Original Article

Comparative Evaluation of Activities of Daily Living Using Virtual Reality Simulation in Glaucoma and Non-Glaucoma Patients

Abstract

Purpose: To compare the performance of activities of daily living (ADL) in Primary open-angle glaucoma patients and non-glaucoma normal controls using virtual reality (VR) simulation at the Lagos State University Teaching Hospital. **Materials and Methods:** This was a comparative clinical analysis involving primary open-angle glaucoma (POAG) patients. A total of 86 patients were enrolled (43 cases and 43 normal non-glaucoma). Each participant completed four VR simulation tasks. Chi-square/Fisher exact test was used to compare variables. The confidence interval was set at 95% for all statistical tests, and a P value of <0.05 was considered significant. **Results:** The mean age of participants in the glaucoma group was 60.3 years, and the mean age in the normal non-glaucoma group was 56.5 years. The number of clicks in the driving task in the normal non-glaucoma and glaucoma group differed by 4.84 clicks (mean normal 21.00, confidence interval [CI], 19.96–22.14, mean glaucoma 16.16, CI, 14.30–18.03, $P < 0.001$). The number of newspapers seen differed by 0.88 (mean normal 9.74, CI, 9.40–10.09; mean glaucoma 8.86, CI, 8.21–9.51, $P = 0.020$). The mean time taken to complete the bus stop simulation task differed by 41.23 s (mean normal 29.72 s, CI, 25.02–34.42; mean glaucoma, 70.95 s, CI, 53.26–88.65, $P < 0.001$). The mean time taken to complete the best dress task differed by 14.39 s (mean normal 9.49, CI, 8.18–10.80; mean glaucoma 23.88, CI, 10.03–37.74, $P = 0.038$). Patients with advanced and severe stages of glaucoma took longer to complete the VR task than those with early glaucoma. **Conclusions:** The VR simulation used in assessing the performance of ADL among POAG participants highlights limitations that vary with varying severity of glaucoma. The conventional clinical investigation used in assessing glaucoma severity might not define the real-time social effect of the disease.

Keywords: *Comparative study, glaucoma, virtual reality*

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Introduction

Glaucoma is the world's second leading cause of blindness and the commonest cause of irreversible blindness.[1] It is a significant and well-recognized cause of reduced the quality of life (QoL) in affected persons.[2] It has been estimated that by the year 2040, there will be up to 80 million people with glaucoma worldwide.[3]

In sub-Saharan Africa, the burden of glaucoma ranks as one of the highest globally, primarily due to the aggressive nature of the disease in people of African descent, poor access to care, late presentation, and consequently late diagnosis, among other factors.[4] The prevalence of glaucoma has been found to be about 4.16% in sub-Saharan Africa.[4]

In Nigeria, glaucoma blindness was one of the major findings of the Nigerian Blindness and Visual Impairment Survey conducted in the year 2005–2007. The prevalence of glaucoma in Nigeria was found to be 5.02% (95% CI 4.60–5.47) in adults aged 40 years and above.[5]

Glaucoma has a profound economic burden primarily because of its effect on the QoL of affected individuals. Affected persons may find it difficult to navigate and to adapt in environments with poor lighting. Poor stereopsis and associated tunnel vision in advanced cases contribute to the visual complaints.[1] It also impairs the peripheral field representation when completing daily indoor and outdoor tasks where peripheral vision is a necessity.[2,6,7]

Primary open-angle glaucoma (POAG) is the most common type of glaucoma in Nigeria.[5] It is an optic neuropathy

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characterized by normal appearing open angles on gonioscopy, retinal nerve fiber layer thinning with ganglion cell loss, and characteristic optic nerve head cupping with visual field defect in the absence of underlying ocular or systemic disease. It causes progressive, painless vision loss.[5]

Activities of daily living (ADL) can be generally classified as either indoor or outdoor. Indoor activities include preparing a meal, reading articles in the dailies, bathing, and housekeeping. Outdoor activities can include driving, shopping, and exercises like running and walking. Glaucoma in its early and late stages can have a significant negative effect on the performance of both indoor and outdoor activities.[8-10]

Virtual reality (VR) creates a totally immersive environment, and the types of possible environments that can be simulated are only limited by the developer's imagination. QoL is defined as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns.[11] It is a broad range of concepts affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships, and their relationship to salient features of their environment.[11] In the backdrop of glaucoma, the definition of QoL can be modified to include ocular health. Glaucoma affects QoL,[2,12] and this translates directly to impaired performance of ADL.[10,13]

