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The relation between sleep disruption and cataract in a large population study

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Abstract

Purpose—To investigate the relation between sleep disruption and nuclear cataract, as well as the impact of cataract removal on sleep, in two discrete population cohorts.

Methods—This is a cross-sectional study of 5070 participants from three large longitudinal epidemiologic studies of age-related eye disease, hearing, olfaction, and cognition. Slit-lamp photos of the lens were obtained to grade nuclear cataract using a standardized protocol. The quality of sleep was assessed using a modified Wisconsin Sleep Cohort Study questionnaire. Multiple linear regression analyses were used to assess the associations between levels of nuclear cataract/cataract extraction and the number of sleep problems. Systemic co-morbidity data were included as potential confounders, including diabetes mellitus, obesity, hypertension, cerebrovascular disease, thyroid disease, tobacco and alcohol use, and the physical component summary score and mental component summary score.

Results—The mean age of the cohort was 57.6 (22 to 95 years). The majority of the cohort demonstrated nuclear cataract levels 2 or 3 (36.8% and 30.1%). Eight percent of the cohort had an intraocular lens (IOL) in at least one eye. There was no statistically significant correlation between sleep problem with the presence of either nuclear cataract or IOL (p>0.05).

Conclusion—In this cross-sectional, population-based study, we found no significant association between nuclear cataract or presence of IOL with poor sleep quality after adjusting potential confounders. Studies of the longitudinal impact of nuclear cataract and cataract removal on sleep are needed to elucidate the role of nuclear cataract and cataract removal on sleep.

Introduction

Normal aging is accompanied by disrupted sleep with increasing sleep fragmentation, nighttime awakenings, and a greater tendency for daytime sleepiness[1]. Disruption of sleep and rest-activity patterns has been increasingly recognized as a health hazard due to its

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Conflict of Interest: No conflicting relationship exists for any author association with a number of poor health outcomes, such as cognitive decline and neurodegenerative disease, cardiovascular disease, diabetes, obesity, and cancer[2–6].

Sleep and rest-activity pattern is one of the key elements of circadian rhythm, a 24-hour pattern of physiology and behavior synchronized with the environmental light-dark cycle[7–9]. External ambient light is by far the most efficient stimulus in modulating circadian rhythm sleep activity[2]. External ambient light is received and transmitted through the eye via intrinsically-photosensitive retinal ganglion cells to the brain sleep center in the hypothalamus and subcortical areas to regulate sleep and other circadian rhythm activities[10, 11]. Adequate light exposure, as well as efficient registration of the external ambient light by the eye, is critical to maintaining a normal circadian rhythm sleep.

Disorganized sleep is observed in blinded people and those with blinding ocular diseases such as glaucoma and age-related macular degeneration[12–15]. Sleep disruption can also occur in individuals who develop age-related ocular change even when visual acuity is preserved. During normal aging, the ability of the eye to transmit external ambient light progressively deteriorates. Age increases crystalline lens light absorption particularly for shorter wavelengths below 500 nm that are most valuable for circadian function[16]. The age-related increase in crystalline lens light absorption and pupil size reduction, taken together, decreases the photoreception in a healthy aging adult by 50% at age 45 and 90% at age 90 compared to a healthy 10-year-old[16, 17].

In a cross-sectional study (n=970) of adults aged 30 to 60 years, the risk of sleep disturbance was significantly higher when the transmission of blue light was decreased by the aging lens [18]. Several studies of sleep quality among patients undergoing cataract extraction surgery found improved sleep quality following cataract removal [19–21]. Further study is underway to investigate the impact of cataract surgery on depression, sleep, body mass regulation and glucose and lipid metabolism [22].

The purpose of this study is to obtain further evidence concerning the relation between sleep disruption and cataract, as well as the impact of cataract removal on sleep, in two large population cohorts.

