Sleep Medicine Reviews 29 (2016) 52–62

Contents lists available at ScienceDirect

Sleep Medicine Reviews

journal homepage: www.elsevier.com/locate/smrv

CLINICAL REVIEW

The effects of light therapy on sleep problems: A systematic review and meta-analysis

Annette van Maanen [a, *], Anne Marie Meijer [a], Kristiaan B. van der Heijden [b], Frans J. Oort [a]

[a] Research Institute of Child Development and Education, University of Amsterdam, The Netherlands
[b] Department of Clinical Child and Adolescent Studies, Leiden University, The Netherlands

ARTICLE INFO

Article history:
Received 30 January 2015
Received in revised form
27 August 2015
Accepted 30 August 2015
Available online 9 September 2015

Keywords:
Bright light therapy
Sleep problems
Circadian rhythm sleep disorders
Insomnia
Meta-analysis

SUMMARY

Although bright light therapy seems a promising treatment for sleep problems, research shows inconclusive results. This meta-analysis is the first to systematically review the effect of light therapy on sleep problems in general and on specific types of sleep problems in particular (circadian rhythm sleep disorders, insomnia, sleep problems related to Alzheimer's disease and dementia). Fifty-three studies with a total of 1154 participants were included. Overall effects and effects on separate circadian and sleep outcomes were examined. We calculated Hedges' g effect sizes and we investigated the effects of twelve moderators (design-related, treatment-related, participant-related). Light therapy was found effective in the treatment of sleep problems in general ($g = 0.39$), and for circadian rhythm sleep disorders ($g = 0.41$), insomnia ($g = 0.47$), and sleep problems related to Alzheimer's disease/dementia ($g = 0.30$) specifically. For circadian rhythm sleep disorders, effects were smaller for randomised controlled trials. For insomnia, we found larger effects for studies using a higher light intensity, and for sleep problems related to Alzheimer's disease/dementia larger effects were found for studies with more female participants. There was indication of publication bias. To conclude, light therapy is effective for sleep problems in general, particularly for circadian outcomes and insomnia symptoms. However, most effect sizes are small to medium.

Introduction

Light has an important influence on sleep and wakefulness. First, light influences the suprachiasmatic nucleus (SCN), a region in the hypothalamus that controls circadian rhythms, through the eye and the retinohypothalamic tract. Second, light inhibits the secretion of melatonin. Third, light is found to have alerting effects through indirect projections on the ascending arousal system, which in turn facilitates thalamic and cortical connections [1,2].

Because light is such an important factor in the regulation of sleep and wakefulness, light has been applied therapeutically as a treatment for sleep disorders. Bright light therapy is a natural, simple form of treatment that has relatively low costs. Moreover, light therapy does not lead to residual effects and tolerance, which are often associated with medication use (e.g., [3,4]), although light therapy also can have side effects such as headache, eye strain, autonomic hyperactivation, and can possibly induce hypomania [5].

Research on light therapy effectiveness has shown inconclusive results, with some studies reporting positive effects whereas others found minor or no effects [6–9]. The reasons for these inconsistencies are not yet clear. To some extent, they might be explained by the large variety in sleep problems targeted with light therapy, large variety in studied groups (regarding age, comorbidity), or differences in study design and treatment characteristics (e.g., treatment duration, light intensity etc.).

Considering the high potential of light therapy for sleep disorders, it is important to gain insight in the general and specific effects of light therapy on different sleep problems, and to identify factors that influence its effectiveness. Therefore, in this meta-analysis we will investigate the effect of light therapy on sleep problems in general and specific sleep problems in particular. Furthermore, we aim to identify possible influences (moderators) on the effects of light therapy.

Abbreviations: ASPS, advanced sleep phase syndrome; CBT, cognitive behavioural treatment; CRSD, circadian rhythm sleep disorder; DSM, diagnostic and statistical manual of mental disorders; DSPS, delayed sleep phase syndrome; ICSD, International classification of sleep disorders; RCT, randomised controlled trial; SCN, suprachiasmatic nucleus.

* Corresponding author. Research Institute of Child Development and Education, University of Amsterdam, PO box 15776, 1001 NG Amsterdam, The Netherlands. Tel.: +31 20 525 1235; fax: +31 20 525 1500.
E-mail address: A.vanMaanen@uva.nl (A. van Maanen).

http://dx.doi.org/10.1016/j.smrv.2015.08.009
1087-0792/

Current state of knowledge

In the early 1980s, Czeisler et al. [10] first showed that the phase of the circadian rhythm in humans could be influenced by modifying the light–dark cycle. Lewy and colleagues found that nocturnal melatonin secretion could be suppressed by bright light [11]. Rosenthal et al. [12] first applied this principle to patients with delayed sleep phase syndrome (DSPS), a circadian rhythm sleep disorder (CRSD) in which the endogenous circadian rhythm is delayed with regard to what is desired. They found that the circadian rhythm of core body temperature and the sleep-wake rhythm of DSPS patients could be shifted by 2 h of bright light exposure in the morning and restriction of light in the evening.

