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Time spent outdoors and sleep normality: A preliminary investigation

Lindsey A. Wood[1,2], **Madeline M. Tomlinson**[1,2], **Jack A. Pfeiffer**[1,2], **Kandi L. Walker**[1,2], **Rachel J. Keith**[2,3], **Ted Smith**[2,3], **Ray A. Yeager**[2,4], **Aruni Bhatnagar**[2,3], **Savanna Kerstiens**[1,2], **Delana Gilkey**[1,2], **Hong Gao**[2,3], **Sanjay Srivastava**[2,3], **Joy L. Hart**[1,2]

[1]Department of Communication, University of Louisville, Louisville, United States

[2]Christina Lee Brown Envirome Institute, University of Louisville, Louisville, United States

[3]School of Medicine, University of Louisville, Louisville, United States

[4]School of Public Health and Information Sciences, University of Louisville, Louisville, United States

Abstract

INTRODUCTION—Sleep deficiency is associated with health risks, and time outdoors is related to health benefits. This study assessed time outdoors and its association with sleep normality.

METHODS—As part of a health study in Louisville, Kentucky, 735 participants completed questionnaires on their health status, behaviors, neighborhoods, and demographics in 2018–2019. The measures included information on sleep, time outdoors, and mental and physical health. Participant characteristics were assessed by dichotomized sleep normality (N=728), and logistic regression (N=709) examined potential associations between time outdoors and sleep.

RESULTS—As time spent outdoors increased from ≤4 hours to >4 – ≤8 hours (OR=1.04; 95% CI: 0.65–1.64) and >8 – ≤12 hours (OR=1.17; 95% CI: 0.63–2.17), odds of normal sleep increased; however, those who spent >12 – ≤16 hours (OR=0.63; 95% CI: 0.31–1.27) or >16 hours (OR=0.83; 95% CI: 0.45–1.53) outdoors had a lower likelihood of normal sleep. No associations between time outdoors and sleep were significant. There was a significant trend of less bodily pain associated with normal sleep ($p<0.001$) and in the association of depression and sleep, where odds of normal sleep decreased as depression severity increased ($p<0.001$).

CONCLUSIONS—Consistent with extant literature, findings indicate associations between less pain and increased odds of normal sleep and between higher severity of depression and lower odds of normal sleep. Findings for an overall association between time outdoors and sleep normality

CORRESPONDENCE TO Joy L. Hart. Department of Communication, University of Louisville, Louisville, KY 40292, United States. joy.hart@louisville.edu.

CONFLICTS OF INTEREST

The authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none was reported.

PROVENANCE AND PEER REVIEW

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were not significant. Future work should seek to better explicate the predictor variables to assess how greenness and activity type shape associations with sleep.

Keywords

sleep; health risks; nature; time outdoors; greenness

INTRODUCTION

Lack of sleep is associated with poor health outcomes, such as diabetes, obesity, and cardiovascular disease (CVD)[1–5]. Despite the importance of sleep, many people in the US report that sleepiness interferes with daily activities[6] and fewer than half report awaking feeling rested[7]. To offset the damaging effects of sleep deficit, researchers have examined improving sleep quality. Contributors to better sleep include a daily routine, physical activity, and exposure to green spaces[8,9]. Living in a greener neighborhood has been suggested to lower the risk of short sleep duration[10] and exposure to nature provides protection from insufficient sleep[11]. However, less is known regarding overall time outdoors and sleep quality.

Spending time outside is associated with positive health outcomes, including decreased risk of diabetes, obesity, and depression[12,13]. Some investigations indicate a relationship between time outside and sleep quality. Murray et al.[8] reported that the interaction between increased time outdoors and increased physical activity had a positive association with total sleep time[8]. In addition, time outside in the morning can improve college students' sleep quality[14] and less exposure to daylight influences sleep deficiencies for the elderly[15].

The purpose of this study was to assess the association between total time spent outdoors per week and sleep normality. We hypothesize that an increase in time outdoors will increase the odds of normal sleep patterns.

METHODS

Sample

During the summers of 2018 and 2019, data were collected from 735 participants (aged 25–70 years) in Green Heart Louisville's health study (i.e., Health, Environment, and Action in Louisville—HEAL). HEAL is a non-randomized clinical trial to assess how an intervention of added greenery may affect health, especially risks for and incidence of CVD. Participants completed questionnaires on health status, health behavior, neighborhood characteristics, and demographic information (Supplementary file Figure 1 gives the study design). Due to missing data, the analytic sample for crude analysis and for the regression was 728 and 709, respectively. This study was approved by the University of Louisville's Institutional Review Board.