Glaucoma patients in most clinics do not readily report the restrictions in their QoL and the limitations experienced in the performance of ADL. It is commonplace to hear glaucoma patients complain of having multiple driving accidents necessitating driving limitation; commuting becomes a hassle as glaucoma patients will express fears in charting unfamiliar routes or destinations, some resort to sedentary lifestyles, a naturally extroverted personality will report claims of living an introverted lifestyle, close relatives of affected persons might directly or indirectly report glaucoma patients making less choices when it comes to picking varieties such as outfits, meals from a menu, and sometimes fidgety when trying to pick objects. These and several other limitations are present in most glaucoma patients, even in the presence of a 6/6 vision and a normal-to-moderate impairment in the visual field.

The primary goal of this research was to compare the performance of ADL in primary open-angle glaucoma patients with normal non-glaucoma persons using VR simulation. The secondary goal was to determine the factors affecting the VR simulation performance of Primary open-angle glaucoma patients.

Materials and Methods

This study was conducted at the Department of Ophthalmology, Lagos State University Teaching Hospital (LASUTH). It was a comparative clinical study. The study was conducted amongst new and follow-up adult patients diagnosed with POAG. Data was gathered for a period of 6 months. The patients included in this study were selected based on the following criteria. Inclusion criteria were age 35 years and above, diagnosis of POAG, participants who understand how to drive a vehicle or have driven a vehicle in the past and have obtained at one time or the other an original driver's license issued by the Federal Road Safety Corp, low to moderate refractive errors(less than six diopters), best corrected binocular visual acuity greater than 6/60 (for the purpose of this study), recent (<3 months) and reliable Humphrey central 24-2 visual field result that was in keeping with glaucomatous optic neuropathy, optical coherence tomography findings in keeping with glaucoma (neuroretinal rim loss, retinal nerve fiber layer thinning and disc damage likelihood score of 5 and above), patients who consented to the study by signing the study informed consent. Exclusion criteria persons younger than 35 years of age, binocular visual acuity less than 6/60 or visual field less than 10 degrees in both eyes, individuals managed for angle-closure glaucoma, ocular comorbid conditions complicating glaucoma such as visually significant cataract, uveitis, non-glaucomatous optic neuropathy, individuals with seizure disorders, individuals with poorly controlled systemic hypertension, individual with any form of anxiety disorders and other neurological conditions, claustrophobic individuals, individuals prone to motion sickness, patients who are currently on treatment that can alter pupil size/reactions such as pilocarpine and atropine, patients who have had laser or surgical ocular procedures in the last 3 months and patients who were not willing to be part of the study.

Inclusion criteria for the normal non-glaucoma group were individuals 35 years or over with low to moderate refractive errors (less than six diopters), absence of any vision function impairing ocular disease such as glaucoma, cataract, age-related macular degeneration, corneal opacity, uveitis, optic atrophy. Exclusion criteria for the normal non-glaucoma group were individuals who, after ocular examination, were found to have ocular abnormalities/pathology.

The number of participants recruited was 86. Consecutive patients were identified and enrolled after screening to ensure eligibility criteria were met. Normal non-glaucoma patients were recruited from general ophthalmology clinics and screened according to the inclusion and exclusion criteria.

Glaucoma patients used in this study were classified using mean deviation into early, moderate, advanced, and severe glaucoma.

The VR simulation was developed by a Nigerian-based 3D production company (InstantARCH 3D). Simulations were created specifically for the purpose of this research and are available on request. A commercially available VR headset (Miniso) with adjustable interpupillary distance and focus was used. The display screen was a Samsung super AMOLED 6.4 inches with a resolution of 720 × 1560 pixels and PPi density of 268.

Ethical approval to conduct this study was obtained from LASUTH Health Research and Ethics Committee. Written informed consent was obtained from each participant after fully explaining the nature of the study.

Study procedure

VR task: The VR task was conducted in a dedicated quiet room. The components of the VR headset were explained to participants, and real-life situations of VR scenes were presented for familiarization. A chaperone was present during the procedure. Four scenes were used in the task in the sequence below.

Virtual drive: The driving task consists of a long stretch of continuous road bordered to the right and left by a narrow sidewalk and tall trees into the distance [Video 1]. The participant sees at fixed intervals a rabbit, a chicken, a street sign, and a pothole at strategic locations. A clicker is expected to be tapped on every object seen during the virtual drive. Participants were instructed to focus straight ahead during the 1-min virtual drive like they would in real-life situations. Participants were not required to search for objects but to keep focusing straight ahead in the distance so as not to miss the images that appeared in their field of view [Video 1].