After the first studies conducted in the 1980s, the research on light therapy has been extended to other sleep disorders, with different light characteristics and varying treatment durations. In 1995, several consensus reports of the task force on light treatment for sleep disorders have been published, summarising the research on light treatment for sleep disorders until then [13–19]. In addition, several reviews appeared which mainly reported about the application of light for sleep problems in older, healthy adults [20] or in elderly with Alzheimer's disease or other types of dementia [21–23]. A systematic review of different treatment options for various forms of sleep disturbance (e.g., increased sleep latency, low sleep efficiency, long daytime sleep duration) in people with Alzheimer's disease/dementia concluded that of the non-pharmacological treatments analysed in that study, bright light was the most effective [24].

Treatment guidelines for the use of light therapy in sleep disorders

To date, there are no clear guidelines available for light therapy in sleep disorders related to Alzheimer's disease/dementia [21], and the research on light treatment for other sleep disorders has led to varying treatment recommendations [25–28]. Although there is no consensus about the ideal treatment characteristics, there is agreement about the timing of treatment according to the phase response curve of light. This implies that exposure to light in the morning – after the lowest point of body temperature at around 04:00 h – shifts the biological clock rhythm to an earlier point in time, whereas light in the evening (before the nightly nadir in temperature) shifts it to a later time. Immediately before or after the temperature nadir, light exposure has its greatest phase-advancing effect, with diminishing effects further away from the temperature nadir. This implies that light therapy in the morning should occur as early as possible, however, without forcing individuals waking up too early, preventing sleepiness during the day [25,29,30].

Important factors to consider in studies of light treatment effectiveness

Although light therapy is nowadays applied to different types of sleep disorders, it was originally applied to CRSD [12]. The core problem of CRSD lies in the misalignment between the endogenous rhythm and the environment, or in the lack of an endogenous rhythm. As light therapy directly affects the circadian rhythm by its influence on the SCN [11], it might be expected that light therapy would have stronger effects on CRSD than on other types of sleep disorders. We therefore hypothesised that the type of sleep problem targeted would be an important factor to consider when investigating light therapy effectiveness (Moderators 1–4).

Another factor that could be of influence is the quality of the study design. Studies without a control group might find larger effects than randomised controlled trials (RCTs), as the latter control for placebo effects (Moderator 5).

Also, effects could be different for subjective and objective outcome measures of sleep (Moderator 6). Both measures have their own disadvantages, as people often have difficulty assessing their sleep and actigraphs cannot always reliably distinguish between inactivity and sleep or between restlessness during sleep and night-time awakenings. The latter is even more problematic in people experiencing sleep problems [31,32].

As mentioned earlier, there are several treatment characteristics that could impact treatment effects. Number of treatment days (Moderator 7), daily treatment duration (Moderator 8), and intensity and spectral characteristics of light (Moderator 9) seem important factors to take into account [25–28]. Another factor to consider is whether additional instructions regarding sleep hygiene or bedtimes are provided (Moderator 10). Good sleep hygiene and regular bedtimes are important factors that can influence treatment effectiveness [26,27].

Sleep does not remain stable over the life course. The proportion of time spent in different sleep stages changes with age [33], and in general older people have less consolidated sleep and they wake up earlier [34]. Moreover, age differences in effects of sleep treatment are found, e.g., melatonin treatment has larger effects in children than in adults [35], although prolonged-release melatonin has been found effective for older adults [36]. Light treatment might have smaller effects in older people due to age-related changes in lens density [37]. We therefore expect age to be a moderator of light therapy effectiveness (Moderator 11).

Although little is known about differential effects of light therapy for men and women, Cajochen [38] recently showed that there are some gender differences in response to light. Women were found to prefer warmer light whereas this was not found for men. In addition, women more often have sleep complaints [39,40]. Therefore, it might be expected that treatment effects vary between men and women (Moderator 12).

Present meta-analysis

The present meta-analysis is the first to systematically review the effect of light therapy on sleep problems in general and on specific types of sleep problems in particular. In the analyses we will not only examine the overall effect of light therapy on sleep, but also on the different circadian and sleep outcomes separately. In addition, we will take into account whether specific study characteristics, treatment characteristics, and sample characteristics act as moderators.

Method

Selection of studies

As a primary search method, we did an extensive literature search using the databases of PsycINFO, Medline, Cinahl, Embase, and the Cochrane Library. We used the following keywords in our search: phototherapy, phototherap*, heliotherapy, heliotherap*, light treatment, light exposure, bright light, sunlight, artificial light, combined with sleep disorders, sleep*, insomnia*, dyssomnia*, somnolence, circadian rhythm, jet lag syndrome, jet lag*, night shift*. We excluded animal studies. Furthermore, an RCT filter was applied to make a selection of papers reporting on randomised controlled trials, to ease the screening process. The search was carried out in two phases. The initial search was carried out in November 2012. An update was done in March 2015. For an example of the full electronic search strategy, see Appendix S1.