ORIGINAL RESEARCH

Association of Glaucoma with Poor Quality of Sleep in an Ethiopian Glaucoma Population – A Comparative Cross-Sectional Study

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Background: Glaucoma is a group of ocular disorders characterized by progressive optic nerve damage resulting in irreversible visual field defects. Poor quality of sleep in glaucoma patients could be explained by the reduction of the light input to the circadian system as a result of damage to photosensitive retinal ganglion cells in the retina. Information is limited on the association of poor quality of sleep with glaucoma in general and the Ethiopian glaucoma population in particular.

Objective: The study aimed to explore the association between poor quality of sleep and glaucoma at a Tertiary Eye Care Center in Ethiopia.

Methods: An institutional-based comparative cross-sectional study was conducted among 200 glaucoma and 201 non-glaucoma participants recruited by systematic random sampling. Each group was administered with a Pittsburgh Sleep Quality Index (PSQI) questionnaire. Stata-14 was employed for data analysis; an independent t-test was used to show the statistical difference in the global mean PSQI score for the two groups. A binary logistic regression model was applied to identify factors associated with poor quality of sleep. Statistical significance was declared at a 95% confidence interval and a p-value of <0.05.

Results: The prevalence of poor quality of sleep was 82.5% among the glaucoma population, which statistically differed ($p<0.001$) from the non-glaucomatous population (55.7%). Poor quality of sleep in glaucoma was associated with older age (adjusted odds ratio (AOR)=4.4, 95% confidence interval (CI): 1.5–5.4), depression (AOR=2.9, 95% CI: 1.1–7.3), visual impairment (AOR=3.9, 95% CI: 1.3–12.3) and severe glaucoma (AOR=2.5, 95% CI: 1.1–5.9).

Conclusion and Recommendation: Poor quality of sleep was significantly higher in the glaucoma population compared to their non-glaucoma control. It was associated with older age, depression, visual impairment and advanced glaucoma. Incorporating psychiatric counseling into the existing glaucoma follow-up was recommended.

Keywords: quality of sleep, comparative, glaucoma, Gondar, Northwest, Ethiopia

Introduction

Glaucoma is a group of ocular disorders characterized by progressive optic nerve damage (optic neuropathy) with resultant irreversible visual field defects.[1–3] According to the World Health Organization, glaucoma is the second leading cause of avoidable blindness, contributing 8% of total blindness worldwide.[4] In Ethiopia, It is the fifth leading cause of blindness; contributing to 5.2% of the total blindness.[5] The prevalence of glaucoma in the study area was 9.79%.[6]

Sleep is an important physiological function of the human body regulated by homeostasis and circadian rhythms.[7–9] Abnormal sleep is characterized by exhaustion, difficulty falling asleep or staying asleep at night, excessive daytime sleepiness, loud snoring or gasping noises while sleeping, unintentional episodes of falling asleep, loss of muscle control and unusual behaviors like sleep walking.[10] Glaucoma has been assumed to be implicated with disturbed sleep quality in several ways: its natural course of the disease and medications to negate its progression are connected with the disruption of circadian rhythm.[11–18]

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Poor quality of sleep is a global phenomenon occurring in the glaucoma population. Based on several epidemiological studies conducted across the world, the prevalence of poor quality of sleep among the glaucoma population varies from 58 to 84.85%.[18–21] Poor quality of sleep leads to changes in body functions, mental illness and other health-related problems.[22] Poor quality of sleep reduces work productivity and performances at a huge cost.[23] It increases the progression of the disease and affects the overall management of the glaucoma population.[24]

The occurrence of poor quality of sleep with glaucoma could be augmented by older age groups, high intraocular pressure (IOP), advanced stage of glaucoma, type of glaucoma, visual field defects, presence of depression, low family income, high body mass index and low level of educational status.[18–20,25,26] The possible mechanism to reduce the occurrence of poor quality of sleep in glaucoma includes provision of appropriate psychiatric care and counseling as well maintenance of relevant medication to treat the disorder.[27]

A scientific hypothesis documented in the literature states that glaucomatous damage of the retinal ganglion cells is associated with poor quality of sleep. Studies on the association of glaucoma with poor quality of sleep were generally limited and the majority of them were conducted in developed countries.

Despite the high prevalence of glaucoma in Ethiopia particularly, in the study area no study has been conducted on the association of glaucoma with poor quality of sleep. Therefore, our study aimed to explore the association of poor quality of sleep with glaucoma at University of Gondar Tertiary Eye Care and Training Center.

Methods

The study population had two groups: "glaucomatous" group consists of participants who had a confirmed glaucoma and "non-glaucomatous" as a comparative group consists of participants without glaucoma attending at University of Gondar Comprehensive Specialized Hospital Tertiary Eye Care and Training Center. The hospital is situated in Gondar City which is located 667 km from the capital, Addis Ababa. The Tertiary Eye Care Center has the capacity of providing eye health care services for more than five million people in the city and surrounding areas.[6] Glaucoma clinic is a major subspecialty clinic in the eye care center at University of Gondar that provides clinical care for about 50 glaucoma follow-up patients per day. Clinical nurses, optometrists and ophthalmologists have been involved in clinical care of the glaucoma and non-glaucoma population in the eye care center. Patients with sleep disturbance and other psychiatric disorders received care at psychiatric clinic in the hospital. The study was conducted from June 6 up to July 8, 2022.

