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Authors

Song, Yeonsu

Moore, Raeanne C

Jeste, Dilip V

et al.

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SCIENTIFIC INVESTIGATIONS

Discrepancy between self-reported and objective sleep duration among dementia caregivers and noncaregivers

Yeonsu Song, PhD, RN[1,2,3]; Raeanne C. Moore, PhD[4]; Dilip V. Jeste, MD[4,5,6]; Mary-Lynn Brecht, PhD[1]; Sonia Ancoli-Israel, PhD[4,5]; Brent T. Mausbach, PhD[4]; Igor Grant, MD[4]

[1]School of Nursing, University of California Los Angeles, Los Angeles, California; [2]Geriatric Research, Education, and Clinical Center, VA Greater Los Angeles Healthcare System, Los Angeles, California; [3]David Geffen School of Medicine, University of California Los Angeles, Los Angeles, California; [4]Department of Psychiatry, University of California San Diego, San Diego, California; [5]Sam and Rose Stein Institute for Research on Aging, University of California San Diego, San Diego, California; [6]Department of Neurosciences, University of California San Diego, San Diego, California

Study Objectives: Poor sleep, including short sleep duration, is common among caregivers of persons with dementia. However, it is unclear whether poor sleep is consistent across both self-reported and objective measures of sleep in caregivers. This study aimed to test the role of caregiving status (caregivers vs noncaregivers) on the discrepancy between self-reported and objective sleep duration.

Methods: This was a cross-sectional study. Study participants were community-dwelling caregivers of spouses with dementia (n = 122) and noncaregivers (n = 53). A sleep duration discrepancy index was created by subtracting objective sleep duration measured with 3 consecutive 24-hour periods of actigraphy from self-reported sleep duration measured with the Pittsburgh Sleep Quality Index. Covariates included participants' demographic characteristics, depressive symptoms, positive and negative affects, personal mastery, and caregiving-role overload.

Results: Caregivers showed a greater discrepancy in sleep duration than did noncaregivers (−0.46 hour vs 0.22 hour, respectively; $P = .003$). In a regression model, however, caregiving status was no longer associated with this sleep duration discrepancy, when covariates were accounted for. Higher positive affect was significantly associated with less sleep duration discrepancy ($R^2 = 11.3\%$, $P = .014$). The Sobel test of mediation showed that 26% of the effect of caregiving on this sleep discrepancy was attributable to caregivers with low positive affect.

Conclusions: The findings suggest a potential mediating role of positive affect on the relationship between caregiving status and sleep duration discrepancy. As an aid for understanding the role of lower positive affect, use of actigraphy may help address sleep discrepancy in caregivers.

Keywords: positive affect, negative affect, stress, well-being, actigraphy, insomnia, objective sleep, self-reported sleep

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Both objective and self-reported sleep measures show poor sleep, including shorter sleep duration, among caregivers of persons with dementia. However, the discrepancy in sleep duration as measured by actigraphy and self-report and the impact of potential mediators (positive and negative affects) on this discrepancy among caregivers are less known.

Study Impact: The combination of self-reported and objective sleep measures will help to inform the diagnosis and treatment strategies to improve sleep quality among caregivers with lack of positive affect. Concurrent assessment of positive affect during the treatment will also provide ancillary data to address potential sleep discrepancy among this vulnerable group.

INTRODUCTION

Poor sleep, whether determined by self-report or objective measures such as polysomnography (PSG) or actigraphy, is common among family caregivers of people with dementia (PwD). Between 44% and 92% of caregivers of PwD experience sleep disturbances, a range that is significantly higher than that among noncaregivers.[1–5] Self-reported poor sleep has been measured with standardized questionnaires, such as Pittsburgh Sleep Questionnaire Index (PSQI),[6] and/or with a sleep diary. Poor sleep reported by caregivers includes difficulty falling and staying asleep,[1,5] poor sleep quality,[4,7,8] frequent nighttime awakenings,[9] long duration of time awake after sleep onset,[10,11] and short nighttime sleep duration.[4,8] Objectively measured poor sleep using PSG or actigraphy includes short sleep duration,[11] low sleep efficiency (ie, percentage of time spent asleep while in bed trying to sleep at nighttime),[11,12] and a long time spent awake during the nighttime.[13,14]

Poor sleep among caregivers of PwD is associated with higher levels of stress and fatigue, lower positive affect, and poorer perceived quality of life.[1] It is also associated with elevated levels of inflammatory markers such as interleukin-6 and C-reactive protein,[10] which are known risk factors for cardiovascular disease.

