

# The effects of bright-light therapy on actigraphical measured sleep last for several weeks post-treatment. A study in a nursing home population

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**SUMMARY** We investigated the time-course of nocturnal actigraphic measures, following the termination of bright-light therapy for sleep disturbances in demented nursing home patients. From an earlier study, 11 nursing home patients ( $86 \pm 9$  years, Mini-Mental Status Examination score  $12 \pm 4$ ) with actigraphically measured sleep efficiency  $< 85\%$ , were recruited to morning bright-light treatment (6000–8000 lux) 2 h per day for 14 days. Actigraphic measures were registered at pretreatment, treatment and at four monthly post-treatment periods. Each actigraphic recording period consisted of seven consecutive days. Sleep improved substantially with treatment; sleep efficiency increased from 73% to 86% and total nocturnal wake time was reduced by nearly 2 h. During the 16 weeks post-treatment period, actigraphic measures gradually returned to pretreatment levels. Sleep efficiency remained significantly higher than the pretreatment level 4 weeks after treatment termination. Sleep onset latency remained significantly reduced up until 12 weeks post-treatment. This study supports previous findings of beneficial effects of bright-light therapy for sleep disturbances in demented nursing home patients. Furthermore, these results are the first to suggest that post-treatment effects of short-term bright-light therapy may last longer than previously assumed.

**KEYWORDS** bright light, dementia, sleep disturbances

## INTRODUCTION

Nocturnal sleep fragmentation, early morning awakening and daytime sleep periods are all common features among the elderly (Ancoli-Israel *et al.*, 1989). Recent studies have suggested that these changes may be explained by reduced amplitude of the human circadian pacemaker – leading to a less obvious distinction between day and night (Dijk *et al.*, 2000; Hofman, 2000). Advancing age and dementia seem to diminish the ability to respond to external time-cues, as well as altering the very architecture of sleep (Bliwise, 1993; Bliwise *et al.*, 1992; Weinert, 2000).

Bright-light treatment for sleep disturbances in aged individuals with dementia is reported to reduce the frequency and duration of nocturnal awakenings, reduce sleep latency, reduce early morning awakening and cause less daytime napping (Fetveit *et al.*, 2003; Mishima *et al.*, 1994; Satlin *et al.*, 1992). The positive effect of bright light is believed to be a result of stronger coupling between light as an external time-cue and the internal sleep–wake rhythm, facilitated by the hypothalamic nucleus suprachiasmaticus (Czeisler *et al.*, 1989).

Little is known about post-treatment effects of bright-light exposure in demented nursing home patients. As far as we know, no previous studies have specifically examined the post-treatment duration of improved sleep in this population. However, a short-acting effect has been implied in crossover-designed studies using washout periods for 1–3 weeks (Haffmans *et al.*, 2001; Mishima *et al.*, 1998). The notion of a short-acting effect may be based on the rapid adaptive circadian rhythm seen in healthy individuals with altered timing of bright-light exposure.

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When short-term bright-light treatment is used to treat seasonal affective disorder (SAD), post-treatment effect is seen to last for several months after termination of treatment (Lingjaerde *et al.*, 1998). This suggests that bright-light treatment may induce long-lasting effects.

Although numerous studies have shown beneficial effects of bright-light treatment for sleep disturbances in demented elderly (Ancoli-Israel *et al.*, 2003; Mishima *et al.*, 1998; Okawa *et al.*, 1991; Satlin *et al.*, 1992), a well-conducted recent study showed no effect of bright light on nocturnal sleep in this population (Ancoli-Israel *et al.*, 2002). Further research in this field is clearly needed. Investigation of post-treatment effects of bright-light exposure is not only important for the management of sleep disorders among demented elderly, but also for the design of future studies in this field – especially when it comes to cross-over designs.

In a recent study, we showed that short-term bright-light treatment significantly improved sleep in demented institutionalized elderly with sleep disturbances (Fetveit *et al.*, 2003). The present study specifically investigates the duration of treatment effect on sleep disturbances in the same study population, after the termination of bright-light treatment.

