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Sleep, Health-Related Quality of Life, and Functional Outcomes in Adults with Diabetes

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Abstract

Purpose—This study explored the association of sleep quality with physical and mental health-related quality of life (HRQoL) and functional outcomes in 116 participants with type 2 diabetes.

Methods—The study is a secondary analysis of baseline data from a clinical trial that examined treatment of obstructive sleep apnea on physical activity and glucose control. Instruments included the Pittsburgh Sleep Quality Index, Medical Outcomes Short-Form Physical Component and Mental Component Scores, and Functional Outcomes of Sleep Questionnaire.

Results—Higher physical HRQoL was significantly associated with better sleep quality and improved functional outcomes of increased activity and productivity. Higher mental HRQoL was associated with improved sleep quality and improved functional outcomes of increased activity, social interactions, vigilance, and productivity. Poor sleep quality was a predictor of decreased functional outcomes while controlling for age, race, education, BMI, marital status and physical and mental HRQoL.

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Conclusion—Poor sleep quality is associated with negative physical, mental, and functional outcomes in adults with type 2 diabetes.

Keywords

sleep quality; health-related quality of life; functional outcomes; type 2 diabetes mellitus

During the last ten years, there has been a change in diabetes care from focusing exclusively on patient adherence and glycemic control to a holistic approach of empowering patients to achieve optimal health (Anderson & Funnell, 2000). According to the World Health Organization, health denotes more than the absence of disease; it comprises the concepts of physical, mental and social wellbeing (2006). Although good sleep quality is acknowledged as critical for health and well-being, the prevalence of inadequate or impaired sleep is wide-spread among adults. Inadequate sleep duration is endemic with 40% of the adult population obtaining less than 7 hours of sleep (National Sleep Foundation, 2005). An estimated 50 to 70 million persons in the United States have a sleep or circadian rhythm disorder that results in impaired sleep quality (Colten & Altevogt, 2006). Individuals with type 2 diabetes are at increased risk for sleep problems including obstructive sleep apnea, insomnia, and restless leg syndrome, and increased frequency of nighttime voiding resulting in sleep fragmentation (Chasens, Umlauf, Pillion, & Wells, 2002; Plantinga, Rao, & Schillinger, 2012). Unfortunately there may be a tendency by patients and health care practitioners to ascribe decreased health outcomes to diabetes status and to overlook the consequence that sleep disturbances may have on their functional outcomes.

Previous research suggests sleep disturbances are associated with an increased risk for worse physical (i.e. an increased risk for cardiovascular disease, hypertension, stroke, diabetes, obesity) and mental health (i.e. increased risk for depression and anxiety) (Colten & Altevogt, 2006). Functional status is conceptually defined as the ability of an individual to meet his or her basic needs and role expectations. Functional outcomes include the ability to achieve an active and productive lifestyle, sustain social relationships with friends and family, maintain attention to tasks and continue healthy intimate and sexual relationships (Weaver et al., 1997). Data from a recent study suggests that adults with type 2 diabetes and poor sleep quality are at risk for decreased health-related quality of life (HRQoL) (Luyster & Dunbar-Jacob, 2011). Poor sleep quality and excessive daytime sleepiness were found to be significantly associated with decreased adherence to diabetes self-management behavior, increased diabetes-related distress, decreased dietary adherence, and more diabetes control problems (Chasens et al., 2013). However, the effect of impaired sleep quality on functional well-being remains unclear among adults with type 2 diabetes. Therefore, the purpose of this study in adults with type 2 diabetes is to explore the association of sleep quality with physical and mental HRQoL and with functional outcomes. While controlling for demographic and clinical variables, and for physical and mental HRQoL, we hypothesize that poor sleep quality is independently associated with decreased functional outcomes in adults with type 2 diabetes.

Research Design and Methods

The study is a secondary analysis of baseline data from a double-blinded, randomized clinical trial (Obstructive Sleep Apnea, Sleepiness and Activity in Diabetes Management). The protocol of the study has been described in detail in previous manuscripts (Chasens, Drumheller, & Strollo, 2012; Chasens, Korytkowski, Sereika, & Burke, 2013). The study was approved by the Institutional Review Board at the University of Pittsburgh; informed consent was obtained prior to beginning data collection. The assessment protocol was standardized in a detailed procedure manual that was routinely reviewed and updated. To ensure consistency, the two data collectors observed each other on the initial assessments and discussed assessment fidelity during weekly meetings.