These significant impacts of poor sleep on caregivers' health outcomes suggest a critical need for sleep assessment using both

self-reported and objective measures to better understand the nuances of the sleep disturbances. Although these caregivers may sleep for adequate amounts of time (eg, 7–8 hours) when assessed with objective sleep measures, it is critical to address their perceived sleep (underestimated or overestimated) for several reasons. First, older adults with poor cognitive function and functional disability are more likely to present greater sleep measurement discrepancy (ie, discordance between self-reported and objective sleep measures).[15] This is a more serious problem for caregivers who are older and perceive their sleep as being deficient, as this can ultimately affect not only their personal health but also the quality of care they provide to their PwD. Second, misperception of a sleep deficit may facilitate excessive concerns and distress about sleep and can contribute to greater anxiety and arousal at nighttime, thus increasing the risk of developing clinical insomnia, where both self-reported and objective sleep is deprived.[16] Third, self-reported recall of sleep can be affected by feelings or mood present at the time of recall.[16] Caregivers commonly experience psychological symptoms such as depression, stress, and negative affect.[17] If these symptoms are present at the moment of recall, they can influence the accuracy of reported sleep.

Unfortunately, studies show only moderate association between actigraphy-measured and self-reported sleep durations.[18] Potential mediating factors seem to play a role in the concordance between these 2 measures of sleep. Studies have shown that patients with insomnia tend to underestimate their perceived sleep duration in comparison with objectively measured sleep duration.[19,20] Moreover, having higher depressive symptoms, poor self-reported health status, and being non-White is associated with lower correlations between actigraphy-measured and self-reported sleep duration.[21,22] Both positive and negative affects may also contribute to differences in sleep measures, given the significant relationship between affect and actigraphy-measured and/or self-reported sleep characteristics in caregivers[7,14,23] and other groups.[24,25]

Taken together, addressing the discrepancy between self-reported and objectively measured sleep is a critical part of initial sleep management, so that a health care provider can further examine if sleep is misperceived or if other factors are mediating the discrepancy. Yet, such sleep discrepancy is not fully explored in caregivers of PwD. Given the heterogeneity of caregiving for PwD and the potential impact of caregiving on caregivers' sleep, it is important to explore sleep discrepancies and related factors. This paper focuses on discrepancy between self-reported and objectively measured sleep durations among spousal caregivers. We hypothesized that caregivers of PwD will show a greater discrepancy in sleep duration (ie, more underestimations of self-reported sleep) than noncaregivers. We also hypothesized that greater discrepancy of sleep duration among the caregivers will remain significant compared to noncaregivers after adjusting for such characteristics of participants as race/ethnicity, depression, and positive affect. As a secondary analysis, we explored potential mediating effects of the negative and positive affect covariates, given the evidence of a relationship between those affects and sleep addressed previously.[7,14,23–25] Therefore, we hypothesized that both negative and positive affects mediate the relationship between caregiving status and sleep duration discrepancy.

