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Gender Differences in the Response to Impaired Sleep in Adults with Diabetes

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Abstract

This study analyzed cross-sectional data to examine gender differences in the association of sleep quality and daytime sleepiness with mood and functional outcomes in adults with type 2 diabetes (T2DM). Measures included demographic and clinical data as well as scales that measured subjective daytime sleepiness, sleep quality, mood disturbances, and functional outcomes. The majority of the sample (N = 116) had poor sleep quality and was subjectively sleepy. We observed in males and females significantly different associative patterns between the predictor variables of daytime sleepiness and sleep quality and the outcome variables of mood and functional outcomes. There was no significant difference in daytime sleepiness or impaired sleep quality between men and women with T2DM; however, there was a difference in the expression of impaired sleep on mood and functional outcomes between genders.

While men have an increased risk for obstructive sleep apnea, and women more frequently report symptoms of insomnia, both genders frequently describe impaired sleep quality. Poor sleep quality negatively affects mood and functional activities sensitive to sleep disruption (Chasens, Umlauf, & Weaver, 2009; Dinges et al., 1997; Weaver et al., 1997); however, it remains unclear if there are differences between men and women in their response to compromised sleep quality.

Type 2 diabetes (T2DM) is a chronic disease that requires not only appropriate medical management, but also the commitment of the patient for daily self-management. Optimal self-management of T2DM requires being adherent to prescribed medications, making healthy diet choices, and engaging in recommended physical activity; however, evidence suggests that impaired sleep quality is associated with poor attitude toward having a diagnosis of diabetes, lower self-care activities such as adherence to good diet choices, and reduced diabetes control (Chasens, Korytkowski, Sereika, & Burke, 2013). The purpose of this study was to determine whether or not there are gender differences in the effect of poor

sleep quality and daytime sleepiness on mood and functional outcomes in participants with T2DM.

The requirements of good sleep include not only the absence of sleep disturbances such as restless leg syndrome (RLS), insomnia, or obstructive sleep apnea (OSA), but also the presence of conditions that permit one to obtain sleep with an adequate duration, fall asleep within a reasonable time of onset after going to bed, maintain sleep continuity with few or only a brief time awake after sleep onset, and feel refreshed upon waking (Buysse, 2014).

Previous studies suggest that sleep disorders (e.g., OSA, insomnia, and RLS) that negatively affect sleep quality frequently co-exist among individuals with T2DM. For example, while OSA affects an estimated 2% of women and 4% of men (Young, Evans, Finn, & Palta, 1997), the prevalence of OSA in persons with T2DM is estimated to range from 40% to 86%, depending on the degree of OSA severity and the age of the sample (Chasens, Umlauf, Pillion, & Wells, 2002; Foster et al., 2009; Punjabi et al., 2002). In one population-based study (Vgontzas et al., 2009), insomnia with short sleep duration (< 5 hours a night) was associated with increased risk for diabetes (Odds Ratio [OR] 2.95, 95% confidence interval [CI] 1.2–7.0). Additionally, Cuellar and Ratcliffe (Cuellar & Ratcliffe, 2008) found that those with T2DM who report symptoms of RLS reported significantly worse sleep quality, longer time to initiate sleep after going to bed, decreased time asleep while in bed, and worse daytime sleepiness compared to persons with diabetes who did not have RSL symptoms (all p -values < .05).

There are limited data on gender differences in functional outcomes of impaired sleep. In one study (Krishnan & Collop, 2006), healthy women reported better sleep than men; however, women of all ages reported more sleep problems such as difficulty obtaining adequate sleep duration and difficulty initiating sleep. Results of a meta-analysis (Zhang & Wing, 2006) of risk factors for insomnia demonstrated a higher relative risk (RR) in women (1.41 [95% CI: 1.28–1.55]) compared to men, with a significant increase in the prevalence of insomnia among post-menopausal women (Moline, Broch, & Zak, 2004).

