BRIEF REPORT

Worsening sleep predicts lower life space mobility during the onset of the COVID-19 pandemic

Emily J. Smail PhD[1] 🔵 🐦 | **Christopher N. Kaufmann PhD**[1] |
Kira E. Riehm PhD[2] | **Mamoun T. Mardini PhD**[1] | **Erta Cenko MSPH**[3] |
Chen Bai MS[1] | **Todd M. Manini PhD**[1]

[1]Department of Health Outcomes & Biomedical Informatics, College of Medicine, University of Florida, Gainesville, Florida, USA

[2]Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, New York, USA

[3]Department of Epidemiology, College of Public Health and Health Professions, University of Florida, Gainesville, Florida, USA

Correspondence
Emily J. Smail, Department of Health Outcomes & Biomedical Informatics, College of Medicine, University of Florida, 2004 Mowry Rd, Gainesville, FL 32603, USA.
Email: emily.smail@ufl.edu

Abstract

Background: Poor sleep health is an understudied yet potentially modifiable risk factor for reduced life space mobility (LSM), defined as one's habitual movement throughout a community. The objective of this study was to determine whether recalled changes in sleep traits (e.g., sleep quality, refreshing sleep, sleep problems, and difficulty falling asleep) because of the COVID-19 pandemic were associated with LSM in older adults.

Methods: Data were obtained from a University of Florida-administered study conducted in May and June of 2020 ($n = 923$). Linear regression models were used to assess the impact of COVID-related change in sleep traits with summary scores from the Life Space Assessment. Analyses were adjusted for demographic, mental, and physical health characteristics, COVID-related avoidant behaviors, and pre-COVID sleep ratings.

Results: In unadjusted models, reporting that any sleep trait got "a lot worse" or "a little worse" was associated with a decrease in LSM (all $p < 0.05$). Results were attenuated when accounting for demographic, mental, and physical health characteristics. In fully adjusted models, reporting that problems with sleep got "a lot worse" or that refreshing sleep got "a little worse" was associated with a lower standardized LSM score ($\beta = -0.38$, 95% CI: -0.74, -0.01, and $\beta = -0.19$, 95% CI: -0.37, -0.00, respectively).

Conclusions: While additional research is needed in diverse people and environments, the results demonstrate an association between sleep traits that worsen in response to a health threat and reduced LSM. This finding suggests that interventions that focus on maintaining sleep health in times of heightened stress could preserve LSM.

KEYWORDS
aging, COVID-19, life space mobility, sleep

INTRODUCTION

Sleep disturbances in older adults have been well-documented during the COVID-19 pandemic.[1] Recent studies have found significant changes in sleep complaints and sleep architecture during the pandemic, including a 37% increase in rates of insomnia,[2] changes in sleep duration and time spent during each sleep stage,[3] changes in sleep patterns, and difficulty achieving refreshing sleep.[4] Data from previous natural disasters and acutely stressful events (e.g., 9/11 terrorist attack, Oklahoma City bombing) show that subjectively-measured sleep disturbance is common in response to stress.[5] Without intervention, these poor sleep outcomes are likely to persist until the stressor is resolved, making it an ideal modifiable risk factor for stress-related consequences of the COVID-19 pandemic.

Not surprisingly, the COVID-19 pandemic has caused a widespread reduction in life space mobility (LSM), defined as the size and frequency of movement within a spatial area,[6] as businesses and attractions closed and people adhered to social distancing recommendations.[7,8] LSM offers unique information on frequency and breadth of movement that goes beyond traditional measures of ability[6] and has been linked to a range of health outcomes including depression,[9] cognitive functioning,[10] morbidity, and mortality.[11] While shared experiences led to a collective reduction in LSM, there is likely individual variation given the differences in family and employment needs during COVID-19. To the best of our knowledge, sleep has yet to be independently studied as a predictor of LSM but was considered as part of a depression symptom inventory that showed an inverse association with LSM.[12]

The objective of this study was to determine whether change in sleep traits (e.g., sleep quality, refreshing sleep, sleep problems, and difficulty falling asleep) because of the COVID-19 pandemic were associated with LSM.