## METHOD

### Subjects

The subjects were selected from an earlier study describing sleep patterns in an entire nursing home population (Fetveit and Bjorvatn, 2002). In the population of 25 subjects in this earlier study, actigraphy showed a mean sleep onset latency of 1 h and a mean wake after sleep onset of more than 2 h. Mean sleep efficiency was 75%, and 18 subjects (72%) were found to have an actigraphically measured sleep efficiency below 85%, indicating sleep disturbances. These 18 subjects were included in the present study. The previous study is below referred to as the 'baseline period'.

Of the 18 included patients, one patient rejected participation, five patients died before the study commenced and one died in the early part of the study. Complete data were obtained from the remaining 11 patients, 10 female and one male. Mean age was 86.1 years (SD = 8.9, range = 72–101). Grades of dementia were assessed by Mini-Mental Status Examination (MMSE) score and Clinical Dementia Rating. Mean MMSE score was 11.7 (SD = 4.2, range = 6–18) and mean Clinical Dementia Rating score was 2.5 (SD = 0.5, range = 2–3), indicating moderate to severe dementia. Patients were diagnosed according to ICD-10 criteria of dementia, resulting in the diagnosis Alzheimer's disease in eight patients and dementia other than Alzheimer's disease in three patients. Due to small numbers, no subdivision of dementia types was made in the following data analysis. Depression among the demented residents was rated with the Cornell Scale for Depression in Dementia, which had a mean score of 6.8 (SD = 2.7, range = 2–11), on a scale from 0 (no depression) to 38 (major depression).

Ophthalmologic screening showed that red reflex was present in all patients. No patients were blind or had severely impaired vision.

All patients had several medical diagnoses, and were taking multiple medications, but no patient used hypnotics, anti-psychotics, cholinesterase inhibitors or benzodiazepines as regular or as-needed medication during the study. Written informed consent was obtained from relatives and the study was approved by The Regional National Committee for Research Ethics.

### Apparatus

Bright-light treatment consisted of light from a specially designed light box (ML-10000; Miljølys A/S, Tynset, Norway), sized 40 × 15 × 10 cm, with a light intensity of 10 000 lux at a distance of 50 cm.

Sleep/wake activity was recorded with an Actiwatch portable recorder (Cambridge Neurotechnology Ltd, Cambridge, UK), which is a small wrist-worn device, sized 1 × 3 × 4 cm, containing an accelerometer that is optimized for highly effective sleep-wake inference from wrist activity that has been previously validated for documenting longitudinal changes in sleep patterns (Lockley *et al.*, 1999). The sensitivity of the Actiwatch was set to medium. Data was collected in 1-min epochs and transferred, via an interface, to a computer and then analysed (Actigraphy Sleep Analysis 98; Cambridge Neurotechnology Ltd, Version 4.13).

### Procedure

The present study was designed as a patients-series, consisting of a 2-week pretreatment period, immediately followed by a 2-week treatment period. Thereafter, 1-week post-treatment registrations were carried out 4, 8, 12 and 16 weeks after treatment termination. A total of 462 days was thus analysed (11 patients, 6 weeks). A prestudy registration of the sleep characteristics (baseline period) took place 8 months before the main experiment. Baseline, pretreatment and treatment periods all consisted of 2 weeks of actigraphical registrations, from which a period of seven consecutive days was used in the subsequent data analysis. For the treatment period, days 8–14 were analysed in order to capture any treatment effects. This period was compared with days 8–14 in the pretreatment period.

In the pretreatment period, all light devices were installed and study personnel were present, imitating the following treatment period, with exception of turning on the light devices. Environmental changes, like increased social interaction, were thus introduced in the pretreatment condition. In the subsequent treatment period, no new environmental changes were introduced, with the exception of light devices being turned on according to treatment schedule. During the treatment period, residents were exposed to morning bright light of an intensity of 6000–8000 lux for a period of about 2 h in relation to breakfast, and within the period 8:00–11:00.