Measures

Sleep—Participants reported sleep habits using Patient Health Questionnaire-9 (PHQ-9)[16] item 3: 'Over the past 2 weeks, how often have you been bothered by any of the following

problems – trouble falling asleep, staying asleep or sleeping too much?', with responses 'not at all', 'several days', 'more than half the days' or 'nearly every day'. This item does not differentiate between insomnia and hypersomnia, but rather includes both as sleeping problems. Therefore, responses were dichotomized as 'normal sleep' and 'non-normal sleep', where normal included 'not at all' responses, and non-normal included all other responses.

Time spent outdoors—Time outdoors per week was reported from participant answers to the question: 'How much time per week do you spend outdoors in nature?'. Response options were 13 categories that ranged from 'less than 1 hour' to 'more than 16 hours'. Due to small sample sizes in some response areas, the categories were collapsed to five, so that time outdoors responses were analyzed as: ≤4, >4 – ≤8, >8 – ≤12, >12 – ≤16, and >16 hours.

Demographic and other variables—Participants were categorized by several demographic characteristics: age, gender, and race. These characteristics, as well as other variables related to perceptions and behavior, were considered as potential confounders (Table 1). Participants reported self-assessments of overall health, level of bodily pain, feeling safe walking in their neighborhood, regular exercise (over 10 minutes duration), smoking status, typical work area, depression status (PHQ-9)[16], and stress level (Perceived Stress Scale, PSS)[17]. Lastly, the Perceived Benefits of Nature (PBN)[18] questionnaire assessed participant views of nature with higher scores indicating greater perceived benefits.

Statistical analysis

Crude associations were assessed between all variables and the dichotomized sleep variable for 728 participants. When comparing categorical variables with sleep, chi-squared or Fisher's exact test were conducted depending on the distribution of the variable. When assessing continuous variables with sleep, Mann-Whitney U tests were conducted due to the non-normal distribution of continuous variables.

To determine the association of time spent outdoors per week and sleep, logistic regression was utilized (n=709). Although not all variables were found to be statistically significant in crude analysis, an initial model included each variable. However, variables were retained in the model only if they were identified as confounders using backward elimination. Variables not retained were: age, gender, race, income, smoker status, and work area. Reported results include adjusted odds ratios for normal sleep, with 95% confidence intervals, of categorized time spent outdoors per week, with the reference being ≤4 hours. Associations were considered significant for $p \leq 0.05$. Analyses were conducted using SAS (version 9.4).

RESULTS

Participant characteristics stratified by sleep status are shown in Table 1 (see Supplementary file Table 1 for more detailed characteristics). The median age of normal sleepers was 51 years. In crude analysis, normal sleep was more prevalent in females (55.1%) and Whites (78.8%) than in males and Non-Whites. Further, normal sleep was more prevalent in those who spent less time outside per week; perceived better general health, less pain, and a

higher sense of safety when walking in their neighborhood; engaged in regular exercise, no smoking, and mainly indoor work; and experienced less severe depression and less stress.

The results of the final logistic regression model produced after backward elimination are shown in Table 2. General health was retained in the model but later removed due to multicollinearity. The main predictor of this analysis was time spent outdoors per week. In the adjusted model, as time spent outdoors increased from ≤4 hours to >4 – ≤8 hours (OR=1.04; 95% CI: 0.65–1.64) and >8 – ≤12 hours (OR=1.17; 95% CI: 0.63–2.17), the odds of normal sleep increased; however, those who spent >12 – ≤16 hours (OR=0.63; 95% CI: 0.31–1.27) or >16 hours (OR=0.83; 95% CI: 0.45–1.53) outdoors had a lower likelihood of normal sleep. No estimates of association between time outdoors and sleep were significant. Likewise, there was no significant trend (p-trend=0.374).

Compared to those who experienced no bodily pain in the past four weeks, those with any pain had lower likelihood of normal sleep. In fact, those that experience very mild (OR=0.26; 95% CI: 0.15–0.46), mild (OR=0.27; 95% CI:0.15–0.50), moderate (OR=0.27; 95% CI: 0.14–0.50) or severe/very severe (OR=0.30; 95% CI: 0.13–0.67) pain had significantly reduced odds of normal sleep. There was a significant trend of less pain being associated with normal sleep (p-trend<0.001).