Materials and methods

The Beaver Dam Eye Study (BDES) is an observational, longitudinal, population-based study of age-related eye disease in Beaver Dam, WI. The baseline examination (1988–1990, n = 4926, ages 43–84) was followed by a five-year (1993–1995, n=3722) and ten- year (1998–2000, n = 2962) follow-up examination, with subsequent examinations at approximately five-year intervals. The Epidemiology of Hearing Loss Study (EHLS) is an observational, longitudinal, population-based study of age-related hearing, olfaction, and cognition in the same cohort as the BDES. The baseline examination took place in 1993–1995 (n = 3753, ages 48–92 years), and the five-year follow-up examination in 1998–2000 (n=2800), with subsequent examinations at approximately five-year intervals.

The Beaver Dam Offspring Study (BOSS) is an observational, longitudinal, population-based study of age-related sensory disorders among the adult children of the EHLS. The baseline examination was conducted from 2005–2008 (n=3296, ages 21–84 years).

The current study combines data from the 1998–2000 examinations of the BDES (cataract assessments) and EHLS (questions regarding sleep problems) with data from the 2005–2008 examination of the BOSS study (which obtained both cataract assessments and sleep data). Details about these cohorts have been described in previous reports [23–25]. The studies were approved by the University of Wisconsin Institutional Review Board. Written informed consent was obtained from participants prior to the examination.

In the BDES, film-based photographs of the lens were taken after pupils were dilated with mydriatic eye drops. Slit-lamp photos were taken to grade the degree of nuclear cataract. The degree of nuclear cataract was classified level 1 to 5 using a standardized protocol[26]. Digital images were obtained in the BOSS and graded following an adaptation of the same cataract grading protocols used in the BDES. Cortical opacities and posterior subcapsular opacities were graded from red reflex images using standardized protocols[26]. The presence of an intraocular lens (IOL) was coded for each eye.

The EHLS and BOSS collected sleep data using a modified version of the Wisconsin Sleep Cohort Study questionnaire. [2728]. In the current study, three sleep questions were used to create a cumulative score to semi-quantify sleep disruption: (1) to what extent have you experienced difficulty getting to sleep, (2) to what extent have you experienced waking up during the night and having a hard time getting back to sleep, and (3) to what extent have you experienced waking up repeatedly during the night? For all three questions, the possible responses were: 0 never, 1 rarely (1/month), 2 sometimes (2–4/month), 3 often (5–15/month), 4 almost always (>16/month).

Participants responding “often” or “almost always” were considered to have sleep problem for the purposes of scoring. The number of sleep problems reported was then summed, ranging from 0 to 3. Both BDES and BOSS obtained other eye outcome data using comparable protocols, including the presence of cataract/cataract surgery, age- related macular degeneration (AMD), diabetic retinopathy and glaucoma. Furthermore, the studies included co-morbidity data as potential confounders, including diabetes mellitus, obesity, hypertension, cerebrovascular disease (CVD), thyroid disease, tobacco and alcohol use, and the physical component summary (PCS) score and mental component summary (MCS) score from the SF-36/SF-12. PCS and MCS are widely used aggregate summary measures concerning individual’s overall physical and mental health[29].

Statistical analysis

Analyses were restricted to participants having sleep data and either nuclear cataract scores in both eyes or an IOL present (n=5070). Primary analyses used the nuclear cataract score in the worse eye; analyses were repeated using the better eye to check for consistency.

Using multiple linear regression analyses, the associations between levels of nuclear cataract and the number of sleep problems was examined, using level 1 nuclear cataract as the

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reference and adjusting for age and sex (Model 1). To assess the effect of potential confounders, this model was then further adjusted for BMI, thyroid disease, PCS, MCS, and smoking. In Model 2, a continuous nuclear cataract score (ranging from 1 to 5) was used. As with Model 1, the age/sex-adjusted models were followed by models adjusted for additional potential confounders. Model 3 tested the association of having level 4 or higher nuclear cataract score in one or both eyes compared to those who had nuclear cataract levels 1–3 in both eyes. Model 4 tested the effect of having an IOL compared to those with intact lenses with any level of nuclear cataract. Adjusted analyses were repeated controlling for the presence of cortical and posterior subcapsular cataract. With all four models, the outcome of interest was the number of sleep problems reported, ranging from 0 to 3.