Four previous papers have reported results from the *Obstructive Sleep Apnea, Sleepiness, and Activity in Diabetes Management* (OSAD) study (Chasens, Drumheller, & Strollo, 2012; Chasens et al., 2013; Chasens, Korytkowski, et al., 2014; Chasens, Sereika, Burke, Strollo, & Korytkowski, 2014). The main results of the parent study demonstrated modest improvements in physical activity (effect size $d = 0.24$), sleep quality ($d = -.62$), daytime sleepiness ($d = -.76$), functional activity ($d = .86$), vigor ($d = .57$), and fatigue ($d = -.72$) in participants randomized to continuous positive airway pressure (CPAP) therapy compared to those receiving sham-CPAP therapy (Chasens, Korytkowski, et al., 2014). Participants were successfully blinded to whether or not they were on active CPAP compared to sham-CPAP as demonstrated by 44% of participants incorrectly “guessing” their group assignment. However, those on active CPAP used their CPAP devices significantly longer than those on sham-CPAP ($p < .05$) (Chasens et al., 2012). Baseline data of participants evaluated ($N = 116$) for inclusion in the RCT found there was a negative correlation between impaired sleep quality and physical ($r = -.25$) and mental ($r = -.41$) health-related quality of life (p -values < .01). Poor sleep quality ($p = .008$) predicted decreased functional outcomes, while

controlling for age, race, education, BMI, A1C, and health-related quality of life (Chasens, Sereika, et al., 2014). Additionally, poor sleep quality was found to be significantly ($p < .05$) associated with self-reported difficulties with diabetes control, lower positive attitude about diabetes, reduced self-care adherence to diabetes management, lower dietary adherence, and increased negative attitude about diabetes (Chasens et al., 2013). The analysis presented in this paper furthers the knowledge on the influence of gender on the expression of sleepiness and its effect on mood and functional outcomes in adults with T2DM.

Understanding gender differences is important because men and women not only have different risk factors and symptom presentation for diseases, but also may respond differently to management of chronic illness. However, it remains unclear whether or not there is a difference in the effect of impaired sleep quality and daytime sleepiness on mood or functional outcomes between men and women with T2DM. Although both men and women may demonstrate poor sleep quality and daytime sleepiness, we hypothesize that the association of sleep quality and daytime sleepiness with mood impairments or functional outcomes differs between the sexes.

Methods

Design

A descriptive correlational design was used to examine gender differences from the baseline data from the *Obstructive Sleep Apnea and Diabetes Management* (OSAD) study. The OSAD study was a two-group, randomized clinical trial (RCT) of community-dwelling adults with T2DM, recruited because of their excessive daytime sleepiness, to obtain pilot data on the effect of continuous positive airway pressure (CPAP) on physical activity and glycemic variability. Eligibility criteria included an Epworth Sleepiness Scale score ≥ 10 , ages 30 years and older, type 2 diabetes verified by the primary care provider or a medication normally prescribed for hyperglycemia, and not pregnant. The parent study protocol was approved by the University of Pittsburgh, Institutional Review Board. All participants provided written, informed consent. A participant incentive of \$30 was provided for the baseline assessment.

Measures

Sociodemographic and clinical factors—A questionnaire developed in the Center for Research in Chronic Disorders at the School of Nursing, University of Pittsburgh was used to collect demographic data (Sereika & Engberg, 2006) which included age, gender, race, marital status, and education. Wearing light clothing with shoes removed, participants were evaluated clinically to obtain height and weight in order to calculate body mass index (BMI, $[\text{kg}/\text{m}^2]$). Glucose control was assessed by measuring the participants' A1C level.

Pittsburgh Sleep Quality Index (PSQI)—Sleep quality, defined as sleep of sufficient duration and depth that results in an individual feeling awake and refreshed during the day, was measured by the PSQI (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The PSQI is a 19-item questionnaire that measures seven sleep-related components (i.e., *subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use*

of sleeping medication, and daytime dysfunction) to obtain a single factor PSQI score. PSQI scores potentially range from 0 to 21; individuals with PSQI scores of 5 or less are categorized as *good sleeper*, and a PSQI score greater than 5 indicates *poor sleeper*. The PSQI has good psychometric properties (i.e., sensitivity of 89.6% and specificity of 86.5%) and can accurately distinguish *good* from *poor* sleep quality; moreover, homogeneity of the seven component scores (Cronbach's $\alpha = .83$). The PSQI has been demonstrated internal consistency of the seven PSQI component scores in this study was slightly lower (Cronbach's $\alpha = .69$). Sleep duration, sleep latency, and sleep efficiency were calculated from the PSQI.

