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Research

Nocturnal sleep, daytime sleepiness, and quality of life in stable patients on hemodialysis

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Abstract

Background: Although considerable progress has been made in the treatment of chronic kidney disease, compromised quality of life continues to be a significant problem for patients receiving hemodialysis (HD). However, in spite of the high prevalence of sleep complaints and disorders in this population, the relationship between these problems and quality of life remains to be well characterized. Thus, we studied a sample of stable HD patients to explore relationships between quality of life and both subjective and objective measures of nocturnal sleep and daytime sleepiness

Methods: The sample included forty-six HD patients, 24 men and 22 women, with a mean age of 51.6 (10.8) years. Subjects underwent one night of polysomnography followed the next morning by a Multiple Sleep Latency Test (MSLT), an objective measure of daytime sleepiness. Subjects also completed: 1) a brief nocturnal sleep questionnaire; 2) the Epworth Sleepiness Scale; and, 3) the Quality of Life Index (QLI, Dialysis Version) which provides an overall QLI score and four subscale scores for Health & Functioning (H&F), Social & Economic (S&E), Psychological & Spiritual (P&S), and Family (F). (The range of scores is 0 to 30 with higher scores indicating better quality of life.)

Results: The mean (standard deviation; SD) of the overall QLI was 22.8 (4.0). The mean (SD) of the four subscales were as follows: H&F – 21.1 (4.7); S&E – 22.0 (4.8); P&S – 24.5 (4.4); and, F – 26.8 (3.5). H&F (r_s = -0.326, p = 0.013) and F (r_s = -0.248, p = 0.048) subscale scores were negatively correlated with periodic limb movement index but not other polysomnographic measures. The H&F subscale score were positively correlated with nocturnal sleep latency (r_s = 0.248, p = 0.048) while the H&F (r_s = 0.278, p = 0.030) and total QLI (r_s = 0.263, p = 0.038) scores were positively associated with MSLT scores. Both of these latter findings indicate that higher life quality is associated with lower sleepiness levels. ESS scores were unrelated to overall QLI scores or the subscale scores. Subjective reports of difficulty falling asleep and waking up too early were significantly correlated with all four subscale scores and overall QLI. Feeling rested in the morning was positively associated with S&E, P&S, and Total QLI scores.

Conclusion: Selected measures of both poor nocturnal sleep and increased daytime sleepiness are associated with decreased quality of life in HD patients, underscoring the importance of recognizing and treating these patients' sleep problems.

Background

Considerable progress has been made in the treatment of chronic kidney disease (CKD). Yet, suboptimal quality of life continues to be a significant problem for patients receiving hemodialysis (HD). Several factors are believed to contribute to this problem including stress [3-5], depression and anxiety [6], anemia [7-9], the confines of treatment [3,10], and vocational inactivity [7]. Sleep complaints and daytime sleepiness are also very prevalent in this group [11,12], but their impact upon quality of life remains to be well characterized. In the general population, nocturnal and daytime sleep abnormalities adversely affect quality of life-related measures such as general health status [13], satisfaction with life [14], mood [15] and work performance [16]. Because sleep problems, such as insomnia, sleep apnea, and periodic limb movement disorder (see Table 1) are very prevalent in the HD population, information about their association with life quality is essential for the optimization of both interventions and clinical outcomes. Here we present a systematic exploration (that was part of a larger study previously reported [17]) of how quality of life is related to specific measures of nocturnal sleep and daytime sleepiness in a sample of stable HD patients. Our hypothesis was that reduced quality of life would be associated with poorer nocturnal sleep and increased daytime sleepiness.