METHODS

Study sample

Data come from a University of Florida-administered survey conducted in May and June of 2020. The purpose of the online survey was to assess changes in technology use, mobility, mood and sleep patterns, socialization, and social and physical activities during the COVID-19 pandemic. Participants were recruited through social media, email lists, websites, and health articles released by UFHealth. Additional participants were ascertained through the purchase of a marketing list with addresses of adults aged 60 and older. Responses were collected

> **Key points**
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> - This study is the first to demonstrate a relationship between sleep health and life space mobility, defined as one's habitual movement throughout a community.
> - Maintaining sleep health in times of emergent health threats could preserve movement in older adults.
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> **Why does this paper matter?**
>
> Older adults were less likely to move throughout their environment during the early stages of the COVID-19 pandemic, which has implications for a myriad of health outcomes including morbidity and mortality. Protecting sleep health may be an important intervention target by which to maintain movement and avoid adverse outcomes associated with reduced mobility.

through the University of Florida Research Electronic Data Capture (REDCap) system. A total of 1199 individuals aged 60+ provided data on at least one question.

Measurement of study variables

Life space Mobility (LSM)

The outcome variable was LSM, which was calculated by asking participants about the frequency of travel within their environment using a modified version of the previously validated Life Space Assessment (LSA).[6] Participants were prompted with the stem, "For the past month, AFTER the COVID-19 outbreak, how often did you go to..." The subsequent portion of the questions asked about increasing concentric circles of mobility within the environment, including 5 domains: (i) other rooms of your home besides the room where you sleep; (ii) an area outside your home such as your porch, deck or patio, hallway (of an apartment building) or garage, in your own yard or driveway; (iii) places in your neighborhood other than your own yard or apartment building; (iv) places outside your neighborhood, but within your town; and (v) places outside your town. Response options included traveling to those areas (1) less than 1 time per week; (2) 1–3 times per week; (3) 4–6 times per week; and (4) daily. The original LSA includes questions about independence of movement that were not included here

since the focus was on frequency of movement during the COVID-19 pandemic. Thus, an LSM score was calculated by multiplying each domain level (1–5) by domain frequency (1–4) and summing the scores for each of the 5 areas. Total scores ranged from 15–60.

Sleep traits

The exposure variables include four sleep questions (e.g., sleep quality, refreshing sleep, sleep problems, and difficulty falling asleep) that assess how sleep disturbances changed during the COVID-19 pandemic. As an anchor, participants were asked about sleep prior to the pandemic using questions from the Patient-Reported Outcomes Measurement Information System (PROMIS™) Sleep Disturbance Short Form.[13] The stem for each question was: In a normal week, about a month BEFORE the COVID-19 outbreak, and the root questions asked: (i) my sleep quality was; (ii) my sleep was refreshing; (iii) I had a problem with my sleep; (iv) I had difficulty falling asleep; with answer choices for each question on a 1–5 Likert scale ("very poor" to "very good" and "not at all" to "very much"). For all sleep-related prompts, change in sleep disturbance since COVID-19 was measured by asking, "How has this changed since AFTER the COVID-19 outbreak," with answer choices (1) It's gotten a lot worse; (2) It's gotten a little worse; (3) Stayed the same; (4) It's gotten a little better; (5) It's gotten a lot better. Categories (4) and (5) were combined for each sleep trait due to fewer people selecting those answers. Exposure variables (i.e., each of the four questions about sleep change) were treated categorically in models, with (3) "stayed the same" as the reference category.