METHODS

Study design and participants

This study used a cross-sectional design and baseline data from the University of California San Diego (UCSD) Alzheimer's Caregiver Study, which aimed to investigate mental and physical health among spousal Alzheimer's caregivers in comparison to noncaregivers in a longitudinal study design.[26] Participants were eligible for the study if they were at least 55 years old and married to and resided with their spouse in community settings in the San Diego, CA area. Caregivers were required to be providing primary care for their spouse with a physician-based chart diagnosis of dementia (eg, Alzheimer disease). Potential participants (both caregivers and noncaregivers) were excluded from the study if they had cognitive impairment (ie, Mini-Mental State Examination score < 27),[27] or other medical factors that might, independently of caregiving status, affect outcomes of interest (eg, biomarkers of inflammation or cardiovascular risk) in the parent study. Examples of exclusions included current cancer treatment, severe hypertension (ie, blood pressure > 200/120 mm Hg), and treatment with steroids, nonselective beta blockers, or oral anticoagulants. If noncaregivers provided care for a spouse with any type of chronic disease, they were excluded from the study. Noncaregivers were recruited from senior centers, senior health fairs, and referrals from the participants already enrolled in our study. Caregivers were recruited from local caregiver support groups, community health fairs, and referrals from local caregiver agencies and other participants. All study processes and protocols were approved by the UCSD institutional review board. All study participants provided informed written consent. Our final analytic sample size was 175 participants (n = 122 caregivers and n = 53 noncaregivers).

Measures

Sociodemographic data collected from participants included age, sex, caregiver status, race/ethnicity, years of education, years married, and employment status. Self-reported comorbidities of participants included history of hypertension and diabetes. Perceived health status was rated from poor to excellent. Body mass index, history of taking antidepressant medications over the past 30 days (yes/no), and duration of daily moderate exercise were also asked.

The 10-item Center for Epidemiologic Studies–Depression (CESD) scale was used to measure depressive symptoms.[28] It asks about the frequency of depressive symptoms that occurred during the previous week, with a higher score indicating worse depressive symptoms. The Epworth Sleepiness Scale was used to assess daytime sleepiness by asking about the chance of dozing off or falling asleep in 8 different situations.[29] A high score indicates a greater degree of daytime sleepiness. Sense of mastery was measured with the Personal Mastery Scale,[30] which asks participants about the level of agreement or disagreement with 7 statements (eg, "There is really no way I can solve some of the problems I have."). Response choices range from 0 (*strongly disagree*) to 3 (*strongly agree*). A higher score indicates better perceived control. Role-related stress was measured with the Pearlin Role Overload scale.[31] It asks participants to

rate their energy level in 4 situations (eg, "You are exhausted when you go to bed at night."), using a 4-point Likert scale ranging from 0 (*not at all*) to 3 (*completely*).

Positive and negative affects were measured with the Positive and Negative Affect Schedule (PANAS).[32] It consists of 20 mood adjectives (10 items of positive affect and 10 items of negative affect) from the original PANAS. Participants rated each item on a 5-point scale ranging from 1 (*very slightly* or *not at all*) to 5 (*extremely*). Total scores for each component of affect were calculated by summing each item. The present study used the total scores of positive and negative affects.

Sleep

The PSQI was used to assess self-reported sleep quality during the past week.[6] It consists of 19 items, which measure 7 components: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. A global score > 5 yields high sensitivity (89.6%) and specificity (86.5%) in distinguishing good and poor sleepers (kappa = 0.75).[6] We used 1 item in the PSQI that asks about sleep duration ("During the past week, how many hours of actual sleep did you get at night?").

Actigraphy was used to measure objective sleep. Participants wore the SleepWatch-O actigraph (Ambulatory Monitoring, Inc., Ardsley, NY) on the nondominant wrist for 3 consecutive days and nights, which is consistent with current clinical and research guidelines of a minimum of 72 hours of actigraphy.[33] The actigraph is a small, unobtrusive, watch-sized device useful in longitudinal and naturalistic assessment of sleep-wake patterns. Criterion validity is well-established, with correlations between actigraphy and PSG reported for total sleep time (r = .81 to .91) and for percent sleep (r = .61 to .78) in older adults.[34] A sleep duration measured with an actigraph was defined as the total time of scored sleep between sleep onset time and sleep end time.