Results

The characteristics of the participants are summarized in Table 1. Cataract and sleep data were collected in a total of 5070 participants, including 2836 women (55.9%) and 2234 men (44.1%). The participants were aged from 22 to 95 years with a mean age of 57.6 years. The majority of the cohort demonstrated nuclear cataract levels 2 or 3 (36.8% and 30.1%). Eight percent of the cohort had an IOL in at least one eye.

In Model 1, compared to having nuclear cataract level 1, there was no association between the level of nuclear cataract and the number of sleep problems when adjusted for age/sex or in a model with additional covariates (Table 2). In Model 2, the level of nuclear cataract was linearly associated with the number of sleep problems in the age/sex-adjusted model ($p=0.03$) but was no longer statistically significant in the model with additional covariates ($p=0.17$). The presence of nuclear cataract (level 4 or 5) was not associated with sleep problems (Model 3, Table 2). There was no association between nuclear cataract and sleep problems in multivariable models including cortical and posterior subcapsular cataract (data not shown). Results were similar in analyses based on the better eye nuclear cataract grade (data not shown). We repeated these models using each specific question about sleep as the outcome and results were similar except there was a significant association in the multivariable adjusted model between the level of nuclear sclerosis and frequent difficulty getting to sleep ($p=0.02$).

Adjusting for age and sex, participants with an IOL had 0.23 more sleep problems than participants with nuclear cataract levels 1–5. However, after adjusting for other potential confounders, there was no association (Model 4, Table 2).

Discussion

While an increasing body of evidence has implicated the impact of the eye on circadian rhythm regulation, the question arises as to whether the intervention for age-related eye disease can promote circadian rhythm activity such as sleep. Several studies reported that cataract extraction improved sleep quality and the improvement lasted up to 12 months following the cataract surgery[19–21].

In this cross-sectional, population-based study, while controlling for confounders we did not find a statistically significant difference in sleep quality in persons with cataract extraction compared to those without cataract extraction. Whereas we acknowledge that our study could be subject to the limitations associated with cross-sectional design, it is noteworthy that other factors may have also contributed to the apparent discrepancy.

First, Alexander and Asplund's studies included a rather short follow-up period of up to 12 months [19, 20]. It is possible that the effect of cataract extraction on sleep promotion in immediate post-surgical phase is merely a reflection of improved psychosocial wellbeing from being able to see better[30], and this effect weans off as time goes by. Second, Alexander and Asplund's studies included an older population (mean age of 77) recruited from an eye clinic, compared to a younger (mean age of 58), community population in our study. It is also possible that other characteristics inherent in the IOL population may also influence the relation between sleep and IOL. For example, individuals who are professionally active may be more proactive in pursuing cataract removal than those who are not, and the psychosocial stress associated with professional activities may affect sleep. In addition, sicker people who suffer from multiple medical problems may be more likely to pursue invasive procedure such as cataract removal; therefore, sleep in those patients may also be confounded by co-existing medical comorbidity. Longitudinal studies with a longer follow-up period and consideration of those confounding factors should provide further information to help elucidate the effect of cataract surgery on sleep quality. Lastly, although a more detailed sleep questionnaire may provide a more reliable sleep assessment, it will unlikely exert a major impact on the different outcome since both Asplund's and our studies used a relatively simple sleep questionnaire. It is of note that we used summary score to address sleep problem in this study, as our interest was in the global measure of disrupted sleep. The repeat analysis using each specific sleep question as the outcome showed similar results except there was a significant association in the level of nuclear sclerosis and frequent difficulty getting to sleep. Whether such a finding is due to chance association or implies that difficulty getting to sleep could be a more sensitive measure is unclear; a longitudinal study of the impact of cataract on sleep may provide further information to elucidate such a finding.