Methods

Sample

The School of Medicine's Internal Review Board and appropriate HD unit physicians and administrators approved the protocol. Because we sought to study relationships among quality of life and sleep variables in patients with CKD receiving intermittent HD independent of the effects of other major chronic illnesses, potential subjects with histories of cardiac disease, chronic lung disease, arthritis, organic brain disease, drug/alcohol abuse, or past psychiatric disorders [1] requiring treatment were excluded from participation. Because of potential drug-related effects on sleep and wakefulness [18], those subjects routinely taking medications known to modulate central nervous system state such as beta-blockers (low lipid-soluble agents were allowed, e.g. atenolol), other antihypertensives such as clonidine and methyldopa, and antidepressants, sedatives, hypnotics, activating agents, or pain medications were also excluded. Finally, potential subjects were screened via a structured interview to exclude those with a history of or current treatment for sleep apnea syndrome, restless legs syndrome, or periodic limb movement disorder. The final sample included 46 stable, otherwise healthy HD patients recruited from 26 HD units in the Atlanta metropolitan area (see Table 2). According to Cohen [19], using a one-tailed test and an alpha level = 0.05, a sample of 46 provided a power of approximately 85% to detect a medium effect size ($r_s = 0.40$).

Demographic and Clinical Features of the Sample

Demographic, clinical, and dialysis related information was obtained via chart review. Monthly laboratory reports were collected for three months immediately prior to inclusion and the values cited in this report represent the means (± SD; standard deviation) for this period. Exceptions include parathyroid hormone (PTH intact) and ferritin, which were measured once during the three-month period. Body mass index (BMI) was calculated using the patient's estimated dry weight (ideal weight at optimal fluid balance) at the time of consent. All subjects received HD three times a week on one of three shifts (based on when a majority of their treatment occurred; shift 1 – 6 am to 10 am; shift 2 – 10 am to 2 pm; shift 3 – 2 pm to 6 pm) for periods of three to five hours. All subjects were metabolically stable and adequately dialyzed [20] (see Table 2).

Evaluation of Nocturnal Sleep and Daytime Sleepiness

On the night of a HD treatment day (i.e., 6 to 12 hours post treatment), all subjects were asked to complete brief nocturnal and daytime sleep questionnaires and to undergo one night of laboratory-based nocturnal polysomnography (PSG) followed by a daytime PSG nap study (Multiple Sleep Latency Test; MSLT). These subjective and objective measures target the most common nocturnal and daytime sleep complaints and primary sleep disorders seen in HD patients [21](see Table 3).

The questionnairse asked subjects to estimate the amount of sleep they typically obtained each night over the past six months. In addition, they were asked to rate, on a scale from 1 (rarely) to 5 (always), the following: how often they had trouble falling asleep, waking up during the night, and waking up too early and not being able to fall asleep again; how often they felt rested in the morning; how often they napped; and, how often they awoke at night from kicking of the legs and gasping/choking. If the subject marked the "do not know" option, the response was coded 0 (missing data). Content validity of the questionnaire is supported by the fact that it targeted major domains of subjective sleep quality measured by several other sleep instruments [22-26] and included specific questions used in a large population-based study of sleep [27]. In addition, it captured perceptions of two polysomnographic measures of interest in this population – limb movements and apneas (see Table 3). Subjects also completed the Epworth Sleepiness Scale (ESS), an inventory designed to evaluate a patient's general level of subjective sleepiness – or more specifically, chance of dozing in real life situations [28,29]. The range of possible scores on the ESS is 0 to 24, with higher scores indicating greater levels

Table 1: Definitions of Sleep Variables Measured in the Study [1,2]