We defined discrepancy of sleep duration by subtracting total sleep time measured with actigraphy (objective sleep duration) from total sleep time reported on the PSQI (self-reported sleep duration). Therefore, a negative value of this discrepancy variable would suggest underestimated self-reported sleep, whereas a positive value would indicate overestimated self-reported sleep. Our approach to calculating the sleep duration discrepancy index has been used in prior studies.[15,20]

Data analysis

Descriptive statistics were calculated for all variables. Pearson correlations were calculated to test the association between discrepancy of sleep duration and other variables (age; the CESD, excluding the sleep item; personal mastery; positive affect; negative affect). A Student's t test was calculated to test the association between sleep discrepancy and caregiving status (*yes*/*no*). Results of this bivariate testing that yielded P-values at ≤ .20 were used to select potential covariates for inclusion in a multiple regression model. Then we ran a multiple regression model with sleep duration discrepancy as a dependent variable, caregiving status (*yes*/*no*) as an independent variable, and other selected covariates. We also tested the mediating effect of a covariate (specifically, negative and positive affect) on sleep duration discrepancy and caregiving status using a Sobel test.[35]

For these statistical tests, $P < .05$ was considered statistically significant. Analyses were conducted using Stata version 15 (Stata Corp., College Station, TX).

RESULTS

Characteristics of study participants

Mean age of the study participants was 74.63 years (standard deviation 7.48). Approximately 70% were women. Participant characteristics by caregiving status are shown in **Table 1**. Caregivers were more likely to be White and perceive their health to be worse than noncaregivers. Caregivers spent less time on moderate exercise, reported more depressive symptoms, higher levels of role-related stress and negative affect, less sense of mastery, and lower levels of positive affect than did noncaregivers. Caregivers had a significantly higher PSQI total score than did noncaregivers (6.62 ± 3.59 vs 4.47 ± 2.62, respectively, P = .001), whereas actigraphy-assessed sleep efficiency was similar between the 2 groups (87.2% vs 87.9%, respectively). Seventy-nine percent of participants who underestimated sleep duration (negative value of sleep discrepancy) had a PSQI total score > 5. No differences were found in either self-reported or objective sleep duration between caregivers and noncaregivers.

Association between caregiving status and discrepancy of sleep duration

As shown in **Table 2**, sleep duration discrepancy was significantly different between caregivers and noncaregivers. Based on actigraphy scores, caregivers significantly underestimated their sleep duration, whereas noncaregivers overestimated their sleep duration (–0.46 hour vs 0.22 hour, respectively; P = .003). In a multiple regression model (**Table 3**), however, caregiving status was no longer significantly associated with discrepancy of sleep duration when adjusting for covariates (ie, White; the CESD, excluding the sleep item; mastery; positive affect; and negative affect). Positive affect was the only significant factor to predict sleep duration discrepancy in the model (P = .037).

A mediating effect of positive affect on sleep duration discrepancy and caregiving status

We ran a Sobel test to determine whether there was an indirect effect of caregiving status on the sleep duration discrepancy by positive affect. The result showed a significant difference from zero ($z = -2.13$, P = .033), which confirmed that positive affect partially mediated the relationship between caregiving status and discrepancy of sleep duration. Using the formula provided by MacKinnon and Dwyer,[36] we determined that approximately 26% of the effect of caregiving on underestimated sleep is attributable to caregivers with low positive affect. The mediational model is shown in **Figure 1**.

DISCUSSION

The current study evaluated the cross-sectional relationship between caregiving status and discrepancy between self-reported

Table 1—Study participant characteristics (n = 175).

