

LIGHT AND SLEEP WITHIN HOSPITAL SETTINGS

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INTRODUCTION

Light is the most important signal that entrains the human circadian system. Hence, light strongly influences the 24 h sleep-wake pattern and has a broad impact on our physiology and behavior. Not surprisingly, light affects performance, health and well-being¹ in society, also within the healthcare settings²⁻⁵.

Lighting standards for hospitals prescribe a horizontal illuminance of at least 300 lux measured at bed level. This is relatively modest as compared to the natural, much higher illuminance outdoors (2000-100000 lux). During daytime, the indoor environment leaves us relatively light deprived, whereas in the late evening, indoor lighting limits our exposure to darkness. Both effects are not optimal for our sleep and health⁶⁻⁸.

Impaired sleep is known to have negative consequences for human health⁹. Unfortunately, sleep within most hospital settings is less optimal as compared to the home situation¹⁰. Improving sleep in the hospital can contribute positively to the clinical care.

The aim of the present study was to investigate the effects of an artificial patient room lighting system that simulates certain aspects of natural daylight and its dynamics on sleep duration, sleep quality, depression, and satisfaction within a group of hospitalized cardiovascular patients.

METHODS

From December 2009 until September 2010, 171 patients (average age 65.9 ± 14.9 SD) of the cardiology ward of the Maastricht University Medical Center (MUMC, NL) enrolled in the study. Typically patients on this ward were stable cardiology patients diagnosed with heart failure, heart infarction, heart rhythm disturbances, or angina pectoris. All patients gave written informed consent. The experimental protocol was approved by the local Medical Ethics Committee of the Maastricht University Medical Center.

Patients were assigned according to normal hospital procedures and irrespectively of their health status, to a control room with standard lighting conditions, or to an intervention room with dynamic and enhanced lighting. Four rooms (having 1, 2 or 4 beds) were available per condition. In total 9 beds were available per condition. One control room had all windows facing west, the other 7 rooms had windows facing north only. The intervention rooms were equipped with a prototype of the Philips HealWell lighting system. This system provides general lighting with automated gradual changes in correlated colour temperature (2700K-6500K) and illuminance across the day, mimicking elements of dawn and dusk. Every day contained a fixed timeslot of more than 1 h in the late morning where the vertical illuminance at eye level exceeded 750 lux. Moreover, the system comprises (multicolour) lighting elements for a pleasant ambience with bedside control for the patients.

Sleep was measured by means of Actiwatch-Spectrum® (Philips Respironics). Subjects wore the Actiwatch on their non-dominant wrist throughout their hospital stay. Movement-induced acceleration counts were stored on a 1-min basis. Total sleep duration, sleep onset latency and sleep efficiency were analyzed by means of Respironics Actiware 5 software. Questionnaires were used to probe depression (Hospital Anxiety and Depression Scale¹¹, HADS) and satisfaction scores on the lighting system of the patient room (using a 7 point scale: 0 = very unsatisfied, 3 = neutral, 6 = very satisfied).

Mixed-effects regression analysis using MLwiN software (MLwiN 2.23, Centre for Multilevel Modelling, Institute of Education, London, UK) was used to test the statistical significance of the intervention and its time dependent effects. This analysis takes into account the interdependency of the data points inherent to the hierarchical structure of the data, in our case the daily measurements i , nested within subjects j . It further allows to use of all available data, even when some observations are missing for a subject¹² as is the case in the present study. The following model equation was used:

$$\text{Outcome}_{ij} = \beta_{0ij} + \beta_1 * \text{DaysAtHospital}_{ij} + \beta_2 * \text{light}_j + \beta_3 * (\text{light} * \text{DaysAtHospital})_{ij}$$

The betas (β_{0-3}) represent the intercept and the effect estimates. $\text{DaysAtHospital}_{ij}$ is the number of days a patient (j) has spent at the hospital at any time point (i) that a particular Outcome_{ij} value is measured. Light_j represents the condition, using 0 for the control group and 1 for the intervention group.

RESULTS AND DISCUSSION

Actiwatch data of 107 subjects were available for analysis. In the dataset the number of subjects present per night was variable and decreased considerably with increasing length of stay. The maximum number of nights that any subject stayed at the hospital was 19. On average subjects stayed in the hospital for 8 ± 5 (SD) days (Figure 1).