Newspaper identification task: the objective of the task was to identify the number of Nigerian newspapers by skimming over the collage displayed on a virtual board [Video 2] within a short undisclosed duration. At 15 s, the virtual display automatically comes to an end [Video 2].

Bus-stop image identification scene: a 3D view of a crowded bus-stop/market [Video 3] was presented to the participant, who was simulated to be standing at the center of a static crowd. The objective was to identify four images (a gray-colored building, a street hawker, a tricycle, and a Lagos State Traffic Maintenance Agency traffic controller (LASTMA), which were presented around the participant at strategic positions in the 3D environments. This task was not time-bound. The overall time taken for the virtual images to be identified was recorded in a task completion form [Video 3].

Best dress scene: a participant was simulated to be in a virtual bedroom [Video 4], and the objective was to identify a blue-themed Ankara fabric amongst a stack of neatly folded clothes in a wardrobe. Participants were to skim around the bedroom till they found the open wardrobe and then tap on the timer immediately after the outfit was seen. This concludes the task. This task was not time-bound [Video 4].

Data were analyzed using International Business Machines (IBM) Statistical Package for Social Sciences version 21.0 software (SPSS Inc., Chicago, IL). Percentages, means, and standard deviation of numerical variables were determined. VR simulation task score was analyzed and compared with biodata/demographics to determine factors associated with various task performance scores. Scores were also compared for both cases and normal non-glaucoma. Student *t*-test was used to compare numeral variables. Chi-square/Fisher exact test was used to compare variables. Confidence interval was set at 95% for all statistical tests, and a P value of <0.05 was considered significant.

Results

Sociodemographic characteristics of the normal non-glaucoma and glaucoma groups

The study comprised 43 (50%) control and 43 (50%) glaucoma patients. Patients between 35 and 69 were (86%). Half (60.5%) of patients recruited in the normal non-glaucoma group were females. Half of the patients in the glaucoma group were males (58.1%), married (76.7%), Christians (74.4%), employed (65.1%), and had a tertiary level of education (72.1%). Two-thirds (67.4%) of the normal non-glaucoma group reported not having other medical conditions, while 53.5% of the glaucoma patients had other medical conditions like hypertension (38.6%) and diabetes (9.1%). No statistically significant difference between the demographic of the two groups [Table 1].

Comparison of VR simulation score in normal and glaucoma groups

Table 2 shows the outcomes of VR tasks completed by the normal non-glaucoma and glaucoma groups. An independent T-test was used to compare data. The normal non-glaucoma group had an average of 21.00 (SD ± 3.71) clicks on the 60 s driving task when compared to the glaucoma group, with 16.16 (SD ± 6.06) clicks, and this was statistically significant (P <0.001). The average number of newspapers seen by the normal non-glaucoma group in 15 s was 9.7, while the glaucoma group saw an average of 8.8 newspapers. It took the normal non-glaucoma group an average of 29.7 s to complete the bus stop scene task compared to 70.9 s for the glaucoma patients, and this was statistically significant (P < 0.001). The normal non-glaucoma group took an average of 9.4 s to complete the best-dressed challenge compared to the glaucoma group's average of 23.8 s to achieve the same task (P < 0.038). [Table 2]

Correlation between visual acuity and VR scores of primary open-angle glaucoma patients

Table 3 shows the correlation between visual acuity and VR scores of POAG patients. There was an insignificant positive correlation between participants with poor visual acuity and the number of clicks in the driving task (r = 0.140; P > 0.05).

Table 1: Sociodemographic profile of respondents

	Normal non-glaucoma group (C) (n = 43)		Glaucoma group (G) (n = 43)	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Age category				
<40	5	11.6	2	4.7
40–49	10	23.3	4	9.3
50–59	13	30.2	13	30.2
60–69	12	27.9	17	39.5
70–79	3	7.0	7	16.3
Gender				
Male	17	39.5	25	58.1
Female	26	60.5	18	41.9
Marital status				
Single	0	0.0	2	4.7
Married	42	97.7	33	76.7
Widowed/Divorced	1	2.3	8	18.6
State of residence				
Lagos	37	86.0	40	93.0
Ogun	6	14.0	3	7.0
Religion				
Islam	16	37.2	11	25.6
Christianity	27	62.8	32	74.4
Occupation				
Employed	36	83.7	28	65.1
Unemployed	4	9.3	2	4.7
Retired	3	7.0	13	30.2
Medical condition				
No	29	67.4	20	46.5
Yes	14	32.6	23	53.5
If yes, what condition?	n = 14		n = 23	
Hypertension	13	30.2	17	38.6
Diabetes	0	0.0	4	9.1
Others	1	2.3	2	4.5
Highest education				
Primary	0	0.0	7	16.3
Secondary	10	23.3	5	11.6
Tertiary	33	76.7	31	72.1