Inclusion Criteria

All of the glaucoma population of age greater than 40 years attending at University of Gondar Specialized Hospital tertiary Eye Care and Training Center were recruited under the glaucoma group. All oculo-visually healthy population of age greater than 40 years attending at University of Gondar, Tertiary Eye Care Center was included under the healthy group as a counterpart.

Exclusion Criteria

Participants with coexisting central nervous system diseases like brain tumor, circulatory system disease like coronary heart diseases, digestive system diseases like gastroesophageal reflex and potential ocular disorders including significant (mature) cataract, optic neuritis, retinal pathology like optic disc edema, diabetic retinopathy and retinal surgery or history of laser therapy were excluded from this study. The population with hypertension and diabetic mellitus diseases and who work in night shift duty were also excluded.

The proceeding in sample size calculation was based on a double population proportion formula on Epi Info version 7 software. Unmatched cohort cross-sectional case control with an assumption of 80% of power, 95% of confidence level, exposed (population with glaucoma) to an unexposed (population without non-glaucomatous) ratio of 1:1 and odds ratio of 2.40 was 1.50 respectively obtained from the pilot study conducted in Bahir Dar Felege Hiwot Referral Hospital.

The computer-generated sample size was 186 for each group. The generated sample size was further computed considering a non-response rate of 10% (186+18.6=204.6). Ultimately, the sample size of the study was 205 in each (glaucomatous and non-glaucomatous counterpart). The study participants were selected using a systematic random sampling technique in glaucoma clinic and outpatient department (OPD). The glaucoma clinic provides service to

patients on three days per week; the glaucoma population attending the clinic was 150 per week (50 on each day). The sampling fraction K was calculated using the total number of glaucoma patients from June 6 to July 8 which was 850 to the final adjusted sample size (K=N/n, 850/205=4.1). The first patient was approached through applying a lottery method and then other consecutive participants were recruited in every 4th case interval on each follow-up day. The Tertiary Eye Care Center provides clinical care approximately for 100 patients per day except follow-up cases, the sampling fraction was calculated, Kth=1000/205=4.8. The non-glaucoma population was then included by every healthy 4th control.

The study was conducted respecting the guideline of the Ethical Principle of the Declaration of Helsinki. The study protocol was assessed and approved by the Ethical Review Board of the University of Gondar, School of Medicine. Verbal informed consent was received from all the population in both groups. The verbal informed consent has been accepted and approved by the Ethical Review Board of The University of Gondar.

Population Data and Sleep Quality Assessment

Data were collected through interviewer-administered questionnaires, and tracing patients' medical folder. Data collection was carried out by three clinical optometrists. The questionnaire was translated to the local language (Amharic) and had four parts: Part I: contains questions on socio-demographic characteristics, Part II: contains questions on anxiety and depression, Part III: contains the PSQ and Part IV: contains a checklist to trace the clinical profile of glaucoma patients. The PSQI is a validated self-rated questionnaire that assesses sleep quality and disturbances during the preceding one month. Nineteen individual items generate seven "component" scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of scores for the seven components yields one global score that was used to compare groups. For the purpose of this study, quality of sleep would be considered as poor if the PSQI score was greater than five.[28–30] The PSQI tool was adequate and validated to test sleep quality on the Ethiopian population.[31]

Assessment and Definition of Risk Factors

The classification of visual impairment was made based on presenting visual acuity as mild vision impairment when the visual acuity was <6/12 but 6/18 or better, moderate and severe vision impairment<6/18 but 3/60 or better, and blindness <3/60.[32] A patient with more than 10 points on the Hospital Depression Scale (HDS) had depression problems.[33]

Data Processing and Analysis

Data were entered via Epi-data version 3.1 and checked for completeness. The collected data were exported to Stata-14 for analysis. Summary statistics, frequencies and cross-tabulations were performed for the descriptive data. Chi-square was done to show the statistical significance of poor quality of sleep in glaucomatous participants over non-glaucomatous group. An independent t-test was used to show the statistical difference of PSQ index score for two groups after checking the assumption.

A binary logistic regression model was employed to identify factors associated with poor quality of sleep among participants. The strength of association had been expressed by using an adjusted odds ratio at 95% confidence interval. P-value <0.05 was considered as statistically significant. A p-value <0.05 was set to ensure a variable is statistically significant.[34,35] The model fitness was ensured with Hosmer and Lemeshow's goodness of fit test.

