environment.

Population-based studies and studies of some cardiovascular populations[11] have suggested that poor sleep contributes to decrements in functional performance and mental health—important components of quality of life. Data obtained from more than 6000 men and women older than 40 years of age enrolled in the Sleep Heart Health Study revealed that sleep-disordered breathing was associated with decrements in functional performance and mental health.[12] However, the finding that disorders of initiating and maintaining sleep were also independently associated with all of the Medical Outcomes Study SF-36 subscales suggests that sleep itself is also a contributor to components of health-related quality of life.

Among HF patients, self-reported sleep quality assessed with a single-item measure, was associated with lower levels of exercise capacity pretreatment and improvements in exercise capacity after a 3-month trial of an unspecified drug treatment;[13] 229 HF patients (a subsample of the Medical Outcomes Study) with self-reported sleep problems had significantly poorer scores on all Medical Outcomes Study Short Form 36 (SF-36) dimensions than HF patients who did not have sleep problems.[2] In a more recent investigation of 223 Swedish patients with Class II–IV heart failure, self-reported difficulty initiating or maintaining sleep was associated with all of the Medical Outcomes Study SF-36 subscales, except the role emotional scale.

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Self-reported characteristics of sleep were disturbed compared with population norms. Limitations of this study include the absence of objective measures of sleep or functional performance and the heterogeneous nature of the study sample that combined both community residing and hospitalized HF patients.

The purpose of the current study was to examine the extent to which sleep quality, duration, and continuity, evaluated with self-report and objective measures, were associated with functional performance and mental health among stable systolic HF patients.

## Methods

### Study Population

The sample included male and female patients who had stable systolic HF with ejection fractions ≤35%. All participants were enrolled in an outpatient HF/heart transplant clinic located in the northeastern United States, lived in their own homes, were on stable doses of cardiovascular medications for at least 2 weeks, and had not been hospitalized within the past month. Patients were excluded who had documented sleep-disordered breathing, cognitive impairment, unstable medical or psychiatric conditions, stroke or tremor affecting the nondominant arm (because of the need to wear a wrist actigraph), or ongoing alcohol or drug abuse or dependence.

### Study Design and Procedures

We used a descriptive cross-sectional design. Participants were recruited at the time of a routine visit to the cardiologist and provided written informed consent. Medical records were reviewed for screening purposes and to obtain clinical data. Six-minute walk tests (6MWT) were performed in the clinic setting, using standardized methods.[14] Participants wore wrist actigraphs (Mini Mitter, Inc, Bend, OR) for 72 continuous hours to record sleep/wake and daytime activity and completed daily sleep diaries during the morning after each of the 3 nights of actigraph recording. They completed a packet of questionnaires, including the Pittsburgh Sleep Quality Index (PSQI), and the SF-36, once during the monitoring period.

### Instruments

The Actiwatch actigraph (Mini Mitter, Inc) was used to evaluate sleep duration and continuity. The actigraph is an electronic accelerometer; it records movement over a preprogrammed epoch of time; and stores the data. Participants were instructed to wear the device on their nondominant wrists (standard site for sleep analysis) continuously for 3 days while going about their normal activities of daily living and to remove it only for bathing. Actigraph data were downloaded into a personal computer. Sleep variables were computed from the actigraph data with a commercially available computer algorithm (Actiware, Mini Mitter, Inc). Actigraphs reliably discriminate between sleep and wake.[15–20] Total sleep time is typically consistent with electroencephalogram measures.[20]

The PSQI[21] was used to assess habitual sleep quality retrospectively over a 1-month interval. A global score is obtained from the sum of scale components including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The PSQI global score has a possible range of 0 to 21 points. A higher score indicates poorer sleep quality. Using a global PSQI score >5 as a measure of poor sleep, the instrument had a diagnostic sensitivity of 89.6% and specificity of 86.5% for distinguishing ''good'' versus ''poor'' sleepers. Validity was also acceptable in comparison with polysomnography.[21]

A sleep diary was used to record daily bed times, times of sleep onset, times and durations of awakenings during the sleep period, final awakening time, and nap times during the day. These data were used to confirm even marker data obtained with the wrist actigraphs.

Functional performance, or the ''day to day corporeal activities people do in the course of their lives to meet basic needs, fulfill usual roles, and maintain health and wellbeing'' [22, p. 198] was measured with the physical function component of the SF-36,[23,24] the 6MWT,[14] and daytime activity levels recorded by the wrist actigraph. Mental health was measured with the Mental Health component of the SF36.