Table 2: Table comparing virtual reality task score in normal and glaucoma groups

Tasks completed	Normal non-glaucoma group (C) (n = 43)		Glaucoma group (G) (n = 43)		P-value
	Mean ± SD	95% CI	Mean ± SD	95% CI	
Number of clicks on driving task	21.00 ± 3.71	(19.96–22.14)	16.16 ± 6.06	(14.30–18.03)	<0.001*
Number of newspapers seen	9.74 ± 1.12	(9.40–10.09)	8.86 ± 2.11	(8.21–9.51)	0.020
Time taken in bus stop task (s)	29.72 ± 15.27	(25.02–34.42)	70.95 ± 57.50	(53.26–88.65)	<0.001*
Time taken in best dress task (s)	9.49 ± 4.26	(8.18–10.80)	23.88 ± 45.01	(10.03–37.74)	0.038

C—normal non-glaucoma group, G—glaucoma group, n—number of participants
SD—standard deviation, CI—confidence interval, *—P value < 0.001

Similarly, there was a weak correlation (0.095; $P > 0.05$) between the visual acuity and the number of newspapers seen during the virtual simulation, where participants with poor visual acuity and advanced glaucoma saw less number of newspapers on the task. In contrast, a significantly negative correlation (-0.338; $P < 0.027$) was observed where glaucoma patients with poor visual acuity took a longer time to complete the bus stop task ($P < 0.05$). Likewise, a negative but insignificant correlation of -0.121 existed between the visual acuity and the time to complete the best dress task, where participants with poor acuity took longer to complete the task. These findings showed that visual acuity is associated with either a positive (time-based task)

Table 3: Correlation between visual acuity and virtual reality scores of primary open-angle glaucoma patients

Variables	Pearson correlation	*P*-value
Visual acuity grade vs. number of click on driving task	0.140	0.372
Visual acuity grade vs. number of newspapers task	0.095	0.543
Visual acuity grade vs. total time taken to complete bus stop task (s)	-0.338	0.027*
Visual acuity grade vs. time taken to complete best dress task (s)	-0.121	0.439

or negative (target-based task) correlation for VR scores in glaucoma patients [Table 3].

Table 4 shows the factors affecting primary open-angle glaucoma patients' VR simulation performances. The average number of clicks on the one-minute driving task, the number of newspapers seen in 15 s, and the time to complete the best-dressed task were not significantly different across all age groups, visual field (MD), occupation, and participants who identified as either indoor or outdoor persons ($P > 0.05$). Patients aged 60–69 years took the longest average time (101.82 ± 76.33) to complete the bus stop task compared to patients aged 50–59 years with 39.85 ± 15.65 s ($P < 0.05$). The average time taken by skilled patients was significantly higher (74.50 ± 56.27) than the unskilled (65.53 ± 60.66), $P < 0.001$. Glaucoma patients that attained primary and secondary education spent significantly higher average time (131.14 ± 103.14 s) and (106.40 ± 57.56) to complete the bus task than those who completed tertiary education (51.65 ± 24.89 s), $P < 0.001$. Patients who considered themselves outdoor persons took an average of 55.84 ± 25.13 s to complete the task compared to the indoor type (91.94 ± 80.46 s), $P < 0.05$. Using the visual field (MD), the time taken to complete the bus stop task increased with glaucoma severity ($P < 0.05$). Patients at the advanced (50.80 ± 11.82 s) and severe stages took longer to complete the task than those at the early glaucoma stages (22.00 ± 14.14).

The average number of clicks in the one-minute driving task, the number of newspapers seen in 15 s, the total time to complete the bus stop tasks, and the time to complete the best-dressed task was not significantly different between genders, previous use of VR devices ($P > 0.05$).

