Research Report

DO LONELY DAYS INVADE THE NIGHTS?
Potential Social Modulation of Sleep Efficiency

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Abstract—*Loneliness predicts morbidity and mortality from broad-based causes, but the reasons for this effect remain unclear. Few differences in traditional health behaviors (e.g., smoking, exercise, nutrition) have been found to differentiate lonely and nonlonely individuals. We present evidence that a prototypic restorative behavior—sleep—does make such a differentiation, not through differences in time in bed or in sleep duration, but through differences in efficacy: In the study we report here, lonely individuals evinced poorer sleep efficiency and more time awake after sleep onset than nonlonely individuals. These results, which were observed in controlled laboratory conditions and were found to generalize to the home, suggest that lonely individuals may be less resilient than nonlonely individuals in part because they sleep more poorly. These results also raise the possibility that social factors such as loneliness not only may influence the selection of health behaviors but also may modulate the salubrity of restorative behaviors.*

Positive social relationships contribute to physical and psychological well-being across the life span (Baumeister & Leary, 1995; Thompson & Nelson, 2001). Loneliness and social isolation, however, predict morbidity and mortality from broad-based causes in later life even after biological risk factors are controlled (House, Landis, & Umberson, 1988; Seeman, 2000). Social isolation is typically defined in the epidemiological literature in terms of marital status, contact with a close friend, religious membership, and membership in voluntary groups (e.g., Berkman & Syme, 1979). The literature on the hypothesized human need to belong, in contrast, has emphasized the psychological impact of social interactions and relationships rather than their presence or absence (e.g., Baumeister & Leary, 1995; Uchino, Cacioppo, & Kiecolt-Glaser, 1996). In the present research, we focus on the construct of loneliness because it represents the individual's interpretation of his or her own social circumstances, or more specifically, the discrepancy between an individual's desired and actual relationships (Peplau & Perlman, 1982). The existing research supports a link between loneliness and mortality, as well (Seeman, 2000). For instance, Herlitz et al. (1998) found that among 1,290 patients who underwent coronary artery bypass surgery, ratings of the statement "I feel lonely" predicted survival at 30 days (relative risk ratio = 2.61; 95% confidence interval: 1.15–5.95) and 5 years (relative risk ratio = 1.78; 95% confidence interval: 1.17–2.71) after surgery independently of preoperative factors also associated with mortality.

Understanding the reasons for the effects of loneliness on health has important social consequences. For instance, Luskin and Newell (1997) reported that in 1994 individuals 65 years or older in age accounted for 36% of all hospital stays and 48% of total days of doctor care even

though they accounted for only about 11% of the U.S. population. As the number of older adults and the number of individuals living alone increases, the costs associated with broad-based morbidity and mortality are also expected to increase (House et al., 1988).

Health behaviors, an early candidate to explain the effects of isolation and loneliness on well-being, could not account for the epidemiological findings (e.g., Seeman, 2000). Health and restorative health behaviors (e.g., sleep, exercise), however, are typically measured in terms of amount (e.g., frequency, time), with the quality or salubrity of these behaviors assumed to be constant across social and cultural contexts—an assumption that has never been tested. We therefore examined whether loneliness might affect health and well-being through its effects on the efficiency of a quintessential restorative behavior—sleep.

METHOD

The design was a 3 (loneliness: lonely vs. middling vs. nonlonely) × 2 (gender: female vs. male) between-participants double-blind factorial. Participants were 64 undergraduates at Ohio State University who participated in a larger study that required spending a night in the Clinical Research Center (CRC). The participants were recruited from the upper, middle, or lower quintile on the UCLA-R Loneliness Scale (Russell, Peplau, & Cutrona, 1980), which was administered during a screening session. We refer to those individuals who scored in the upper quintile (total score $\geq$ 46) as the lonely group, those scoring in the middle quintile (33 < total score < 39) as the middling group, and those scoring in the lower quintile (total score < 28) as the nonlonely group. The UCLA-R Loneliness Scale is a 20-item scale that assesses an individual's social circumstances by self-report. Adequate reliability (e.g., Cutrona, 1982) and validity (e.g., Russell et al., 1980) have been established.