Mental and physical health characteristics

Depressive symptoms, anxiety symptoms, and number of chronic conditions were included to account for mental and physical characteristics that have previously been associated with sleep. Depressive symptoms were measured using the PROMIS Depression-8a questions that were modified to include the time anchor, "In a normal week, about a month BEFORE the COVID-19 outbreak," with frequency options ranging from (1) never to (5) always.[14] Responses were included as continuous scores, ranging from 8 to 40. Similarly, anxiety symptoms were measured using the Neurology Quality of Life (neuro-QoL) Anxiety Short Form.[15] Response options followed the same 1–5 Likert format and total scores ranged from 8 to 40. Respondents were also asked to report any chronic conditions (out of a 26-item list) for which they had a physician diagnosis. These conditions were summarized into a count index that ranged from 0 to 11.

COVID-related avoidant behaviors

We also adjusted for four COVID-related behaviors that reflected avoiding people or groups. Participants were prompted with, "Which of the following have you done since the COVID-19 outbreak to keep yourself safe from coronavirus (in addition or more than you normally do)," with possible behaviors including, "avoided social gatherings," "avoided public places/crowds," "avoided in-person contact with high-risk people," and "avoided in-person contact with friends or family." Responses were summed to create a continuous score ranging from 0 to 4.

Demographic characteristics

Covariates included sociodemographic characteristics: age (in years), sex (female or male), race (White; non-White [including African American/Black, Asian, Native Hawaiian/Pacific Islander, Native American/Alaskan Native]; and Other [including "don't want to say" or "other"]), and marital status (married or not married).

Statistical analyses

We restricted our analysis to 923 participants (77%) with complete information on all analytic variables. To improve interpretability of results, we created z-scores for LSM; regression parameters are interpretable as differences in units of standard deviations of LSM after COVID-19. We used multivariable, linear regression models to examine the associations of sleep traits with LSM. Models were designed to evaluate the unadjusted association (Model 1), and the collective influence of demographics (Model 2), mental and physical health conditions (Model 3) and COVID-19 precautionary behaviors and pre-COVID sleep ratings (Model 4). To test whether model fit improved with additional covariates, we used F-tests. In all cases, the models with more covariates performed significantly better. Model estimates were also compared to those from a multiply imputed dataset, created to estimate missing covariates for all participants. There was no indication that missing data affected the results (all estimates were of similar significance and magnitude with overlapping confidence intervals), so we defaulted to models with complete cases. Data cleaning and analyses were performed in Stata 17.[16] The figure was generated in RStudio 4.1.2 using the *dwplot* function.[17]

RESULTS

Sample characteristics

As shown in Table 1, just over half of the 923 respondents were female (55.7%) and the vast majority were non-Hispanic White (95.8%). Median age was 73.0 years, and

TABLE 1 Sample characteristics (N = 923)

Variable	Level	
Demographic characteristics		
Age (median, IQR)		73.0 (68.0, 78.0)
Sex	Male	409 (44.3%)
	Female	514 (55.7%)
Race	White	884 (95.8%)
	Non-white or Multiracial	22 (2.4%)
	Prefer not to answer	17 (1.8%)
Marital status	Not married	328 (35.5%)
	Married	595 (64.5%)
Mental and physical characteristics - median (IQR)		
Depressive symptoms		10.0 (8.0, 13.0)
Anxiety symptoms		12.0 (10.0, 15.0)
Number of chronic conditions[a]		2.0 (1.0, 3.0)
COVID-related avoidant behaviors – median (IQR)		
COVID-related avoidant behavior score		4.0 (3.0, 4.0)
Outcome: Life space mobility - median (IQR)		
Life space mobility score		31.0 (27.0, 37.0)
Exposure: Change in sleep traits - N(%)		
Sleep quality	A lot worse	33 (3.6%)
	A little worse	140 (15.2%)
	Same	713 (77.2%)
	Better	37 (4.0%)
Refreshing sleep	A Lot Worse	26 (2.8%)
	A Little Worse	127 (13.8%)
	Same	735 (79.6%)
	Better	35 (3.8%)
Problems with sleep	A lot worse	28 (3.0%)
	A little worse	126 (13.7%)
	Same	727 (78.8%)
	Better	42 (4.6%)
Difficulty falling asleep	A lot worse	25 (2.7%)
	A little worse	88 (9.5%)
	Same	787 (85.3%)
	Better	23 (2.5%)
Pre-COVID sleep ratings		
Sleep quality	Very poor	11 (1.2%)
	Poor	66 (7.1%)
	Fair	270 (29.2%)
	Good	414 (44.9%)
	Very good	162 (17.6%)
Refreshing sleep	Not at all	26 (2.8%)
	A little bit	110 (11.9%)
	Somewhat	308 (33.4%)