Sample

Sample size was not determined *a priori* for the secondary analysis being reported. The study sample was purposely recruited from individuals who responded to flyers displayed in locations within the university medical center and in surrounding neighborhoods. Minority recruitment was achieved by targeting advertisement of the study in locations in predominantly minority neighborhoods. Potential participants were provided an explanation of the purpose of the study and screened by telephone for the diagnosis of type 2 diabetes and excessive daytime sleepiness; sleepiness was determined by a score of 10 or more on the Epworth Sleepiness Scale (Johns, 1991). Potential participants were excluded if they were less than 30 years old, had previous treatment for sleep apnea, were non-ambulatory, or had a history of an automobile accident related to dozing while driving. Persons who met the initial eligibility criteria were invited to the Neuroscience Clinical Translational Research Center for a baseline evaluation. A total of 116 community-dwelling adults consented to participate in the study; this paper reports the results of the analysis of these participants who completed the baseline assessment.

Measures

Paper-and-pencil measures were prepared in random order for participants to complete at home during the week following their clinical evaluation. This methodology was intended to reduce subject burden and to reduce systematic inaccurate responses influenced by participant fatigue. Participants mailed the questionnaires back in pre-paid envelopes and on receipt, questionnaires were reviewed for completeness. To reduce missing data, participants were called and asked if they could clarify incomplete or unclear data.

Demographic and Clinical Characteristics—Demographic information (age, gender, race, educational level, marital status) was collected with a survey developed in the School of Nursing at the University of Pittsburgh. Educational level was dichotomized as “high school or less education” and “post high school education”. Marital status was dichotomized as “married/partnered” or “single”.

Diabetes status was determined by the subject showing a current prescription bottle of a medicine appropriate for hyperglycemia or a note from their primary care provider confirming the diagnosis of type 2 diabetes. All women of childbearing potential had a urine

pregnancy test to rule out pregnancy. Height and weight were measured without shoes in light street clothing and used to determine body mass index (BMI, kg/m^2; Centers for Disease Control and Prevention, 2011). A venipuncture was performed for a blood sample to determine A1C level; the glycated hemoglobin is an indicator of global glucose control over the last 3 months (Goldstein, Little, Lorenz, Malone, Nathan, & Peterson, 1995).

Sleep Quality—Sleep quality was determined by the validated Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The PSQI is a 19-item self-report instrument that consists of 7 components (perceived sleep quality, time required to initiate sleep, sleep duration, sleep efficiency, sleep disruptions, use of hypnotic medications, and daytime sleepiness) which are individually scored from 0–3 and then summed to yield a global score. PSQI scores range from 0–21, scores greater than 5 are sensitive (89.6%) and specific (86.5%) to identify persons with poor sleep from persons with good sleep. The PSQI has high internal consistency with a reported Cronbach's alpha of .83; the Cronbach's alpha in our sample was .70.

Physical and Mental HRQoL—A modified version of the Medical Outcomes Short-Form (SF-36v2) questionnaire was used to obtain the Physical Component Summary (PCS) and the Mental Component Summary (MCS) used to evaluate these two components of HRQoL outcomes (Ware, Snow, & Kosinski, 1990; Ware & Kosinski, 2001). Scores of the PCS and MCS were transformed to a scale from 0 (lowest) to 100 (highest) with a mean score of 50 and a standard deviation of 10; "expected" scores for each component range from 20 to 58 for the PCS and 17 to 62 for the MCS. The PCS subscales (Physical Functioning, Role-Physical, Bodily Pain, and General Health) had a Cronbach's alpha of .81 in our sample; the MCS subscales (Vitality, Social Functioning, Role-Emotional, and Mental Health) had a Cronbach's alpha of .88 in our sample.