Light levels were measured with a photometer (Elvos LM-1010, Elvos GmbH, Ludwigsburg, Germany). According to everyday routines, patients were separated in two groups and served breakfast in two adjacent rooms. If sufficient space on the breakfast table, light boxes were placed in front of the patient in a distance of 60–70 cm from eye level. Otherwise, light boxes hung from the ceiling, facing the patient at eye level in an equivalent distance. Each patient had her/his own light box, which was kept in position throughout the pretreatment and treatment exposure periods.

Sleep evaluations for pretreatment, treatment and post-treatment periods were carried out using an actigraph, which registered the sleep/wake pattern and was worn on the resident's wrist of the dominant hand at all hours. No subjects had tremor or other involuntary movements that could produce miscalculations of actigraph recordings.

Nursing staff registered rising and bedtime. These were defined as light on in the morning and light out in the evening, so that reading or resting in bed before actual sleep intention was not considered a part of the night-time period. Rising time was governed by nursing home routines and was consistent with time. Effort was made to make the bedtime as accurate as possible. Bedtime was largely decided by patients themselves, but always involved assistance from nursing staff, who then noted bedtime, defined as lights out. It was great awareness among the staff to get the accurate time for lights out. Based on individual rising and bed times several actigraphical variables were calculated: sleep efficiency (percent sleep of total bedtime), total sleep time, total wake time, number of awakenings, length of each awakening, sleep onset latency, wake after sleep onset and early morning awakening (time from wakeup to rising). The ratio between each individual's daytime and night-time activity was analysed based on actigraphical registrations and expressed as the light/dark ratio (L/D ratio). Mean level of activity during the 24-h day was expressed as 'mesor' and the peak hour of activity during the 24-h day as 'acrophase'. Non-parametric indices of the phase of the circadian rhythm were reported as the onset of the least active 5-h period (L5 onset) and the onset of the most active 10-h period (M10 onset) in the average 24-h pattern. L5 onset values were transformed to a linear range so that 00:20 was expressed as 24:20. Results were transformed back to correct time points.

In order to evaluate possible influence of seasonal changes in environmental light conditions on sleep efficiency, a regression model was used, including the predictor variables 'day length' and 'rate of change in day length'. The rate of change was calculated as the first derivative of the day length, i.e. the average day length during the week of the registration minus the average day length during the previous week.

#### Data handling/statistics

Data were analysed with the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA). Repeated measures of each sleep variable were initially analysed for overall effect

with the General Linear Model for Repeated Measures (GLMRM). Findings of significant overall effects were further evaluated with least significant difference (LSD) comparisons between pretreatment and subsequent registrations, which included treatment and post-treatment time points (4, 8, 12 and 16 weeks). A backward stepwise regression analysis was carried out to evaluate the effect of seasonal changes in environmental light on sleep efficiency.

#### RESULTS

Analysis for overall effect showed that treatment increased sleep efficiency ( $F_{5,50} = 3.95$ ,  $P = 0.004$ ) and L/D ratio ( $F_{5,50} = 3.18$ ,  $P = 0.014$ ). Treatment reduced total wake time ( $F_{5,50} = 4.80$ ,  $P = 0.001$ ), sleep onset latency ( $F_{5,50} = 3.38$ ,  $P = 0.010$ ) and early morning awakening ( $F_{5,50} = 2.83$ ,  $P = 0.025$ ). Treatment did not produce any overall significant changes in wake after sleep onset ( $F_{5,50} = 1.42$ ,  $P = 0.233$ ), total sleep time ( $F_{5,50} = 1.23$ ,  $P = 0.308$ ) or time in bed ( $F_{5,50} = 1.86$ ,  $P = 0.119$ ).

