Objective sleep characteristics and loneliness in a national sample of older adults: does social isolation modify the association?

Background

Loneliness and social isolation are both associated with adverse health outcomes, including increased risk for mortality (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015; House, Landis, & Umberson, 1988; Luo, Hawkley, Waite, & Cacioppo, 2012). However, these are two distinct concepts, which have surprisingly low correlation (Coyle & Dugan, 2012). Individuals may feel lonely despite frequent social interactions, and individuals with few social connections may not report feeling lonely. Social isolation is generally measured through questions about experiences, such as marital status, number of social contacts, and participation in group activities (Berkman & Syme, 1979). Loneliness, however, is conceptualized as a person's perceived feeling of isolation, reflecting the difference between their experiences and their desired social relationships, and is often accompanied by feelings of distress (Peplau & Perlman, 1982).

There is evidence that the effects of social isolation and loneliness on health and well-being are heightened among older adults (Cacioppo & Hawkley, 2003). However, there is also evidence that the relationship between social isolation and loneliness is weaker among older adults, because older adults are able to adapt to changing levels of social connectedness in ways that limit feelings of loneliness (Lang & Carstensen, 1994; Schnittker, 2007). Nonetheless, the fact that older adults are more likely to experience life transitions such as loss of a spouse, health problems, and functional limitations could contribute to concurrent changes in social connectedness and loneliness (Brummett & Mark, 2001; Hawkley & Kocherginsky, 2018).

An important dimension of health that changes with age is sleep, including more sleep disturbances, poorer self-reported sleep quality, and shorter deep sleep and REM sleep at older ages (Floyd, Medler, Ager, & Janisse, 2000; Ohayon, Carskadon, Guilleminault, & Vitiello, 2004; Schubert et al., 2002). Sleep quality has been linked to both social isolation and loneliness in lab studies and in observational studies (Cacioppo et al., 2002; Smith, Kozak, & Sullivan, 2012). One study among Hutterites, who live a communal lifestyle in which all community members have frequent social interactions, found that feelings of loneliness were still related to actigraph-measured sleep fragmentation, with those reporting feeling lonelier having more fragmentation (Kurina et al., 2011). A recent study turned this observation around and asked whether sleep loss could trigger social isolation or loneliness. Simon & Walker (2018) carried out a randomized lab-based study in which 18 participants were sleep deprived or not and then underwent MRIs. Using a "Theory of Mind" approach to brain activity, the part of the brain that responds when other individuals are threatening was activated after the sleep deprived state. Sleep deprived participants also described wanting greater distances from other people, suggesting sleep deprivation may cause social isolation or loneliness.

Here we follow up this intriguing hypothesis about how poor quality sleep or short sleep may be linked to social isolation or loneliness with observational data. We consider whether objectively measured sleep characteristics, including actigraph-estimated wake after sleep onset (WASO), sleep

fragmentation, and total sleep time, are associated with perceived loneliness or with social connectedness. We then consider whether this potential sleep-loneliness relationship varies with levels of social disconnectedness. We hypothesize that individuals with less social connectedness may have a stronger association between poor sleep and feelings of loneliness, either because social withdrawal is the link between poor sleep and loneliness or because richer social interaction mutes the negative impact of poor sleep on feeling lonely.

Data

This study uses data from Wave 2 of the National Social Life, Health, and Aging Project (NSHAP). NSHAP is a nationally-representative study of community-dwelling older adults born between 1920 and 1947 which has fielded three waves: in 2005/06, 2010/11, and 2015/16. In Wave 2, spouses and co-resident partners of original cohort members were also invited to participate. In each wave, respondents participated in in-home interviews which included biomeasure collection. The NSHAP Sleep Study is a substudy of NSHAP which began in Wave 2. A randomly-selected one-third of all Wave 2 respondents (n=1,117) were invited to participate, which included wearing a wrist actigraph for 72 hours (three nights).

During the in-home interview, those selected were asked whether they would like to participate in the ancillary study. The protocol required they be recontacted to arrange delivery of materials. Of the 1,117 baseline respondents who were asked to participate, 897 initially agreed. Among them, 823 were successfully recontacted in the available timeframe, and 801 returned usable sleep data. As some spouses were outside the initial birth year range, this analysis is limited to those born between 1920 and 1947 (n=759).