Inclusion criteria for the study were that participants (a) scored no higher than 13 on the Beck Depression Inventory (Beck & Beck, 1972), (b) had a body mass index no greater than 27, (c) were enrolled in at least 6 credit hours in the quarter during which they were tested, (d) were not first-quarter freshmen during the quarter they were tested, (e) were not last-quarter seniors, (f) were not speech or needle phobic, (g) were not married nor living with a significant other, (h) were U.S. citizens, and (i) scored no more than 8 on a 12-point lie scale taken from the Minnesota Multiphasic Personality Inventory that was included to determine the credibility of participants' responses.

We used the Nightcap (Ajilore, Stickgold, Rittenhouse, & Hobson, 1995; Mamelak & Hobson, 1989) to measure sleep efficiency in the lonely, middling, and nonlonely participants. Using the Nightcap, for instance, Pace-Schott, Kaji, Stickgold, and Hobson (1994) found significant differences in sleep efficiency between self-described "good" and "poor" sleepers.

Sleep was measured on the first night of our study at the CRC and then approximately 2 weeks later for five consecutive nights at home. A Nightcap (currently available as REMview sleep monitor manufactured by Respironics, Inc., Pittsburgh, Pennsylvania) that employs two

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sensors (one for measuring eyelid movement and a second for measuring head-roll movement) was used to obtain sleep measures (Ajilore et al., 1995; Mamelak & Hobson, 1989). Eye motion was detected by a small piezoelectric sensor placed directly on the eyelid. Head-roll movement was detected by a multipolar mercury switch attached to a bandanna worn on the head. The two sensors were attached to a self-contained storage unit that operated on a 9-V battery. The data were stored in 1-min epochs, each of which was scored for eye movement, body movement, or no movement. If an epoch contained both eye and body movement, then it was scored as a body-movement epoch. In initial experiments, Mamelak and Hobson (1989) showed that a prototype of the Nightcap successfully distinguished wake, REM, and NREM (non-REM) states with an overall Nightcap-polysomnography agreement rate of 86%.

Sleep measures were calculated as outlined in Ajilore et al. (1995). The first, *total time*, is the number of minutes participants spent in bed with the Nightcap on. Because the times the participants went to bed and were awakened in the CRC were controlled by the experimenter, who was blind to experimental condition, total time in the laboratory portion of the study was not expected to differ as a function of gender or condition. *Sleep efficiency* is the percentage of time participants were in bed that they were actually sleeping. Sleep efficiency was our primary measure of the quality of sleep.

Sleep efficiency consists of various specific components. *Sleep onset* is defined as the first time in the record that 5 consecutive minutes of neither eye movement nor body movement occurred. *Sleep duration* is the number of minutes in the record scored as sleep. *Awakenings* were scored during the middle of sleep when either 3 consecutive body-movement minutes occurred or a single minute of both active body and eye movements was observed. Minutes were scored as awake until 5 consecutive minutes of neither eye nor body movements occurred. Time that participants spent awake during the night after their initial sleep onset was scored as *wake time after onset*, which can be thought of as an index of restless or fragmented sleep.

All Nightcap recordings were given a quality rating ranging from 1 (unscorable) to 5 (very high quality) by one of the authors (R.S.), who was blind to gender and experimental condition. A score of 5 indicated clearly alternating periods of eyelid movement activity and quiescence approximating the REM/NREM ultradien period (60–90 min). A score of 4 indicated the same alternating periods with one REM-NREM transition ambiguous, and a score of 3 indicated these alternating periods with two or more alternating transitions ambiguous. Scores of 3 or higher meant our sleep measures could be quantified accurately; therefore, recordings with these scores were included in the data set to be analyzed. A score of 2 or lower indicated that the quality of the recording was sufficiently poor that these measures could not be extracted accurately. Data from participants whose records were scored as 2 or lower were not included in the data set. For 54 of the 64 participants (84.4%), the data from nights in the CRC met our inclusionary criteria. Of this final group of participants, 33 were male and 21 were female; 16 fell into the lonely group, 17 into the middling group, and 21 into the nonlonely group. The number of high-quality recordings did not differ as a function of condition, $\chi^2(64, N = 64) = 4.86$, n.s.