Epworth Sleepiness Scale (ESS)—Subjective daytime sleepiness, defined as the self-reported likeliness for falling asleep in a variety of situations ranging from ones in which vigilance is essential (e.g., driving a car) to ones in which falling asleep may be expected (e.g., lying down to rest in the afternoon), was measured with the ESS (Johns, 1991, 1992). The ESS is a single-factor, 8-item questionnaire with scores that range from 0 to 24; a score of 11 or greater indicates significant sleepiness. The ESS has a high reported internal consistency (Cronbach's $\alpha = .88$); internal consistency of the ESS in this study was slightly lower (Cronbach's $\alpha = .76$).

Profile of Mood States (POMS)—Mood states, defined as relatively long lasting positive or negative emotional moods, were measured by the POMS measure (McNair, Lorr, & Druppleman, 1971). The POMS is a reliable and valid measure that presents 65 adjectives (e.g., *tense*, *discouraged*, and *listless*) on a Likert scale (i.e., from 0 = *not at all* to 4 = *extremely*) to assess feelings during the past week. There are six factors of mood that are examined in the POMS (i.e., *Tension-Anxiety*, *Depression-Dejection*, *Anger-Hostility*, *Vigor-Activity*, *Fatigue-Inertia*, and *Confusion-Bewilderment*); these factors are summed (with Vigor-Activity reversed) to obtain the summary Total Mood Disturbance (TMD) score. The POMS has been shown to be sensitive to detecting impaired mood in studies examining sleep, and the six POMS factors are internally consistent with the TMD score (Cronbach's $\alpha = .84$); the internal consistency of the six factors of the POMS to the TMD score in this study was slightly lower (Cronbach's $\alpha = .78$).

Functional Outcomes of Sleep Questionnaire (FOSQ)—(Weaver et al., 1997). The FOSQ was used to assess the effect of sleepiness on daily activity. The FOSQ consists of 30 questions, grouped into five subscales (i.e., *General Productivity*, *Social Outcomes*, *Activity Level*, *Vigilance*, and *Intimate Relationships and Sexual Activity*) through factor analysis. Each question on the FOSQ has a range of responses from 1 (*extreme difficulty due to sleepiness*) to 4 (*no difficulty*) that includes an alternative response (*do not do for other reasons*). The FOSQ total score ranges from 5 to 20, with higher scores indicating less difficulty in performing activities due to sleepiness. The internal consistency (Cronbach's α for the total score = 0.95; subscore scores range from 0.86 to 0.91) of the FOSQ has been demonstrated through psychometric testing, and the FOSQ is sensitive to correctly identifying normal subjects (total FOSQ = 17) from those with sleep difficulties ($p = 0.0001$). In this study, the FOSQ demonstrated internal consistency (Cronbach's $\alpha = .92$ for the total score; subscale scores ranged from .74 to .91).

Statistical Analysis

Data analyses were conducted using IBM SPSS Statistics v20. A preliminary examination of the data included univariate and bivariate sample distributions to determine whether or not the data were distributed normally. Summary statistics were presented as mean (SD) for the continuous variables (age, A1C, BMI, sleep quality, subjective sleepiness, and mood) and as frequencies for the categorical data (gender, race, marital status, and education). Bivariate relations between continuous variables were examined with Pearson correlation for the entire sample and by gender. Since marital status was associated with gender, partial correlations were calculated when the dependent variable of interest was also associated with marital status. Student's *t*-test was used to examine differences in demographic and clinical variables with continuous data (age, BMI, A1C, daytime sleepiness, sleep quality, mood, and functional outcomes) between males and females. Chi-square tests were used to determine if there was a difference in the proportion of categorical variables of race, educational level, and marital status between male and female participants. Statistical significance was set as $p < .05$.