Characteristics	Mean (SD) or n (%)		t or χ^2	df	P
	Caregivers (n = 122)	Noncaregivers (n = 53)			
Age, mean (SD)	74.31 (8.01)	75.37 (6.07)	0.86	173	.387
Female, n (%)	86 (70.49%)	35 (66.04%)	0.34	1	.558
Race/ethnicity					
Hispanic, n (%)	10 (8.20%)	7 (13.20%)	1.06	1	.304
White, n (%)	116 (95.08%)	45 (84.90%)	5.20	1	.023
Years of education	15.12 (3.04)	15.55 (3.07)	0.85	173	.398
Years married	42.88 (16.64)	43.15 (16.42)	0.10	173	.923
Employed, n (%)	20 (16.39%)	6 (11.32%)	0.75	1	.386
Body mass index (kg/m^2)	26.55 (4.74)	26.31 (6.21)	−0.28	173	.783
Comorbidities					
History of hypertension	69 (56.56%)	23 (43.30%)	2.57	1	.109
History of diabetes†	15 (12.30%)	2 (3.77%)	3.06	1	.064
Taking antidepressant	32 (26.23%)	12 (22.64%)	0.25	1	.615
Self-reported health status†			24.51	4	< .001
Poor	4 (3.28%)	1 (1.89%)			
Fair	13 (10.66%)	1 (1.89%)			
Good	48 (39.34%)	8 (15%)			
Very good	42 (34.43%)	22 (41.51%)			
Excellent	15 (12.30%)	21 (39.62%)			
≥ 30 minutes of moderate exercise/d	66 (54.10%)	40 (75.47%)	7.07	1	.008
CESD, excluding the sleep item	8.99 (3.88)	7.04 (2.24)	−3.42	173	< .001
ESS total score	5.58 (3.96)	5.21 (4.90)	−0.53	173	.594
Personal Mastery Scale score	11.49 (3.32)	15.15 (3.82)	6.39	173	< .001
Pearlin Role Overload score	5.14 (3.19)	1.43 (1.99)	−7.82	173	< .001
PANAS, Negative affect	17.89 (6.10)	13.57 (5.34)	−4.47	173	< .001
PANAS, Positive affect	31.81 (7.50)	36.72 (6.87)	4.08	173	< .001
PSQI total score	6.62 (3.59)	4.47 (2.62)	−3.93	173	< .001
PSQI total sleep time, hour	6.84 (1.37)	7.15 (1.05)	1.48	173	.140
Actigraphy total sleep time, hour	7.27 (1.13)	6.97 (0.91)	−1.71	164	.089

†Fisher's exact test. CESD = Center for Epidemiological Studies–Depression scale, ESS = Epworth Sleepiness Scale, PANAS = Positive and Negative Affect Schedule, PSQI = Pittsburgh Sleep Quality Index, SD = standard deviation.

and objective sleep durations at night. We also tested the mediating role of positive affect and negative affect in the relationship between caregiving status and discrepancy of sleep duration. Our hypotheses were partially supported, such that being a caregiver was significantly associated with more underestimated self-reported sleep duration. The group difference in discrepancy of sleep duration may be the result of poorly perceived sleep quality among the caregivers (PSQI total score > 5, on average). It also aligns with existing knowledge of the higher degree of sleep discrepancy among patients with insomnia.[19,37] In a large, population-based study, sleep misperception was prevalent in insomnia patients with objectively measured normal sleep duration but not in those with short sleep duration.[37] Their sleep misperception was significantly associated with depressive, anxious-ruminative personality traits, and poor coping resources.

In our study, the relationship between sleep duration discrepancy and caregiving status was no longer significant when accounting for the following covariates: participants' race/ethnicity, mastery, role overload, depressive symptoms, and positive and negative affects. Additionally, we found that low positive affect, in part, mediated the relationship between caregiving status and discrepancy of sleep duration.

Our finding on the contribution of positive affect to sleep discrepancy among caregivers is in concordance with prior studies of sleep and positive affect. In a cross-sectional study, caregivers with high levels of positive affect reported fewer sleep problems than those with low levels of positive affect; however, this association was not statistically significant among noncaregivers.[7] In our previous work, increased levels of positive affect were longitudinally associated with better self-reported sleep quality (measured with PSQI) among spousal caregivers of PwD.

Table 2—Bivariate Pearson Correlations between participant characteristics and sleep duration discrepancy (n = 166).