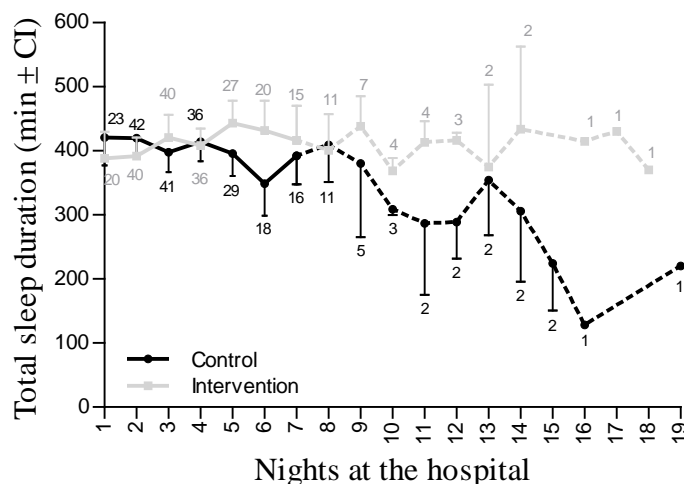


Figure 1. Raw data overview. Mean (\pm 95% CI) total sleep duration per night of hospitalization for the control (black line) and the intervention (grey line) group. The number of subjects per group contributing to a given mean is indicated next to each point. The dotted line reflects data after the 7th night in the hospital, after this night the majority of the subjects are dismissed.

The control and the intervention group hardly differed in their medication usage. Virtually all patients were on β -blockers and hypnotics were used very restrictively. Whether the different

diagnoses, and the slight differences in their distribution across the control and intervention group, could trigger different responses to light remains to be analyzed. For the sleep parameters, the regression analyses showed that there were no significant differences between the control and the intervention group in the first hospital night ($p = 0.42$). Moreover, there was no significant effect ($p = 0.12$) of DaysAtHospital (β_1). However, a significant interaction effect between light exposure and DaysAtHospital (β_3) was observed (Table 1). When a given patient is hospitalized in an intervention room on the first night and remains hospitalized in that room for 6 more nights (i.e., totaling to 7 nights, chosen to match the average stay-duration of 8 days), total sleep duration (TSD) in the 7th night increases by an average of 50.5 min as compared to the situation where this patient would have spent the 6 additional nights in a standard room. When expressing this change as % of the TSD during the first night in the hospital, this corresponds to a relative increase of 13%. Similarly, a reduction by 9 minutes (or a relative 55%) is observed for sleep onset latency, whereas sleep efficiency improved by 3% (or a relative 3.3%). A large part of the patients was dismissed before the 8th night of hospitalization. In view of the small sample size, the regression output after this period should be interpreted with caution. We tested how our model responds towards a reduction in the follow-up time by analyzing the data collected during those first 8 days only. This yielded similar findings as compared to the analysis over all 19 nights, see Table 1. These results indicate that, despite of the negative effects that β -blockers could have on sleep, sleep was more consolidated and rapid for patients in the intervention group. The increased daytime light exposure and the dawn and dusk elements of the intervention could stand at the basis of this effect. It is generally accepted that sleep is necessary to remain healthy⁹. Therefore, improving sleep can be deemed to be of clinical relevance.

HADS scores have been collected for 154 patients. Regression analysis for the depression score of the HADS (7 items, each with a 0-3 point scale) showed a modest interaction effect (β_3). This effect results in a reduction of the depression score by 1.0 points after 8 days of hospitalization ($p = 0.08$). Moreover, no significant differences were observed between the control (4.7 ± 0.4 SEM) and intervention (5.4 ± 0.6 SEM) group at the onset of the study ($p = 0.28$), nor was there an effect of DayAtHospital (β_1 , $p = 0.11$). Satisfaction scores were collected for patients ($N = 90$) and staff (36 questionnaires returned). In both groups satisfaction scores for the intervention lighting system are higher by about 1.2 points as compared to the standard room lighting system. The reduced depression scores and the increased satisfaction may be supportive for a positive effect of lighting on recovery^{13, 14}.

Table 1.: Regression model estimates (\pm SEM) for actigraphy data on total sleep duration, sleep onset latency and sleep efficiency within the intervention group. The intercepts correspond to the first night of hospitalization. The slopes give the light by DaysAtHospital interaction (β_3) representing the average absolute change for every extra night spent at the hospital beyond night one. Values are given for the overall analysis (up to 19 nights of hospitalization) and for the analysis restricted to the first 7 nights of hospitalization. All p-values are 2-sided.

Output	Analysis over all 19 nights		Analysis over the first 7 nights	
	intercept	slope (β_3)	intercept	slope(β_3)
Total sleep duration (min)	403.0 (\pm 14.5)	8.4 (\pm 2.7) *	399.3 (\pm 15.9)	8.5 (\pm 5.5) **
Sleep onset latency (min)	16.8 (\pm 3.2)	-1.5 (\pm 0.7) **	17.0 (\pm 3.6)	-2.6 (\pm 1.3) **
Sleep efficiency (%)	83.5 (\pm 1.4)	0.5 (\pm 0.2) †	83.5 (\pm 1.5)	0.35 (\pm 0.4) ††

(*) $p < 0.01$ (**) $p < 0.05$ (†) $p = 0.06$ (††) $p = 0.3$

CONCLUSIONS

This preliminary analysis shows that the present lighting intervention achieves modest benefits on various sleep parameters and depression scores of cardiovascular patients. Moreover the intervention is positively appreciated by patients and nursing staff. More evidence based research with larger sample size and different patient populations is needed to identify how patient room lighting can help optimizing the healing environment.

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