Results

Demographic and Clinical Characteristics

Table 1 presents demographic information, clinical characteristics, daytime sleepiness, and sleep quality for the total sample and by gender. Overall, the members of the sample ($N = 116$) were middle-aged (IQR 47–58 years; range 31–82 years), well-distributed by race (53% minority), predominantly female (56%), and not currently married or partnered (59%). The majority of participants were overweight (18% with BMI ≥ 25) or obese (74% with BMI ≥ 30) and had sub-optimal glucose control (50% of the sample had A1C $\geq 7.0\%$). The majority (56%) of participants had some post high school education. There was no statistically significant difference in age, racial distribution, education, BMI, or A1C level between males and females. Male participants were significantly ($p = .024$) more likely to be married or partnered compared to female participants. Single participants had significantly lower scores on several aspects of mood disturbances (e.g., Vigor-Activity and Confusion-Bewilderment) and functional outcomes (e.g., General Productivity, Activity Level, Vigilance, and Total FOSQ) compared to married and/or partnered participants. There was no difference between men and women in sleep duration or sleep efficiency; women had significantly longer sleep latency.

Daytime Sleepiness and Sleep Quality

A majority of the sample was excessively sleepy during the daytime (62% displayed ESS > 10) or had poor sleep quality (84% had PSQI > 5). In the full sample, increased daytime sleepiness had a small yet significant association with poor sleep quality ($r = .19$, $p < .05$). There was no significant difference in daytime sleepiness or sleep quality scores between men and women. Additionally, there was no significant difference in daytime sleepiness or sleep quality between white and non-white participants, married/partnered and single participants, and participants with more or less than a high school education.

There was no significant difference between men and women on the POMS TMD score or on the subscores for Tension-Anxiety, Depression-Dejection, Anger-Hostility, Fatigue-Inertia, or Confusion-Bewilderment. Men had significantly higher Vigor-Activity scores compared to women ($p < .01$), but there was no significant difference between men and women on the total FOSQ score or the subscores for Social Outcomes, Activity Level, Vigilance, Intimate Relationships, and Sexual Activity. Men had significantly higher scores compared to women on General Productivity ($p = .02$).

Daytime Sleepiness, Sleep Quality, and Mood

Correlation analyses were conducted to examine the relationships between daytime sleepiness, sleep quality, and mood (POMS TMD and subscale scores) for the full sample and by sex (see Table 2). Because single participants had significantly lower subscores for Vigor-Activity and Confusion-Bewilderment ($p < .05$) compared to married or partnered participants, partial correlations controlling for marital status were computed when evaluating those variables. In the total sample, there was no significant association between daytime sleepiness and POMS TMD scores. However, increased Fatigue-Inertia in the total sample was significantly associated with daytime sleepiness ($r = .28, p < .01$). This association was not statistically significant in males, while increased daytime sleepiness was significantly associated with Fatigue-Inertia in females ($r = -.35, p < .01$). Daytime sleepiness was significantly associated with decreased Vigor-Activity in females ($r = -.30, p = .03$).

In the total sample, sleep quality was significantly associated with not only the POMS TMD score, but also the following POMS mood subscores: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Fatigue-Inertia, and Confusion-Bewilderment ($r = .23$ to $.34$; all p values $< .05$). The association between sleep quality and Vigor-Activity was not statistically significant. Men and women presented different relationships between sleep quality and mood disturbances. In women, there was no significant association between sleep quality and any of the POMS scores; in males, there was a statistically significant association between sleep quality and all POMS scores ($r = .462$ to $.554$; all p -values $< .01$).

Daytime Sleepiness, Sleep Quality, and Functional Outcomes

Correlation analyses were conducted to examine the relationships between daytime sleepiness, sleep quality, and functional outcomes sensitive to sleep (FOSQ total score and subscale scores) for the full sample and by sex (see Table 3). In the total sample, increased daytime sleepiness was significantly associated with decreased functional outcomes (FOSQ total score) and with all of the subscores except Intimate and Sexual Relationships ($r = -.29$ to $-.41$; p -values $< .05$). Males displayed a statistically significant association between increased daytime sleepiness and decreased Vigilance ($r = -.36$); however, the associations between daytime sleepiness and the FOSQ total score and the five FOSQ subscale scores were not statistically significant. Females displayed a pattern of moderate to strong significant correlations between increased daytime sleepiness and decreased General Productivity, Social Outcomes, Activity Level, Vigilance, and FOSQ Total Score ($r = -.30$ to $-.57$; all p -values $< .01$).