Wrist Actigraphy

Collection of the sleep data has been fully described elsewhere (Lauderdale et al., 2014; McSorley, Bin, & Lauderdale, 2018). Briefly, prospective participants were introduced to the substudy during their in-home interview, including an actigraph demonstration and protocol description. Those who agreed and were recontacted received a mailed packet with an actigraph, a prepaid return mailer, instructions, and a booklet with additional sleep questions. Participants were instructed to wear the wrist actigraph (Actiwatch Spectrum model from Phillips Respironics) for 72 hours. The Actiwatch was set to record activity data in 15-second epochs. When the device was returned, data were downloaded and analyzed, using Phillips Respironics software and their validated settings (Lauderdale et al., 2014).

A participant's rest intervals were first set by the software, based only on the activity pattern. Then each record was reviewed by the investigators and the rest intervals revised based on additional information that the software did not use: the participant-initiated event marker time stamp (pressed when a participant went to bed and awoke in the morning) and the light sensor on the actigraph. The software scores each 15-second epoch as sleep or not based on the activity pattern in that epoch and surrounding epochs. The sleep interval is the period within each rest interval that begins with the first epoch scored as sleep and ends with the last epoch scored as sleep.

Sleep measures used in this study were: Total Sleep Time (TST – sum of all epochs scored as sleep); wake after sleep onset (WASO – sum of all wake epochs during the sleep interval); and sleep fragmentation (the sum of the percent of epochs recorded as moving and the percent of immobile periods less than one minute long). Sleep measures were calculated as an average over the number of nights, which was three for most respondents.

Loneliness and Social Disconnectedness

To assess loneliness, NSHAP uses a 3-item version of the UCLA Loneliness Scale (Russell, Peplau, & Cutrona, 1980). The correlation among the 3-item scale and the UCLA Loneliness Scale is 0.82 (Hughes, Waite, Hawkley, & Cacioppo, 2004). The scale assesses frequency of feeling left out, isolated, and lacking companionship, each with response options of never, hardly ever, some of the time, and often. As per recommendation of the NSHAP study, we collapse never and hardly ever into one category to create a three-level response (Payne, Hedberg, Kozloski, Dale, & McClintock, 2014). Responses were given scores of 0, 1, and 2 yielding a range of 0 to 6 with higher scores indicating more feelings of loneliness.

Lack of social connection is measured using the scale proposed by Cornwell and Waite for NSHAP (Cornwell & Waite, 2009). The scale combines eight items which asses respondents' connections to other individuals and social groups. The items are social network size, proportion of social network members who live in the same household, social network range (i.e., types of relationships), frequency of contact with network members, number of non-family non-spouse friends, and participation in social activities outside the home including volunteering, attending meetings of an organized group, and socializing with friends and family. The response values to each item were standardized, the values averaged, and the scale was flipped so that higher scores represent social disconnectedness instead of connectedness. We then additionally standardize the averaged scale, for ease of interpretation.

Covariates

In our models, we adjust for demographics including age, sex, education (less than high school, high school or equivalent, vocational certificate/some college/associates degree, and bachelors or more), and racial/ethnic group (white, black, Hispanic (non-black), and other). We additionally adjust for marital status with the categories married/living with a partner, separate/divorced, widowed, and never married.

Methods

We present demographic, sleep characteristics, and measures of loneliness and social disconnectedness for all study participants with measures available.

We used Poisson regression to assess the association between each sleep parameter and loneliness score because of the distribution of the loneliness outcome variable. We used OLS regression

to similarly assess whether each sleep parameter was associated with social disconnectedness. We standardized the actigraph measures of sleep disruption (WASO, fragmentation) to facilitate comparisons. All of the models are adjusted for demographics. We then interact the sleep parameter and social disconnectedness scale in order to assess whether at different levels of social disconnectedness, the observed relationship between the sleep parameter and feelings of loneliness differs. We then rerun these models including marital status, which is not part of the social disconnectedness scale.

All analyses took into account the study design and sampling weights to account for the complex survey design and nonresponse (O'Muircheartaigh, English, Pedlow, & Kwok, 2014). All data were analyzed using Stata Version 15.1 (StataCorp LP, College Station, TX).

Initial Findings

Sample Characteristics

Table 1 shows characteristics of the NSHAP Sleep Study. Average age was about 72 years and the sample was slightly more female than male. The racial and ethnic representation was similar to the general population in the target age range. The majority of the sample was either married or living with a partner (67%).

Average total sleep time was 7.2 hours, with the plurality of the population recording between 7 and eight hours of sleep per night. Average WASO was just under 40 minutes and the average fragmentation index was 14.4 (range 1.2-50.3).