Brief Arousal – An abrupt change (3 to 14 seconds) from a "deeper" stage of NREM sleep to a "lighter" stage, or from REM sleep to wakefulness.
Brief Arousal Index – number of brief arousals/hour of sleep; normally < 15/hour
Excessive Daytime Sleepiness – Difficulty in maintaining the alert, awake state. Can be measured subjectively using questionnaires (such as the Epworth Sleepiness Scale; see text) or objectively (polysomnographically) using the Multiple Sleep Latency Test (see text).
Insomnia/Sleep Fragmentation (subjective) – difficulty initiating or maintaining sleep; often characterized by difficulty falling and/or staying asleep, early morning awakenings, or unrefreshing sleep.
Mean Sleep Latency – the average period of time from the start of a nap opportunity to the first epoch of sleep as measured by the Multiple Sleep Latency Test.
Periodic Limb Movement – a rapid partial flexion of the foot at the ankle, extension of the big toe, and partial flexion of the knee and hip[that occurs during sleep. The movements occur with a periodicity of 5 to 90 seconds, lasting 0.5 to 5.0 seconds.
Periodic Limb Movement Index (PLMI) – number of periodic limb movements/hour of sleep.
Periodic Limb Movement with Arousal Index – number of limb movements/hour of sleep associated with an abrupt change from a deeper stage of NREM sleep to a lighter stage, or from REM sleep to wakefulness
Respiratory disturbance – Cessation (apnea) or reduction in breathing (hypopnea; airflow reduced by at least 50%) during sleep, lasting 10 seconds or longer, often associated with a fall in blood oxygen saturation.
Respiratory Disturbance Index (RDI) – number of apneas/hypopneas per hour of sleep.
Sleep Efficiency (SE) – The proportion of sleep in the episode filled by sleep; the ratio of TST to time in bed. Normal values range typically from 80% to 95% and decrease with age.
Sleep Latency (SL) – The onset of sleep defined as the first of three consecutive epochs of Stage 1 sleep or the first epoch of any other stage of sleep. Normal sleep latency averages < 20 minutes.
Total Sleep Time (TST) – The amount of actual sleep time in a sleep episode; the time is equal to the total sleep episode less the awake time; average normal TST is 7.5 hours.

of subjective sleepiness. A score > 11 is often used to identify individuals with significant subjective sleepiness levels [30]. Acceptable validity, test-retest reliability, and internal consistency reliability of the ESS have been reported [28,29].

The PSG consisted of a standard montage (electrode placement) of electroencephalography (EEG) (C3/A2 or C4/A1 and O2/C3 or O1/C4), monopolar left and right electrooculography (EOG) referenced to the opposite mastoid, surface mentalis electromyography (EMG), respiratory airflow and effort, electrocardiography (ECG), anterior tibialis EMG, and pulse oximetry. All recordings were made on a Grass Model 78 polysomnograph recorded with a paper speed of 10 mm/sec and scored in 30-second epochs. Sleep variables calculated for each subject included: Total sleep time (TST, minutes); sleep efficiency (SE = TST/time in bed × 100); the percentage of TST spent in stages 1, 2, 3 & 4, and REM (rapid-eye-movement) sleep [31]; and the latency to three consecutive epochs of sleep (sleep latency, SL, minutes). Periodic leg movements and movements with arousals [32], apneas, and total brief arousals [33] were scored using conventional criteria. The brief arousals, apneas, limb movements, and limb movements with arousals observed were expressed as the number of events per hour of sleep. All PSGs were scored by the same certified polysomnographic technician and verified by the Director of the Sleep Disorders Center.

The morning following the nocturnal PSG, daytime sleepiness was quantified using the Multiple Sleep Latency Test (MSLT) following standard procedures [34]. Approximately 1.5 to 2 hours after awakening, subjects were allowed five 20 – minute nap opportunities at 2-hour intervals across the day. The SL on any given nap opportunity was defined as the time from lights out to the first 30-second epoch scored as sleep. Each nap was terminated after 20 minutes or after a maximum of 15 minutes from sleep onset. The average SL across all naps was calculated and expressed as the mean sleep latency. The range of possible mean sleep latency scores on the MSLT is 0 to 20 minutes, with a low score indicating greater sleepiness. According to the International Classification of Sleep Disorders (ICSD), a mean sleep latency ≤ 5 minutes suggests "severe or pathological" sleepiness, a mean sleep latency between 5 minutes and 10 minutes suggests "moderate sleepiness", and a mean sleep latency > 10 minutes suggests "mild or normal sleepiness". An alternative schema also used to interpret MSLT scores is based on supporting evidence derived from comparisons of normal subjects to patients with sleep abnormalities[15,35-37] and uses a MSLT score < 8 minutes as indicative of abnormal sleepiness.

