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Research report

Exposure to light at night and risk of depression in the elderly

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ABSTRACT

Background: Recent advances in understanding the fundamental links between chronobiology and depressive disorders have enabled exploring novel risk factors for depression in the field of biological rhythms. Increased exposure to light at night (LAN) is common in modern life, and LAN exposure is associated with circadian misalignment. However, whether LAN exposure in home settings is associated with depression remains unclear.
Methods: We measured the intensities of nighttime bedroom light and ambulatory daytime light along with overnight urinary melatonin excretion (UME) in 516 elderly individuals (mean age, 72.8). Depressive symptoms were assessed using the Geriatric Depression Scale.
Results: The median nighttime light intensity was 0.8 lx (interquartile range, 0.2–3.3). The depressed group ($n=101$) revealed significantly higher prevalence of LAN exposure (average intensity, ≥5 lx) compared with that of the nondepressed group ($n=415$) using a multivariate logistic regression model adjusted for daytime light exposure, insomnia, hypertension, sleep duration, and physical activity [adjusted odds ratio (OR): 1.89; 95% confidence interval (CI), 1.10–3.25; $P=0.02$]. Consistently, another parameter of LAN exposure (duration of intensity ≥10 lx, ≥30 min) was significantly more prevalent in the depressed than in the nondepressed group (adjusted OR: 1.71; 95% CI, 1.01–2.89; $P=0.046$). In contrast, UME was not significantly associated with depressive symptoms.
Limitation: Cross-sectional analysis.
Conclusion: These results suggested that LAN exposure in home settings is significantly associated with depressive symptoms in the general elderly population. The risk of depression may be reduced by keeping nighttime bedroom dark.

1. Introduction

Epidemiological data have demonstrated a higher prevalence of major depressive disorder (MDD) in recent decades, which is associated with increased risk of dementia and cardiovascular diseases and worse mortality outcomes (Compton et al., 2006; Saczynski et al., 2010; Ariyo et al., 2000). Nevertheless, the etiology of MDD remains poorly understood. Recent advances in the knowledge of fundamental links between chronobiology and MDD have led to exploring novel risk factors for depression in the field of biological rhythms (Bunney and Bunney, 2000; McClung, 2013). MDD is frequently accompanied by circadian misalignment such as abnormal sleep/wake cycles and altered melatonin secretion and signaling, which are related to disruption of the master biological clock, typically found in night-shift workers (Boivin, 2000; Crasson et al., 2004; Wu et al., 2013; Schernhammer et al., 2004).

Physiologically, light exposure is the most important entraining environmental cue for the circadian timing system which is regulated by the suprachiasmatic nucleus (SCN) of the master biological clock (Brzezinski, 1997). The circadian phase–response curve to light suggests that exposure to daytime light advances the subsequent circadian phase and that exposure to light at night (LAN) delays the subsequent circadian phase (Khalsa et al., 2003). In modern society, several individuals are exposed to relatively lower levels of daytime light because they spend most of their daytime hours indoors. In contrast, increased LAN exposure is observed because of artificial lighting, not only in night-shift workers but also in individuals with normal circadian lifestyles (Navara and Nelson, 2007). Therefore, the light exposure patterns in modern life may be more closely related to circadian phase delay and circadian misalignment compared with that in naturalistic life.

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Although the beneficial effects of daytime bright light therapy in patients with MDD have been confirmed by recent randomized controlled studies, humans are insufficiently exposed to daytime bright light in real life situations (Lieverse et al., 2011; Riemersma-van der Lek et al., 2008). For example, about a half of the elderly population receives only 1 h of daytime light exceeding 1000 lx, and females receive a much shorter duration of daytime bright light compared with that in males (Obayashi et al., 2012; Campbell et al., 1998). Less daytime light exposure may consequently increase the risk for MDD, but it remains unclear whether daytime light exposure in home settings is associated with MDD.

Recent experimental studies conducted in mammals indicate that chronic exposure to dim LAN (5 lx) causes mood impairments compared with complete darkness during nighttime, and the intensity of dim LAN exposure, such as half as that of a candle, is common in bedrooms (Bedrosian et al., 2012; Fonken et al., 2012). In addition, dim LAN is effective at resetting the circadian phase and suppressing melatonin secretion in human physiology, and melatonin is hypothesized to be one of the major contributors to the association between LAN exposure and mood impairments (Zeitzer et al., 2000). Therefore, LAN exposure in home settings may cause the risk of MDD by altering the melatonin secretion; nevertheless, it remains unclear whether LAN exposure is associated with MDD in humans.

In this cross-sectional study of 516 elderly individuals, we evaluated the associations of daytime and nighttime light exposure in home settings and melatonin secretion with depressive symptoms. Ambulatory daytime light intensity and nighttime bedroom intensity were measured using light meters, and urinary 6-sulfatoxymelatonin excretion (UME), the major melatonin metabolite, was used as an index of melatonin secretion because there is evidence that UME correlates closely with secreted levels (Baskett et al., 1998).

