Change in Sleep State of the Elderly before and after Cataract Surgery

Mizuho Tanaka1), Kyoko Hosoe2), Tsunekazu Hamada2) and Takeshi Morita1)

1) Department of Living Environmental Science, Fukuoka Women’s University
2) Hamada Eye Clinic

Abstract It seems likely that the influences of light upon circadian rhythms will decrease with aging, particularly those rhythms that are more influenced by light with a higher color temperature and richer in short wavelengths. More specifically, cataract patients’ optical systems transmit light poorly, especially the shorter wavelengths that affect the circadian system more. The present study investigated melatonin secretion profiles and sleep patterns before and after cataract surgery. Fifteen subjects were studied for 3 consecutive weekdays before, and one month after, their cataract surgery. UV-cutting intra-ocular lenses were used for patients after surgery. No statistically significant differences between before and after surgery were observed in the amount of light received and the amount of activity. This means that there were no significant changes in their lifestyle during the experimental period. Considering the group as a whole, no significant differences were present in melatonin secretion, sleep parameters, or sleepiness before and after the surgery. However, individual subjects responded differently. The subjects showed a negative correlation between the wake-up time and sleep efficiency after surgery. The amount of light received during the night time influenced sleep more significantly than during the day time. J Physiol Anthropol 29(6): 219–224, 2010 http://www.jstage.jst.go.jp/browse/jpa2 [DOI: 10.2114/jpa2.29.219]

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Introduction

Aging is associated with changes to the transparency of the cornea and lens. These structures become more opaque, and light transmission deteriorates. The amount of deterioration depends on the wavelength of the light, and transmission of short wavelengths in particular falls in the aged compared to younger controls (Brainard et al., 1997). In the pathological condition known as a cataract, this reduction in transmission can be very marked.

Light of short wavelengths is also important in the control of body temperature, melatonin secretion, and the sleep-wake rhythm. Melatonin is often used as an indicator of the circadian clock, and its effect in inducing sleep is widely known (for example, Cajochen et al., 2003). Brainard et al. (2001) examined the influence of various monochromatic lights on melatonin secretion and revealed an action spectrum with a peak at 464 nm. Morita and Tokura (1998) also reported an influence of light with a different spectral distribution on circadian rhythms during daily life; light with a high color temperature (which contains more short wavelengths) reduced melatonin secretion and decreased core temperature in the evening and night, and exerted an inhibitory effect on nocturnal sleep. Further, in the morning, such light increased core temperature and decreased melatonin secretion, acting to entrain the body clock and promote daytime activities. In addition, the amount of light exposure in the daytime affects sleep through core temperature and the profile of nocturnal melatonin secretion; after spending the daytime in bright light, individuals showed a greater decrease of core temperature during the night, and deeper sleep (Tokura et al., 1998).

Accordingly, it seems likely that these influences of light upon circadian rhythms will decrease with aging, particularly those rhythms (such as melatonin secretion, for example) that are more influenced by light with a higher color temperature and richer in short wavelengths. More specifically, cataract patients, whose optical systems transmit light poorly, especially the shorter wavelengths that affect the circadian system more, would be expected to have poor sleep as a consequence of the inadequacies of light transmission in the daytime. Moreover, cataract surgery should improve not only their sight but also the quality of their sleep. Asplund and Lindblad (2002, 2004) carried out an investigation into sleep with cataract patients. The results revealed that a considerable proportion of the patients reported improvement in their sleep 1 and 9 months after cataract surgery. However this study was made using a subjective questionnaire rather than physiological measurements.

The present study investigated melatonin secretion profiles and sleep patterns before and after cataract surgery in daily life. We focused on the relation of environmental light and human photoreception which affects directly and rapidly
melatonin secretion and then sleep condition. Accepting that surgery will increase the amount of light entering the eye, particularly light of short wavelengths, this can affect melatonin secretion and sleep parameters.

**Methods**

Fifteen cataract patients (9 males and 6 females aged 62-80 years, mean age = 70.5 y, SD = 7.2 y) participated. These subjects were selected by an ophthalmologist. Patients were chosen who required surgery due to eyesight less than 0.7 decimal (about 20/28 to 20/29 in feet) or who had been identified as suffering from acquired tritanopia (based on the desaturated 15-hue test, Lanthony, France). Informed consent was obtained from each patient prior to the beginning of the experiment. UV-cutting intra-ocular lenses (IOLs) were used for patients after surgery.

The surgery was carried out between May and December, 2008. Each subject was studied for 3 consecutive weekdays (avoiding weekends, when lifestyle might be abnormal) before, and one month after, their cataract surgery (Fig. 1).

Each subject was instructed to keep his/her normal daily life during the experimental period, and wore a portable illuminance and activity monitor (Actiwatch-L: Mini mitter) on the wrist of their nondominant arm throughout the study days (including when sleeping) except for times of exposure to water (such as bathing, for example). The amounts of light exposure and activity during normal daily life were measured continuously.

The data were then used to calculate summed exposure and activity during two periods: “daytime,” from wake-up time to 18:00 h; and “nighttime,” from 18:00 h to retiring time. The average values from the first two days of study were used for analysis of the amounts of light exposure and activity, and the sleep parameters. The third day, when saliva collection took place (see Fig. 1), was excluded from these analyses.

The subjects also recorded their wake-up and retiring times the previous night. The quality of sleep was evaluated with using one of five possibilities, ranging from (1), “Unable to sleep at all” to (5), “Slept well.” Sleep efficiency and sleep latency, based on the activity record during sleep time, were calculated by Actiware-Sleep software.