Results

Socio-Demographic Characteristics, Clinical Profiles and Follow-Up Practices of Patients with Diabetes

Among the total of 410 sample size, 401 composed of 200 glaucomatous and 201 non-glaucomatous were enrolled which represents a response rate of 97.80%. Among the total participants, nearly half (52.7%) in non-glaucomatous and 60.0% in glaucoma were males. The majority of the study participants in the non-glaucomatous group (75%) and in the glaucoma group (77%) were married. Almost half of the non-glaucomatous group (49.3%) and the majority of the

glaucoma group (73%) had no formal education. The median age of the study participants was 53 years for non-glaucomatous and 56 years in the glaucomatous group (Table 1).

Clinical Characteristics of the Study Participants

In the glaucoma groups, over half of the participants (54.5%) were under the blindness category, followed by mild VI (24.5%); whereas, in the non-glaucomatous groups, 58.71% had vision of 6/18 or better, and the remaining participants had vision of better than 6/60. The majority of the participants in both groups had normal body mass index. Nearly one-quarter (23%) of glaucoma participants were closed angle glaucoma. The median duration of glaucoma treatment was 24 months. Two-thirds of the glaucoma population has taken a single medication (timolol) (Table 2).

Prevalence of Poor Quality of Sleep and PSQI Score

The quality of sleep was poor among 82.5% (95% CI: 77.2–87.7) and 55.7% (95% CI: 48.8–62.6) of the glaucoma and non-glaucoma population respectively. The figure on poor quality of sleep in the glaucoma population was significantly higher than what has been found for non-glaucoma population (χ^2=33.65, p<0.0001). Similarly, the mean global PSQI score showed a significant difference between population in the glaucoma (M=8.96, 95% CI: 8.45–9.46) and non-glaucoma group (M=6.42, 95% CI: 5.98–6.68) on independent t-test (T=7.49, p<0.0001) (Table 3).

Factors Associated with Poor Quality of Sleep Among Study Participants

Following a bi-variable logistic regression analysis, a multivariable binary logistic regression model was run for age, educational status, depressive status, visual impairment and IOP level for each comparable group independently. In the glaucomatous group the stage of glaucoma and frequency of medication taken per day were included. Age, depression, visual impairment and stage of glaucoma were significantly associated with poor quality of sleep among the glaucoma population but only age was significantly associated with poor quality of sleep in the non-glaucomatous population (Tables 4 and 5).

Participants with age above 60 years were 4.4 times more likely to have poor quality of sleep than the age 40–60 years among the glaucoma group (AOR=4.4, 95% CI: 1.50–13.24). Likewise, participants with age above 60 years were 2.5 times more likely to have poor quality of sleep as compared to age between 40–60 years in the non-glaucoma group (AOR=2.5, 95% CI: 1.20–5.42). In the glaucomatous group, participants with depression were 2.9 times more likely to have poor quality of sleep compared to those without depression (AOR=2.9, 95% CI: 1.14–7.33).

Table 1 Social-Demographic Characteristics of the Non Glaucoma and Glaucoma Populations Attending at University of Gondar Tertiary Eye Care and Training Center, Northwest Ethiopia, 2022 (n=401)

Variables	Non-Glaucoma (n=201)	Glaucoma (n=200)	Total	p-value
Age				
40–60 years	142 (70.6)	126 (63.0)	268 (66.8)	0.104
Above 60 years	59 (29.4)	74 (37.0)	133 (33.2)	
Sex				
Male	106 (52.7)	120 (60)	226 (56.4)	0.143
Female	95 (47.3)	80 (40)	175 (43.6)	
Address				
Urban	125 (62.2)	72 (36.0)	197 (48.1)	0.000
Rural	76 (37.8)	128 (64.0)	204 (50.9)	
Marital status				
Currently married	150 (74.6)	154(77.0)	304 (75.8)	0.579
Not married	51 (25.4)	46 (23.0)	97 (24.2)	
Educational status				
No formal education	99 (49.3)	146 (73.0)	245 (61.1)	0.000
Formal education	102 (50.8)	54 (27.0)	80 (20.0)	

Abbreviation: n, sample size.

Table 2 Clinical Characteristics of Glaucoma and Non Glaucoma Populations Attending at University of Gondar Tertiary Eye Care and Training Center, Northwest Ethiopia, 2022 (n= 401)

Variables	Non-Glaucoma (n=201)	Glaucoma (n=200)	Total	p-value
Depression status				
No	99 (79.84)	160 (57.76)	259 (64.59)	0.001
Yes	25 (30.92)	117 (42.24)	142 (35.41)	
Body mass index				
Normal	153 (76.12)	138 (69.0)	291 (72.6)	0.111
Abnormal	48 (23.88)	62 (31.0)	110 (27.4)	
Level of VI				
No/mild VI	118 (58.71)	31 (15.5)	149 (37.16)	0.000
Moderate VI	83 (41.29)	49 (24.5)	132(32.92)	
Severe VI	–	11 (5.5)	11 (72.82)	
Blind	–	109 (54.5)	109 (27.18)	
Visual impairment				
Yes	108 (53.7)	177 (88.5)	285 (71.1)	0.000
No	93 (46.3)	23 (11.5)	116 (28.9)	
IOP				
Normal	193 (96.0)	67 (33.5)	260 (64.8)	0.000
Abnormal	8 (4.0)	133 (66.5)	141 (35.2)	
Type of glaucoma				
OAG	–	154 (77.0)	154 (77.0)	
ACG	–	46 (23.0)	46 (23.0)	
Stage of glaucoma				
Early	–	29 (14.5)	29 (14.5)	
Moderate	–	60 (20.0)	60 (20.0)	
Advanced	–	69 (34.5)	69 (34.5)	
Terminal	–	14 (7.0)	14 (7.0)	
Absolute	–	28 (14.0)	28 (14.0)	
Frequency of taking medication per day				
≤2	–	136 (68.0)	136 (68.0)	
≥3	–	64 (32.0)	64 (32.0)	