Additionally, compared to those with no or minimal depression, those with mild (OR=0.13; 95% CI: 0.08–0.22), moderate (OR=0.01; 95% CI: 0.01–0.52), moderately severe (OR=0.04; 95% CI: 0.01–0.17) or severe (OR=0.02; 95% CI:0.01–0.14) depression had significantly lower likelihood of normal sleep. There was a significant trend in the association of depression and sleep, where the odds of normal sleep decreased as depression severity increased (p-trend<0.001).

DISCUSSION

Sufficient sleep has been shown to reduce the risk of adverse health outcomes, including CVD, diabetes, and obesity[10]. Therefore, exploring predictors of sleep quality is pertinent for improving individual and community health. Consistent with previous research, we found individuals who spent ≤12 hours outside per week had higher odds of normal sleep compared to those who spent little to no time outside. However, our findings differ from previous work indicating time spent in green spaces improves sleep. That is, we did not find a significant relationship between time outdoors and sleep normality, whereas other studies have found associations between greenness and sleep[10,11]. Thus, future work needs to consider specific characteristics of time outside (e.g. time outdoors may not involve green spaces or allow for an appreciation of them) and to more clearly specify what time outdoors in nature means, as there is no clear evidence to suggest that time spent in non-green outdoor spaces has the same health benefits as time spent in green outdoor spaces. In addition, this study highlighted associations between less bodily pain and greater odds of normal sleep, and between higher levels of depression and lower likelihood of normal sleep, findings consistent with extant literature[19].

Limitations

The study has several limitations. First, the cross-sectional design allows for assessment of association but prohibits assessment of temporality. Thus, future work is needed to examine any possibility of causal relationships. Second, self-reported information may be subject to recall bias. Third, few participants reported high stress, leading to imprecise CIs for this association. Despite the limitations, the study provides insights for future work exploring time outdoors and sleep quality.

CONCLUSIONS

Our findings reinforce previous work on the relationship between experiencing depression or pain and sleep normality. The association of time outdoors with sleep indicates a possible threshold effect, in that spending ≤12 hours outdoors per week increased the odds of reporting sleep normality; however, findings for an overall association were non-significant. Future research should seek to explicate possible relationships between sleep and time in any outdoor setting, in greenness, and in specific outdoor activities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. Buxton OM, Marcelli E. Short and long sleep are positively associated with obesity, diabetes, hypertension, and cardiovascular disease among adults in the United States. Soc Sci Med. 2010;71(5):1027–1036. 10.1016/j.socscimed.2010.05.041 [PubMed: 20621406]
2. Shan Z, Ma H, Xie M, et al.Sleep duration and risk of type 2 diabetes: a meta-analysis of prospective studies. Diabetes Care. 2015;38(3):529–537. 10.2337/dc14-2073 [PubMed: 25715415]
3. Cappuccio FP, Taggart FM, Kandala NB, et al.Meta-analysis of short sleep duration and obesity in children and adults. Sleep. 2008;31(5):619–626. 10.1093/sleep/31.5.619 [PubMed: 18517032]
4. Yazdanpanah MH, Homayounfar R, Khademi A, Zarei F, Shahidi A, Farjam M. Short sleep is associated with higher prevalence and increased predicted risk of cardiovascular diseases in an Iranian population: Fasa PERSIAN Cohort Study. Sci Rep. 2020;10:4608. 10.1038/s41598-020-61506-0 [PubMed: 32165672]
5. Hoevenaar-Blom MP, Spijkerman AM, Kromhout D, van den Berg JF, Verschuren WM. Sleep duration and sleep quality in relation to 12-year cardiovascular disease incidence: the MORGEN study. Sleep. 2011;34(11):1487–1492. 10.5665/sleep.1382 [PubMed: 22043119]
6. National Sleep Foundation. Sleep in America® Poll2020:Americans Feel Sleepy 3 Days a Week, With Impacts on Activities, Mood & Acuity. https://www.sleepfoundation.org/wp-content/uploads/2020/03/SIA-2020-Q1-Report.pdf?x72630#:~:text=The%20National%20Sleep%20Foundation's%202020,mental%20acuity%2C%20productivity%20and%20more.&text=In%20the%20most%20commonly%20reported,sleepy%20can%20impact%20their%20mood. AccessedSeptember 7, 2020.