In the total sample, poor sleep quality was moderately associated with decreased functional outcomes (FOSQ total score) and with the five FOSQ subscales (General Productivity, Social Outcomes, Activity Level, Vigilance, and Intimacy and Sexual Relationships ($r = .22$ to $-.44$; all p -values $< .05$). The pattern of associations between impaired sleep quality and functional outcomes differed between males and females. In males, decreased Activity Level was strongly associated with poor sleep quality ($r = -.58$, $p < .001$), while this association was not as strong in females ($r = -.26$, $p < .05$). Additionally, in males, there was no significant association between poor sleep quality and Intimacy and Sexual Relationships, while in females poor sleep quality had a statistically significant negative association ($r = -.39$, $p = < .01$).

Discussion

Few studies have examined the effect of gender on impaired sleep quality and components of mood and functional outcomes related to the self-management of diabetes. The main outcome of this study suggests that men identify impaired sleep quality with lower mood and functional outcomes, while women identified a stronger association between daytime sleepiness and decreased mood and functional outcomes. The results suggest that there may be biological sex-based difference in the expression of impaired sleep as well as socially constructed behavioral gender-based differences in the expression of impaired sleep.

The underlying mechanism where men and women may respond differently to daytime sleepiness and poor sleep quality is not clear. Results of small experimental studies in healthy young adults suggest that there are significant intra-individual differences in sleep architecture (Tucker, Dinges, & Van Dongen, 2007) and trait-like neuro-behavioral function (Van Dongen, Baynard, Nosker, & Dinges, 2002) in response to sleep deprivation. While gender, age, and ethnicity were examined, the sample size precluded definitive statements about individual factors that may influence vulnerability to impaired sleep.

The conclusion that men and women express impaired sleep differently stands in contrast with the findings of Hyde, who asserts that gender differences are generally small and that other contextual issues may influence potential differences (2005). We found that marital status affects certain aspects of mood and functional outcomes; however, there continued to be differences in the expression of impaired sleep between the genders after controlling for marital status.

A limitation of our analysis is that the relatively modest sample size was determined a priori without a power analysis; therefore, there is a possibility of type 2 error in some of the analyses. A larger sample size would allow further analyses such as use of the three-factor PSQI model to determine specific causes of sleep disturbances between men and women. (Cole et al., 2006) While the study variables were evaluated by reliable and valid questionnaires, there was no objective measurement of sleep to determine the presence and severity of sleep disorders such as insomnia, RLS, and OSA. Additionally, the sample recruited for the parent study was screened for daytime sleepiness, which may not be representative of all persons with T2DM. Unfortunately, in this secondary analysis that

explored differences in the expression of sleepiness between men and women, menopausal status was not reported.

Conclusions

In conclusion, the results of this study suggest that although both men and women may equally suffer from excessive daytime sleepiness or impaired sleep quality, there are gender differences in their responses to sleepiness and poor sleep quality with respect to differences in mood and functional outcomes. Future research on this topic need to recruit larger samples of men and women so that subgroup analysis can be conducted by gender to account for potential confounding variables such as marital or partner status. It would be valuable to replicate this study among persons without T2DM and with specific sleep disorders such as OSA or insomnia.

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Table 1
Demographic Information, Clinical Characteristics, Daytime Sleepiness, and Sleep Quality for the Total Sample and by Gender