	Discrepancy, Mean (SD)	*P*
Sex		.215
Female (n = 113)	−0.34 (1.39)	
Male (n = 53)	−0.06 (1.21)	
Caregiving status		.003
Caregiver (n = 115)	−0.46 (1.36)	
Noncaregiver (n = 51)	0.22 (1.18)	
Ethnicity		.384
Hispanic (n = 16)	−0.53 (1.90)	
Non-Hispanic (n = 150)	−0.22 (1.27)	
Race		.163
White (n = 153)	−0.29 (1.34)	
Others (n = 13)	0.25 (1.23)	
Employment status		.470
Employed (n = 26)	−0.07 (1.38)	
Unemployed/retired (n = 140)	−0.28 (1.33)	
History of hypertension		.798
Yes (n = 88)	−0.22 (1.34)	
No (n = 78)	−0.28 (1.34)	
History of diabetes		.550
Yes (n = 17)	−0.43 (1.28)	
No (n = 149)	−0.23 (1.35)	
Taking antidepressant		.340
Yes (n = 43)	−0.40 (1.32)	
No (n = 123)	−0.20 (1.34)	
Moderate exercise/d		.784
< 30 minutes/d (n = 66)	−0.28 (1.32)	
≥ 30 minutes/d (n = 100)	−0.23 (1.35)	
	Pearson Correlation Coefficient	
Age	−0.013	.865
Years of education	0.083	.287
Years married	0.042	.593
Body mass index	0.002	.976
Self-reported health status	0.091	.245
CESD, excluding the sleep item	−0.130	.095
ESS total score	0.062	.429
Personal Mastery Scale score	0.194	.012
Pearlin Role Overload score	−0.198	.011
PANAS, Negative affect	−0.123	.115
PANAS, Positive affect	0.254	.001

CESD = Center for Epidemiological Studies–Depression scale, ESS = Epworth Sleepiness Scale, PANAS = Positive and Negative Affect Schedule, SD = standard deviation.

This relationship remained significant when controlling for negative affect, female sex, caregiver health conditions, caregiving-related burden, and dementia-related behaviors. However, there was no significant relationship between actigraphy-measured

Table 3—A multiple regression model predicting sleep duration discrepancy (n = 166).

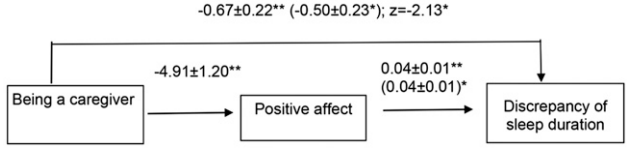
Independent Variables	Discrepancy, Beta (95% CI)	*P*
Being a caregiver	−0.35 (−0.88, 0.18)	.198
White vs others	−0.40 (−1.17, 0.36)	.299
Personal Mastery Scale score	0.014 (−0.06, 0.08)	.690
Pearlin Role Overload score	−0.03 (−0.11, 0.05)	.499
CESD score†	−0.02 (−0.09, 0.06)	.655
PANAS, Negative affect	0.01 (−0.03, 0.06)	.588
PANAS, Positive affect	0.03 (0.00, 0.06)	.037

F (7, 158) = 2.58; $P = .015$, $R^2 = 10.3\%$; Adjusted $R^2 = 6.3\%$. †Excluding the sleep item. CESD = Center for Epidemiological Studies–Depression scale, CI = confidence interval, PANAS = Positive and Negative Affect Schedule.

sleep parameters (sleep duration, sleep efficiency, and wake after sleep onset) and positive affect.[14] In another study of caregivers of PwD, self-reported and objective total wake time and perceived sleep quality were not significantly associated with positive affect at both within- (day-to-day) and between-person levels. Instead, lower self-reported total wake time and higher perceived sleep quality significantly predicted lower negative affect (accounting for 43% of day-to-day variance and 21% of average variance in negative affect) among this group.[23] Nevertheless, none of the studies investigated discrepancy between self-reported and objective sleep duration among caregivers of PwD. Similar results were found in prior studies of other groups (eg, noncaregivers). For example, among older adults, using 14 days of data assessment, positive affect was associated with self-reported sleep quality but not with objective sleep quality.[24] Findings on the relationship between positive affect and sleep duration were inconsistent across studies of other groups.[38,39]

Our study did not explicitly test how low levels of positive affect are different from negative affect. Some studies addressed whether positive affect and negative affect may not reflect opposite aspects of emotion. Instead, they may play independent or different roles given a particular situation or moment.[40] Future studies are needed to investigate the role of negative affect or the mutual effect of positive and negative

Figure 1—Mediational model for association between caregiver status and discrepancy of sleep duration.



*$P < .05$; **$P < .01$. Values are presented as standardized coefficient ± SE. Values outside parentheses are zero-order betas. Values inside parentheses are partial regression coefficients when both caregiving status and positive affect are included in the model. z = Sobel test.

affects in this population, for example, by measuring both types of affect multiple times during the day using ecological momentary assessment.