TABLE 1 (Continued)

Variable	Level	
	Quite a bit	331 (35.9%)
	Very much	148 (16.0%)
Sleep problems	Not at all	313 (33.9%)
	A little bit	362 (39.2%)
	Somewhat	176 (19.1%)
	Quite a bit	58 (6.3%)
	Very much	14 (1.5%)
Difficulty falling asleep	Not at all	429 (46.4%)
	A little bit	331 (35.9%)
	Somewhat	109 (11.8%)
	Quite a bit	45 (4.9%)
	Very much	9 (1.0%)

[a]Chronic conditions include high blood pressure, high cholesterol, angina, myocardial infarction, congestive heart failure, coronary artery disease, irregular heartbeat, peripheral arterial disease, stroke, transient ischemic attack, respiratory disorder, anemia, depression, bipolar disorder, memory disorder, neuropathy, Parkinson's disease, diabetes, kidney failure, severe osteoarthritis, lung cancer, breast, cervical, uterine or ovarian cancer, prostate cancer, or colon cancer.

TABLE 2 Association of COVID-related change in sleep traits and life space mobility in unadjusted and fully adjusted models ($N = 923$)

	Model 1 (unadjusted)		Model 4 (fully adjusted)	
	Beta	95% CI	Beta	95% CI
Sleep quality (ref: stayed the same)				
A lot worse	−0.77	[−1.11,−0.43]*	−0.34	[−0.69,0.00]
A little worse	−0.31	[−0.48,−0.13]*	−0.15	[−0.33,0.02]
Better	0.09	[−0.23,0.41]	0.21	[−0.10,0.52]
Refreshing sleep (ref: stayed the same)				
A lot worse	−0.69	[−1.07,−0.31]*	−0.32	[−0.70,0.06]
A little worse	−0.39	[−0.57,−0.21]*	−0.19	[−0.37,−0.00]*
Better	−0.07	[−0.40,0.25]	0.08	[−0.24,0.40]
Sleep problems (ref: stayed the same)				
A lot worse	−0.74	[−1.11,−0.38]*	−0.38	[−0.74,−0.01]*
A little worse	−0.31	[−0.49,−0.12]*	−0.12	[−0.31,0.07]
Better	−0.02	[−0.32,0.28]	0.08	[−0.22,0.37]
Difficulty falling asleep (ref: stayed the same)				
A lot worse	−0.66	[−1.04,−0.27]*	−0.25	[−0.64,0.13]
A little worse	−0.33	[−0.54,-0.12]*	−0.16	[−0.37,0.06]
Better	−0.22	[−0.63,0.18]	−0.04	[−0.43,0.36]

*Denotes significance at a $p = 0.05$ level.

Note: Model 1: Unadjusted. Models 2 and 3: Omitted for brevity. Available in supplemental material. Model 4: Adjusted for age, sex, race, marital status, depressive symptoms, anxiety symptoms, number of chronic conditions, COVID-related avoidant behaviors, and pre-COVID sleep ratings.