Evaluation of Quality of Life

Quality of life was defined as a person's sense of well-being reflecting satisfaction or dissatisfaction with the areas of life that are deemed important. Immediately before the nocturnal PSG, all subjects completed the Quality of Life Index (QLI, Dialysis Version) developed by

Table 2: Demographic/Clinical/Dialysis-Related Features of the Sample

Demographic Variables	**Mean (SD*) or n****	**Median**	**Range**
Age	51.6 (10.8)	52.0	32.0 to 74.0
Gender (n)			
• Males	24		
• Females	22		
Race (n)			
• Black	36	--	--
• White	10		
Marital Status (n)			
• Married	27	--	--
• Divorced	4		
• Single	15		
Years of Education	12.3 (2.0)	12.0	7.0 to 18.0
Clinical Variables			
Etiology of Renal Failure (n)			
• Diabetes	15	--	--
• Hypertension	22		
• Glomerulonephritis	3		
• Other	6		
BUN (mg/dL)	65.0 (16.8)	63.0	39.3 to 105.0
Creatinine (mg/dL)	12.0 (2.8)	12.4	3.6 to 17.5
Sodium (meq/L)	139.9 (3.0)	139.5	132.3 to 147.3
Potassium (meq/L)	4.9 (0.7)	4.6	3.8 to 6.4
CO_2 (meq/L)	20.6 (2.8)	20.7	13.8 to 27.7
Calcium (mg/dL)	9.5 (0.8)	9.6	7.5 to 11.4
Phosphorous (mg/dL)	5.4 (1.5)	5.3	2.8 to 10.5
Hematocrit (%)	35.8 (3.2)	36.2	28.9 to 43.2
Ferritin (μ/L)	549.1 (394.3)	515.0	13.4 to 1764.0
PTH (pg/ml)	222.9 (197.7)	184.5	13.0 to 1144.0
Body Mass Index (kg/m^2)	26.8 (5.6)	26.8	17.0 to 40.1
• Black Males (n = 18)	25.8 (5.1)		18.8 to 36.8
• Black Females (n = 18)	28.0 (5.8)		17.0 to 40.1
• White Males (n = 6)	25.3 (6.1)		20.7 to 36.6
• White Females (n = 4)	27.3 (7.1)		18.3 to 35.5
Days hospitalized	2.2 (3.3)	0	0 to 12
Dialysis Variables			
Kt/V	1.5 (0.3)	1.5	1.1 to 2.6
Treatment time (minutes)	219.0 (24.1)	220.0	165.0 to 270.0
Shift			
• 1	18	--	--
• 2	13		
• 3	15		
Months on HD	37.5 (36.0)	28.5	5.0 to 184.0

* SD = standard deviation, ** = number

Ferrans and Powers [38,39], a questionnaire consisting of 64 items divided into two sections. The first section assesses how satisfied the subject is with 32 aspects of life while the second assesses the importance of those same aspects. Responses to the satisfaction items range from "very satisfied" (6) to "very dissatisfied" (1). Responses to the importance items range from "very important" (6) to "very unimportant" (1). Scores are calculated by weighting each satisfaction response with its paired importance response. Overall QLI scores and four subscale scores are calculated: Health & Functioning, Social & Economic, Psychological & Spiritual, and Family. The range of scores on the overall scale and the subscales scores is 0 to 30 with a higher score indicating a better quality of life.

Table 3: Common Sleep Problems/Disorders in Hemodialysis Patients: Comparison of Subjective and Objective Measures

Problem	Subjective (prior six months)	Objective (one night of PSG and daytime MSLT)
Insufficient sleep	Amount of sleep typically obtained	Total sleep time
Insomnia/Sleep Fragmentation	Difficulty:	
	• Falling asleep	Nocturnal sleep latency
	• Staying asleep	Sleep efficiency
	• Early morning awakenings	Arousals
	• Unrefreshing sleep	
Daytime sleepiness	Frequency of daytime napping	Nocturnal sleep latency
	Epworth Sleepiness Scale	Multiple Sleep Latency Test
Periodic Limb Movement Disorder	Waking from legs kicking	Periodic limb movements/hour
Sleep Apnea Syndrome	Waking from gasping/choking	Apneas/hour

PSG = polysomnography, MSLT = Multiple Sleep Latency Test

The instrument has excellent validity and reliability [38]. Content validity was established by administering a questionnaire that included sixty-four items applicable to both healthy graduate students and dialysis patients (n = 88). Six items relative to dialysis were added and the instrument was administered to dialysis patients (n = 37). Correlations between the instrument and an overall satisfaction with life question of 0.75 (graduate students) and 0.65 (dialysis patients) supported criterion-related validity. Support for reliability was provided by test-retest correlations of 0.87 (graduate students) and 0.81 (dialysis patients) and Cronbach alphas of 0.93 (graduate students) and 0.90 (dialysis patients)[40].