The variables sleep efficiency, sleep onset latency, wake after sleep onset, early morning awakening, total wake time and time in bed improved significantly from the pretreatment to the treatment period (Table 1). In the post-treatment period, all these variables gradually returned to pretreatment levels – and after 16 weeks there were no significant difference from pretreatment for any variable. Sleep onset latency remained statistically reduced up until 12 weeks post-treatment. The duration of bright-light treatment effect on each variable in the post-treatment period is shown in Table 1. Further analysis of the above sleep variables in the period 23:00–07:00 are presented in Table 2. The individual values for sleep efficiency improved for all patients with treatment and were subsequently reduced for all patients during the post-treatment period, regardless whether the registration period was based on individually recorded bed and rising times or a fixed registration period (23:00–07:00).

The subjects in this study were recruited from an earlier descriptive study (baseline period). Mean sleep efficiency in the baseline period (72.9%, SD = 8.1) was similar to the pretreatment value in the present study (72.9%, SD = 16.0), indicating stability over time. The variable 'sleep efficiency' is given special emphasis as it includes the variables sleep onset latency, wake after sleep onset and early morning awakening, and is therefore a useful general expression of nocturnal sleep patterns. Sleep efficiency increased significantly with bright-light treatment, and remained significantly higher than the pretreatment level for more than 4 weeks post-treatment (Table 1).

At pretreatment, acrophase was at 16:07 (SD = 3:58), mesor was 58.32 (SD = 51.5), L5 onset was at 0:48 (SD = 2:47) and M10 onset was at 11:05 (SD = 3:06). Treatment did not produce any overall significant changes for either acrophase ( $F_{5,50} = 1.58$ ,  $P = 0.18$ ), mesor ( $F_{5,50} = 1.61$ ,  $P = 0.17$ ), L5 onset ( $F_{5,50} = 1.46$ ,  $p = 0.22$ ) or M10 onset ( $F_{5,50} = 1.61$ ,  $P = 0.17$ ).

**Table 1** Objective sleep/wake data in 11 nursing home patients, before, during and after bright-light treatment

	<i>Mean value (95% CI); P-value of difference compared with pretreatment</i>					
	<i>Pretreatment</i>	<i>Treatment</i>	<i>4th week after</i>	<i>8th week after</i>	<i>12th week after</i>	<i>16th week after</i>
Sleep efficiency (%)	72.9 (62.1–83.6)	85.6 (79.2–92.0); <i>P</i> = 0.006*	77.5 (69.6–85.4); <i>P</i> = 0.049*	76.6 (68.7–84.6); <i>P</i> = 0.26	77.1 (71.2–83.0); <i>P</i> = 0.37	72.4 (61.7–83.0); <i>P</i> = 0.92
Sleep onset latency	1:17 (0:31–2:03)	0:17 (0:05–0:29); <i>P</i> = 0.011*	0:37 (0:00–1:14); <i>P</i> = 0.004*	0:49 (0:19–1:18); <i>P</i> = 0.012*	0:42 (0:23–1:02); <i>P</i> = 0.04*	0:57 (0:14–1:40); <i>P</i> = 0.4
Wake after sleep onset	1:49 (1:04–2:35)	1:23 (0:40–2:05); <i>P</i> = 0.037*	2:01 (1:01–3:00); <i>P</i> = 0.45	1:49 (1:05–2:32); <i>P</i> = 0.96	1:52 (1:20–2:24); <i>P</i> = 0.91	2:03 (1:11–2:57); <i>P</i> = 0.42
Early morning awakening	0:16 (0:03–0:29)	0:01 (0:00–0:03); <i>P</i> = 0.027*	0:08 (0:00–0:17); <i>P</i> = 0.23	0:13 (0:03–0:22); <i>P</i> = 0.61	0:12 (0:01–0:22); <i>P</i> = 0.53	0:24 (0:05–0:43); <i>P</i> = 0.46
Total wake time	3:24 (2:01–4:48)	1:40 (0:51–2:29); <i>P</i> = 0.003*	2:47 (1:43–3:50); <i>P</i> = 0.023*	2:52 (1:51–3:53); <i>P</i> = 0.18	2:46 (2:05–3:27); <i>P</i> = 0.28	3:30 (2:10–4:50); <i>P</i> = 0.88
Total sleep time	9:10 (7:42–10:38)	10:12 (9:08–11:17); <i>P</i> = 0.076	9:33 (8:27–10:39); <i>P</i> = 0.32	9:38 (8:20–10:56); <i>P</i> = 0.46	9:31 (8:27–10:35); <i>P</i> = 0.59	9:12 (7:47–10:37); <i>P</i> = 0.97
Time in bed	12:32 (11:41–13:24)	11:56 (10:57–12:55); <i>P</i> = 0.015*	12:23 (11:31–13:16); <i>P</i> = 0.50	12:21 (11:33–13:09); <i>P</i> = 0.46	12:18 (11:34–13:03); <i>P</i> = 0.39	12:42 (12:00–13:24); <i>P</i> = 0.65
L/D ratio	1.59 (1.23–2.06)	2.38 (1.33–3.43); <i>P</i> = 0.097	2.02 (1.23–2.83); <i>P</i> = 0.093	2.42 (1.52–3.32); <i>P</i> = 0.016*	1.68 (1.25–2.11); <i>P</i> = 0.56	1.64 (1.18–2.10); <i>P</i> = 0.76