Abbreviations: ACG, angle closure glaucoma; IOP, intraocular pressure; n, sample size; OAG, open angle glaucoma; VI, visual impairment.

Participants with impaired vision had a 3.9 times higher chance to encounter poor quality of sleep than participants with normal visual acuity in the glaucoma population (AOR=3.9, 95% CI: 1.25–12.25). Participants with advanced glaucoma were 2.5 times more likely to have poor quality of sleep than those with moderate glaucoma (AOR=2.6, 95% CI: 1.08–5.95). Participants with glaucoma were 2.6 times more likely to have poor quality of sleep than those without glaucoma (AOR=2.6, 95% CI: 1.54–4.367) (Table 6).

Discussion

The magnitude of poor quality of sleep was 82.5% and 55.7% among the glaucoma and non-glaucoma population respectively: these figures showed a statistically significant difference. In another dimension, mean PSQI score of the population with glaucoma (8.96) was also significantly higher than that of non-glaucoma counterparts (6.42). Even though poor quality of sleep is a global phenomenon, which affects all age groups throughout the world, such a degree of poor quality of sleep in glaucoma patients is remarkably higher as compared to the figure of poor quality of sleep among the non-glaucoma population.

Interestingly, the magnitude of poor quality of sleep in glaucoma was higher compared to the previous studies in Southwest Nigeria (61.3%),[21] Beijing, China, 66.36%,[18] Tokyo, Japan 34.5%[36] and Germany, 75.5%.[20] The variation may be due to the difference in demographic characteristics and source of population recruited in the studies. For instance, the age of participants in Southwest Nigeria and Beijing China was 26–84 and below 18–80 years respectively.

Table 3 Independent *t*-test for Global PSQI Score in Non-Glaucoma and Glaucoma Populations Attending at University of Gondar Tertiary Eye Care and Training Center, Northwest Ethiopia, 2022 (n=401)

Parameter		Mean (M)	SD	T$_{399}$	*p*-value
Subjective sleep quality	Non-glaucoma	0.70	0.72	−5.577	0.001*
	Glaucoma	1.12	0.78		
Sleep latency (min)	Non-glaucoma	28.29	22.17	−1.284	0.200
	Glaucoma	31.07	21.21		
Sleep duration	Non-glaucoma	6.27	1.46	1.586	0.113
	Glaucoma	6.03	1.55		
Habitual sleep efficiency	Non-glaucoma	75.21	14.64	5.421	0.001*
	Glaucoma	66.98	15.74		
Daytime dysfunction	Non-glaucoma	1.27	1.60	−6.148	0.001*
	Glaucoma	2.43	2.13		
Sleep medication	Non-glaucoma	0.11	0.43	1.228	0.220
	Glaucoma	0.06	0.37		
Score of sleep disturbance	Non-glaucoma	7.27	4.03	−4.902	0.000*
	Glaucoma	9.44	4.79		
Global PSQI score	Non-glaucoma	6.42	3.161	−7.49	0.001*
	Glaucoma	8.96	3.604		

Abbreviations: SD, standard deviation; min, minute; n, sample size; PSQI, Pittsburgh Sleeping Quality Index; T$_{399}$, *t*-statistic with 399 degrees of freedom and *p*-value less than 0.01.

Table 4 Multivariable Binary Logistic Regression of Factors Associated with Poor Quality of Sleep in Glaucoma Populations Attending at University of Gondar Tertiary Eye Care and Training Center, Northwest Ethiopia, 2022 (n=200)

Variables	Quality of Sleep		COR (95% CI)	AOR (95% CI)	P
	Good	Poor			
Age					
40–60 years	30	96	1.0	1.0	0.007
Above 60 years	5	69	4.3 (1.59–11.68)	4.4 (1.50–13.24)	
Educational status					
Formal education	17	37	1.0	1.0	0.449
No formal education	18	128	3.3 (1.53–6.97)	1.4 (0.58–3.46)	
Depression					
No	27	83	1.0	1.0	0.025
Yes	8	82	3.3 (1.43–7.777)	2.9 (1.14–7.33)	
Visual impairment					
No	10	13	1.0	1.0	0.019
Yes	25	152	4.7 (1.85–11.81)	3.9 (1.25–12.25)	
IOP level					
Normal	8	59	1.0	1.0	0.393
Abnormal	27	106	0.5 (0.23–1.25)	0.6 (0.20–1.88)	
Stage of glaucoma					
Early and Moderate	23	66	1.0	1.0	0.033
Advanced and above	12	99	2.9 (1.339–6.174)	2.5 (1.08–5.95)	
Frequency of taking medication					
≤2	29	107	1.0	1.0	0.095
>2	6	58	2.6 (1.028–6.676)	2.4 (0.86–6.86)	

Abbreviations: AOR, adjusted odds ratio; COR, crude odds ratio; CI, confidence interval; IOP, intraocular pressure; n, sample size.