Data Analysis

Descriptive statistics were used to summarize all data. Because examination of the data revealed that they did not meet the assumption of normality necessary for the use of parametric statistical tests, nonparametric procedures were used. Differences in quality of life scores in groups of patients based on categorical variables were detected using the Mann Whitney-U (two categories) or the Kruskal-Wallis (three or more categories) procedures [41]. Correlations between quality of life scores and interval/ratio/ordinal measures were performed using the Spearman rho (r_s) correlation procedure (one-tailed test; our hypothesis was that poorer nocturnal sleep and increased daytime sleepiness would be associated with decreased quality of life) [41]. Internal consistency reliability of the QLI in this sample was supported by Cronbach's alphas of 0.91 for the overall scale and 0.80, 0.94, 0.81, and 0.91, respectively, for the Health & Functioning, Social &Economic, Psychological & Spiritual, and Family subscales. Results were also similar to those previously reported in a larger, more representative sample of HD patients (see Table 4) [38]. The significance level was set at $\alpha = 0.05$. Because of the exploratory nature of this study, we chose not to use the Bonferroni correction for multiple correlations and to accept the greater possibility of making a Type II error [22].

Results

The demographic, clinical, and dialysis-related features of the sample are included in Table 2. Similar to national statistics for HD patients [42], the mean age was 51.6 (10.8) years with a relatively even gender distribution; diabetes and hypertension were the most common causes of CKD. Unlike the national population of HD patients, a majority of subjects in this sample were black reflecting the racial composition of the available population. Subjects had a relatively high level of education because of the need to read and complete study questionnaires.

The mean total QLI and the four subscale scores are reported in Table 4. Overall QLI, the Health & Functioning, and the Psychological & Spiritual scale scores were significantly higher than those reported by Ferrans & Power (t-test) in a larger randomly selected sample of HD patients [38], probably reflecting the overall stable condition and otherwise general good health of this sample. Also similar to the Ferrans & Powers study, subjects were most satisfied with their Family quality of life; relationships among children/spouses/significant others and family's happiness were both the most satisfying and most important. Correlations between items of satisfaction and importance regarding children ($r_s = 0.41$, df = 44, p = 0.005), family ($r_s = 0.28$, df = 44, p = 0.038), and spouse ($r_s = 0.61$, df = 44, p = 0.000) were statistically significant. Health & Functioning life quality was the least satisfying and job satisfaction, ability to travel, and amount of stress/worries in life ranked lowest in this regard. However, these items were also among the least important, possibly reflecting adjustment to the life constraints imposed by the disease and its treatment [38].

Table 4: Quality of Life Index Scores Reported by HD Sample in This Study and by HD Patients Studied by Ferrans/Powers*

Scale	Study Sample (n = 46)			Ferrans &Powers Study (n = 349)*		
	Mean (SD)	Range	Internal Consistency**	Mean (SD)	Range	Internal consistency
Health & Functioning Subscale ***	21.1 (4.7)	10.29–29.54	0.80	18.64 (5.7)	2.8–30.0	0.87
Social & Economic Subscale	22.0 (4.8)	10.71–30.0	0.94	21.29 (5.4)	3.2–30.0	0.82
Psychological & Spiritual Subscale ***	24.5 (4.4)	15.07–30.0	0.81	21.60 (6.7)	0.9–30.0	0.90
Family Subscale	26.8 (3.5)	18.0–30.0	0.91	25.25 (5.1)	0.0–30.0	0.77
Total QOLI Score ***	22.8 (4.0)	14.53–29.67	0.91	20.7 (4.8)	7.3–29.8	0.90