Sleep and Loneliness

The first column of results in Table 2 shows Poisson regression models with the loneliness scale as the outcome. When adjusted for demographics, increased levels of both measures of sleep quality, WASO and fragmentation, were associated with higher ratings on the loneliness scale. Total sleep time was not associated with loneliness. We also looked at total sleep time as a categorical measure, and did not find that short or long sleepers had more feelings of loneliness, compared to those that slept 7 to 8 hours per night (not shown).

Sleep and Social Disconnectedness

The second column of results in Table 2 shows OLD regression models with the social disconnectedness measure as the outcome. Similar to loneliness, WASO and fragmentation were associated with higher levels of social disconnectedness. Total sleep time was not associated with social disconnectedness, either as a linear or categorical variable.

Interaction Models between Sleep Parameters and Social Disconnectedness

We test the interaction between social disconnectedness and the three sleep measures. In the sleep duration model, the interaction term was not significantly associated with loneliness. In the two disruption models, the interaction terms were significant ($\beta_{WASO*Social\ Disconnectedness}$=0.12, p<0.01; $\beta_{Fragmentation*Social\ Disconnectedness}$=0.08, p=0.03). Figures 1, 2, and 3 show a visualization of the interaction between the sleep parameters and level of social disconnectedness on loneliness. Each line represents the relationship between the given sleep parameter and the modeled score on the loneliness scale, at the given level of social disconnectedness. The levels of social disconnectedness which are visualized are at the following percentiles the population: 5%, 25%, 50%, 75%, and 95%. The relationship between both WASO and fragmentation and loneliness is strongest among those with the highest levels of social disconnectedness. There is no difference between the relationship of total sleep time to loneliness by level of social disconnectedness.

Results were not substantively different when including marital status in any of the models.

Table 1: Characteristics of the NSHAP Sleep Study (N=759)

	Mean (sd) or %
Demographics	
Age	71.9 (7.4)
Female	54.0%
Race/Ethnicity	
White	82.3%
Black	7.5%
Hispanic	6.8%
Other	3.4%
Education	
<High School	14.5%
High School	24.4%
Some College	37.2%
College Degree or Higher	24.8%
Marital Status	
Married/Living w Partner	67.2%
Separated/Divorced	8.9%
Widowed	21.6%
Never Married	2.3%
Sleep Characteristics	
Total Sleep Time (hours)	7.2 (1.3)
<6 hours	13.7%
6 - <7 hours	27.6%
7 - <8 hours	34.1%
8 - <9 hours	17.8%
>= 9 hours	6.8%
WASO (minutes)	37.8 (22.7)
Fragmentation	14.4 (6.0)

Abbreviations: WASO, wake after sleep onset

Table 2: Model parameters for Sleep Characteristics and Loneliness, from Poisson Regressions Models, and Social Disconnectedness, from OLS Regression Models, in the NSHAP Sleep Study.

This table represents six different models.

		Loneliness[1]			Social Disconnectedness[2]		
		Coef.	**95% CI**	**p-value**	**Coef.**	**95% CI**	**p-value**
Model[2]	**Individual Sleep Parameters**						
	Actigraph Measured Sleep Characteristics						
1	WASO[4]	0.16	[0.06,0.26]	<0.01	0.11	[0.03,0.19]	0.01
2	Fragmentation[4]	0.14	[0.04,0.23]	0.01	0.10	[0.03,0.18]	0.01
3	Total Sleep Time	-0.06	[0.15,0.02]	0.16	0.01	[0.06,0.07]	0.88

Abbreviations: WASO, wake after sleep onset

All models are adjusted for age, gender, race/ethnicity, and education

[1]Poision regression models with loneliness scale (0-6) as outcome

[2]OLS regression models with Social Disconnectedness measure standardized, as outcome

[3]Model numbers indicate separate models

[4]WASO and Fragmentation are standardized

Figure 1: Relationship of WASO to Loneliness at different levels of Social Disconnectedness

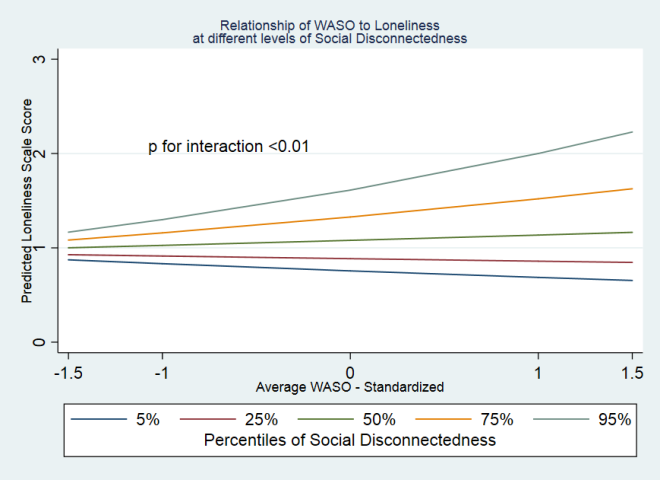


Figure 2: Relationship of Fragmentation to Loneliness at different levels of Social Disconnectedness