The SF36 is a 36-item self-report questionnaire. It elicits information on physical functioning (limitations in behavioral performance of everyday physical activities) role-physical functioning (extent of disability in everyday activities because of physical problems), bodily pain (severity of bodily pain and resulting limitations in activities), general health perceptions (perception of health status), vitality (energy level and fatigue), social functioning (limitations in social activities from physical or emotional problems), role-emotional (problems with work or daily activities as a result of emotional problems), mental health (psychologic distress and wellbeing), and reported health transition. Extensive psychometric testing and factor analysis of the SF-36 has produced 2 component scores from the 36-item instrument that are reliable and valid indicators of physical function and mental health.[24] These component scores were used in the current study.

The Actiwatch was also used to record daytime activity. Wrist-worn actigraphs are reliability able to discriminate levels of activity associated with changes in speed and incline during treadmill testing[26,27] and actigraph measures of daily movement are highly correlated with self-reported daily activity and moderately correlated with oxygen consumption during treadmill testing.[28] One actigraph was used to quantify both daytime activity and nocturnal sleep.

### Statistical Analysis

Actiware software was used to compute daily sleep and daytime activity variables. The primary sleep period was identified based on the times that participants depressed the actigraph even markers to indicate times of ''lights out'' and ''lights on'' and validated with sleep diary recordings. The following variables were computed: nocturnal time in bed, sleep duration, percentage wake after sleep onset, sleep latency (lights out time to sleep onset), wake time, number of wake bouts, duration of wake bouts, and activity count, an indicator of restless sleep, (counts/minute) during time in bed. Daytime activity was computed for the period from the last morning awakening until lights out time for each day of the 3-day recording period. Three of the participants removed the Actiwatch during the day. Therefore, complete data were available on 58 of the 61 participants for daytime activity.

All of the sleep and dependent variables, with the exception of sleep latency, were normally distributed. The SF36 data were used to compute the physical function and mental component scores based on standardized weightings.[25] Missing items were isolated and within the published limits for imputation; scores were computed for subscales with missing items based on these guidelines.[24] Statistical analyses included descriptive statistics, bivariate

correlations, and regression analyses. The level of statistical significance was determined a priori at $P < .05$.

## Results

The sample included 61 patients (22 women, 39 men) with stable systolic HF and ejection fractions ≤ 35% ($M = 22.9 \pm 8\%$). The mean age range was 59 ± 12.85 (range 28–83) years. Participants fell into the following New York Heart Association (NYHA) classifications: I (n = 2), II (n = 34), III (n = 21), and IV (n = 4). Mean body mass index was 30.39 ± 6.40 and was not significantly different between men and women. Participants had cardiomyopathy (n = 41, 71%), hypertension (n = 35, 59%), dysrhythmias (n = 19, 34%), diabetes mellitus (n = 23, 39%), chronic obstructive pulmonary disease (n = 7, 13%), and clinical depression (n = 6, 11%). Participants reported $M = 2.3 \pm 0.22$ comorbid health problems. Medical history included myocardial infarction (n = 22, 36%), stroke (n = 6, 11%), coronary artery bypass (n = 25, 41%), and valve surgery (n = 2, 3%). Thirty-four percent of participants (n = 21) took sleeping medication at least occasionally, as indicated by responses to the sleep medication component of the PSQI.

Descriptive statistics appear in Table 1 for the sleep, functional performance (physical function, daytime activity, and 6 MWT), and mental health variables. Overall, sleep characteristics were highly variable.

We explored the relationships between the demographic and clinical variables and the sleep, functional performance, and mental health variables (Table 2). There were no statistically significant associations between age, gender, comorbidity (number of comorbid health problems), and the sleep variables. There was a positive relationship between NYHA and PSQI ($r = 0.40$, $P < .001$), but no statistically significant relationship between NYHA and the actigraph-derived sleep variables.

Women were older than men ($M = 61.6 \pm 11.9$ vs. $M = 55 \pm 13.7$ years, $P < .05$) and had lower 6MWT ($M = 835 \pm 313$ versus $M = 1135 \pm 355$ feet, $P = .03$), but there were no statistically significant gender differences in physical function, daytime activity, or mental health. Use of sleeping medication (PSQI component) was negatively related to daytime activity (eta = −0.40, $P = 0.002$), physical function (eta = −0.25, $P = .05$), and 6MWT (eta = −0.27, $P$ = NS), but not mental health.

The correlations between the sleep and dependent variables are listed in Table 2. There were small to moderate negative correlations between PSQI and physical function, 6MWT, and mental health, but no statistically significant relationship between PSQI and daytime activity. Time in bed was negatively correlated with physical function, daytime activity, and 6MWT, although its relationship with 6MWT was not statistically significant because of the smaller available sample. There were no statistically significant correlations between sleep duration, number of wake bouts, and functional performance or mental health.

