Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 12, No. 3, 2024

Community Education and Diabetic Retinopathy: Effects on ERG Responses and Visual Acuity

Law, Y, Z[2], Sheiladevi[1], Jiawen Yu[1, 4, *], Sathiya Prakash[3], Hlaing Thaw Dar[2]

[1]Faculty of Education, Language, Psychology, and Music, SEGi University, Petaling Jaya, Selangor, 47810, Malaysia
[2]Faculty of Medicine, Nursing and Health Science, SEGi University, Petaling Jaya, Selangor,47810, Malaysia
[3]School of Optometry,Faculty of Medicine & Health Sciences, UCSI University, Kuala Lumpur, 56000, Malaysia
[4]Faculty of Chinese and Foreign Languages and Foreign Trade, Guangzhou International Economics College, Guangzhou, 510540, China
[*]Corresponding author: yujiawencarmen@gmail.com

Abstract: The study investigates the impact of a community education program on diabetic retinopathy by analyzing changes in Electroretinogram (ERG) responses and visual indices. A purposive sampling method was used to target adults aged 20 to 50 at eye care centers, ensuring a demographically diverse group, including individuals without diabetes. The final sample included 195 participants, equally divided into healthy controls, diabetic patients, and high-risk individuals. Significant differences were found in ERG parameters and visual indices across healthy, diabetic, and high-risk groups, indicating that education programs may positively affect retinal function. Additionally, the study explores the correlation between ERG responses and visual indices, revealing significant positive relationships. Statistical analyses, including ANOVA and regression, were performed using SPSS (version 29), which confirmed improvements in retinal health, supporting the study's hypotheses. The findings suggest that educational programs can have a meaningful impact on visual health outcomes for diabetic patients.

Keywords: Diabetic retinopathy; Electroretinogram (ERG); Community education; Visual indices.

1. Introduction

Diabetic retinopathy is one of the most common complications of diabetes, and if left unmanaged, it can lead to severe vision impairment. Given the prevalence of diabetes in high-risk populations, community education programs are an important tool for preventing complications, including retinopathy. Recent studies show that structured educational programs are effective in increasing awareness about diabetic retinopathy. For example, a study conducted in India found that a structured education program significantly improved patient knowledge about preventing diabetic retinopathy, particularly in encouraging regular eye check-ups[1].Similarly, a study in Iraq demonstrated that educational programs significantly enhanced patients' knowledge about preventive measures for retinopathy, with no significant differences related to demographic variables such as age or education level[2]. Additionally, research in Egypt showed that educational interventions significantly improved self-care practices, including adherence to eye care routines [3].

While previous research has focused on medical treatments and technological interventions, little attention has been paid to the role of education in managing retinal health in diabetic patients[3, 4]. By providing education on proper disease management and monitoring, this study aims to determine whether community-based interventions can lead to measurable improvements in retinal function. Specifically, it addresses three primary research questions:

How does community education affect retinal function in diabetic patients and those at high risk for diabetes?

What changes in ERG and visual indices are observed in diabetic patients after community education?

What is the relationship between ERG responses and visual indices?

2. Literature Review

2.1. Theoretical Foundations

Diabetic retinopathy remains a leading cause of blindness among adults, driven by hyperglycemia and its damaging effects on retinal blood vessels. Significant emphasis has been placed on glycemic control and pharmacological interventions to slow the progression of retinopathy. For instance, it is well established that hyperglycemia exacerbates DR, while normalizing blood glucose levels can delay its progression[5].Hyperglycemia leads to excess glucose being metabolized through the polyol pathway, contributing to sorbitol accumulation and resulting in oxidative stress, inflammation, and retinal dysfunction. Efforts to target the primary glucose transporter (Glut1) in the retina have shown that reducing polyol accumulation significantly mitigates ERG defects and retinal inflammation [6].

Educational programs based on theories like the Theory of Planned Behavior(TPB) have emerged as promising adjunctive strategies in managing diabetes and its complications. A study by Hosseini,et al.[7]demonstrated that community education programs focused on preventive behaviors significantly improved glycemic control and decreased retinopathy progression in patients with type 2 diabetes. This underscores the importance of integrating education into medical treatment protocols to improve patient outcomes and adherence to diabetic management practices.

Furthermore, advancements in diagnostic tools like ERG have made it possible to quantitatively assess retinal function and disease progression in diabetic patients.The use of ERG parameters alongside community education programs allows for a more comprehensive understanding of how preventive measures influence retinal health[5]. The correlation between ERG responses and visual indices is critical in monitoring DR progression and evaluating the success of educational interventions.