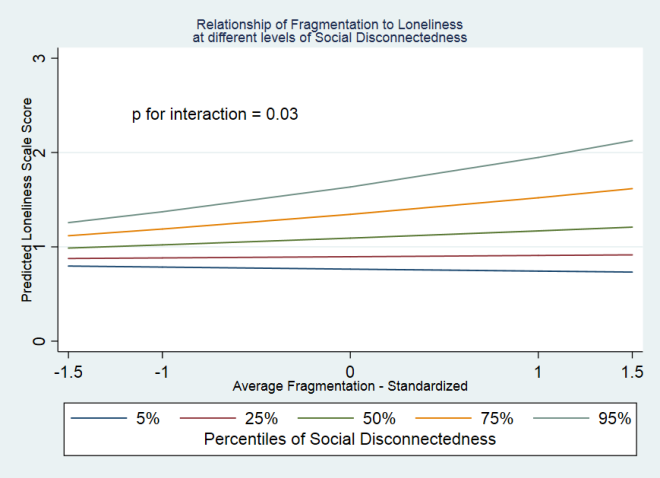
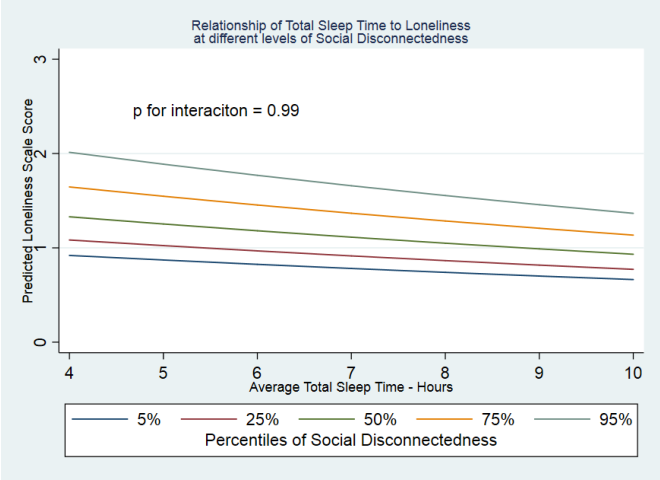


Figure 3: Relationship of Total Sleep Time to Loneliness at different levels of Social Disconnectedness



References

Ben Simon, E., & Walker, M. P. (2018). Sleep loss causes social withdrawal and loneliness. *Nature Communications*, *9*(1), 3146. http://doi.org/10.1038/s41467-018-05377-0

Berkman, L. F., & Syme, S. L. (1979). Social networks, host resistance, and mortality: a nine-year follow-up study of Alameda County residents. *Americal Journal of Epidemiology*, *109*(2), 186–204.

Brummett, B. H., & Mark, D. B. (2001). Characteristics of Socially Isolated Patients With Coronary Artery Disease Who Are at Elevated Risk for Mortality. *Psychosomatic Medicine*, *63*, 267–272. http://doi.org/10.1097/00006842-200103000-00010

Cacioppo, J. T., & Hawkley, L. C. (2003). Social Isolation and Health, with an Emphasis on Underlying Mechanisms. *Perspectives in Biology and Medicine*, *46*(3x), S39–S52. http://doi.org/10.1353/pbm.2003.0063

Cacioppo, J. T., Hawkley, L. C., Berntson, G. G., Ernst, J. M., Gibbs, A. C., Stickgold, R., & Hobson, J. A. (2002). Do lonely days invade the nights? Potential social modulation of sleep efficiency. *Psychological Science*, *13*(4), 384–387. http://doi.org/10.1111/j.0956-7976.2002.00469.x

Cornwell, E. Y., & Waite, L. J. (2009). Social disconnectedness, perceived isolation, and health among older adults. *Journal of Health and Social Behavior*, *50*(1), 31–48. http://doi.org/10.1177/002214650905000103

Coyle, C. E., & Dugan, E. (2012). Social isolation, loneliness and health among older adults. *Journal of Aging and Health*, *24*(8), 1346–1363. http://doi.org/10.1177/0898264312460275