Functional Outcomes—Functional outcomes were determined by the Functional Outcomes of Sleep Questionnaire (FOSQ), a disease-specific instrument designed to evaluate the impact of sleepiness on activities of everyday life (Weaver et al., 1997). The FOSQ is a psychometrically sound instrument yielding a Total Score that is derived from 5 subscales (General Productivity, Social Outcomes, Activity Level, Vigilance, and Intimate Relationships and Sexual Activity) that query the influence of sleepiness on daytime activities identified as sensitive to sleep disturbance. Each question on the FOSQ has a range of responses from 1 "extreme difficulty due to sleepiness" to 4 "no difficulty", the total score is calculated from the mean of the subscale scores multiplied by 5 yielding a potential range of scores for the Total Score from 5 to 20. The FOSQ has internal reliability (subscore alpha range from 0.86 to 0.91, Total Score alpha = 0.95) and the ability to correctly differentiate between normal subjects (Total FOSQ ≥ 17) and those with sleep difficulties ($P = 0.0001$). In our sample, the FOSQ had a Cronbach's alpha .92 for the Total Score and alphas ranged from .74 (General Productivity) to .91 (Social Outcomes), see Table 1 for descriptions and Cronbach's alpha of the subscales.

Statistical Analysis—Statistical analysis was done using IBM SPSS Statistics 20. Statistics were computed to describe the sample characteristics including frequencies,

interquartile range, and percent for categorical variables and means with standard deviations, and minimum and maximum scores for ordinal and ratio level data. Pearson correlation coefficients were used to examine the strength of associations between continuous variables. Chi-square test was used to determine independence between categorical variables; Student's *t*-test was used to determine differences between normally distributed continuous variables.

Hierarchal regression models were examined to determine the significant predictors for the dependent variable of functional outcomes (FOSQ Total Score). Models were computed with age, race, education, A1C level, and BMI entered in the first block, physical (PCS) and mental (MCS) HRQoL entered to the second block, and sleep quality (PSQI) entered to the third block of the model. Data were examined for collinearity; all variables had a high tolerance value and low variance inflation factor levels suggesting that collinearity was not a problem. Additional models were computed to determine the independent effect of the demographic variables, physical and mental health-related quality of life on sleep-related quality of life. The value for removal of variables was ≥.100. The level of statistical significance for all analyses was set at $p<.05$.

Results

Description of the Sample

The sample of adults with type 2 diabetes (see Table 2 for description) was well distributed by race and gender (53% non-White, 55% female) with the majority middle-aged (IQR 47 to 58.75 years), single, and with some education post high-school. Fifty percent of the sample had an A1C greater than 7.0%, indicating suboptimal glycemic control (Mean A1C = 7.4% ± 1.58, range 5.1% -13.9%); almost all the participants were over-weight or obese (Mean BMI = 34.96 ± 6.76, IQR 29.92 to 39.63).

Poor sleep quality (PSQI >5) was reported by the majority of participants (80%; Mean PSQI= 10.39 ± 4.08), not surprising considering that daytime sleepiness was a telephone screening criteria. There was no significant difference in sleep quality between White and non-White participants; in addition, there was no statistically significant associations between sleep quality and the variables of age, BMI, or A1C level. Approximately 60% of the sample had impaired functional outcomes sensitive to sleep disturbances (Mean FOSQ Total Scores= 15.73 ± 2.74). There was a statistically significant association between improved FOSQ Total Scores and age ($r=.257$, $p=.007$) but no significant association between FOSQ Total Scores and either BMI or A1C level. Sample mean scores on PCS (41.79 ± 9.21) and on MCS (43.82 ± 12.79) were significantly ($p=.001$) lower than the norm value of 50 ± 10. There were significant correlations between MCS and age and BMI (respectively, $r=.211$, $r=-.209$, p-values $< .05$). There was no significant difference in sleep quality, sleep-related quality of life, physical or mental health-related quality of life by gender.

Sleep Quality, Functional Outcomes, and Health-related Quality of Life

Impaired sleep quality (see Table 3) had small-to-moderate correlations (r= −.232 to −.457, all *p*-values = <.001) with decreased scores on the FOSQ Total Score and with all of the FOSQ subscores (Activity Level, Social Outcomes, General Productivity, Vigilance, and Intimacy and Sexual Relationships). In addition, impaired sleep quality was significantly associated with lower scores on the PCS and MCS (respectively, *r*= −.249 and *r* = −.454, *p* =.001). Higher physical HRQoL (PCS) was significantly (all *p* values <.05) associated with improved functional outcomes (FOSQ Total Score *r* = .219), increased Activity Level (*r* =. 280) and increased General Productivity (*r* =. 215). Higher mental HRQoL (MCS) had moderately strong correlations with improved sleep quality (*r* = −.408), improved functional outcomes (FOSQ Total Score *r* = .454), increased Activity Level, Social Outcomes, Vigilance, and General Productivity (*r* = .322 to .554, all *p*-values <.05).