7. National Sleep Foundation. Sleep in America® Poll2019: Sleep Health & Scheduling. https://www.sleepfoundation.org/wp-content/uploads/2019/02/SIA_2019_Sleep_Health_and_Scheduling.pdf?x90559. AccessedSeptember 7, 2020.
8. Murray K, Godbole S, Natarajan L, et al.The relations between sleep, time of physical activity, and time outdoors among adult women. PLoS One. 2017;12(9):e0182013. 10.1371/journal.pone.0182013 [PubMed: 28877192]
9. Moss TG, Carney CE, Haynes P, Harris AL. Is daily routine important for sleep? An investigation of social rhythms in a clinical insomnia population. Chronobiol Int. 2015;32(1):92–102. 10.3109/07420528.2014.956361 [PubMed: 25187987]
10. Astell-Burt T, Feng X, Kolt GS. Does access to neighbourhood green space promote a healthy duration of sleep? Novel findings from a cross-sectional study of 259 319 Australians. BMJ Open. 2013;3(8):e003094. 10.1136/bmjopen-2013-003094
11. Grigsby-Toussaint DS, Turi KN, Krupa M, Williams NJ, Pandi-Perumal SR, Jean-Louis G. Sleep insufficiency and the natural environment: Results from the US Behavioral Risk Factor Surveillance System survey. Prev Med. 2015;78:78–84. 10.1016/j.ypmed.2015.07.011 [PubMed: 26193624]
12. Richardson MB, Chmielewski C, Wu CYH, et al.The effect of time spent outdoors during summer on daily blood glucose and steps in women with type 2 diabetes. J Behav Med. 2020;43(5):783–790. 10.1007/s10865-019-00113-5 [PubMed: 31677087]
13. Beyer KMM, Szabo A, Hoormann K, Stolley M. Time spent outdoors, activity levels, and chronic disease among American adults. J Behav Med. 2018;41(4):494–503. 10.1007/s10865-018-9911-1 [PubMed: 29383535]
14. Carney CE, Edinger JD, Meyer B, Lindman L, Istre T. Daily activities and sleep quality in college students. Chronobiol Int. 2006;23(3):623–637. 10.1080/07420520600650695 [PubMed: 16753946]
15. Mishima K, Okawa M, Shimizu T, Hishikawa Y. Diminished melatonin secretion in the elderly caused by insufficient environmental illumination. J Clin Endocrinol Metab. 2001;86(1):129–134. 10.1210/jcem.86.1.7097 [PubMed: 11231989]
16. Spitzer RL, Kroenke K, Williams JB. Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. Primary Care Evaluation of Mental Disorders. Patient Health Questionnaire. JAMA. 1999;282(18):1737–1744. 10.1001/jama.282.18.1737
17. Cohen SPerceived Stress Scale. Mind Garden. https://www.mindgarden.com/documents/PerceivedStressScale.pdf. Published 1994. AccessedSeptember 7, 2020.
18. Dzhambov AM. Perceived Benefits of Nature Questionnaire: Preliminary Results. Ecopsychology. 2014;6(2):109–115. 10.1089/eco.2013.0108
19. Strine TW, Chapman DP. Associations of frequent sleep insufficiency with health-related quality of life and health behaviors. Sleep Med. 2005;6(1):23–27. 10.1016/j.sleep.2004.06.003 [PubMed: 15680291]

Table 1.

Participant characteristics stratified by sleep status, Louisville, Kentucky, 2018–2019 (N=728)

Characteristics	Normal sleep (n=296) n (%) or median (IQR)	Non-normal sleep (n=432) n (%) or median (IQR)	p*	Missing
Age (years)	51.0 (37.4–61.1)	50.9 (38.2–60.3)	0.788	0
Gender			**0.008**	0
Female	163 (55.1)	280 (64.8)		
Male	133 (44.9)	152 (35.2)		
Race			0.836	7
White	230 (78.8)	333 (77.6)		
Black	51 (17.5)	76 (17.7)		
Other	11 (3.8)	20 (4.7)		
Income (US$)			0.292	40
<20000	61 (22.2)	109 (26.4)		
20000–44999	75 (27.3)	130 (31.5)		
45000–64999	71 (25.8)	85 (20.6)		
65000–89999	36 (13.1)	51 (12.4)		
90000–124999	23 (8.4)	31 (7.5)		
≥125000	9 (3.3)	7 (1.7)		
Hours spent outdoors per week			0.361	3
≤4	118 (40.1)	190 (44.1)		
>4 – ≤8	77 (26.2)	110 (25.5)		
>8 – ≤12	42 (14.3)	41 (9.5)		
>12 – ≤16	22 (7.5)	34 (7.9)		
>16	35 (11.9)	56 (13.0)		
Health			**<0.0001**	1
Excellent	22 (7.4)	14 (3.25)		
Very good	128 (43.2)	96 (22.3)		
Good	117 (39.5)	203 (47.1)		
Fair	23 (7.8)	98 (22.74)		
Poor	6 (2.0)	20 (4.7)		