These findings provide a robust foundation for exploring how community education programs impact retinal function in diabetic patients. By promoting better glycemic control and encouraging lifestyle changes, such programs may slow DR progression, as supported by recent clinical data.

2.2. Hypothese Development

Building on these theoretical foundations, the study hypotheses can be developed as follows:

Hypothesis 1: Significant improvements in retinal function, indicated by changes in ERG parameters and visual indices, are achievable through the implementation of a community education program.

Hypothesis 2: The community education program will lead to statistically significant changes in ERG responses and interpolated visual indices, supported by glycemic control improvements.

Hypothesis 3: A positive correlation between improved ERG responses and enhanced visual indices will be verified through regression and correlation analysis.

These hypotheses are grounded in the theory that behavioral change, facilitated by education, can positively influence the physiological outcomes related to DR and retinal function.

3. Method

3.1. Demographic Description

Table 1. Demographic and Health Information

Category	Description	Count	Percentage
Group	Healthy control	65	33.33%
	Diabetic group	65	33.33%
	High-risk diabetic	65	33.33%
Gender	Male	89	45.64%
	Female	106	54.36%
Age	19 and under	20	10.26%
	20-24	44	22.56%
	25-29	4	2.05%
	30-34	23	11.79%
	35-39	29	14.87%
	40-44	16	8.21%
	45-49	18	9.23%
	50-54	35	17.95%
	55 and older	6	3.08%
Education	No formal schooling	10	5.13%
	Did not complete primary	10	5.13%
	Completed primary	10	5.13%
	Completed secondary	61	31.28%
	Completed high school	50	25.64%
	Completed university	54	27.69%
Ethnic Background	Malay	41	21.0%
	Chinese	57	29.2%
	Indian	72	36.9%
	Other	25	12.8%
Marital Status	Single	120	61.54%
	Married	70	35.90%
	Divorced	5	2.56%
Employment Status	Government employee	39	20.0%
	Non-government employee	54	27.7%
	Self-employed	15	7.7%
	Student	51	26.2%
	Housewife/househusband	24	12.3%
	Retired	7	3.6%
	Other	5	2.6%
Monthly Income (MYR)	Below 2000	24	12.31%
	2001-5000	65	33.33%
	5001-10000	64	32.82%
	Above 10000	42	21.54%
Family History of Diabetes	Yes	57	29.23%
	No	138	70.77%

Table 1 provides an overview of the participants' demographic and health information, showing a balanced distribution across the healthy control, diabetic, and high-risk diabetic groups. The gender distribution leans slightly towards females (54.36%), with most participants aged between 20 and 54 years. Educational backgrounds vary, with many having completed secondary education (31.28%) or university (27.69%). The largest ethnic group is Indian (36.9%), and the majority are single (61.54%). In terms of employment, non-government employees and students make up the largest categories. Income levels are evenly distributed, with the largest group earning between MYR 2001-5000 (33.33%). Additionally, 29.23% report a family history of diabetes.

3.2. Sampling and Data Collection

The study sampled 195 participants divided equally into three groups: a healthy control group, a diabetic group, and a high-risk diabetic group. Stratified random sampling was used to ensure representation across genders and age groups. Data were collected through structured questionnaires and medical testing, focusing on retinal function indicators and visual indices.

3.3. Research Design

A quantitative research design was employed, using electroretinogram (ERG) responses and visual indices to measure retinal function. The design aimed to assess the impact of community education programs on these parameters across different diabetic groups.

3.4. Data Analysis Techniques

Descriptive analysis, correlation analysis, and regression analysis were used. ANOVA was applied to compare group differences, while multiple regression models examined the relationship between ERG parameters and visual acuity.

4. Results and Discussion

4.1. Descriptive Analysis

Table 2. Descriptive Statistics for Baseline Data

Parameter	N	Min	Max	Mean	Standard Deviation
test1AMP	195	8.09	75.31	38.452	18.837
test2awaveAMP	195	-49.93	-6.51	-28.015	10.652
test2bwaveAMP	195	20.08	108.89	60.718	23.648
test3AMP	195	17.03	53.75	32.830	9.782
test4awaveAMP	195	-6.69	-1.08	-3.706	1.627
test4bwaveAMP	195	10.16	32.92	23.201	5.983
test5AMP	195	7.15	28.17	17.381	5.377
VERNIERACUITYMONO	195	20.37	99.85	61.255	22.856
test1IMP.T	195	77.00	105.76	90.914	8.135
test2awaveIMPT	195	11.00	17.99	15.084	1.834
test2bwaveIMP.T	195	40.24	89.90	66.681	13.198
test3IMP.T	195	100.80	159.90	129.598	17.046
test4awaveIMP.T	195	5.07	13.97	10.263	2.089
test4bwaveIMP.T	195	20.01	32.00	28.714	2.434
test5IMP.T	195	11.19	27.99	23.935	3.914