Floyd, J. A., Medler, S. M., Ager, J. W., & Janisse, J. J. (2000). Age-related changes in initiation and maintenance of sleep: a meta-analysis. *Res Nurs Health*, *23*(2), 106–17. http://doi.org/10.1002/(SICI)1098-240X(200004)23:2<106::AID-NUR3>3.0.CO;2-A

Hawkley, L. C., & Kocherginsky, M. (2018). Transitions in Loneliness Among Older Adults: A 5-Year Follow-Up in the National Social Life, Health, and Aging Project. *Research on Aging*, *40*(4), 365–387. http://doi.org/10.1177/0164027517698965

Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D. (2015). Loneliness and Social Isolation as Risk Factors for Mortality: A Meta-Analytic Review. *Perspectives on Psychological Science*, *10*(2), 227–237. http://doi.org/10.1177/1745691614568352

House, J. S., Landis, K. R., & Umberson, D. (1988). Social relationships and health. *Science*, *241*(4865).

Hughes, M. E., Waite, L. J., Hawkley, L. C., & Cacioppo, J. T. (2004). A Short Scale for Measuring Loneliness in Large Surveys: Results From Two Population-Based Studies. *Res Aging*, *26*(6), 655–672. http://doi.org/10.1088/1367-2630/15/1/015008.Fluid

Kurina, L. M., Knutson, K. L., Hawkley, L. C., Cacioppo, J. T., Lauderdale, D. S., & Ober, C. (2011). Loneliness Is Associated with Sleep Fragmentation in a Communal Society. *Sleep*, *34*(11), 1519–

1526. http://doi.org/10.5665/sleep.1390

Lang, F. R., & Carstensen, L. L. (1994). Close emotional relationships in late life: further support for proactive aging in the social domain. *Psychology and Aging*, *9*(2), 315–324. http://doi.org/10.1037//0882-7974.9.2.315

Lauderdale, D. S., Schumm, L. P., Kurina, L. M., McClintock, M., Thisted, R. A., Chen, J.-H., & Waite, L. (2014). Assessment of Sleep in the National Social Life, Health, and Aging Project. *J Geront B Phychol Sci Soc Sci*, *69*(Suppl 2), S125–33. http://doi.org/10.1093/geronb/gbu092

Luo, Y., Hawkley, L., Waite, L., & Cacioppo, J. (2012). Loneliness, health, and morality in old age: A national longitudinal study. *Social Science Medicine*, *74*(6), 907–914. http://doi.org/10.1016/j.socscimed.2011.11.028.Loneliness

McSorley, V. E., Bin, Y. S., & Lauderdale, D. S. (2018). Sleep Characteristics and Cognitive Function and Decline among Older Adults. *Under Review*.

O'Muircheartaigh, C., English, N., Pedlow, S., & Kwok, P. K. (2014). Sample Design, Sample Augmentation, and Estimation for Wave 2 of the NSHAP. *J Geront B Phychol Sci Soc Sci*, *69*(Suppl 2), S15–26. http://doi.org/10.1093/geronb/gbu053

Ohayon, M. M., Carskadon, M. A., Guilleminault, C., & Vitiello, M. V. (2004). Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep*, *27*(7), 255–73.

Payne, C., Hedberg, E. C., Kozloski, M., Dale, W., & McClintock, M. K. (2014). Using and Interpreting Mental Health Measures in the National Social Life, Health, and Aging Project. *J Geront B Phychol Sci Soc Sci*, *69*(Suppl 2), S99–S116. http://doi.org/10.1093/geronb/gbu100

Peplau, L. A., & Perlman, D. (1982). *Loneliness: A sourcebook of current theory, research and therapy*. New York, NY: Wiley.

Russell, D., Peplau, L. A., & Cutrona, C. E. (1980). The Revised UCLA Loneliness Scale : Concurrent and discriminate validity evidence The Revised UCLA. *J Pers Soc Psychol*, *39*(3), 472–480. http://doi.org/10.1037/0022-3514.39.3.472

Schnittker, J. (2007). Look (closely) at all the lonely people: age and the social psychology of social support. *J Aging Health*, *19*(4), 659–682. http://doi.org/10.1177/0898264307301178

Schubert, C. R., Cruickshanks, K. J., Dalton, D. S., Klein, B. E. K., Klein, R., & Nondahl, D. M. (2002). Prevalence of sleep problems and quality of life in an older population. *Sleep*, *25*(8), 889–93.

Smith, S. S., Kozak, N., & Sullivan, K. A. (2012). An investigation of the relationship between subjective sleep quality, loneliness and mood in an Australian sample: Can daily routine explain the links? *International Journal of Social Psychiatry*, *58*(2), 166–171. http://doi.org/10.1177/0020764010387551