RESULTS

Test of Hypothesis

Total time in bed in the CRC did not differ as a function of loneliness or gender, $Fs < 1$, as would be expected given that bedtime and awakening were controlled by the experimenters. Sleep efficiency was analyzed next to test the experimental hypothesis that the quality of the restorative behavior of sleep varied as a function of loneliness. Analyses revealed a significant main effect for loneliness, $F(2, 47) = 3.12, p = .05$. Cell means and pair-wise comparisons are summarized in Table 1. As hypothesized, participants who were lonely had less efficient sleep than nonlonely participants, whereas individuals middling in loneliness evidenced intermediate sleep efficiency. Neither the main effect for gender nor the Gender × Loneliness interaction approached significance.

Analyses of the remaining sleep measures in the CRC revealed what aspects of sleep architecture varied as a function of loneliness. The analyses confirmed that most aspects of sleep were comparable, but that an index of restless sleep, wake time after onset, varied as a function of loneliness, $F(2, 48) = 3.60, p < .05$. As was found for sleep efficiency, participants who were lonely spent more time awake after sleep onset than participants who were nonlonely; individuals middling in loneliness did not differ from either group on this measure, although their scores were more similar to the nonlonely than to the lonely group. No other main effects or interactions approached significance ($ps > .20$).

Generalizability

Data collected in the CRC may not have been representative of the quality of sleep participants experienced at home. Therefore, Nightcap recordings were also obtained from the participants during five consecutive nights in their residence. As for the CRC data, data were included only if the quality of the recording was scored as 3 or higher. Measures were averaged across evenings and then subjected to 3 (condition: lonely vs. middling vs. nonlonely) × 2 (gender: male vs. female) × 2 (site of recording: CRC vs. home) analyses of variance to assess the generalizability of the results obtained in the more controlled environment of the CRC. Poor quality or incomplete recordings resulted in a final sample size of 37 participants for these analyses. In this group were 23 males and 14 females, 12 lonely, 13 middling, and 12 nonlonely. Again, the number of high-quality recordings did not differ as a function of loneliness, $\chi^2(45, N = 45) = 14.18$, n.s.

The results replicated the CRC results (see Table 1): Total time did not differ across conditions, whereas the main effect for loneliness on sleep efficiency was again significant, $F(2, 29) = 5.63, p < .01$ ($M_{lonely} = 83\%, M_{middling} = 90\%, M_{nonlonely} = 89\%$). A main effect for gender was also found for the measure of sleep efficiency, $F(1, 29) = 4.51, p < .05$, with sleep efficiency lower for men ($M = 85\%$) than for women ($M = 90\%$). The analyses for total time and sleep efficiency showed no significant effects for site of recording (CRC vs. home), $Fs < 1$, nor did any interactions approach significance, $Fs < 1$.

Even though the sample size was smaller in this analysis than in the analysis of the CRC data, the effect for loneliness on the measure wake time after onset was again significant, $F(2, 29) = 2.66, p = .04$, one-tailed ($M_{lonely} = 28.66$ min, $M_{middling} = 8.07$ min, $M_{nonlonely} = 11.41$ min). The results for this measure showed no other significant main effects, and no interactions with collection site approached significance. The only other significant effect was a main effect for gender on sleep duration, $F(1, 30) = 7.32, p = .01$, with the duration of sleep shorter for males ($M = 342.8$ min) than females ($M = 379.3$ min).

DISCUSSION

Recent evidence has demonstrated that sleep deprivation can have profound autonomic, metabolic, and hormonal effects. Spiegel, Lep-