Table 5 Multivariable Binary Logistic Regression of Factors Associated with Poor Quality of Sleep in Non-Glaucoma Populations Attending at University of Gondar Tertiary Eye Care and Training Center, Northwest Ethiopia, 2022 (n=201)

Variables	Quality of Sleep		COR (95% CI)	AOR (95% CI)	P
	Good	**Poor**			
Age					
40–60 years	73	69	1.0	1.0	0.015
Above 60 years	16	43	2.8 (1.47–5.51)	2.5 (1.20–5.42)	
Educational status					
Formal education	51	51	1.0	1.0	0.227
No formal education	38	61	1.6 (0.92–2.81)	1.4 (0.80–2.60)	
Depression					
No	72	77	1.0	1.0	0.149
Yes	17	35	1.9 (0.99–3.73)	1.7 (0.83–3.34)	
Visual impairment					
No	48	45	1.0	1.0	0.807
Yes	41	67	1.7 (0.99–3.060)	1.1 (0.57–2.08)	
IOP level					
Normal	85	108	1.0	1.0	0.271
Abnormal	4	4	0.8 (0.19–3.24)	0.4 (0.09–1.93)	

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio; IOP, intraocular pressure.

Table 6 Multivariable Binary Logistic Regression of Factors Associated with Poor Quality of Sleep in Glaucoma and Non-Glaucoma Population Attending at University of Gondar Tertiary Eye Care and Training Center, Northwest Ethiopia, 2022 (n=401)

Variables	Quality of Sleep		COR (95% CI)	AOR (95% CI)	p-value
	Good	**Poor**			
Presence of glaucoma					
No	89	112	1.0	1.0	0.001*
Yes	35	165	3.7 (2.37–5.93)	2.6 (1.54–4.367)	
Age					
40–60 years	103	165	1.0		0.002*
Above 60 years	21	112	3.3 (1.96–5.64)	2.5 (1.41–4.43)	
Educational status					
Formal education	68	88	1.0		0.047
No formal education	56	189	0.4 (0.25–0.59)	1.6 (1.01–2.63)	
Depression					
No	99	160	1.0		0.008
Yes	25	117	2.9 (1.76–4.77)	2.1 (1.20–3.51)	
Visual impairment					
No	58	58	1.0		0.151
Yes	66	219	3.3 (2.10–5.24)	1.5 (0.86–2.56)	

Abbreviations: COR, crude odds ratio; AOR, adjusted odds ratio; CI, confidence interval and *p-value less than 0.01.

Including a young glaucoma population in the study would underestimate the magnitude of poor quality of sleep. Moreover, the studies in Tokyo, Japan and Germany were selectively on a glaucoma population with visual impairment and visual field defect respectively. The limited number of the glaucoma population in these studies results in low figures of poor quality of sleep.

According to the current study, the glaucoma population had significantly higher poor quality of sleep as compared with non-glaucoma participants. The same result was reported in Glostrup, Denmark,[37] Germany,[20] Southwest Nigeria,[21] Japan,[19] South-East Asian[26] and China.[18] Overall; this study determined that participants with glaucoma were 2.6 times more likely to have poor quality of sleep than participants without glaucoma. The possible reasons for significant poor quality of sleep among glaucoma participants may be biological or psychological changes.

There is a growing body of supportive evidence that glaucoma can lead to anxieties about going blind, altered sense of well-being, and concerns about future health or disrupted circadian physiology associated with retinal ganglion cells dysfunction.[38]

However, other previous studies in Denmark[37] and Shinseikai, Japan[39] revealed no statistically significant difference in the quality of sleep between the glaucomatous and non-glaucomatous population. The possible reason for these variations could be the difference in clinical characteristics of the source population and proportion difference between the glaucoma and non-glaucoma groups.

The glaucoma population recruited in Japan study was prostaglandin medication users, against high population of timolol users in the present study. Timolol can increase total wake time, increase the incidence of nightmares and sleep disturbance.[40] Additionally, the population in glaucoma groups was smaller than their non-glaucoma counterpart and these result in a comparable quality of sleep between the two groups as many poor sleepers might be included in the non-glaucoma counterpart.

