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Sleepless night, the moon is bright: longitudinal study of lunar phase and sleep

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SUMMARY Popular belief holds that the lunar cycle affects human physiology, behaviour and health. We examined the influence of moon phase on sleep duration in a secondary analysis of a feasibility study of mobile telephone base stations and sleep quality. We studied 31 volunteers (18 women and 13 men, mean age 50 years) from a suburban area of Switzerland longitudinally over 6 weeks, including two full moons. Subjective sleep duration was calculated from sleep diary data. Data were analysed using multiple linear regression models with random effects. Mean sleep duration was 6 h 49 min. Subjective sleep duration varied with the lunar cycle, from 6 h 41 min at full moon to 7 h 00 min at new moon ($P < 0.001$). Average sleep duration was shortened by 68 min during the week compared with weekends ($P < 0.001$). Men slept 17 min longer than women ($P < 0.001$) and sleep duration decreased with age ($P < 0.001$). There was also evidence that rating of fatigue in the morning was associated with moon phase, with more tiredness ($P = 0.027$) at full moon. The study was designed for other purposes and the association between lunar cycle and sleep duration will need to be confirmed in further studies.

KEYWORDS circalunar, meteorology, moon, sleep duration, sleep pattern

INTRODUCTION

People have believed for centuries that the moon cycle influences human physiology, behaviour and health. As Laycock (1843) pointed, the influence of the moon was acknowledged in magic and alchemy, as well as in mythology and astrology. The word 'lunatic' has been around since the 13th century to describe a recurring insanity dependent on the phases of the moon. Popular wisdom also links the full moon with sleeplessness, as reflected in poems and songs including the title of this paper (Yoko Ono and John Lennon's 'Sleepless night, the moon is bright'). Remarkably, it seems that not only laymen but a high proportion of health professionals continue to hold this belief: in New Orleans a questionnaire sent to 325 people indicated that 140 individuals (43%) thought that lunar phenomena could alter personal behaviour. Mental health professionals (social workers, clinical psychologists, nurses' aides) were more likely to believe this than other occupational groups (Vance, 1995). In another survey 80% of the participating emergency department nurses and 64% of emergency physicians believed that the moon affects patients (Danzl, 1987). Most of the nurses (92%) found full moon shifts more stressful.

However, many investigations relating lunar phase to admissions to psychiatric hospitals (Adamou, 2001; Amaddeo *et al*., 1997; Gorvin and Roberts, 1994), general practice consultation rates (Neal and Colledge, 2000; Wilkinson *et al*., 1997), spontaneous deliveries (Ghiandoni *et al*., 1998; Kelly and Martens, 1994), attempted suicides (Martin *et al*., 1992), crisis calls (Byrnes and Kelly, 1992) or epileptic seizures (Benbadis *et al*., 2004) failed to show an association. Raison *et al*. (1999) argued that in ancient times, but not in modern urban areas, the moon was a significant source of light, which affected the sleep–wake cycle and thus influenced the incidence of bipolar disorders and epileptic seizures. We used sleep diary data from 31 volunteers to examine the influence of moon phase on sleep duration in a suburban residential area in Switzerland.

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METHODS

The study was performed near Basel, Switzerland, during the 6 weeks between October 20 and November 29, 2002. There were full moons on October 21 (08:19 hours) and November 20 (02:33 hours). The data were collected as part of a pilot study of exposure to mobile telephone base stations and sleep quality. All people aged 16–80 years who were not working night shifts and lived in the vicinity of a mobile phone base station that became operational during the study period were eligible. Study participants were asked to complete a structured diary before going to bed and immediately after getting up in the morning. They recorded the time of going to bed, switching off lights, waking up in the morning and the estimated time between switching lights off and onset of sleep (sleep latency). Participants used alarm clocks as necessary. They also documented episodes of waking up during the night and the intake of caffeine, alcohol and sleeping medications. Sleep quality was rated in the morning on four bipolar visual analogue scales: (i) fatigue versus full of energy, (ii) bad versus good mood, (iii) physically well versus not well, (iv) distressed versus relaxed. Information on weather conditions was obtained from the local meteorological station and referred to the preceding day.

Statistical analysis

We investigated lunar and meteorological influences on subjective sleep duration, subjective sleep-onset latency, number of wake up periods and sleep quality by means of multilevel regression models. In order to allow for repeated measures from the same individual we used a two-level model with random effects for the subject. All covariates were modelled as fixed effects. *P*-values were derived from maximum likelihood ratio tests. Moon phase was parameterized using a cosine function which assumed the value of 0 at new moon and 1 at full moon. We calculated sleep duration as the time between switching off lights and waking up in the morning, minus the estimated sleep latency (time taken to fall asleep) and time awake during the night. Sleep duration was predicted from the model according to moon phase, age, sex, weekday, time of going to bed, intake of alcohol, coffee, or sedatives, and whether study participants slept during the preceding day. Based on the model we estimated the adjusted sleep duration for each exposure, with values of all covariates set at the observed mean. Results are presented as predicted sleep durations in decimal hours with 95% confidence intervals (95% CI). Analyses were carried out using 'gllamm' in Stata (version 8.2; College Station, TX, USA).

