Effect of simulated dawn on quality of sleep – a controlled study

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Abstract

Background

Morning light exposure administered as simulated dawn looks a promising method to treat Seasonal Affective Disorder, but it may moreover help with resetting the inaccurate organisation of body clock functions relative to sleep occurring in winter among people in general. Disturbances in sleep patterns are common and may compromise wellbeing even in the short term. Our hypothesis was that simulated dawn could improve the subjective quality of sleep during winter.

Methods

A community-based trial with 100 volunteer subjects provided with dawn simulators. Study period lasted for eight weeks, and subjects used the dawn simulators for two weeks at a time, each subject acting as his own control (ABAB-design). Main outcome measure was subjective quality of sleep recorded each morning with the Groningen Sleep Quality Scale.

Results

Quality of sleep improved while subjects were using dawn simulator-devices (p<0.0001). The treatment became beneficial after eight days’ use of dawn simulators, but the effect did not last after the use was ceased.

Conclusion

Dawn simulation may help to improve the subjective quality of sleep during wintertime. Further research is needed to verify these findings and to elucidate the mechanism by which dawn simulation acts on the sleep-wake schedule.
Background

Intrinsic biological rhythms allow living organisms to anticipate environmental changes. They are generated by inherited time-keeping mechanisms, known as clocks, and driven by signals from the individual's natural habitat to match the solar day [1]. Their accuracy depends on the individual's response characteristics, on which health status has a vital influence. Loss of sleep may create health hazards even in the short-term [2]. In winter, there is often inaccurate co-ordination in the timing of circadian rhythms relative to the sleep-wake cycle. Light is the most important Zeitgeber, or time-giver in humans [3]. During winter there is a lower light intensity and therefore it is possible that the biological clockwork becomes less stable. We hypothesised that to a number of people simulated dawn [4,5] would be of some help during winter in particular. It might keep the endogenous clock in a desired phase position relative to standard clock time, preventing desynchronization, facilitating sleep and improving the process of waking up.

Seasonal Affective Disorder (SAD) is a form of recurring major depression, in which a depressive episode usually begins in autumn/winter and remission follows in spring/summer (winter-SAD). Bright light (over 2500 lux) is considered the treatment of choice in winter-SAD. However, in a recently published controlled trial Avery et al. found that dawn simulation was superior to both placebo and bright light treatment in alleviating symptoms of SAD [6]. In an earlier report, slow dawn (increasing illuminance over 45 min, peaking at 100 lux) was better than rapid dawn (4 s, peaking at 100 lux) in improving mood and quality of sleep in subjects with subsyndromal-SAD [7]. We present here, to our knowledge (PubMed search by 15 Jan 2003), the first study on the effect of dawn simulation on a non-clinical population.
Methods

Our aim was to study whether simulated dawn improves the quality of sleep during winter. We derived a random sample of the adult population to achieve a reliable estimation of the size of the population that would benefit from simulated dawn. The sample, comprising 1000 subjects aged over 17 years, with 1:1 sex ratio, was drawn from the national population register of Finland. Subjects who were not shift workers and who had not been hospitalised nor taking medication during the previous six months were eligible for the study. The first 100 eligible respondents to the invitation letter were enrolled in the trial, after giving their written informed consent. This trial was part of a larger, binational study whose report is currently under preparation [8]. The study protocol is in concordance with the Helsinki declaration and its amendments, and it was approved by the local ethics committee.

With a dawn simulator the luminance is weak initially but intensifies gradually over 30 minutes, mimicking sunrise. The trial was preceded by two days of adaptation during which subjects were instructed to use the dawn simulator and adjust the maximum level of illuminance. They were asked to set it at 200 lx for the first morning, but allowed to change it to either 100 or 300 lx for the second. Finally, they were asked to stick to the preferred level and use it daily throughout the trial. The dawn simulator was thus to function as their alarm clock on workdays, and they were also instructed to use it in the same way, and set for the same time, at weekends. The trial lasted eight weeks: two weeks of simulated dawn were followed by two weeks without, and this cycle was then repeated once. Half of the subjects followed the opposite design, starting without simulated dawn. Compliance was monitored regularly by the research assistant who instructed all the subjects.