Repeated measures of actigraphic variables (hours : minutes for all variables except sleep efficiency and L/D ratio) before, during bright-light treatment and 4, 8, 12 and 16 weeks after treatment termination. Treatment and post-treatment registrations are compared with pretreatment ( $*P < 0.05$ ). Treatment followed immediately after pretreatment registrations.

**Table 2** Objective sleep/wake data in 11 nursing home patients in the period 23:00–07:00, before, during and after bright-light treatment

	<i>Mean value (95% CI); P-value of difference compared with pretreatment</i>					
	<i>Pretreatment</i>	<i>Treatment</i>	<i>4th week after</i>	<i>8th week after</i>	<i>12th week after</i>	<i>16th week after</i>
Sleep efficiency (%)	77.1 (70.3–83.8)	88.0 (84.6–91.4); <i>P</i> = 0.001*	83.8 (78.9–88.8); <i>P</i> = 0.005*	80.0 (73.7–88.2); <i>P</i> = 0.33	80.3 (75.3–85.3); <i>P</i> = 0.38	76.4 (67.5–85.4); <i>P</i> = 0.86
Sleep onset latency	0:26 (–0:03–0:57)	0:09 (0:04–0:14); <i>P</i> = 0.25	0:22 (0:09–0:34); <i>P</i> = 0.68	0:27 (0:12–0:42); <i>P</i> = 0.98	0:25 (0:11–0:39); <i>P</i> = 0.92	0:35 (0:02–1:08); <i>P</i> = 0.69
Wake after sleep onset	1:15 (0:46–1:43)	0:48 (0:33–1:03); <i>P</i> = 0.012*	0:51 (0:32–1:10); <i>P</i> = 0.027*	1:02 (0:40–1:25); <i>P</i> = 0.10	1:02 (0:43–1:21); <i>P</i> = 0.39	1:00 (0:32–1:29); <i>P</i> = 0.29
Early morning awakening	0:08 (–0:01–0:18)	0:00 (0:00–0:01); <i>P</i> = 0.08	0:03 (–0:04–0:11); <i>P</i> = 0.41	0:06 (–0:01–0:14); <i>P</i> = 0.72	0:06 (–0:01–0:14); <i>P</i> = 0.78	0:17 (0:00–0:34); <i>P</i> = 0.35
Total wake time	1:49 (1:17–2:22)	0:57 (0:41–1:14); <i>P</i> = 0.001*	1:16 (0:53–1:41); <i>P</i> = 0.005*	1:35 (1:06–2:06); <i>P</i> = 0.33	1:33 (1:10–1:58); <i>P</i> = 0.38	1:52 (1:10–2:36); <i>P</i> = 0.86
Total sleep time	6:11 (5:37–6:42)	7:03 (6:45–7:18); <i>P</i> = 0.001*	6:42 (6:18–7:06); <i>P</i> = 0.005*	6:23 (5:53–6:53); <i>P</i> = 0.33	6:27 (6:01–6:49); <i>P</i> = 0.38	6:08 (5:23–6:49); <i>P</i> = 0.86

Repeated measures of actigraphic variables (hours : minutes for all variables except sleep efficiency) in the period 23:00–07:00, before, during bright-light treatment and 4, 8, 12 and 16 weeks after treatment termination. Treatment and post-treatment registrations are compared with pretreatment ( $*P < 0.05$ ). Treatment followed immediately after pretreatment registrations.