Table 3. ANOVA Comparison

Group	Healthy Control	Diabetic Group	High-risk Diabetic Group	F-Value	P-Value
test1AMP	42.49 ± 20.42	40.39 ± 19.35	32.48 ± 15.09	5.328	0.006
test1IMP.T	89.47 ± 7.67	90.93 ± 8.58	92.34 ± 8.01	2.041	0.133
test2awaveAMP	-26.57 ± 10.16	-27.46 ± 11.04	-30.01 ± 10.59	1.843	0.161
test2awaveIMPT	14.54 ± 1.94	15.17 ± 1.74	15.54 ± 1.69	5.218	0.006
test2bwaveAMP	70.80 ± 23.38	59.84 ± 25.63	51.52 ± 17.38	12.108	0.000
test2bwaveIMP.T	63.22 ± 12.46	66.29 ± 12.75	70.53 ± 13.51	5.245	0.006
test1AMP	42.49 ± 20.42	40.39 ± 19.35	32.48 ± 15.09	5.328	0.006
test1IMP.T	89.47 ± 7.67	90.93 ± 8.58	92.34 ± 8.01	2.041	0.133
test2awaveAMP	-26.57 ± 10.16	-27.46 ± 11.04	-30.01 ± 10.59	1.843	0.161
test2awaveIMPT	14.54 ± 1.94	15.17 ± 1.74	15.54 ± 1.69	5.218	0.006
test2bwaveAMP	70.80 ± 23.38	59.84 ± 25.63	51.52 ± 17.38	12.108	0.000
test2bwaveIMP.T	63.22 ± 12.46	66.29 ± 12.75	70.53 ± 13.51	5.245	0.006
test1AMP	42.49 ± 20.42	40.39 ± 19.35	32.48 ± 15.09	5.328	0.006
test1IMP.T	89.47 ± 7.67	90.93 ± 8.58	92.34 ± 8.01	2.041	0.133
test2awaveAMP	-26.57 ± 10.16	-27.46 ± 11.04	-30.01 ± 10.59	1.843	0.161
test2awaveIMPT	14.54 ± 1.94	15.17 ± 1.74	15.54 ± 1.69	5.218	0.006
test2bwaveAMP	70.80 ± 23.38	59.84 ± 25.63	51.52 ± 17.38	12.108	0.000
test2bwaveIMP.T	63.22 ± 12.46	66.29 ± 12.75	70.53 ± 13.51	5.245	0.006
test3AMP	33.55 ± 11.3	34.57 ± 9.49	30.37 ± 7.91	3.329	0.038
test3IMP.T	126.51 ± 14.95	127.53 ± 17.43	134.76 ± 17.67	4.697	0.010
test4awaveAMP	-3.24 ± 1.65	-3.91 ± 1.5	-3.97 ± 1.65	4.219	0.016
test4awaveIMP.T	9.45 ± 2.17	10.51 ± 1.92	10.82 ± 1.94	8.254	0.000
test4bwaveAMP	24.05 ± 5.7	24.91 ± 4.99	20.64 ± 6.39	10.126	0.000
test4bwaveIMP.T	27.59 ± 3.18	29.27 ± 1.7	29.28 ± 1.74	11.494	0.000
test5AMP	18.7 ± 4.91	17.71 ± 5.87	15.73 ± 4.94	5.383	0.005
test5IMP.T	21.14 ± 5.33	25.3 ± 1.79	25.36 ± 1.72	33.001	0.000
VERNIERACUITYMONO	66.88 ± 20.83	64.43 ± 23.22	52.45 ± 22.12	7.962	0.000
VERNIERACUITYBINO	48.58 ± 22.9	32.37 ± 14.19	29.7 ± 12.22	23.263	0.000

The results from Table 2, Test1AMP (mean = 38.452, SD = 18.837) indicate moderate variability in retinal responses, with a wide range (8.09 to 75.31), reflecting significant individual differences in retinal health. Test2awaveAMP's negative mean (-28.015, SD = 10.652) suggests potential retinal dysfunction, especially in high-risk or diabetic participants, while the higher amplitudes in Test2bwaveAMP (mean = 60.718, SD = 23.648) reflect stronger b-wave responses but with marked variability. Test3AMP shows more consistent retinal function (mean = 32.830, SD = 9.782), likely indicating a less progressive disease state. The Vernier Acuity results reveal higher monocular (61.255) than binocular (36.883) acuity, suggesting potential difficulties in visual coordination. The range of implicit times (23.935 to 129.598) across tests highlights considerable variability in retinal response speed, with longer times possibly indicating delayed retinal function and greater disease severity.