The glaucoma population in the Denmark study was mainly normal tension glaucoma, as opposed to high tension glaucoma in the present study. High tension glaucoma can cause ischemic–reperfusion damage to the whole retina including photoreceptors and ganglion cells[41,42] leading to reduction of melatonin secretion and causes poor sleep quality.[43]

These findings implied that glaucoma patients do not only experience impaired visual functions but also poor sleeping condition. Thus, sleep among glaucoma patients may be a clinically important issue to consider in the overall care and management of glaucoma population.

The current study has also indicated that the magnitude of poor quality of sleep among participants with advanced and moderate glaucoma was 89.19% and 74.16%, respectively, higher compared to a study conducted in Japan.[19] This difference could be explained by the variation in population enrollment and classification on the stage of glaucoma. The population included in the previous study was selected via a screening scheme that could potentially recruit many earlier glaucoma populations who would probably have a comparable sleep quality with the non-glaucoma population.

This study also identified that, older age, depression, visual impairment and advanced glaucoma were significantly associated with poor quality of sleep among glaucoma population. However, the older age was the only significant factor in poor quality of sleep among non-glaucomatous counterparts.

The population with advanced glaucoma was 2.5 times more likely to have poor quality of sleep than the population with moderate glaucoma. This might be due to the fact that, in advanced glaucoma, there is a significant damage to the photoreceptor cells, reducing the light input to the retinal ganglion cells connected to the hypothalamus which controls circadian rhythms and melatonin secretion that regulates the quality of sleep.[16,26] On the contrary, in another study in South-East Asia,[26] the severity of glaucoma had no significant effect on quality of sleep.

The former study utilized a visual field parameter called mean deviation (MD) to assign the severity of glaucoma. Due to the sensitivity nature of the parameter, many early glaucoma patients could probably fall into the severe groups without having obvious structural defect. This might lead to a comparable sleep quality with the healthy control.[44]

In this study, participants over the age of 60 years had a 4.4-fold increased risk of having poor quality of sleep compared to those between the ages of 40 and 60 years with glaucoma. This result was supported by the study at Beijing, China.[18] The association could be explained by that fact that age-related degenerative changes to the suprachiasmatic nucleus in the hypothalamus altered the melatonin level and here by disrupting the sleep quality.[45] However; a study in South-East Asia revealed that age did not significantly affect quality of sleep among the glaucoma population.[26]

The population with glaucoma who had vision impairment were 3.9 times more likely to have poor sleep than those with normal vision. This relationship might be explained by the scientific evidence that visual impairment reduces daytime light exposure and physical activity, which can diminish melatonin secretion at night.[46,47]

However; there was no statistically significant difference in poor quality of sleep between visual impairment and normal vision in Southwest Nigeria,[21] in Japan[19] and in Southeast Asia.[26] In contrast to earlier studies, the majority of the glaucoma patients in this study (85.5%) had visual impairment.

In this study, the glaucoma population with depression had 2.9-fold increased risk of having poor quality of sleep compared to participants without depression. This result was in line with the study in South-East Asia[26] and Southwest Nigeria.[21] The possible reason for the association is that the degenerative nature of disease and lifelong long medication causes depression[19,38] and this results in poor quality of sleep.[48]

Understanding the psychological concerns and quality of sleep connected with glaucoma may help with the identification, prevention and management of emotional disorders related to poor quality of sleep.

As a limitation, the study did not investigate the biological mechanism of poor quality of sleep and recall bias could have affected the ascertainment of data on some of the variables such as family monthly income. Moreover, visual field measurement was not considered in the definition of visual impairment and label severe glaucoma, hence the study was unable to correlate this parameter with disturbed sleep quality.

Conclusion

The quality of sleep was poor among 85.5% of glaucoma population and significantly higher compared to their non-glaucoma counterparts. It was associated with older age, depression, visual impairment and advanced stage of glaucoma.

Acknowledgments

Disclosure

The authors report no conflicts of interest.