* [38], ** Cronbach's alphas, *** p = 0.005, 0.007, 0.005 respectively: t-test

Table 5: Subjective (Questionnaires) Measures of Nocturnal Sleep and Daytime Sleepiness

Variable	Mean	Median	Mode
Typical sleep duration	377.7 (78.9)	360.0	420.0
How often they felt rested upon awakening in the morning*	3.0 (1.0)	3.0	3.0
How often they had trouble *:			
• Falling asleep	2.9 (1.2)	3.0	3.0
• Waking up at night	2.5 (1.2)	2.0	2.0
• Waking up too early and not being able to fall asleep	2.8 (1.1)	3.0	3.0
How often legs kicked or twitched*	1.9 (1.0)	2.0	1.0
How often awake gasping/choking*	1.6 (1.0)	1.0	1.0
How often they napped*	2.7 (1.1)	3.0	3.0
Epworth Sleepiness Scale	7.4 (4.6)	7.0	6.0

* 0 = don't know (classified as missing data and not included in the analyses), 1 = never, 2 = rarely, 3 = sometimes, 4 = most of time, 5 = always

There were no significant differences in total QLI or subscale scores in groups of subjects based on gender, race, marital status, etiology of renal failure, or treatment time of day. There were also no significant relationships detected between these scores and age, years of education, the number of days hospitalized in the past year, or other parameters measured listed in Table 2.

Data from the nocturnal and daytime sleep questionnaires are presented in Table 5. Subjects estimated sleeping an average of 6.3 hours (377.7 ± 78.9 minutes) per night and most reported having difficulty falling asleep, waking up at night, or waking too early in the morning "sometimes". Subjects were typically unaware that their legs kicked during the night and only rarely experienced gasping or choking. Most subjects reported that they also "sometimes" napped and felt rested during the day. The mean ESS Scale score was 7.4 ± 4.6 suggesting normal subjective daytime sleepiness levels. However, 30.4% (n = 14) had scores ≥ 11, suggesting that clinically significant sleepiness was a problem for many of the subjects [17].

Data from the nocturnal PSGs are presented in Table 6. The mean TST for the group was 5.6 hours (335.8 ± 64.8 minutes) with a SE of 78.2% ± 14.0, values lower than normative data reported for individuals of the same gender and similar in age [43] but consistent with the results of other PSG studies in HD patients [44,45]. General features of nocturnal sleep, including percentage of time spent in the various stages of sleep, were unremarkable. Mild sleep apnea (RDI < 15 apnea/hour) [2] and periodic limb movement disorder (PLMI < 25 limb movements/hour) [1] characterized the group despite clinical screening to eliminate subjects with these problems. The average MSLT score was 10.2 ± 4.2 minutes; 15 of the subjects (32.6%) had scores less than 8 minutes and 6 (13.0%) had pathologic daytime sleepiness (MSLT scores < 5 minutes), indicating that objectively measured daytime sleepiness was also a problem for many of the subjects [1,15,17,36,37]. There were no significant univariate relationships noted between subjective and objective measures of sleep.

The correlations between the quality of life scores and subjective and polysomnographic nocturnal/daytime sleep variables appear in Table 7. Increased perceived difficulty falling asleep and waking up early in the morning were negatively associated with total QLI scores and all four subscale scores. Feeling more rested in the morning was positively associated with Social & Economic (r_s =

Table 6: Polysomnographic Measures of Nocturnal Sleep and Daytime Sleepiness

Variable	Mean (SD)	Median
Total Sleep Time (minutes)	335.8 (64.8)	343.0
Sleep Efficiency (%)	78.2 (14.0)	82.4
Sleep Latency (minutes)	31.1 (37.6)	15.9
RDI (events/hour)	13.1 (20.4)	5.4
PLMI (events/hour)	23.0 (36.7)	5.5
PLMs with arousals (events/hour)	9.3 (13.2)	2.4
BAI (events/hour)	30.9 (24.2)	21.1
Mean Sleep Latency (min)	10.2 (4.2)	10.3