Patients who drove made a significantly higher average number of clicks in one-minute driving tasks (18.34 ± 4.97) than those who did not (11.64 ± 5.75), $P < 0.05$. Those that read newspapers made an average of 16.85 ± 6.09 clicks than those who did not (13.90 ± 5.69 clicks), $P < 0.05$ [Table 4].

Discussion

ADL translates directly to QoL. However, some studies reveal that coping mechanisms are common amongst younger persons with early to moderate glaucoma in a bid to compensate for the effect of the disease on their ADL, hence the better performance during the VR simulation when compared to older patients with early to moderate glaucoma.[14,15] It is, however, possible that age-related decline in visual and physical performance might have contributed to their VR simulation performance.

The VR simulation score has opened up a new dimension to the understanding of the psychosocial aspect of glaucoma disease in the real world. The four simulated tasks have scores that were poorer in the glaucoma group when compared with the normal non-glaucoma group. A similar finding was obtained in the study by Lam *et al.*,[16] who used VR simulation to identify vision-related disability in glaucoma and normal non-glaucoma group.

Driving and navigating in crowded places as an outdoor task requires a detailed representation of the peripheral field of vision. The glaucoma group had poor VR scores on the two outdoor tasks explored in this study. Only these tasks were statistically significant hence shedding more light on the restrictions glaucoma patients face in the limitations of outdoor activities. Lam *et al.*,[17,16] in their study using VR simulation, found day time simulation among glaucoma and normal non-glaucoma didn't reveal any statistically significant difference between both groups, but when shopping simulation was compared amongst both groups, the time required to complete task was longer by 15.2 s (95% CI, 5.5–24.9 s) or 34.1% (95% CI, 12.4%–55.7%). A similar finding was observed in the bus stop scene explored in this study. This can be explained by the crowding phenomenon caused by multiple visual stimuli within a narrow field of vision leading to confusion of visual stimuli. This finding has revealed more information on the disability glaucoma patient's face in the setting of multiple environmental stimuli.

It was evident that some respondents' especially younger groups with early glaucoma, had normal VR simulation scores in all four simulations despite having mild visual field defects. This highlights the fact that visual disability might not necessarily translate to limited performance in ADL and this should be considered when addressing patients with unique sociodemographic characteristics.

Two of the simulation tasks (bus stop scene and best dress task) used in the study required that participants engaged in searching eye and body motion in order to complete the task objective. The performance here, too, was better in the younger groups than the older groups, perhaps due to the agility and physical properties found in the younger group.

Also, it was observed that familiarity with a particular environment or task, such as the driving task and newspaper

Table 4: Factors affecting the virtual reality simulation performance of primary open-angle glaucoma patient

Parameter	N	Virtual reality simulations			
		Number of clicks on driving task	Number of newspapers seen	Time to complete bus stop task (s)	Time to complete best dress task (s)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Age category (*P* -value)		0.378	0.105	0.040*	0.388
<40	2	14.00 ± 8.49	10.00 ± 0.0	53.00 ± 57.98	16.00 ± 12.73
40–49	4	16.75 ± 5.32	9.50 ± 1.00	48.25 ± 32.51	12.75 ± 9.61
50–59	13	18.62 ± 5.09	9.23 ± 1.74	39.85 ± 15.65	11.38 ± 6.69
60–69	17	14.18 ± 7.11	7.82 ± 2.68	101.82 ± 76.33	41.29 ± 68.51
70–79	7	16.71 ± 4.27	10.00 ± 0.0	71.86 ± 27.85	13.43 ± 8.72
Gender		0.800	0.615	0.576	0.576
Male	25	15.96 ± 5.91	9.00 ± 2.02	66.72 ± 54.00	27.20 ± 57.79
Female	18	16.44 ± 6.43	8.67 ± 2.28	76.83 ± 63.15	19.28 ± 15.90
Occupation		0.317	0.113	0.001*	0.121
Skilled	26	16.50 ± 5.27	8.77 ± 2.10	74.50 ± 56.27	28.77 ± 56.84
Unskilled	17	15.65 ± 7.25	9.00 ± 2.18	65.53 ± 60.66	16.41 ± 13.17
Do you have any medical conditions?		0.067	0.038*	0.541	0.220
No	20	14.35 ± 6.55	8.15 ± 2.58	76.80 ± 75.88	33.00 ± 63.98
Yes	23	17.74 ± 5.25	9.48 ± 1.37	65.87 ± 35.78	15.96 ± 13.86
Highest education		0.068	0.618	0.001*	0.001*
Primary	7	12.57 ± 5.86	9.43 ± 0.98	131.14 ± 103.14	17.00 ± 12.79
Secondary	5	13.00 ± 4.69	8.20 ± 2.68	106.40 ± 57.56	91.00 ± 117.79
Tertiary	31	17.48 ± 5.93	8.84 ± 2.11	51.65 ± 24.89	14.61 ± 10.17
Do you drive?		<0.001*	0.166	0.011*	0.784
No	14	11.64 ± 5.75	8.21 ± 2.61	102.36 ± 85.49	26.64 ± 17.35
Yes	29	18.34 ± 4.97	9.17 ± 1.79	55.79 ± 28.89	22.55 ± 53.80
Do you read the newspaper?		0.021*	0.364	0.007*	0.852
No	10	13.90 ± 5.69	9.40 ± 0.97	108.40 ± 91.77	20.10 ± 12.29
Yes	33	16.85 ± 6.09	8.70 ± 2.34	59.61 ± 37.41	25.03 ± 51.01
Ever used a virtual reality device?		0.097	0.203	0.516	0.476
No	38	15.61 ± 6.22	8.71 ± 2.21	73.05 ± 60.34	25.68 ± 47.58
Yes	5	20.40 ± 1.67	10.00 ± 0.0	55.00 ± 25.90	10.20 ± 8.35
Do you consider yourself an indoor or outdoor person?		0.291	0.348	0.041*	0.924
Indoor	18	15.00 ± 7.33	8.50 ± 2.38	91.94 ± 80.46	24.67 ± 14.82
Outdoor	25	17.00 ± 4.95	9.12 ± 1.90	55.84 ± 25.13	23.32 ± 58.22