References

1. World Health Organization (WHO). *Visual Impairment and Blindness 2012. Fact Sheet No 282*. World Health Organization (WHO); 2012.
2. Abraham O. School vision screening programs for Reducing children with uncorrected refractive error in low and middle-income countries. Systematic review. Faculty of Health Science, Department of Public Health and Family Medicine; 2019. Available from: http://hdl.handle.net/11427/31171. Accessed November 2, 2022.
3. Durowade KA, Salaudeen AG, Akande TM, et al.Prevalence and risk factors of glaucoma among adults in rural and urban communities of Ilorin west local government area north-Central Nigeria. *Int J Clin Med Res*. 2016;3(1):6–12.
4. Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. *Br J Ophthalmol*. 2012;96(5):614–618. doi:10.1136/bjophthalmol-2011-300539
5. Mulusew A, Yilikal A. Prevalence of congenital color vision defects among school children in five schools of Abeshge District, Central Ethiopia. *J Ophthalmol East Central South Africa*. 2013;17(1):115.
6. Tegegn MT, Belete GT, Ferede AT, Assaye AK. Proportion and associated factors of low vision among adult patients attending at University of Gondar Tertiary eye Care and Training Center, Gondar Town, Ethiopia. *J Ophthalmol*. 2020;2020. doi:10.1155/2020/7042905
7. Manzar ZW, Hussain ME, Hussain ME. Sleep and physiolog ical systems: a functional perspective. *Biol Rhythm Res*. 2015;46:195–206. doi:10.1080/09291016.2014.966504
8. Banks DD, Dinges DF. Behavioral and physiological consequences of sleep restriction. *J Clin Sleep Med*. 2007;15:519–528. doi:10.5664/jcsm.26918
9. Phillips B, Gelula R. *Sleep-Wake Cycle: Its Physiology and Impact on Health*. National Sleep Foundation; 2006:1–9.
10. Espana RA, Scammell TE. Sleep neurobiology from a clinical perspective. *Sleep*. 2011;34(7):845–858. doi:10.5665/SLEEP.1112
11. Gooley JJ, Lu J, Fischer D, Saper CB. A broad role for melanopsin in nonvisual photoreception. *J Neurosci*. 2003;23(18):7093–7106. doi:10.1523/JNEUROSCI.23-18-07093.2003
12. Schmoll LG, Dhillon B, Skene D, Riha RL, Riha RL. The role of retinal regulation of sleep in health and disease. *Sleep Med Rev*. 2011;15(2):107–113. doi:10.1016/j.smrv.2010.06.001
13. Gubin D, Malishevskaya T, Astakhov Y, et al. Progressive retinal ganglion cell loss in primary open-angle glaucoma is associated with temperature circadian rhythm phase delay and compromised sleep. *Chronobiol Int*. 2019;36(4):564–577. doi:10.1080/07420528.2019.1566741
14. Gooley JJ, Lu J, Chou TC, Scammell TE, Saper CB. Melanopsin in cells of origin of the retinohypothalamic tract. *Nat Neurosci*. 2001;4(12):1165. doi:10.1038/nn768
15. Berson DM, Dunn FA, Takao M. Phototransduction by retinal ganglion cells that set the circadian clock. *Science*. 2002;295(5557):1070–1073. doi:10.1126/science.1067262
16. Gracitelli CP, Duque-Chica GL, Roizenblatt M, et al. Intrinsically photosensitive retinal ganglion cell activity is associated with decreased sleep quality in patients with glaucoma. *Ophthalmology*. 2015;122(6):1139–1148. doi:10.1016/j.ophtha.2015.02.030
17. Waller EA, Bendel RE, Kaplan J. Sleep disorders and the eye. *Mayo Clin Proc*. 2008;83(11):1251–1261. doi:10.4065/83.11.1251
18. Wang H, Zhang Y, Ding J, Wang N. Changes in the circadian rhythm in patients with primary glaucoma. *PLoS One*. 2013;8(4):62841. doi:10.1371/journal.pone.0062841
19. Ayaki M, Shiba D, Negishi K, Tsubota K. Depressed visual field and mood are associated with sleep disorder in glaucoma patients. *Sci Rep*. 2016;6(1):1–7. doi:10.1038/srep25699

20. Agorastos A, Skevas C, Matthaei M, et al. Depression, anxiety, and disturbed sleep in glaucoma. *J Neuropsychiatry Clin Neurosci*. 2013;25 (3):205–213. doi:10.1176/appi.neuropsych.12020030

21. Ogunsemi O, Bodunde O, Afe T, et al. Quality of sleep and psychological distress in glaucoma. *Ann Health Res*. 2016;2(1):24–30.

22. Harvey AG, Whitaker KL, Moskovitz D, Virk H, Virk H. The subjective meaning of sleep quality: a comparison of individuals with and without insomnia. *Sleep*. 2008;31:383–393. doi:10.1093/sleep/31.3.383

23. Rosekind MR, Gregory KB, Mallis MM, Brandt SL, Seal B, Lerner D. The cost of poor sleep: workplace productivity loss and associated costs. *J Occup Environ Med*. 2010;52:91–98. doi:10.1097/JOM.0b013e3181c78c30

24. Lee SS, Nilagiri VK, Mackey DA. Sleep and eye disease: a review. *Clin Experiment Ophthalmol*. 2022;50(3):334–344. doi:10.1111/ceo.14071

25. Lee J-A, Han K, Min JA, Choi JA. Associations of sleep duration with open angle glaucoma in the Korea national health and nutrition examination survey. *Medicine*. 2016;95(52):e5704. doi:10.1097/MD.0000000000005704

26. Chin JY, Toh ZH, Lo YT, et al. Effects of primary glaucoma on sleep quality and daytime sleepiness of patients residing at an equatorial latitude. *Int J Ophthalmol*. 2020;13(9):1451–1458. doi:10.18240/ijo.2020.09.18

27. Agorastos A, Huber CG. The role of melatonin in glaucoma: implications concerning pathophysiological relevance and therapeutic potential. *J Pineal Res*. 2011;50(1):1–7. doi:10.1111/j.1600-079X.2010.00816.x

28. Folkard S, Arendt J, Aldhous M, Kennett H. Melatonin stabilises sleep onset time in a blind man without entrainment of cortisol or temperature rhythms. *Neurosci Lett*. 1990;113(2):193–198. doi:10.1016/0304-3940(90)90302-P

29. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213. doi:10.1016/0165-1781(89)90047-4

30. Buysse DJ, Reynolds CF, Monk TH, Hoch CC, Yeager AL, Kupfer DJ. Quantification of subjective sleep quality in healthy elderly men and women using the Pittsburgh Sleep Quality Index (PSQI). *Sleep*. 1991;14(4):331–338.