RESULTS

We contacted 76 households and enrolled 37 eligible study participants from 27 households. All participants gave written consent.

Six people did not complete the study for reasons that included: hospital admission, language problems, death in the family, and problems related to old age. We excluded nights spent outside the usual home and incomplete data. In addition, we excluded the night when the clocks changed from summer to winter time (October 26–27). It is very likely that some of the study participants recorded their morning awakening time without taking the change in time into account (see Fig 1). We thus analysed data from 31 participants and 1145 of 1271 (90%) person-nights. The mean age of study participants was 50 years (SD = 16.0 years) (Table 1). Participants reported consuming caffeine 4 h prior to sleep on 23% of nights (263/1145), any alcohol consumption on 17% of nights (198/1145), more than two glasses of alcoholic drinks on 2% of nights (23/1145). Only three people used sleeping drugs (one night each). The average times of going to bed and waking up were 23:22 and 06:56 hours.

Fig 1 shows the moon phase and predicted subjective sleep duration from the adjusted model during the study period, and Table 2 shows the predicted sleep durations for moon phase, sex, age and weekday. There was strong evidence for an effect of moon phase and weekday, with 19 min less sleep during the full compared with the new moon, and 68 min additional sleep during the weekend compared with other days. There was also evidence that men slept longer than women, and that sleep duration decreased with age (Table 2). Meteorological conditions on the preceding day were not found to affect sleep duration. Our model explained 45.0% of the total variance in sleep

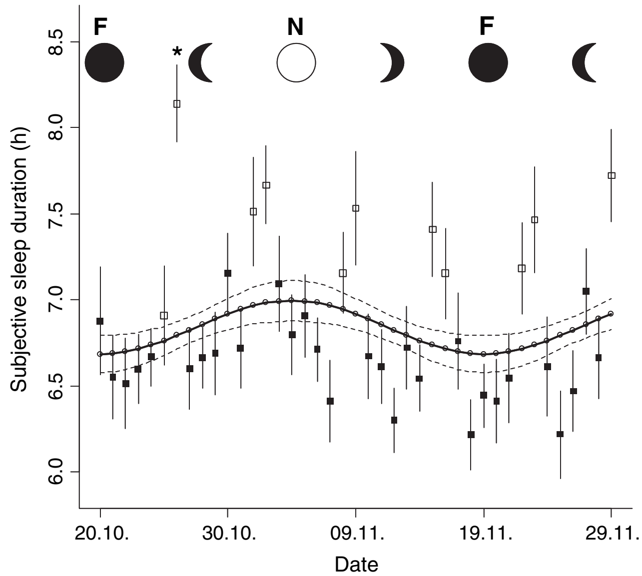

Figure 1. Predicted subjective sleep duration according to moon phase, with 95% confidence intervals (dashed lines). Filled and empty circles represent full (F) and new (N) moons. Squares show mean observed sleep durations, with standard errors of the mean (vertical lines) for workdays (black squares) and weekends (open squares). *October 26–27: change from summer to winter time (clocks went back by 1 hour). This night was excluded from data analysis.

Table 1 Characteristics of study participants

	Number of participants	*Proportion (%)*
Age (years)		
17–35	5	16
36–60	18	58
> 60	8	26
Sex		
Female	18	58
Male	13	42
Educational level		
None/training on the job	5	16
Apprenticeship	14	45
Higher education/University	12	39
Professional activity during study period		
Employed	21	68
Household work	3	10
Retired	5	16
In education	2	7
Living condition		
Living alone	3	10
Living with partner	14	45
Living with partner and children	10	32
Others	4	13
Health status (SF-36)		
Excellent	2	7
Very good	13	42
Good	15	48
Fair	0	0
Poor	1	3
Self-rated sleep quality at baseline*		
Good	18	58
Fair	10	32
Disturbed	3	10

*From a self-diagnosis test (Müller and Paterok, 1999).

Table 2 Subjective sleep duration in decimal hours according to moon phase and other variables

Variable	*Sleep duration in hours (95% CI)*	*P* value
Moon phase		
New moon	7.00 (6.88–7.11)	< 0.001
0.25	6.92 (6.83–7.01)	
0.50	6.84 (6.76–6.92)	
0.75	6.76 (6.68–6.85)	
Full moon	6.69 (6.58–6.79)	
Sex		
Female	6.72 (6.62–6.82)	< 0.001
Male	7.00 (6.87–7.12)	
Age (years)		
17 (min)	7.75 (7.59–7.91)	< 0.001
35	7.24 (7.15–7.33)	
60	6.54 (6.44–6.64)	
76 (max)	6.09 (5.93–6.24)	
Weekday*		
Monday	6.68 (6.51–6.84)	< 0.001
Tuesday	6.46 (6.31–6.61)	
Wednesday	6.44 (6.29–6.60)	
Thursday	6.67 (6.51–6.82)	
Friday	6.55 (6.39–6.70)	
Saturday	7.50 (7.34–7.66)	
Sunday	7.88 (7.69–8.08)	