**Table 1.** Descriptive Statistics for Sleep, Functional Performance, and Emotional Wellbeing (n = 61)

| Variable | Mean | SD | Range |
|---|---|---|---|
| Self-reported sleep variables | | | |
| Habitual Sleep Quality (PSQI) | 7.21 | 3.39 | 2–16 |
| Actigraph sleep variables | | | |
| Time in bed (h) | 8.20 | 1.59 | 4.73–11.55 |
| Sleep duration (h) | 6.54 | 1.51 | 3.1–9.2 |
| Percentage wake after sleep onset | 10.26 | 4.18 | 4.3–19.9 |
| Sleep latency (min) | 28.47 | 32.79 | 0–143 |
| Wake time (min) | 44.55 | 21.92 | 15–103 |
| Number of wake bouts | 52.64 | 25.82 | 22.7–141 |
| Duration of wake bouts (min) | .89 | .31 | .3–2.0 |
| Nocturnal activity count (counts/min) | 4.63 | 2.04 | 2–9.2 |
| Functional performance variables | | | |
| SF-36 Physical function component | 23.94 | 1.47 | 21–28 |
| 6-minute walk test distance (feet) (n = 32) | 1050 | 365 | 300–1860 |
| Daytime activity (counts/min) (n = 58) | 54.43 | 22.95 | 12.10–107.41 |
| Mental health | 23.94 | 1.59 | 19–27 |

Because it was severely skewed, we dichomotized the sleep latency variable (latency <30 minutes and latency >30 minutes) before the analyses. Sleep latency was negatively associated with physical function (eta = –0.27, $P = .04$), but not related to the other functional performance variables or mental health. Wake time was negatively related to all of the functional performance variables.

We performed a series of 4 hierarchical multiple regression analyses to evaluate the extent to which the sleep, demographic, and clinical variables explained physical function, daily activity level, 6MWT, and mental health.

**Table 2.** Correlations Between Clinical, Demographic, Sleep, Functional Performance, and Mental Health Variables N = 61 +/++

| Variables | Physical Function | 6MWT | Daytime Activity | Mental Health |
|---|---|---|---|---|
| Clinical/demographic variables | | | | |
| Age | −0.05 | −0.30 | −0.28* | 0.20 |
| Gender | −0.18 | −0.38* | 0.07 | 0.04 |
| NYHA | −0.38† | −0.40* | −0.37† | −0.14 |
| Comorbidity | −0.34† | −0.49† | −0.14 | −0.29* |
| Sleep variables | | | | |
| Sleep quality (PSQI)+++ | −0.40‡ | −0.42* | −0.20 | −0.34† |
| Time in bed | −0.31* | −0.35 | −0.31* | −0.05 |
| Sleep duration | −0.20 | −0.22 | −0.21 | −0.08 |
| Percentage wake after sleep onset | −0.29* | −0.29 | −0.23 | 0.12 |
| Sleep latency (> 30 min.) | −0.27* | −0.22 | 0.05 | 0.02 |
| Wake time | −0.37† | −0.33 | −0.32† | 0.03 |
| Number of wake bouts | −0.16 | −0.12 | −0.20 | −0.01 |
| Duration of wake bouts | −0.24 | −0.41* | −0.20 | 0.14 |
| Nocturnal activity | −0.32† | −0.39* | −0.23 | 0.11 |

+For 6MWT, n = 32.
++For daytime activity, n = 58.
+++Higher PSQI indicates poorer sleep quality.
*$P < .05$.
†$P < .01$.
‡$P < .001$.

**Table 3.** Summary of Hierarchical Multiple Regression for Sleep Variables explaining Physical Function (SF-36 PF Component Score), Daytime Activity, 6-Minute Walk, and Emotional Well-Being

| Step | Variable | $r$ | $r^2$ | F (change) | $P$ (change) | Overall F (df), $P$ |
|---|---|---|---|---|---|---|
| Equation 1: Regression of Physical Function on Wake Time and PSQI | | | | | | |
| 1 | NYHA | .46 | .21 | 3.82 | .008 | |
| | Age | | | | | |
| | Gender | | | | | F (6,60) = 6.46 |
| | Comorbidity | | | | | $P < .001$ |
| 2 | PSQI | .65 | .42 | 9.44 | .001 | |
| | Wake time | | | | | |
| Equation 2: Regression of Daytime Activity on Wake Time and PSQI | | | | | | |
| 1 | NYHA | .48 | .23 | 3.87 | .008 | |
| | Age | | | | | |
| | Gender | | | | | F (6,57) = 4.00 |
| | Comorbidity | | | | | $P = .002$ |
| 2 | PSQI | .57 | .32 | 3.53 | .04 | |
| | Wake time | | | | | |
| Equation 3: Regression of Six Minute Walk Test on Wake Bout Time and PSQI | | | | | | |
| 1 | NYHA | .63 | .39 | 4.39 | .007 | |
| | Age | | | | | |
| | Gender | | | | | F (6,31) = 4.79 |
| | Comorbidity | | | | | $P = .002$ |
| 2 | PSQI | .73 | .54 | 3.79 | .04 | |
| | Duration of wake bouts | | | | | |
| Equation 4: Regression of Mental Health on Wake Bout Time and PSQI | | | | | | |
| 1 | NYHA | .39 | .15 | 2.55 | .05 | |
| | Age | | | | | |
| | Gender | | | | | F (6,60) = 4.17 |
| | Comorbidity | | | | | $P = .003$ |
| 2 | PSQI | .55 | .30 | 6.45 | .006 | |
| | Duration of wake bouts | | | | | |