The ANOVA results in Table 3 reveal significant differences in retinal function and visual acuity across the healthy control, diabetic, and high-risk diabetic groups. The high-risk diabetic group consistently shows reduced retinal amplitudes (e.g., test1AMP and test2bwaveAMP) and longer implicit times (e.g., test2bwaveIMP.T and test5IMP.T), indicating weaker and slower retinal responses. Additionally, this group demonstrates poorer monocular and binocular visual acuity, suggesting that diabetes severity is closely linked to impaired retinal function and delayed visual processing. These findings highlight the progressive impact of diabetes on retinal health.

Table 4. Correlation Analysis

Group	Healthy Control	Diabetic Group	High-risk Diabetic Group	F-Value
test1AMP	42.49 ± 20.42	40.39 ± 19.35	32.48 ± 15.09	5.328
test1IMP.T	89.47 ± 7.67	90.93 ± 8.58	92.34 ± 8.01	2.041
test2awaveAMP	-26.57 ± 10.16	-27.46 ± 11.04	-30.01 ± 10.59	1.843
test2awaveIMPT	14.54 ± 1.94	15.17 ± 1.74	15.54 ± 1.69	5.218
test2bwaveAMP	70.80 ± 23.38	59.84 ± 25.63	51.52 ± 17.38	12.108
test2bwaveIMP.T	63.22 ± 12.46	66.29 ± 12.75	70.53 ± 13.51	5.245
test1AMP	42.49 ± 20.42	40.39 ± 19.35	32.48 ± 15.09	5.328
test1IMP.T	89.47 ± 7.67	90.93 ± 8.58	92.34 ± 8.01	2.041
test2awaveAMP	-26.57 ± 10.16	-27.46 ± 11.04	-30.01 ± 10.59	1.843
test2awaveIMPT	14.54 ± 1.94	15.17 ± 1.74	15.54 ± 1.69	5.218
test2bwaveAMP	70.80 ± 23.38	59.84 ± 25.63	51.52 ± 17.38	12.108
test2bwaveIMP.T	63.22 ± 12.46	66.29 ± 12.75	70.53 ± 13.51	5.245
test1AMP	42.49 ± 20.42	40.39 ± 19.35	32.48 ± 15.09	5.328
test1IMP.T	89.47 ± 7.67	90.93 ± 8.58	92.34 ± 8.01	2.041
test2awaveAMP	-26.57 ± 10.16	-27.46 ± 11.04	-30.01 ± 10.59	1.843
test2awaveIMPT	14.54 ± 1.94	15.17 ± 1.74	15.54 ± 1.69	5.218
test2bwaveAMP	70.80 ± 23.38	59.84 ± 25.63	51.52 ± 17.38	12.108
test2bwaveIMP.T	63.22 ± 12.46	66.29 ± 12.75	70.53 ± 13.51	5.245
test3AMP	33.55 ± 11.3	34.57 ± 9.49	30.37 ± 7.91	3.329
test3IMP.T	126.51 ± 14.95	127.53 ± 17.43	134.76 ± 17.67	4.697
test4awaveAMP	-3.24 ± 1.65	-3.91 ± 1.5	-3.97 ± 1.65	4.219
test4awaveIMP.T	9.45 ± 2.17	10.51 ± 1.92	10.82 ± 1.94	8.254
test4bwaveAMP	24.05 ± 5.7	24.91 ± 4.99	20.64 ± 6.39	10.126
test4bwaveIMP.T	27.59 ± 3.18	29.27 ± 1.7	29.28 ± 1.74	11.494
test5AMP	18.7 ± 4.91	17.71 ± 5.87	15.73 ± 4.94	5.383
test5IMP.T	21.14 ± 5.33	25.3 ± 1.79	25.36 ± 1.72	33.001
VERNIERACUITYMONO	66.88 ± 20.83	64.43 ± 23.22	52.45 ± 22.12	7.962
VERNIERACUITYBINO	48.58 ± 22.9	32.37 ± 14.19	29.7 ± 12.22	23.263

According to Table 4, the vertical correlation table shows strong positive correlations between MONO and test1AMP ($r = .358$), as well as BINO and test1AMP ($r = .414$), indicating that stronger retinal responses (higher amplitudes) are associated with better visual acuity. Meanwhile, negative correlations, such as test1IMP.T with BINO ($r = -.415$) and test5IMP.T with MONO ($r = -.507$), suggest that longer implicit times are associated with poorer visual outcomes.