Predicted sleep duration from multiple hierarchical random-effect models (model variables: moon phase, age, sex, weekday, time of going to bed, intake of alcohol, coffee, sedatives, and sleeping during the preceding day. Age was modelled as a continuous variable).
*Weekday relates to the morning of the respective night.

duration. Differences according to moon phase tended to be larger in women although statistical evidence for this was weak (test for interaction, $P = 0.38$). Sleep latency and wake up events were not associated with moon phase. Rating of fatigue in the morning was associated with moon phase, with more tiredness ($P < 0.027$) at full moon. In contrast, levels of distress, mood and well-being were not influenced by the moon.

Finally, the increase in electromagnetic field exposure was negligible after the mobile phone base station came into operation and no change in sleep duration was observed.

DISCUSSION

Our study provides evidence for the widely held belief that sleep duration varies with moon phase. The difference was modest; about 20 min less sleep at full compared with new moon. In contrast to popular wisdom, the effect appears to be graded, and not restricted to the days around full moon. Women appeared to be affected more than men by moon phase, again confirming popular belief, but statistical evidence for this was weak.

Strengths and weaknesses of the study

We obtained sleep diary data for over 1000 person-nights, during a period that included two full moons. Our analytic strategy increased statistical power by modelling moon phase as a continuous cosine function, required no arbitrary definitions of full and new moon periods and took the clustered nature of the data into account. The lunar effect was robust and independent from different model assumptions. Omitting data from the night when the clocks changed (October 26–27) did not modify the lunar effect. Our results could be biased because of the fact that all study participants were living in the same area. However, we could not identify specific nights with substantially different sleep patterns, except for the probable artefact of the night when the clocks changed. Although self-administered sleep diaries to measure sleep duration are less accurate than polysomnographic laboratory studies (Carskadon *et al.*, 1976), our data are a reflection of the actual sleep behaviour, including intimate activities and other nocturnal interests (Jean-Louis *et al.*, 2000). Sleep duration measured from wrist activity using actigraphs might have increased precision (Cole *et al.*, 1992). However, any measurement error would be expected to be non-differential, leading to attenuation of associations. Participants were unaware of the study hypothesis, and so were we: the idea of performing this analysis was born during a coffee break many months later.

Studies of sleep duration

The average subjective sleep duration in our study population was similar to the healthy subjects from the European SIESTA database where the median recorded sleep duration ranged from 7.3 h in 20-year-old persons to 6.0 h in 80-year-old persons (Danker-Hopfe *et al.*, 2005). In a representative British population sample aged 16 years and older, the average reported sleep duration was 7.04 h (SD 1.55). There was no difference between men and women (Groeger *et al.*, 2004). We identified two previous studies of sleep duration and moon phase, which included a total of five individuals (Binkley, 1992; Binkley *et al.*, 1990). Neither study showed an effect even though the single volunteer in one study maximized exposure to the lunar cycle by sleeping in a room with uncovered windows and a skylight (Binkley, 1992).

How could moon phase influence sleep duration?

Prior to the advent of modern lighting the moon was an important source of light, which would have affected sleep directly not only through nocturnal illumination, but also because it allowed social activities outside the house. Such a direct or indirect light effect is still conceivable in the studied suburban region with moderate artificial light sources. Lunar lighting conditions exert well known direct effects on the physiology and behaviour of various animals, including primates (Donati *et al.*, 2001; Takemura *et al.*, 2004; Wolfe and Summerlin, 1989). A direct light effect on humans is harder to imagine because most people sleep in covered places and the full moon is frequently invisible due to cloudy weather. In humans, circalunar hormone cycles has been observed not only in women, but also in men (Celec *et al.*, 2003; Rensing *et al.*, 2001). The observed changes in sleep duration might be explained by such circulanar hormone cycles. A nocebo effect is also possible, meaning that study participants tended to go later to bed during the full moon period because they expected to sleep less well.

Conclusions and future research

In view of the small differences in subjective sleep duration observed in our study, sleep deprivation is unlikely to cause an increase in psychiatric disturbances around full moon as has been hypothesized (Raison *et al.*, 1999). Indeed, seizure frequency in temporal lobe epilepsy, which is highly sensitive to sleep deprivation, only increases with 1–2 h of sleep loss (Rajna and Veres, 1993).

Sleep duration is influenced by many factors resulting in large between and within subject variability. This has to been taken into account in the statistical analysis, but few rigorous analyses of the relation between moon cycles and sleep–awake phases in humans have been performed so far. Our study was designed for other purposes and the association between lunar cycle and sleep duration will need to be confirmed in further studies. Ideally, future studies should examine lunar influences on sleep and mental health in communities that are not exposed, or little exposed, to artificial light.

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