Table 4: Continued

Parameter	N	Virtual reality simulations			
		Number of clicks on task completion	Number of newspapers seen	Total time to complete bus stop task (s)	Time to complete best dress task (s)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Visual acuity		0.409	0.781	0.022*	0.433
Normal (6/6–6/9)	9	17.89±4.83	9.56±0.88	32.11±8.95	10.67±5.55
Worse than normal (<6/9)	34	16.89±2.66	9.64±0.73	45.02±15.56	12.35±5.69
Clinical cup disc ratio (CDR)					
Glaucoma (CDR ≥ 0.55)	43	16.16±6.06	8.86±2.11	70.95±57.50	23.88±45.01
MD		0.902	0.516	<0.001*	0.052
Early-moderate glaucoma	10	18.18±7.75	9.32±2.23	28.50±17.46	9.44±7.26
Advanced-severe glaucoma	18	18.47±4.69	8.79±1.93	65.67±20.08	16.83±10.06

n—number of participants, SD—standard deviation, CI—confidence interval, *—*P* value < 0.001

task, helped improve the performance when compared with those who were not familiar with such activities. It can be hypothesized that moderate to advance glaucoma patients will fare well in familiar environments or in performing familiar tasks either indoors or outdoors.

Sociodemographic factors found to reflect negatively on the VR performance scores amongst glaucoma patients include age (with older persons having lower), gender (males worse than females), unskilled occupation, and lower level of educational achievement (tertiary education having better QoL scores). None of these factors, however, were statistically significant. Identification as either outdoor or indoor personalities revealed a significant difference in the performance of participants in the glaucoma group on the bus stop VR simulation task (*P* value 0.041).

Conclusion

Primary open-angle glaucoma is a disease that affects significantly the QoL of affected individuals. Clinical parameters such as visual acuity, visual field, and cup disc ratio might not sufficiently describe the impact of the disease on the ADL of affected individuals. VR simulations explored in this study identified other variables that contribute positively and negatively to the QoL of glaucoma patients. It is possible that VR simulation could be incorporated as a screening tool for glaucoma that can highlight the need for detailed ocular examination, thus giving Ophthalmologist more information on disease severity and also give real-time comparison and reliability of other clinical parameter such as visual field assessment.

Limitation

Subjectivity during the virtual task could have been addressed with advanced technologies that can track eye and pupil movements in response to perceived visual stimuli. Subjectivity in the timing of virtual tasks was also a significant limitation, as automated timing mechanisms for virtual tasks could have been more objective. During study recruitment for normal non-glaucoma, the elder population between 50 and 70 years could not be conveniently compared to the case group, mostly due to the presence of varying crystalline lens opacity, especially the nuclear sclerotic type.

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Conflicts of interest

There are no conflicts of interest.

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