RDI = respiratory disturbance index, PLMI = periodic limb movement index, PLMs = periodic limb movements, BAI = brief arousal index

Table 7: Correlations between Measures of Nocturnal Sleep/Daytime Sleepiness and Quality of Life Scores

Variable	Health & Functioning	Social & Economic	Psychological & Spiritual	Family	Total QLI
Subjective measures (questionnaires) *					
Typical sleep duration (n = 46)	--	r_s = 0.301 P = 0.022	--	--	--
How often they had trouble :					
• Falling asleep (n = 45)	r_s = - 0.387 p = 0.004	r_s = - 0.402 p = 0.003	r_s = - 0.422 p = 0.002	r_s = - 0.497 p = 0.000	r_s = - 0.472 p = 0.001
• Waking up at night (n = 44)	--	--	--	--	--
• Waking up at night and not being able to get back to sleep (n = 45)	r_s = - 0.426 p = 0.002	r_s = - 0.480 p = 0.000	r_s = - 0.373 p = 0.006	r_s = - 0.461 p = 0.001	r_s = - 0.496 p_s = 0.000
How often they felt rested upon awakening in the morning (n = 46)	--	r_s = 0.325 p = 0.014	r_s = 0.319 p = 0.015	--	r_s = 0.332 p = 0.012
Nocturnal kicking/twitching (n = 30)	--	--	--	--	--
Nocturnal gasping/choking (n = 41)	--	--	--	--	--
How often they napped (n = 46)	--	--	--	--	--
Epworth Sleepiness Scale (n = 46)	--	--	--	--	--
Objective Measures (polysomnography) **					
Total Sleep Time (min)	--	--	--	--	--
Sleep Efficiency (%)	--	--	--	--	--
Sleep Latency (min)	r_s = 0.248 p = 0.048	--	--	--	--
RDI (events/hour)	--	--	--	--	--
PLMI (events/hour)	r_s = -0.326 p = 0.013	--	--	r_s = -0.248 p = 0.048	--
PLMs with arousal (event/hour)	r_s = -0.247 p = 0.049	--	--	--	--
BAI (events/hour)	--	--	--	--	--
Mean Sleep Latency (min)	r_s = 0.278 p = 0.030	--	--	--	r_s = 0.263 p = 0.038

*those subjects who responded that "don't know" (0) were excluded from the analysis, **all analyses include all subjects (n = 46)

0.325, df = 44, p = 0.014), Psychological & Spiritual (r_s = 0.319, df = 44, p = 0.015), and Total QLI (r_s = 0.332, df = 44, p = 0.012) scores. ESS scores were unrelated to quality of life measures. Health & Functioning scores were positively correlated with nocturnal sleep latency (r_s = 0.248, df = 44, p = 0.048) while MSLT scores were positively correlated with both Health & Functioning (r_s = 0.278, df = 44, p = 0.030) and the total QLI scores (r_s = 0.263, df = 44, p = 0.038). These findings collectively indicate that less daytime sleepiness was associated with better quality of life. Although increased numbers of periodic limb movements (PLMI) were associated with lower Health & Functioning (r_s = -0.326, df = 44, p = 0.013) and Family (r_s = -0.248, df - 44, p = 0,048) subscale scores, no other rela-

tionships were noted between PSG and quality of life measures.

Discussion

Numerous studies in the general population have demonstrated that poor or reduced amounts of nocturnal sleep and excessive daytime sleepiness adversely affect a variety of quality of life and functional health status indicators [15,46-50]. Both problems have also recently been associated with cardiovascular disease [46-49], the most common cause of death in the HD population [42]. However, although sleep disorders and excessive daytime sleepiness [51] are very prevalent in the HD population, limited information is available with regard to the extent to which these problems affect life quality. Previous reports suggest that poor subjective sleep[52,53] and sleep-related breathing disorders [54] have adverse effects, but the scope of these studies with regard to sleep measures is limited. Thus, we examined how quality of life is related to both subjective and objective measures of nocturnal sleep and daytime sleepiness in a sample of stable HD patients.