most respondents were married (64.5%). Participants had a median of 10 pre-COVID depressive symptoms, indicating a low amount of depression, a median of 12 anxiety symptoms, indicating a low amount of anxiety, a median chronic condition count of 2, and a median avoidant behavior score of 4. Participants had a median LSM score of 31, 8 points lower than the median self-reported LSM prior to the start of the pandemic. For all sleep traits,
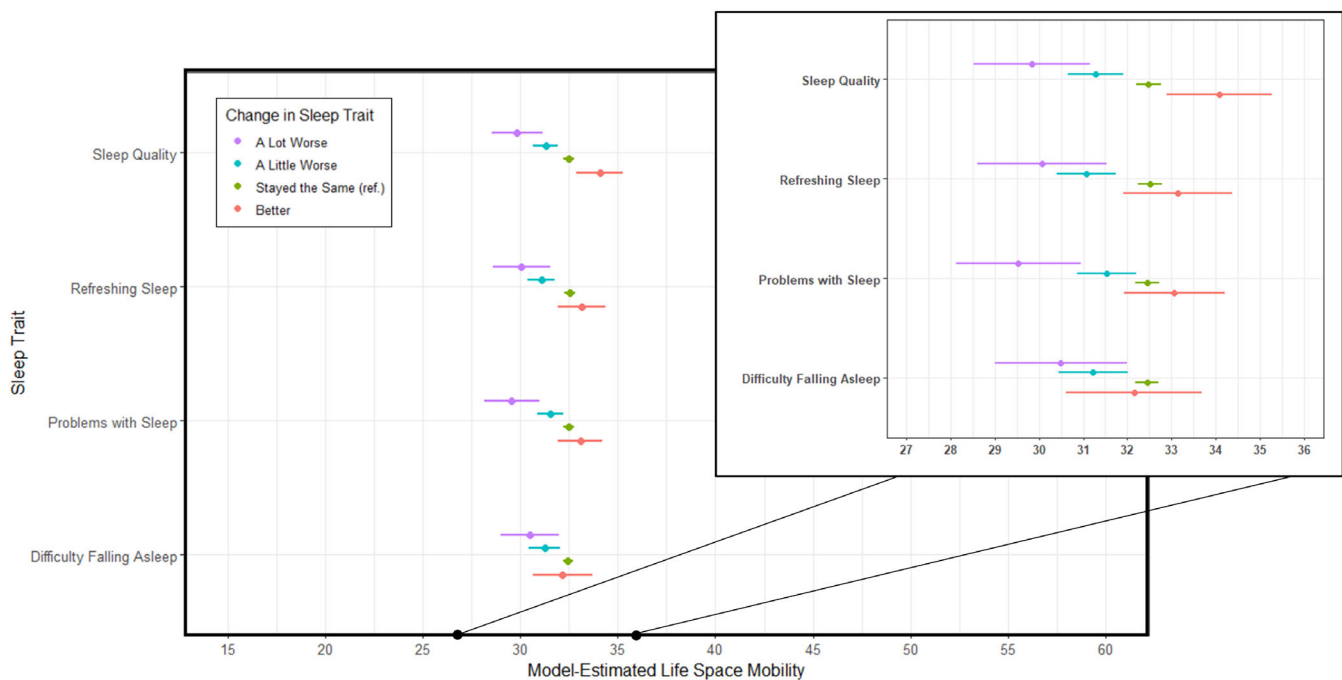
FIGURE 1 Fully adjusted mean estimates and standard errors of LSM after COVID-19 by level of COVID-related change in each sleep trait

between 12% and 18% of participants reported that their sleep got worse after the start of the pandemic.

Associations of sleep and life space mobility

In unadjusted models, reporting that a sleep trait got "a lot worse" or "a little worse" compared to "staying the same" since the beginning of the COVID-19 pandemic was significantly associated with a decrease in LSM (all $p < 0.05$) in a dose-dependent manner (p-value for trend ≤0.001). In particular, reporting that any sleep trait got "a lot worse" was associated with a 0.66–0.77 reduction in standardized LSM, while reporting that any sleep trait got "a little worse" was associated with a 0.31–0.39 lower standardized LSM after the onset of COVID-19. Results were attenuated following adjustment for demographic characteristics, although all associations remained significant (Tables S1–S4). Adjustments for depressive symptoms, anxiety symptoms, and chronic condition count further attenuated the associations. Finally, when adjusting for COVID-related avoidant behaviors and pre-COVID sleep ratings, only two associations remained significant: reporting that refreshing sleep got "a little worse" ($\beta = -0.19$, 95% CI: −0.37, −0.00), and reporting that problems with sleep got "a lot worse" ($\beta = -0.38$, 95% CI: −0.74, −0.01; Table 2, Figure 1). No significant associations were found between reporting a "better" sleep trait and LSM.