There are a few possible underlying mechanisms for the findings. First, stressful caregiving situations may lower positive affect, which may bias retrieval of memory for sleep duration.[16] Second, memory of sleep may be biased based on emotional feelings present at the time of recall.[16] Third, cognitive-emotional hyperarousal at bedtime, combined with rumination during presleep and coping strategies focusing on less positive affect,[41] may have contributed to misperception of sleep by creating a tendency toward interpreting sleep as wakefulness. Last, it is possible that objective sleep duration measured with actigraphy may have been simply overestimated. Studies have shown that actigraphy overestimates sleep duration[15,42]; however, it provides relatively unobtrusive sleep monitoring over time and is largely acceptable to patients with sleep disorders.[43]

Large cohort studies that have compared sleep duration have used different instruments for measurement. For example, in a study of middle-to-old adults, self-reported sleep duration (measured with the PSQI) was only modestly associated with the sleep duration estimated by in-home PSG, whereas the correlations of PSG with actigraphy-assessed sleep duration was stronger.[21] In that study, PSG-measured sleep duration was shorter than self-reported sleep duration estimates but longer compared with actigraphy-measured sleep duration. PSQI-assessed sleep duration was almost an hour longer than actigraphy-measured sleep duration,[21] which was similar in another study.[22] Further studies are needed to compare sleep duration across multiple measures, including PSG, actigraphy, PSQI, and sleep diaries in caregivers of PwD.

In our study, daytime sleepiness measured with the Epworth Sleepiness Scale was not different between caregivers and noncaregivers. There were no significant differences between daytime sleepiness and actigraphy-measured daytime sleep durations, which suggest a possible discrepancy between perceived daytime sleepiness and objectively measured daytime duration. Additionally, less daytime sleepiness was significantly associated with both increased PSQI- and actigraphy-measured sleep durations but not with nighttime sleep duration discrepancy. Although increased sleep duration at night can reduce the self-reported feeling of sleepiness during the daytime, future studies exploring the relationship between self-reported-objective sleep discrepancy and daytime sleepiness or other symptoms of daytime impairment (eg, fatigue) among caregivers are needed.

We did not find a notable role of negative affect on sleep duration discrepancy. This may be explained by low levels of negative affect among both spousal caregivers and noncaregivers, and the relationship between negative affect and positive affect was only modestly significant in our study. Another possible reason may be in part that caregiving appraisal among spousal caregivers is different from that of adult-child caregivers. Spousal caregivers may accept their commitment to caregiving more readily than adult-child caregivers.[44] In 1 study, caregiving satisfaction was a significant factor in positive affect among spousal caregivers but not among adult-child caregivers.[44] This suggests a potential role of positive affect on spousal caregiving appraisal among spousal caregivers. Some studies reported that higher levels of burden were significantly associated with worse depressive symptoms among adult-child caregivers than among spousal caregivers of PwD.[45] Another study also showed that adult-child caregivers reported more negative perceptions of the quality of life of PwD than did spousal caregivers.[46] Such negative caregiving experience and perceptions regarding PwD may increase levels of negative affect among adult-child caregivers. Future studies are warranted to investigate sleep discrepancy in relationship to affect among different types of caregivers (eg, spousal caregivers, adult-child caregivers).

Findings of this study have clinical implications. Caregivers with higher levels of positive affect more accurately reported their sleep compared to objectively measured sleep. In other words, caregivers with lower levels of positive affect may benefit from objective sleep assessments due to their potential tendency to inaccurately report their sleep. The accuracy of estimations of self-reported sleep duration increased in accordance with objective sleep durations when participants experienced higher levels of positive affect. This suggests that positive affect may play a role as a protective factor on misperception of sleep, particularly among spousal caregivers. While use of objective sleep measures is not required for routine insomnia diagnosis, using both self-reported and objective sleep tools may help assess and monitor treatment response when caregivers complain of poor sleep. Studies have shown significant improvement in sleep discrepancy among insomnia patients after they received cognitive behavioral therapy for insomnia (CBTI), suggesting that underestimated self-reported sleep can be modified through CBTI and may be related to improvement in poor sleep.[19] Longitudinal sleep monitoring along with concurrent assessment of positive and negative affects can also guide optimal treatment strategies, for example, through the addition of approaches to enhance positive affect to cognitive behavioral therapy–based recommendations.