The study was performed in two periods: 4 October to 29 November, and 10 January...
to 7 March. The main outcome measure was quality of sleep, assessed daily using the 14-item Groningen Sleep Quality Scale (GSQS) [9]. Data were screened and analysed with the S-Plus 2000 Professional for Windows Release 1 (Mathsoft, Inc.). To estimate the intervention effect on the GSQS, a linear mixed-effects model (LME) for longitudinal data was used [10]. The absolute value of the GSQS was set as the dependent variable, and treatment effect, the interaction of treatment and time, and baseline characteristics as independent fixed effects. The LME accounts for intra-individual variation in a repeated measures design by setting the variation as a random effect and treating each individual as a cluster in modelling. To test whether the treatment effect lasted after each intervention, a carry-over indicator was included in the model.

**Results**

Of the 94 participants, 78 (83%) completed the trial: 47 women and 31 men aged on average 35.1 years (range 18 to 70). Dropouts from the study were mostly due to busy social or occupational schedules. In the statistical analysis treatment effect and the interaction of treatment and time were highly significant (Table 1). The quality of sleep improved constantly during the daily administration of simulated dawn. However, the improvement was not linear, but followed a logarithmic curve. It took eight days for the treatment benefit to appear. The level of light intensity, age, sex and season (autumn/winter) were accounted for and did not influence the outcome.
Discussion

Sleep problems are common: in a nation-wide survey in the United States, one individual in three reported having occasional difficulty sleeping, and nearly 10% complained of sleep problems occurring on a regular, nightly basis [11]. Disorders of sleep tend to increase with age [12]. Our results suggest that simulated dawn improves the quality of sleep during the dark months in autumn and winter. It appears effective in relatively healthy males and females regardless of age, and may benefit a substantial proportion of the adult population.

Simulated dawn has been shown to prevent the phase delay naturally occurring in the human circadian pacemaker [13]. In addition, even one simulated dawn is sufficient to phase advance the timing of the onset of melatonin secretion [14]. This phase advance is probably the mechanism explaining the observed benefits on sleep. However, we did not measure melatonin levels in this field study, so the hypothesis cannot be confirmed. More experimental data on the response of the circadian system to low light intensities and short stimuli are needed for verification and assessment of its mechanisms of action.

A shortcoming of the study is admittedly its design: we did not have a placebo condition, and the so the subjects were aware of the nature of the intervention they were currently receiving. However, it took eight days for the treatment benefit to appear. We believe this decreases the risk that the observed benefits on sleep are merely due to placebo effect, which usually wanes as trial continues.

Conclusions

Simulated dawn appears to be a safe and effective means of alleviating sleep disturbances related to the shortening photoperiod during winter.
Competing interests

None declared

Authors' contributions

SL analyzed the data and wrote the final manuscript, TP and YM participated in the planning and co-ordinating of the study and co-authored the manuscript. JH planned the statistical analysis. JL contributed to planning and supervising the study. All authors have read and approved the final manuscript.

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Table 1. Estimates of the effect of simulated dawn and baseline characteristics on the quality of sleep scale.

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>95% CI</th>
<th>p value</th>
</tr>
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<tbody>
<tr>
<td>Treatment effect</td>
<td>-2.4</td>
<td>-3.3 to -1.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Treatment x log (time) effect</td>
<td>1.2</td>
<td>0.6 to 1.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>Treatment carry-over effect</td>
<td>-0.1</td>
<td>-1.0 to 0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Age</td>
<td>0.01</td>
<td>-0.01 to 0.03</td>
<td>0.4</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>0.04</td>
<td>-0.5 to 0.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Time of year (autumn/winter)</td>
<td>-0.2</td>
<td>-0.7 to 0.4</td>
<td>0.5</td>
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