The predictor variables 'day length' and 'rate of change in day length' did not show significant relationship with sleep efficiency in a backward stepwise regression analysis.

## DISCUSSION

The present study demonstrates that some of the positive effects of morning bright-light treatment for sleep disturbances among demented institutionalized elderly extend further in the post-treatment period than previously assumed. Actigraphically measured sleep efficiency differed significantly from pretreatment values 4 weeks after termination of treatment. The most persistent change was seen in sleep onset latency,

which remained significantly reduced for 12 weeks post-treatment. This is the first study to specifically address the issue of post-treatment effects of bright-light therapy.

Several studies have shown that bright-light treatment improves sleep in demented nursing home patients (Ancoli-Israel *et al.*, 2003; Fetveit *et al.*, 2003; Mishima *et al.*, 1998; Okawa *et al.*, 1991; Satlin *et al.*, 1992). However, negative studies also exist. A well-conducted controlled study in patients with dementia of mixed origins did not show improved sleep (Ancoli-Israel *et al.*, 2002). In another study, the same authors reported that light exposure consolidated sleep in patients with Alzheimer's disease, suggesting that the effects of bright light may differ between dementia types

(Ancoli-Israel *et al.*, 2003). Similarly, the effects of bright light on the peak of the activity rhythm differed between these two studies (Ancoli-Israel *et al.*, 2002, 2003). In our studies (Fetveit *et al.*, 2003 and the present one), where most of the patients had Alzheimer's disease, we did not find any changes in the peak of the activity rhythm following acute treatment or in the post-treatment period. This is in agreement with the study of Ancoli-Israel *et al.* (2003) in patients with Alzheimer's dementia.

The present study has some limitations. The sample size is very small. We included all patients in a nursing home with 25 patients, but before starting the bright-light experiment we excluded patients who slept well, based on actigraphically scored sleep efficiency above 85%. In addition, some patients died before the study commenced. Thus, we ended up with a sample of eleven. We do think that one major reason why our study demonstrates greater improvements in sleep compared with other studies is the fact that we only studied patients with sleep disturbances. Other studies have included patients without first recording sleep, thus including well-sleeping patients. Bright-light treatment is not likely to improve sleep in good sleepers. We also want to emphasize that all eleven patients in our study experienced sleep improvements with bright light, and that all patients had a return of sleep variables back to baseline with time. Although our results are encouraging, and in agreement with several other studies, additional research with larger sample sizes is still needed to fully evaluate the efficacy of bright light in the treatment of sleep disturbances in institutionalized patients with dementia.

In our opinion, actigraphical calculations based on individual bed and rising times produce optimal data for the study of sleep patterns, but are dependent on accurate measures of the actual times. In our study, nursing staff registered lights out and lights on. Rising time (lights on) was governed by nursing home routines and consistent with time and we believe these measurements are very reliable. Bedtime (lights out) was largely decided by the patients themselves, but always involved assistance by staff, who then was able to note the accurate time for lights out. To avoid considerations about the reliability of nursing staff bed and rising time registrations, sleep in fixed night-time periods might be evaluated, and this is done in some previous reports (Ancoli-Israel *et al.*, 2002; Yamadera *et al.*, 2000). In our study, sleep in the fixed night-time period 23:00–07:00 seemed more consolidated than individually measured time in bed (Tables 1 and 2.). The disadvantage of creating such a fixed window for longer registration periods is the inevitable exclusion of sleep outside the registration period and/or the inclusion of periods out of bed. Still, results from the fixed window in the present study show similar significant improvement in sleep with treatment and lasting effects in the post-treatment period. One major difference was that the pronounced reduction in sleep onset latency following bright light was not present in the fixed window, due to the fact that most patients were already asleep at 23:00.