Studying the role of cataract formation and cataract removal in sleep regulation has several implications. Age-related cataract formation is associated with decreased light transmission through the eye to the brain which poses a negative impact on brain functions such as sleep and cognition.[10, 31–33] It is possible that the declines in both vision and non-image-forming function contributes to the negative impact of cataract on quality of life [31, 32]. As the impact of sleep loss and sleep disorders on public health has been increasingly recognized and studied, a better understanding of how ocular health influences sleep may promote new intervention strategies for sleep disorders. Furthermore, cataract removal has become the most common surgical procedure among individuals older than age 65 years in the United States[33]. However, cataract surgery may be deferred in elderly patients who have cognitive decline. A more precise estimate of the relative benefit of cataract surgery may have an impact on clinical decision-making regarding cataract removal in such a population.

We acknowledge several limitations in the present study: (1) The outcome of a cross-sectional study may be influenced by uncontrolled confounding factors and it does not permit examination of temporal relation of changes in sleep after cataract surgery, (2) the sleep questions used in this study are not specific for circadian rhythm sleep disruption, thus may have included sleep problems contributed by other conditions such as nocturnal micturition, chronic pain, sleep-related breathing or movement disorders, the grading of the cataract used in this study is based on film-based photos rather than a direct measure of light transmission through the eye[18], although one would argue that the grading system used in the present study is in line with the other studies and perhaps represents a more practical way to assess cataract when the impact of cataract surgery on sleep is concerned, and (4) there is a possibility of underestimating sleep problems due to participants' self-selection. For example, in the EHLS cohort follow-up study in 1998–200, nonparticipants had lower socioeconomic status and those who died before being reexamined had more cardiovascular diseases[23]. Those nonparticipants may therefore have more sleep problem[23, 34]. Thus participants in the cohorts selected in this study may have better sleep quality than the general population [34].

Conclusion

In this cross-sectional, community-based population study, we found no significant association between advanced nuclear cataract or presence of IOLs with poor sleep quality after adjusting for age, sex, BMI, thyroid disease, quality of life, and smoking. Studies of the longitudinal impact of nuclear cataract and cataract removal on sleep are needed to elucidate the role of nuclear cataract and cataract removal on sleep.

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Table 1

Characteristics of participants including the 1998–2000 examinations of the BDES and EHLS as well as the 2005–2008 examination of the BOSS study

Characteristic	N	%
Sex		
Female	2836	55.9
Male	2234	44.1
CVD	458	9.1
Diabetes	453	9
History of heavy drinking	1079	21.3
Hypertension	2335	46.2
Smoking status		
Never	2568	50.7
Past	1778	35.1
Current	721	14.2
Thyroid disease	579	11.4
Characteristic	**N**	**Mean (SD)**
Age (years)	5070	57.6 (13.6)
BMI	5003	30.0 (6.3)
Mental component score	5031	54.2 (7.7)
Physical component score	5031	48.2 (9.5)
Nuclear cataract in the worse eye (level)	**N**	**%**
1	874	17.2
2	1863	36.8
3	1526	30.1
4	388	7.7
5	16	0.3
IOL in both eyes	403	8

[1]Adjusted for age and sex.

[2]Adjusted for age.

Table 2

Parameter estimates from linear regression models. Parameter estimates is an estimate of the amount of the sleep problem per each level of nuclear cataract

Models	Age/sex adjusted		Further adjusted[a]	
	Parameter est.	P-value	Parameter est.	P-value
Model 1				
Level 1	REF	--	REF	--
Level 2	0.01	0.76	0.00	0.91
Level 3	0.09	0.10	0.07	0.21
Level 4	0.13	0.09	0.05	0.49
Level 5	0.35	0.15	0.34	0.18
Model 2				
Nuclear cataract level (1–5)	0.05	0.03	0.03	0.17
Model 3				
No eyes level 4+	REF	--	REF	--
One eye level 4+	0.04	0.57	0.00	0.99
Two eyes level 4+	0.08	0.28	0.01	0.85
Model 4				
No IOL	REF	--	REF	--
Any IOL	0.23	<0.001	0.06	0.23

[a]Models were adjusted for age, sex, BMI, thyroid disease, PCS/MCS, and smoking.