Perhaps the most important finding of this study is that selected indicators of poor nocturnal sleep and increased daytime sleepiness are associated with reduced quality of life. Sleep complaints that characterize insomnia [52,55], including difficulty initiating sleep, early morning awakenings, and feeling unrefreshed in the morning, are particularly important. A recent study by Williams et al. [52], also noted that complaints of insomnia were associated with pain, depression, and decreased physical functioning. These findings suggest that the assessment and treatment of insomnia-related complaints should be included in any overall plan of care designed to optimize quality of life as well as other important clinical outcomes. Numerous pharmacological and/or cognitive behavioral techniques are efficacious for treatment of insomnia but controlled clinical trials designed to evaluate their effectiveness in HD patients remain to be conducted [56-59].

Relationships between TST (measured subjectively or via PSG) and quality of life measures were not observed, although subjects obtained an average of only 6 hours of sleep per night. Excessive daytime sleepiness and decreased functional status are prevalent in health community samples that are sleep restricted to this extent [15,35,46-50,60,61]. We also found that subjective reports of napping less and PSG measures indicating less daytime sleepiness were associated with higher quality of life. Because sleep requirements vary, overall perceived sleep quality, including subjective responses to sleep and the ability to function optimally during the day, may be more important than absolute amount of sleep obtained. It is interesting to note that Kripke et el. recently demonstrated an increased risk of mortality associated with chronic nocturnal sleep periods less than or equal to six hours [62]. In a 10-year follow-up from NHANES I, Qureshi et al. also found an increase in stroke in persons who reported greater than eight hours or less than six hours per night [63]. Increased napping has also been associated with increased mortality in the elderly [64,65]. Studies designed to examine the relationship between specific nocturnal and daytime sleep measures and these other important clinical outcomes remain to be conducted with the HD population.

Subjects were typically unaware that their legs kicked or twitched during the night. Nonetheless, PSG revealed that periodic limb movements were prevalent in this sample. Greater numbers of movements and movements with arousals per hour were associated with decreased Health & Functioning subscale scores, an observation consistent with previous reports of increased morbidity and mortality in HD subjects with limb movements [66,67]. Moreover, it is possible the association of increased limb movements and decreased family subscale scores may reflect spousal problems with and/or reaction to nocturnal kicking and sleep problems as marital discord is often seen when one of the partners has a sleep disorder. Because of the high prevalence of both sleep abnormalities and divorce in the HD population, investigations of the effects of sleep problems on marital relationships represents an important area for future research. In contrast to a previous report [54], we did not find a significant relationship between apnea and quality of life measures, most likely because those with a strong history of or receiving treatment for the condition were systematically eliminated from participation in this study.

Conclusions

In summary, our results support our initial hypotheses that better sleep quality and less daytime sleepiness are associated with improved quality of life in stable HD subjects. The overall good health/stability and particular racial characteristics of the sample limit the generalizability of the results to the whole HD patient population. The small sample size may have also limited our ability to detect some relationships. Nonetheless, the data support findings from other studies that have linked general measures of disturbed sleep in HD subjects with a variety of quality of life related variables [7,38,68-71]. Some of these indicated that other clinical outcomes such as a dialysis patient's ability to learn and perform home dialysis [72-75]; spousal and family normalcy [75,76]; anxiety and depression [77]; and days of disability [78] are associated with reduced sleep quality. Our results suggest that clinicians should specifically query about nocturnal sleep quality and daytime sleepiness as they are clinical variables essential to consider when designing a comprehen-

sive treatment program aimed at optimizing the quality of life of HD patients.

Authors' contributions

KPP was the primary investigator on this project, analyzed the data, and wrote the initial draft of the manuscript.

NGK assisted with the data analysis, interpreting results, and in manuscript development.

DLB was Co-Investigator and assisted in all phases of project implementation and the preparation and revisions of the manuscript.

JLB was Co-Investigator and assisted in all phases of project implementation and the preparation and revisions of the manuscript.

DBR was a Consultant and assisted in all phase of project implementation and the preparation and revisions of the manuscript.

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