DISCUSSION

Using COVID-related survey data collected in May and June of 2020, we found significant associations between change in sleep traits and LSM in older adults. Across sleep traits, the estimates were attenuated when covariates were considered, suggesting that these associations are likely influenced by sociodemographic, mental, and physical health characteristics as well as COVID-related avoidant behaviors and pre-COVID sleep ratings. These results align with previous literature suggesting that sleep is related to movement.[18,19] This relationship may stem from physical consequences of poor sleep, including fatigue, pain, and inflammation[20,21] that discourage mobility. Not surprisingly, results were attenuated when adjusting for COVID-related avoidant behaviors and endorsing more avoidant behaviors was associated with lower LSM. Yet, for most individuals early in the pandemic, it was still possible (and encouraged) to find novel ways to get outside, move about the community, get exercise, and socialize. Worsening sleep patterns may have impacted motivation and ability to try new or infrequently used methods of exercise and socialization (e.g., hiking, picnics, swimming).

The findings in this study might be clinically meaningful. Using the full LSA instrument (range: 0–120), Kennedy et al. (2019) found that a decline in walking status was associated with a decline in life space of 2.9 points.[22] Using a shorter version of the assessment focused on frequency of movement with a truncated

range of scores (range: 15–60), we found participants scored approximately 2.5 points lower when any sleep trait got "a lot worse". Though the two measures are not directly comparable, the magnitude of change found in this study warrants further research. Further, since LSM is calculated at a composite level, we cannot discern whether those with lower life space are keeping closer to home or have a lower frequency of visiting certain life space levels. Future studies with larger and more diverse samples should evaluate the frequency of achieving individual LSM levels and their association with sleep health.

Though this paper has many strengths, such as the use of a validated LSM and sleep measures in a vulnerable population of older adults, it has limitations that should be noted. First, only a small sample of individuals reported that their sleep got "worse" or "better" due to COVID-19, which may have affected the precision of our results (i.e., large confidence intervals). Second, the sample is limited to a small geographic area in Florida in a largely white sample; results may not be generalizable to other areas and populations. Finally, we were unable to confirm the direction of the relationship due to the cross-sectional nature of the survey - it is possible that LSM affected change in sleep traits through changing routines and habits that resulted from the COVID-19 pandemic. More research is needed to determine directionality, how this relationship varies by demographic backgrounds, and whether this relationship exists independently of the COVID-19 pandemic.

Results from this study suggest an independent association between sleep traits and LSM. When results are confirmed in subsequent research, interventions to maintain sleep health might be useful for improving community mobility in times of emergent health threats.

AUTHOR CONTRIBUTIONS

Emily Smail, Chris Kaufmann, and Todd Manini contributed to the study concept and design. Emily Smail performed data cleaning and statistical analysis and interpretation. Emily Smail and Kira Riehm designed the figure. Emily Smail contributed to the preparation of the manuscript, which was revised and edited with critical feedback from Chris Kaufmann, Kira Riehm, Mamoun Mardini, Erta Cenko, Chen Bai, and Todd Manini.

ORCID

Emily J. Smail https://orcid.org/0000-0003-2627-052X

TWITTER

Emily J. Smail @EmilySmail2

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

Table S1: Association of COVID-related change in sleep quality and life space mobility ($N = 923$).

Table S2: Association of COVID-related change in refreshing sleep and life space mobility ($N = 923$).

Table S3: Association of COVID-related change in sleep problems and life space mobility ($N = 923$).

Table S4: Association of COVID-related change in difficulty falling asleep and life space mobility ($N = 923$).

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