Predictors of Functional Outcomes

Table 4 depicts the results of the hierarchal regression model to determine predictors of functional outcomes. While education, race, BMI were not statistically significant, increased age was predictive (*p* =.005) for increased functional outcomes. Physical and mental HRQoL added significantly to the model (independent adjusted R2 = .286 (*p* = .001). Sleep quality (PSQI), added to the 3rd block of the model, was a statistically significant predictor (*p*<.008) of functional outcomes while controlling for age, race, education, BMI, marital status, physical and mental HRQoL.

Discussion

This study provides evidence that decreased sleep quality in adults with type 2 diabetes contributes to lower functional outcomes that impact multiple areas of daily life. Utilizing a validated measure of functional status, higher scores on the PSQI indicating worse sleep quality were significantly associated with decreases in general productivity, activity level, vigilance, social outcomes, and intimacy and sexual relationships. These findings suggest that many of the decrements in daily living may be secondary to undiagnosed and untreated sleep disorders in patients with diabetes. In addition, decrements in functional outcomes were significantly associated with increased sleepiness even while controlling for demographic, clinical, and physical and mental HRQoL. This suggests that impaired sleep is an independent risk factor for decreased well-being among persons with type 2 diabetes.

The increased emphasis on collaboration with the patient correctly places the patient at the center of decision-making and increases the importance of providing persons with diabetes with the skills required to meet their unique challenges. It is frequently unclear why some patients have difficulty in maintaining the energy needed for optimal management. While improving sleep will not solve the difficulty in integrating diabetes education and self-management skills into daily diabetes management, understanding the relationship between impaired sleep and to management of chronic disease management is very important. Therefore, interventions to identify and refer for treatment individuals with type 2 diabetes and co-existing sleep disorders may not only improve their nighttime sleep but may also remove a barrier to effective diabetes self-management.

Limitations of this study are the cross-sectional correlational approach, which precludes assigning causality to poor sleep quality for reduced physical and mental HRQoL or decreased functional outcomes. Participants in this study may not be representative and may have worse sleep quality then the population of adults with type 2 diabetes. The purposeful sampling strategies used by the parent study to recruit a sample with obstructive sleep apnea, restricts the ability to generalize the findings. Finally, the unexplained variance in in the hierarchal regression model to predict functional outcomes sensitive to impaired sleep remains unclear. However, this variance may be associated by the incidence and severity of sleep disorders (i.e. OSA, restless leg syndrome or insomnia), variables that were not objectively evaluated in the study.

Previous studies have shown that there is a high prevalence of sleep disorders in adults with type 2 diabetes, therefore it is safe to conjecture that there likely was a number of persons with undiagnosed sleep problems in the sample (Reichmuth, Austin, Skatrud, & Young, 2005; Vgontzas, Liao, Pejovic, Calhoun, Karataraki, & Bixler, 2009; Yagg, Araujo, McKinlay, 2006). This suggests that further examination is needed to determine the effect of treatments to improve sleep among persons with type 2 diabetes. A recommendation for future study include expanding this analysis with a more representative sample of adults with type 2 diabetes with objective measures of sleep.

Conclusions and Implications

Poor sleep quality and reduced mental and physical HRQoL is associated with decreased functional outcomes in adults with type 2 diabetes. Our results add to an evolving body of knowledge that suggests sleep disorders negatively impact persons with type 2 diabetes. Poor sleep quality was associated with decrements to physical quality of life, mental quality of life, and the ability to be involved in daily activities. This suggests that multiple aspects of functional activities are negatively affected by impaired sleep. Previous studies suggest that impaired sleep is highly prevalent among persons with type 2 diabetes (Reichmuth, Austin, Skatrud, & Young, 2005; Resnick et al., 2003; Vgontzas, Liao, Pejovic, Calhoun, Karataraki, & Bixler, 2009; Yagg, Araujo, & McKinlay, 2006). Results of this study suggest that impaired sleep may be an unrecognized barrier to health-related quality of life and optimal functioning; these results agree with previous studies on sleep quality and HRQoL in adults with diabetes (Luyster& Dunbar-Jacob, 2011). Clinical implications of this study reinforce the International Diabetes Federation’s statement on the need to recognize the importance of evaluation of sleep in persons with type 2 diabetes and the need for appropriate referral for treatment (Shaw, Punjabi, Wilding, Alberti, & Zimmet, 2008). In conclusion, continued research is needed to determine the effect of promotion of healthy sleep and the treatment of sleep disorders in persons with type 2 diabetes on HRQoL, self-management activities, and functional outcomes.