Characteristics	Normal sleep (n=296) n (%) or median (IQR)	Non-normal sleep (n=432) n (%) or median (IQR)	p*	Missing
Bodily pain in past 4 weeks			**<0.0001**	2
None	95 (32.3)	35 (8.2)		
Very mild	88 (29.9)	106 (24.7)		
Mild	54 (18.4)	91 (21.2)		
Moderate	38 (12.9)	111 (25.9)		
Severe/very severe	19 (6.5)	86 (20.1)		
Feel safe to walk neighborhood, day or night			**0.001**	6
Strongly agree	45 (15.5)	36 (8.4)		
Agree	115 (39.5)	144 (33.4)		
Neither agree nor disagree	36 (12.4)	71 (16.5)		
Disagree	65 (22.3)	103 (23.9)		
Strongly disagree	30 (10.3)	77 (17.9)		
Regular exercise			**0.008**	8
Yes	194 (66.0)	239 (56.1)		
No	100 (34.0)	187 (43.9)		
Smoker			**0.005**	39
Never	155 (55.9)	180 (44.3)		
Former	56 (18.9)	78 (19.2)		
Current	71 (25.2)	149 (36.5)		
Work area			**0.0021**	81
Mainly outdoors	32 (11.9)	45 (11.9)		
Travel to different buildings/sites	15 (5.6)	17 (4.5)		
In a motor vehicle	4 (1.5)	8 (2.1)		
Mainly indoors	180 (66.9)	206 (54.5)		
Unemployed	38 (14.1)	102 (27.0)		
Depression			**<0.0001**	0
None or minimal	259 (87.5)	153 (35.4)		
Mild	31 (10.5)	144 (33.3)		
Moderate	1 (0.3)	74 (17.1)		
Moderately severe	4 (1.4)	38 (8.8)		

Characteristics	Normal sleep (n=296) n (%) or median (IQR)	Non-normal sleep (n=432) n (%) or median (IQR)	p*	Missing
Severe	1 (0.3)	23 (5.3)		
Stress			**<0.0001**	0
Low	189 (63.8)	143 (33.1)		
Moderate	98 (33.1)	240 (55.6)		
High	9 (3.0)	49 (11.3)		
Perceived benefits of nature	57.0 (49.0–66.0)	57.0 (47.0–65.0)	0.972	0

PHQ: Patient Health Questionnaire.

*Based on chi-squared, Fischer's exact, or Mann-Whitney U tests.

Table 2.

Adjusted odds ratios for normal sleep, Louisville, Kentucky, 2018–2019 (N=709)

Characteristics	AOR	95% CI	p-trend
Hours outside per week			0.374
≤4	Ref.		
>4 – ≤8	1.04	0.65–1.64	
>8 – ≤12	1.17	0.63–2.17	
>12 – ≤16	0.63	0.31–1.27	
>16	0.83	0.45–1.53	
Bodily pain			**<0.001**
None	Ref.		
Very mild	**0.26**	**0.15–0.46**	
Mild	**0.27**	**0.15–0.50**	
Moderate	**0.27**	**0.14–0.50**	
Severe/very severe	**0.30**	**0.13–0.67**	
Feel safe to walk neighborhood			0.342
Strongly disagree	Ref.		
Disagree	1.84	0.95–3.56	
Neither agree nor disagree	1.11	0.54–2.30	
Agree	1.43	0.77–2.66	
Strongly agree	2.00	0.94–4.26	
Exercise regularly			
No	Ref.		
Yes	0.87	0.58–1.31	
Depression			**<0.001**
None or minimal	Ref.		
Mild	**0.13**	**0.08–0.22**	
Moderate	**0.01**	**0.01–0.52**	
Moderately severe	**0.04**	**0.01–0.17**	
Severe	**0.02**	**0.01–0.14**	
Stress			**0.879**
Low	Ref.		
Moderate	0.81	0.53–1.22	
High	2.90	0.89–9.52	
Perceived benefits of nature	1.01	0.99–1.02	

AOR: adjusted odds ratio. AOR and 95% CI were estimated from logistic regression for normal sleep. General health was removed from the model due to multicollinearity. Ref.: reference.