2. Methods

2.1. Participants and study protocol

Between September 2010 and April 2012, 537 elderly subjects voluntarily enrolled in a study titled "Housing Environments and Health Investigation among Japanese Older People in Nara, Kansai Region: a prospective community-based cohort (HEIJO-KYO) study." Of these, 516 home-dwelling participants met the inclusion criteria of age ≥60 years and completed light measurement records and a questionnaire regarding depressive symptoms. All the participants provided written informed consent, and the study protocol was approved by the medical ethics committee of Nara Medical University.

The protocols were described in our previously reported study (Obayashi et al., 2012). In brief, after collecting demographic and medical information using a standardized questionnaire, we initiated 48-h measurements of light exposure and instructed the participants to collect their urine the following night and to maintain a standardized sleep diary by logging the time they went to bed and the period of time they spent in bed.

2.2. Ascertainment of depressed mood

Depressive symptoms were measured by the short version of the Geriatric Depression Scale (GDS-15) (Burke et al., 1991). A cut-off value of 5 was used for detection of depressed mood. Previous studies validating this cut-off value indicated that sensitivity and specificity for clinical depression ranges from 80 to 100% and from 56 to 90.5%, respectively (Burke et al., 1991; Lyness et al., 1997; Schreiner et al., 2003; Murata et al., 2008). Depressed mood was ascertained on the basis of self-reported medical history, current antidepressive therapy, or whether the GDS-15 score was ≥5.

2.3. Light exposure assessment

Ambulatory daytime light exposure was measured at 1-min intervals using a wrist light meter (Actiwatch 2; Respironics Inc., PA, USA), which was worn on the non-dominant wrist. Values <1 lx during the out-of-bed period were considered missing data because of the possibility that the sensor got covered by clothing, and these values were not included in the analyses (Scheuermaier et al., 2010). If the amount of time for which data were missing exceeded half of the period, the parameters were treated as blank data. The following were defined as the two parameters for daytime light exposure: (1) the average light intensity during the out-of-bed period (DLavg); and (2) the duration of light exposure ≥1000 lx during the out-of-bed period (DL1000).

LAN exposure was measured at 1-min intervals using a light meter (LX-28SD; Sato Shouji Inc., Kanagawa, Japan) with the sensor fixed at 60 cm above the floor, near the head of the bed, and facing the ceiling. The following were defined as the two LAN exposure parameters: (1) the average light intensity during the in-bed period (NLavg); and (2) the duration of light exposure ≥10 lx during the in-bed period (NL10).

Daytime light and LAN exposure were presented as continuous data and as categorical data by the predefined cut-off values for 500 lx of DLavg, 60 min of DL1000, 5 lx of NLavg, and 30 min of NL10.

2.4. UME assessment

The urine collection protocol involved discarding the last void at bedtime and collecting each subsequent void until the first morning void. Samples were stored in a dark bottle at room temperature, the total volume was measured, and then the samples were stored at −20 °C until assay. Urinary 6-sulfatoxymelatonin concentrations were measured using a highly sensitive enzyme-linked immunosorbent assay kit (RE54031; IBL International, Hamburg, Germany). UME was calculated as follows: UME (μg)=6-sulfatoxymelatonin concentration (μg/mL) × total overnight urine volume (mL).

2.5. Assessment of other measurements

Body mass index (BMI) was calculated as weight (kg)/height (m^2). Current smoking status, alcohol consumption habits, and socioeconomic status such as current household income and education level, habitual sleep duration, and habitual bedtime were evaluated using a questionnaire. Estimated glomerular filtration rate (eGFR) was calculated using the Japanese Society of Nephrology-Chronic Kidney Disease Practice Guide formula: eGFR (mL/min/1.73 m^2)$=194\times$ [serum creatinine (mg/dl)]$^{-1.094}\times$[Age (years)]$^{-0.287}$. The result was multiplied by a correction factor of 0.739 for females. Diabetes mellitus was diagnosed on the basis of the following assessment: medical history; current antidiabetic therapy, fasting plasma glucose levels ≥7.0 mmol/L; and glycated hemoglobin levels ≥6.5% of the National Glycohemoglobin Standardization Program value. Insomnia was diagnosed on the basis of medical history and current administration of sleeping pills. Hypertension was diagnosed on the basis of medical history and current antihypertensive therapy. Habitual physical activity was evaluated using the International Physical Activity Questionnaire (short Japanese version), which contains questions regarding the amount of time spent in moderate and vigorous activities and walking per week (Craig et al., 2003). The day length in Nara (latitude: 34°N) from sunrise to sunset on the measurement days