In the first step of each equation we entered age, gender, comorbidity, and NYHA class (Table 3). In the second step, we included PSQI and the actigraph variable with the highest bivariate correlation with the dependent variable. Single actigraph variables, rather than groups of variables, were included because these variables were intercorrelated with each other and the need for parsimony.

Age, gender, comorbidity, and NYHA explained 21%, whereas PSQI and wake time explained an additional 20% of the variance in physical function (Eq. 1). Wake time explained the largest percentage of the variance in the dependent variable, as indicated by the semipartial correlation. PSQI and wake time explained 9% of the variance in daytime activity. Wake time was the most relevant sleep variable, as indicated by $sr^2$ (Eq. 2). In the third equation, PSQI and duration of wake bouts explained 14% of the variance in 6MWT, in excess of the 39% of the variance explained by age, gender, NYHA, and comorbidity. For each of the regression equations, individual sleep variables explained the largest unique variance in the functional performance variables relative to the demographic and clinical variables.

Wake bout duration and PSQI explained 15% of the variance in mental health. PSQI was the most relevant sleep variable. With both variables in the equation only PSQI was relevant to mental health.

## Discussion

These multivariate findings, in which we statistically controlled for age, gender, comorbidity, and NYHA, suggest that sleep continuity and quality are independently associated with functional performance and mental health, and not simply a reflection of comorbidity, aging, or gender. Although the proportion of variance explained by the sleep variables was modest at 9% to 20%, the individual sleep variables made the most relevant unique contributions to the explained variance in the functional performance variables, as compared with the clinical and demographic variables.

The sleep continuity variables, including wake time and duration of wake bouts, explained the largest proportion of the variance in functional performance. However, sleep quality was the most important sleep variable relative to mental health; the magnitude of its relationship was similar to that of comorbidity. These findings suggest that the perception of sleep may be most relevant to mental health, whereas its objective characteristics may be more relevant to functional performance.

The pattern of relationships between sleep quality, duration, and continuity and functional performance suggest that sleep quality and continuity may be more important than quantity. Consistent negative relationships between time in bed and the functional performance variables suggest that lying in bed may not lead to increase sleep or rest that improve functional performance. On the other hand, persons who have poorer functional performance may compensate by taking more time in bed. The causal direction of these relationships requires further study.

A strength of this study was its focus on multidimensional subjective and objective attributes of sleep among HF patients living in their home environments. Given typically

poor correlations between objective and subjectively evaluated sleep,[6,7] and our observation of different patterns of relationships between the objective and subjective sleep variables and the dependent variables, objective data added important information to previous self-report findings. Actigraphy permitted quantification of individual sleep characteristics that would be obscured by use of the global sleep quality score obtained from the PSQI alone.

We did not employ polysomnography because our goal was to nonintrusively evaluate sleep in the home environment. Although we excluded patients with known primary sleep disorders, such as sleep-disordered breathing and periodic limb movement disorder, it is likely that some participants had these conditions and that they contributed to the sleep characteristics that we observed. The influence of sleep disordered breathing, and more detailed analysis of illness- and treatment-related variables should be considered in future studies.

The study findings underscore the importance of clinical evaluation and intervention for sleep problems. Although causal relationships cannot be inferred from the current study due to its cross-sectional design, improving the sleep of HF patients may also improve functional performance and mental health. Based on our findings, treatments that improve sleep consolidation (eg, reducing duration of sleep latency, arousals and awakenings, the duration of arousals and awakenings) are likely to be more effective than those that increase sleep time alone. The potential benefits of treating HF patients for sleep-disordered breathing have frequently been emphasized. However, insomnia and other sleep-related problems may also contribute to decreased sleep continuity and perceptions of poor quality sleep that may subsequently lead to decrements in functional performance. The finding of negative relationships between hypnotic use and functional performance suggests the need for further study of the direction of these relationships and the effects of specific hypnotic agents.

Given the significance of functional performance and mental health to quality of life among HF patients, there is a need for prospective studies to determine the trajectory of sleep disturbance among HF patients and clinical trials to examine the impact of interventions on sleep and functional performance outcomes in HF patients.

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