Table 1. *Sleep measures as a function of loneliness*

	Group					
	Lonely		Middling		Nonlonely	
Variable	Mean	SD	Mean	SD	Mean	SD
Clinical Research Center (n = 53–54)						
Sleep efficiency (%)	83[b]	(13)	88[ab]	(7)	90[a]	(3)
Sleep duration (min)	345.25[a]	(65.47)	343.00[a]	(41.39)	347.14[a]	(51.36)
Sleep onset (min)	39.69[a]	(47.20)	25.75[a]	(20.80)	24.19[a]	(9.51)
Wake time after onset (min)	17.81[b]	(20.86)	9.75[ab]	(10.31)	6.76[a]	(5.35)
Total time (min)	396.81[a]	(56.41)	370.47[a]	(47.17)	372.38[a]	(52.92)
Number of awakenings	1.88[a]	(2.25)	1.59[a]	(1.58)	1.52[a]	(1.33)
Home (n = 45–46)						
Sleep efficiency (%)	83[a]	(7)	90[b]	(4)	89[ab]	(6)
Sleep duration (min)	355.09[a]	(75.18)	384.14[a]	(68.97)	335.26[a]	(101.09)
Sleep onset (min)	34.39[a]	(24.81)	18.47[a]	(11.25)	20.55[a]	(15.11)
Wake time after onset (min)	28.66[b]	(39.10)	8.07[a]	(5.07)	11.41[a]	(10.03)
Total time (min)	404.55[a]	(82.13)	407.43[a]	(64.22)	408.16[a]	(196.26)
Number of awakenings	1.95[a]	(1.29)	1.54[a]	(0.71)	1.57[a]	(1.22)

Note. Sample sizes varied because of missing data. Means in the same row that do not share subscripts differ at $p < .05$ (Hochbert pair-wise comparison).

roult, and Van Cauter (1999), for instance, found that sleep deprivation was associated with lowered glucose tolerance, elevated evening cortisol concentrations, and increased sympathetic tonus—effects thought to mark increased wear and tear on the organism (allostatic load, cf. Seeman & McEwen, 1996). The present research demonstrated for the first time that sleep—the quintessential restorative behavior—is poorer in lonely than nonlonely individuals. This difference was found on the overall measure of sleep efficiency and on a related measure, time awake after sleep onset. These results, which were observed in controlled laboratory conditions and in a home setting, suggest that one heretofore unrecognized mechanism by which social isolation and loneliness may be associated with broad-based morbidity and mortality is chronic sleep disruption.

In the National Sleep Foundation's 2001 Sleep in America poll, adults in the United States reported spending less time sleeping than they did 5 years before (National Sleep Foundation, 2001). Sixty-three percent got less than the recommended 8 hr of sleep each night; 31% reported sleeping less than 7 hr per weeknight, and 22% reported being so sleepy during the day it interfered with daily activities a few days or more a week. The poll results also indicated that unhappily married couples (who are conceivably lonelier than their happily married counterparts) were more likely to report sleep problems than happily married couples (77% vs. 69%).

Loneliness predicted sleep efficiency in our study, but it is not known whether loneliness is what caused poorer sleep efficiency. It may instead be the case that restless nights impair social and cognitive functioning, leading to loneliness, rather than vice versa. A third possibility is that both sleep efficiency and loneliness are a function of some third or larger set of variables, such as hyperarousal or depression. Future research needs to address whether social disruptions and associated feelings of loneliness contribute to sleep problems, sleep problems undermine interpersonal relationships and contribute to feelings of loneliness, loneliness and sleep problems reciprocally influence each other, or a third variable causes both loneliness and sleep problems. In regard to the latter possibility, sleep problems are known

to co-occur with depression, but participants in the present research were selected to be free of strong dysphoric feelings or depression. Given the restricted range, depression was unrelated to sleep in the current study. The sleep-debt methodology of Spiegel et al. (1999) may prove useful to test whether disruptions in sleep poison interpersonal relationships and heighten feelings of loneliness.

Finally, Cohen and Wills (1985) suggested that relationships could benefit health through either direct effects (e.g., selection of healthier behaviors) or stress-buffering effects (e.g., receiving assistance in times of need). The present findings raise the possibility that social factors such as loneliness not only may influence the selection of health behaviors but also may modulate the quality or salubrity of restorative health behaviors. Sleep is an especially good health behavior to examine in this respect because it is the model restorative behavior and is typically performed with minimal, if any, interaction with other people (thereby avoiding potentially confounding differences in interactional behavior). Although the finding that loneliness predicts sleep efficiency may be important in its own right, the possibility that the salubrity of other restorative behaviors could be diminished by loneliness may help explain why simple counts of health behaviors have not accounted for differences in morbidity and mortality between socially isolated and connected individuals.

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