Characteristics, % (n) or Mean (SD)	Total (N = 116)	Males (n = 52)	Females (n = 64)	p-value
Age (years)	52.4 (9.5)	52.1 (9.2)	52.7 (9.7)	.73
Race				
White	47% (54)	54% (28)	41% (26)	.19*
Non-white	53% (62)	46% (24)	59% (38)	
BMI (kg/m ²)	34.96 (6.8)	33.79 (6.2)	35.91 (7.1)	.09
A1C%	7.4 (1.6)	7.6 (1.8)	7.2 (1.4)	.15
Marital status				.02
Married/Partnered	40% (47)	52% (27)	31% (20)	
Single	60% (69)	48% (25)	69% (44)	
Education				
More than high school	56% (65)	52% (27)	59% (38)	.46
High school or less	44% (51)	48% (25)	41% (26)	
Epworth Sleepiness Scale	12.16 (4.0)	12.33 (4.2)	12.02 (3.9)	.68
PSQI Global Score (PSQI)	10.39 (4.1)	9.67 (4.2)	10.97 (3.9)	.10
Sleep duration (hours)	6.0 (1.7)	6.0 (1.6)	6.1 (1.7)	.61
Sleep efficiency (%)	73.7 (20.6)	74.8 (21.8)	72.8 (19.8)	.64
Sleep latency (minutes)	30.3 (29.1)	24.3 (20.5)	34.9 (33.8)	.046

Table 2
Correlations among Study Variables of Daytime Sleepiness, Sleep Quality, and Mood by Total Sample and Sex

	POMS Tension-Anxiety	POMS Depression-Dejection	POMS Anger-Hostility	POMS Vigor-Activity	POMS Fatigue-Inertia	POMS Confusion-Bewilderment	POMS Total Mood Disturbance
ESS (Total Sample)	.165	.115	.069	-.056 ^a	.275 ^{**}	.145 ^a	.163
ESS (Males)	.170	.102	.117	.089 ^a	.201	.124 ^a	.117
ESS (Females)	.157	.131	.010	-.299 ^{**a}	.348 ^{**}	.122 ^a	.213
PSQI (Total Sample)	.315 ^{**}	.331 ^{**}	.249 ^{**}	-.180 ^a	.290 ^{**}	.230 ^{**a}	.337 ^{**}
PSQI (Males)	.510 ^{**}	.466 ^{**}	.462 ^{**}	-.507 ^{**a}	.464 ^{**}	.457 ^{**a}	.554 ^{**}
PSQI (Females)	.148	.220	.083	.212 ^a	.131	.008 ^a	.122

Note.

^{**} Correlation is significant at the 0.01 level (2-tailed);

^{*} Correlation is significant at the 0.05 level (2-tailed).

^a Partial Correlation controlling for marital status. ESS = Epworth Sleepiness Scale. PSQI = Pittsburgh Sleep Quality Index. POMS = Profile of Mood States. Higher scores on POMS Total Mood Disturbance and Subscales (except Vigor-Activity) indicates worse mood disturbance. Higher scores on ESS indicate more severe sleepiness. Higher scores on PSQI indicate worse sleep quality.

Table 3
Correlations among Study Variables of Daytime Sleepiness, Sleep Quality, and Functional Outcomes by Total Sample and Sex

	FOSQ General Productivity	FOSQ Social Outcomes	FOSQ Activity Level	FOSQ Vigilance	FOSQ Intimate & Sexual	FOSQ Total Score
ESS Total Sample	-.319 ^{***a}	-.285 ^{**}	-.410 ^{***a}	-.404 ^{***a}	-.114	-.374 ^{***a}
ESS Males	-.263 ^a	-.159	-.289 ^a	-.388 ^{***a}	-.151	-.309 ^{***a}
ESS Females	-.383 ^{***a}	-.399 ^{**}	-.565 ^{***a}	-.455 ^{***a}	-.075	-.450 ^{***a}
PSQI Total Sample	-.443 ^{***a}	-.378 ^{**}	-.416 ^{***a}	-.220 ^{***a}	-.287 ^{**}	-.434 ^{***a}
PSQI Males	-.507 ^{***a}	-.456 ^{***}	-.579 ^{***a}	-.260 ^a	-.194	-.479 ^{***a}
PSQI Females	-.348 ^{***a}	-.309 [*]	-.256 ^{***a}	-.161 ^a	-.386 ^{**}	-.371 ^{***a}

Note.

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

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

^aPartial Correlation controlling for marital status. ESS = Epworth Sleepiness Scale, PSQI = Pittsburgh Sleep Quality Index, FOSQ = Functional Outcomes of Sleep Questionnaire. Higher scores on FOSQ total score and subscores indicate better functional outcomes. Higher scores on ESS indicate more severe sleepiness. Higher scores on PSQI indicate worse sleep quality.