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Table 1

Description of Functional Outcomes of Sleep (FOSQ) Subscales: Number of Items and Cronbach's Alpha for Sample

Scale	Number of Items	Description	alpha
General Productivity	8	Difficulty in concentrating, memory, completing daily activities, or working	.75
Social Outcomes	2	Difficulty in participating in social activity with friends and family in and out of home	.91
Activity Level	9	Difficulty in being active during different times of the day because of sleepiness, role expectations not met due to sleepiness, not able to keep up activity like others their age	.86
Vigilance	7	Difficulty in driving, watching movies, television or religious services because of sleepiness	.79
Intimate Relationships and Sexual Activity	4	Desire or ability to participate in intimacy or sexual activity affected because of sleepiness	.88

Table 2

Demographic and clinical characteristics of participants with type 2 diabetes (N=116)

Variables		*M* ± *SD* (range) or n (%)
Age (years)		52.41 ± 9.48 (31-82)
Gender	Female	64 (55%)
Race		
	White	54 (47%)
	Black or African American	48 (41%)
	Asian	3 (3%)
	Biracial*	11 (9%)
Education		
	≤ High School	51 (44%)
	>High School	65 (56%)
Living situation		
	Married/partnered	47 (41%)
	Single	69 (61%)
Body Mass Index (BMI)		34.96 ± 6.76 (23-51)
A1C		7.40 ± 1.58 (5.1-13.9)

**Note*. Biracial = self-identified as African American and Native American

Table 3

Pearson Correlations of Sleep Quality, Physical and Mental Health-Related Quality of Life, and Functional Outcomes

Variables	PSQI	PCS	MCS
1. PSQI	1		
2. PCS	−.249**	1	
3. MCS	−.408**	.072	1
4. FOSQ Total Score	−.454**	.219*	.454**
5. FOSQ Activity Level Subscore	−.439**	.280**	.502**
6. FOSQ Social Outcomes Subscore	−.378**	.119	.454**
7. FOSQ General Productivity Subscore	−.457**	.215*	.554**
8. FOSQ Vigilance Subscore	−.232**	.113	.322**
9. FOSQ Intimate relationships & Sexual Activity Subscore	−.287**	.108	.169

Note. PSQI= Pittsburgh Sleep Quality Index; PCS= Short Form-36v2 Physical Component Score; MCS= Short Form-36v2 Mental Component Score FOSQ= Functional Outcomes of Sleepiness Questionnaire

* Correlation is significant at the .05 level (2-tailed).

** Correlation is significant at the .01 level (2-tailed).

Table 4
Hierarchal Regression Model to Predict Functional Outcomes

Dependent Variable: FOSQ Total Score									
	Variable	**B**	**SE**	**95% CI**		**Beta**	**p-value**	**R^2 Δ**	**Model**
				LL	**UL**				
Block 1	Age	.070	.024	.021	.118	.237	.005	.105	R^2 model =.408 *df* = 8 *P* =.001
	Race	−.281	.445	−1.165	.602	−.052	.529		
	Education	.395	.436	−.470	1.261	.073	.367		
	BMI	.011	.033	−.115	.039	.028	.733		
	A1C	−.055	.147	−.346	.236	−.031	.709		
Block 2	SF-36 Physical Component	.052	.024	.004	.100	.180	.035	.257	
	SF-36 Mental Component	.075	.019	.038	.112	.358	.001		
Block 3	PSQI	−.161	.059	−.278	−.044	−.245	.008	.046	

Note. FOSQ= Functional Outcomes of Sleepiness Questionnaire, BMI= Body Mass Index; A1C= glycosylated hemoglobin; SF-36= Short Form-36, PSQI= Pittsburgh Sleep Quality Index,