Previously, the latest registrations in a post-treatment period was made by Van Someren *et al.* (1997), who tested the effect

of increased daytime environmental illumination on rest–activity rhythm disturbances. Average light intensity in the treatment period of 4 weeks, was 1136 lux, as opposed to a pretreatment illumination of approximately 400 lux. Treatment conditions significantly improved rest–activity variables, but there was no treatment effect in a post-treatment registration 4 weeks after the main experiment. Due to different outcome measures, an immediate comparison with the present study is not possible, but it is reasonable to believe that improvements in actigraphically measured rest–activity variables reported by Van Someren also imply improved sleep, and thus harmonize with our findings. Still, the post-treatment effect on rest–activity variables was shorter than the effect on sleep variables in the present study, perhaps because of different intensity of the light exposure in the two studies (6000–8000 lux versus 1136 lux).

In another study examining rest–activity rhythms, Mishima *et al.* (1998) measured the effect of 2-h morning bright light (5000–8000 lux) versus dim light (300 lux) among 22 demented institutionalized elderly, using a randomized crossover design. There was a significant lower night-time activity in the first post-treatment week, but no further post-treatment registrations were reported. The interval between bright light and dim light conditions (washout period) was minimum 4 weeks. The finding of lasting positive effect in the first post-treatment week harmonizes well with the present study. If, however, our findings of prolonged post-treatment improvement in sleep variables also apply for rest–activity variables, washout periods less than 12 weeks may imply possible carryover effects, and thus complicate the interpretation of the results. Another crossover study (Haffmans *et al.*, 2001) reports beneficial effect of  $\frac{1}{2}$  h morning bright light (10 000 lux) on motor restless behaviour in dementia. The washout period was limited to 1 week. Reports by Sloan *et al.* (1996) and Bliwise (2000) have shown that there are close relations between nocturnal sleep and daytime behavioural symptoms and agitation in demented elderly. Therefore, a recommendation with regards to length of washout periods following bright-light treatment in sleep studies could be relevant to behavioural studies in this population as well.

One may argue that seasonal variations of environmental light may interfere with prolonged studies of artificial bright-light treatment. However, several studies report low levels of illumination in nursing home environments all year around (Ancoli-Israel *et al.*, 1991, 1997; Shochat *et al.*, 2000), indicating that environmental light seems unlikely to interfere with bright-light studies over several months. However, seasonal rhythms, even in the presence of circadian disturbances, have been reported in demented elderly subjects (Van Someren *et al.*, 1996). Although no influence of seasonal variables was found in our data, we believe that seasonality cannot totally be ruled out in any experimental sleep study in this population.

The present study demonstrates a prolonged positive effect on nocturnal sleep following bright-light treatment. In spite of the lack of previous studies which specifically investigates

post-treatment duration of bright-light effects, a notion of a short acting effect has prevailed in both sleep and behavioural studies. Although it is difficult to exactly stipulate how many weeks the effects of bright light may last, the present study suggests that a washout period of more than 12 weeks may be necessary in future crossover-designed studies. Prolonged post-treatment effect following bright-light therapy is well-documented in the treatment of SAD (Lingjaerde *et al.*, 1998), supporting this notion. The present results may also imply that bright-light treatment schedules for demented elderly could be flexible and yet effective – for example, with alternating periods of bright-light treatment.

The present data support previous reports of a positive effect of bright-light treatment on sleep disturbances, as the positive effects on sleep gradually diminished following bright-light treatment. No other factors like medication or illness were identified as explanations of this return to pretreatment conditions.

In conclusion, this study demonstrates that bright-light treatment is efficient for sleep disturbances in demented institutionalized elderly. The positive effects seem to last up to 12 weeks post-treatment, which is substantially longer than previously assumed.

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