Nevertheless, this study has several limitations. Most of our study participants were White and their education level was relatively high; therefore, both perceived sleep and levels of affect may be different in other racial/ethnic groups or among those with a lower level of education. Given the eligibility criteria of our study, the study participants were relatively healthy. Thus, caregivers and noncaregivers with more severe medical conditions may represent their sleep or affect differently. We cannot avoid the possibility that noncaregivers may have provided their spouses or other family members with care as well, for old age or other reasons. Although both the sleep questionnaire (PSQI) and actigraphy were collected over the same 3-day period, the time points reflecting sleep were different between the 2 instruments—ie, our study participants were asked about self-reported sleep (measured with the PSQI) retrospectively, based on the past week, whereas objective sleep was measured prospectively for 3 nights. Although caregiver participants showed poor global sleep quality (mean PSQI total score > 5), we did not assess insomnia disorder that was clinically diagnosed based on the *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition,[47] and/or *International Classification of Sleep Disorders*, third edition.[48] Other sleep disorders, such as sleep apnea, were not assessed in the present study. Given the evidence of greater sleep discrepancy among patients with sleep disorders,[19,37] further assessment of participants' clinical

criteria for sleep disorder may help to identify clinically relevant at-risk groups, particularly among caregivers with underestimated sleep duration. Moreover, it is possible that caregivers diagnosed with concurrent insomnia and sleep apnea may underestimate their sleep duration at a greater level[49] and therefore experience higher levels of negative affect. Our study did not measure night-to-night variability in sleep discrepancy, which has shown a significant relationship with insomnia symptoms in older adults in prior studies.[50] Particularly, sleep monitoring containing both days of full-time and part-time caregiving (eg, days when care recipients were in an adult day care program) would have elucidated potential variability in sleep discrepancy within and between the groups (ie, caregivers vs noncaregivers). Night-to-night sleep measures, along with simultaneous assessment of positive and negative affects, may provide better information about sleep discrepancy linked to fluctuation of caregiver affect. Sample sizes of the caregiver and noncaregiver groups are considerably different in our study. Thus, the control group might not be as representative of the general population as the caregiver group is. We cannot avoid type 1 error on testing factors associated with sleep duration discrepancy. Additionally, we did not measure other covariates that may play a critical role in sleep discrepancy. For example, in a study of patients with major depression, underestimated self-reported sleep duration was significantly associated with a higher percentage of N1 stage of sleep, more time awake after sleep onset, and lower percentage of slow-wave sleep.[51] This may suggest that sleep discrepancy may be associated with certain medical or psychiatric conditions and that assessing sleep duration using only 1 measure may bias true association.

In summary, caregivers of PwD perceived their total sleep duration as being less than when it was measured objectively, compared to noncaregivers. Measuring both self-reported and objective sleep duration and addressing its discrepancy are clinically important for caregivers with poor sleep, particularly when they have low levels of positive affect. Future studies are needed to understand the potential mechanisms underlying sleep discrepancy among caregivers. These may provide us with practical guidance on optimal measures of sleep in this vulnerable group. Further studies are warranted to investigate sleep discrepancy in relationship to both caregiving experiences (eg, nighttime caregiving responsibilities awakening caregivers, positive and negative caregiving aspects) and factors related to care recipients, such as dementia-related problematic behaviors.

ABBREVIATIONS

CESD, Center for Epidemiologic Studies–Depression
PSG, polysomnography
PSQI, Pittsburgh Sleep Quality Index
PwD, people/person with dementia

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Address correspondence to: Yeonsu Song, PhD, RN, 700 Tiverton Avenue, 3-242 Factor, School of Nursing, University of California Los Angeles, Los Angeles, CA 90095; Email: ysong@sonnet.ucla.edu

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