From 10:00 h in the morning of the third study day to 6:00 h in the morning of the fourth day, saliva was collected every four hours with Salivette (Akitiengesell Shaft & Co) (Figure 1). The concentration of melatonin was analyzed by the ELISA method (Direct Saliva Melatonin ELISA kit EK-DSM, Buhlmann). The total amount of melatonin secreted, the maximum amount of secretion, and the time of maximum secretion were estimated. To obtain the total amount of melatonin secreted, the 4-h concentrations of melatonin were summed. The maximum amount of melatonin secreted and the time of maximum secretion were calculated by spline interpolation.

**Results**

Whereas the results of the desaturated 15-hue test before cataract surgery showed acquired tritanopia, the errors in the permutations of color tips became decrease after cataract surgery in all subjects.

Three of the original group of 15 subjects provided incomplete data; the analyses were performed on only the 12 subjects who provided complete data. The statistical differences were determined by pair t-test and Wilcoxon signed ranks test according to the normality of the data. No statistically significant differences between before and after surgery were observed in the amount of light received and the amount of activity; there were no significant changes their lifestyle during the experimental period.

Figure 2 indicates the times of wake-up and retiring, and the amounts of light exposure and activity, before and after surgery. No statistically significant differences were observed, indicating that there were no significant changes to lifestyle produced by the surgery. Figure 3 shows comparisons in melatonin secretion, sleep parameters, and sleepiness before and after the surgery. Considering the group as a whole, no significant differences were present. However, individual subjects responded differently; some showed increased melatonin secretion and improved sleep parameters, whereas others showed deteriorations in these variables. This difference might be because morning or daytime exposure to light,

![Fig. 1 The schedule of the survey.](image-url)
especially light of short wavelength, promotes melatonin secretion and nocturnal sleep but exposure at night has the opposite effect. That is, an earlier wake-up time means that the effect of morning daylight predominates, whereas a later retiring time accentuates the opposite effect of light at night. To investigate this possibility, the relations between the wake-up or retiring times and the sleep parameters were examined. In this analysis, 11 subjects were used; one was excluded because of incomplete sleep data. Because the data were not normally distributed, Spearman’s rank-correlation coefficient was used for statistical analysis. For the relationship between retiring time and sleep efficiency, a strong negative correlation \(r = -0.75; p = 0.017\) was observed after surgery and, for the relationship between wake-up time and sleep efficiency, there was a negative tendency \(r = -0.58; p = 0.067\) after surgery (Fig. 4). There were no significant correlations between retiring time or wake-up time and sleep efficiency before surgery. No significant correlations were present for melatonin secretion and wake-up or retiring times either before or after surgery (Fig. 5).

**Discussion**

After cataract surgery the errors in a 15-hue test decreased. This indicates that transmission of light of short wavelengths in particular became better after cataract surgery. In comparisons between before and after cataract surgery, no significant statistical differences were observed in sleep parameters and melatonin secretion. On the other hand, the subjects showed a negative correlation between the wake-up or retiring times and sleep efficiency after surgery. This means that the sleep efficiency of subjects with earlier wake-up and

![Fig. 2 Change of wake-up time, retiring time, light, and activity before and after cataract surgery. The gray lines are an individual subject’s data, and the full line is the average.](image-url)
Fig. 3  Comparisons between melatonin, sleep parameter, and sleepiness before and after cataract surgery. The gray lines are an individual subject’s data, and the full line is the average.

Fig. 4  The relations between wake-up or retiring time and sleep efficiency before and after surgery. Circles are an individual subject’s data; open circles are before surgery, closed circles are after surgery.
retiring times was higher than in those with later wake-up and retiring times. After the surgery, subjects’ eyes received more light of short wavelengths and this affected sleep efficiency. The relationships between wake-up or retiring time and sleep efficiency indicate that the amount of light received during the nighttime influenced sleep more significantly than did the amount of light received during the daytime. Consequently, the amount of light obtained during daytime as a result of the surgery works to improve sleep (if the retiring time is early), but the light received during the nighttime affects sleep negatively (with later retiring times). Lehnkering and Siegmund (2007) reported that sleep efficiency in younger people exhibited a difference between morning type and evening type. It showed that sleep efficiency was significantly better for morning than evening type. The elderly who have undergone cataract surgery can take in light in almost the same way that younger people can. Our results also indicate that sleep factors of the elderly depend on their lifestyle, too, as Lehnkering and Siegmund reported. Asplund and Lindblad (2002 and 2004) examined sleep improvement both one month and nine months after cataract surgery with 407 aged patients. But 15.8% of the men and 31.4% of the women still experienced poor sleep 9 months after surgery. Accepting the result of this study, it was thought that no improvement in sleep was caused by their lifestyle.

This experiment revealed that, after cataract surgery, the subjects can take in considerable light of short wavelengths and that this significantly influences biological rhythmicity. As a result of surgery, the subjects responded not only positively to morning and daytime light but also negatively to light in the nighttime. According to a report (2008), the UV-cutting IOLs improve the level of light reception, which influences circadian rhythms, to those of the lenses of younger people. Accepting this, the elderly who have undergone such surgery, and so receive light in the same way as younger people, should pay attention to the influence of light in the nighttime.

In field studies, many factors in daily life affect psychological and physiological reactions in a complicated manner. But it is also important that the results available from those field studies show the nature of our daily life, whereas caution is required in the interpretation of the results. It is necessary to study further in the field and under dim light conditions.

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References


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Correspondence to: Takeshi Morita, Department of Living Environmental Science, Fukuoka Women’s University 1–1–1 Kasumigaoka, Higashi-ku, Fukuoka 813–8529, Japan
Phone: +81–92–673–0293
e-mail: morita@fwu.ac.jp