31. Salahuddin M, Maru TT, Kumalo A, Pandi-Perumal SR, Bahammam AS, Manzar MD. Validation of the Pittsburgh Sleep Quality Index in community dwelling Ethiopian adults. *Health Qual Life Outcomes*. 2017;15(1):1–7. doi:10.1186/s12955-017-0637-5

32. Bourne RR, Flaxman SR, Braithwaite T, et al. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *Lancet Global Health*. 2017;5(9):888–897. doi:10.1016/S2214-109X(17)30293-0

33. Wondie Y, Mehnert A, Hinz A. The Hospital Anxiety and Depression Scale (Hads) applied to Ethiopian cancer patients. *PLoS One*. 2020;15 (12):243357. doi:10.1371/journal.pone.0243357

34. Hosmer DW, Hjort NL. Goodness-of-fit processes for logistic regression: simulation results. *Stat Med*. 2002;21(18):2723–2738. doi:10.1002/sim.1200

35. Hosmer DW, Hosmer T, Le Cessie S, Lemeshow S. A comparison of goodness-of-fit tests for the logistic regression model. *Stat Med*. 1997;16 (9):965–980. doi:10.1002/(SICI)1097-0258(19970515)16:9<965::AID-SIM509>3.0.CO;2-O

36. Ayaki M, Kawashima M, Negishi K, Tsubota K. High prevalence of sleep and mood disorders in dry eye patients: survey of 1000 eye clinic visitors. *Neuropsychiatr Dis Treat*. 2015;11:889. doi:10.2147/NDT.S81515

37. Ahmadi H, Lund-Andersen H, Kolko M, Bach-Holm D, Alberti M, Ba-Ali S. Melanopsin-mediated pupillary light reflex and sleep quality in patients with normal tension glaucoma. *Acta Ophthalmol*. 2020;98(1):65–73. doi:10.1111/aos.14133

38. Lichter PR. Glaucoma therapy and quality of life. *Ophthalmol Clin North Am*. 1991;4:897–904.

39. Ra S, Ayaki M, Yuki K, Tsubota K, Negishi K. Dry eye, sleep quality, and mood status in glaucoma patients receiving prostaglandin monotherapy were comparable with those in non-glaucoma subjects. *PLoS One*. 2017;12(11):188534. doi:10.1371/journal.pone.0188534

40. Schweitzer PK. Drugs that disturb sleep and wakefulness. Principles and practice of sleep medicine. 2000.

41. Adachi M, Takahashi K, Nishikawa M, Miki H, Uyama M. High intraocular pressure-induced ischemia and reperfusion injury in the optic nerve and retina in rats. *Graefes Archiv Clin Exp Ophthalmol*. 1996;234(7):445–451. doi:10.1007/BF02539411

42. Lafuente M, Villegas-Perez M, Selles-Navarro I, Mayor-Torroglosa S, De Imperial JM, Vidal-Sanz M. Retinal ganglion cell death after acute retinal ischemia is an ongoing process whose severity and duration depends on the duration of the insult. *Neuroscience*. 2002;109(1):157–168. doi:10.1016/S0306-4522(01)00458-4

43. Ciulla L, Moorthy M, Mathew S, et al. Circadian rhythm and glaucoma: what do we know? *J Glaucoma*. 2020;29(2):127–132. doi:10.1097/IJG.0000000000001402

44. Lucy KA, Wollstein G. Structural and functional evaluations for the early detection of glaucoma. *Expert Rev Ophthalmol*. 2016;11(5):367–376. doi:10.1080/17469899.2016.1229599

45. Wu YH, Swaab DF. The human pineal gland and melatonin in aging and Alzheimer's disease. *J Pineal Res*. 2005;38(3):145–152. doi:10.1111/j.1600-079X.2004.00196.x

46. Obayashi K, Saeki K, Iwamoto J, et al. Positive effect of daylight exposure on nocturnal urinary melatonin excretion in the elderly: a cross-sectional analysis of the HEIJO-KYO study. *J Clin Endocrinol Metab*. 2012;97(11):4166–4173. doi:10.1210/jc.2012-1873

47. An Y, Joo C-K. The U-shaped association between self-reported sleep duration and visual impairment in Korean adults: a population-based study. *Sleep Med*. 2016;26:30–36. doi:10.1016/j.sleep.2016.08.005

48. Cheng W, Rolls ET, Ruan H, Feng J. Functional connectivities in the brain that mediate the association between depressive problems and sleep quality. *JAMA Psychiatry*. 2018;75(10):1052–1061. doi:10.1001/jamapsychiatry.2018.1941