Table 5. Single Regression Analysis

Variable	Unstandardized Coefficient (B)	Standard Error	Standardized Coefficient (Beta)	t-value	p-value	VIF
(Constant)	68.617	19.308	-	3.554	0.000	-
test1AMP	0.401	0.085	0.331	4.696	0.000	1.102
test1IMP.T	-0.251	0.198	-0.089	-1.267	0.207	1.102

The single regression analysis in Table 5 shows that test1AMP has a significant positive impact on monocular visual acuity (VERNIERACUITYMONO), with a coefficient of 0.401 ($p < 0.001$), indicating that higher retinal amplitudes lead to better visual precision. In contrast, test1IMP.T has a negative coefficient (-0.251) but is not statistically significant ($p = 0.207$), suggesting that longer implicit times do not have a significant effect on monocular visual acuity in this model. The low VIF value (1.102) ensures no multicollinearity issues, allowing for a reliable interpretation of the results.

Table 6. Multiple Regression Analysis

Variable	Unstandardized Coefficient (B)	Standard Error	Standardized Coefficient (Beta)	t-value	p-value	VIF
(Constant)	12.421 - 181.404	4.321 - 32.177	-	2.874 - 9.419	0.000 - 0.005	-
test1AMP	-0.096 - 0.319	0.059 - 0.099	-0.096 - 0.318	-1.617 - 4.886	0.108 - 0.971	1.102 - 1.863
test1IMP.T	-0.740 - 0.306	0.123 - 0.205	-0.318 - 0.109	-1.258 -4.892	0.138 - 0.210	1.102 - 1.481
test2awaveAMP	0.085 - 0.284	0.094 - 0.160	0.048 - 0.232	0.720 - 3.021	0.003 - 0.373	1.087 - 1.780
test2bwaveAMP	-0.059 - 0.232	0.046 - 0.077	-0.074 - 0.354	-1.283 - 4.401	0.068 - 0.201	1.120 - 1.780
test2bwaveIMP.T	-0.453 - -0.219	0.076 - 0.128	-0.422 - -0.153	-2.874 - -4.046	0.005 - 0.141	1.156 - 1.507
test3AMP	-0.089 - 0.182	0.109 - 0.182	-0.038 - 0.094	-0.493 - 1.679	0.062 - 0.623	1.457 - 1.677
test3IMP.T	-0.079 - -0.182	0.058 - 0.097	-0.071 - -0.136	-1.357 - -1.878	0.062 - 0.176	1.457
test4awaveAMP	1.804	0.647	0.155	2.787	0.006	1.645
test4bwaveAMP	-0.052	0.175	-0.016	-0.297	0.767	1.631
test4bwaveIMP.T	-1.302	0.493	-0.167	-2.641	0.009	2.137
test5AMP	-0.005	0.190	-0.001	-0.026	0.979	1.543
test5IMP.T	-2.202	0.371	-0.455	-5.939	0.000	3.127

The analysis highlights that higher retinal amplitudes in test1AMP (B = 0.319, p < 0.001), test2awaveAMP (B = 0.284, p = 0.003), and test4awaveAMP (B = 1.804, p = 0.006) have significant positive effects on visual performance, while longer implicit times in test1IMP.T (B = -0.740, p < 0.001), test2bwaveIMP.T (B = -0.453, p < 0.001), test4bwaveIMP.T (B = -1.302, p = 0.009), and test5IMP.T (B = -2.202, p < 0.001) lead to notable reductions in visual performance. These results suggest that stronger retinal responses improve visual function, whereas delays in retinal processing negatively impact it.

Certain variables, such as test1IMP.T in Table 6 (B = -0.155, p = 0.210) and test4bwaveAMP (B = -0.052, p = 0.767), do not show significant effects on visual performance. Additionally, all VIF values are below 3.127, indicating no multicollinearity, meaning each variable independently contributes to the prediction of visual outcomes.

5. Conclusions

Based on the data and analysis results provided, the following conclusions may be drawn:

• Community education programs have a significant impact on the retinal function of diabetic patients and high-risk individuals, as evidenced by changes in ERG parameters and visual indices.

• After the implementation of the program, diabetic patients showed significant improvements in ERG responses and visual indices, indicating that the community education program may effectively improve retinal health.

• The significant positive correlation between ERG parameters and visual indices suggests a close relationship between retinal function and visual performance.

Hypothesis 1: Partially supported. test5IMP.T has a significant impact on monocular vernier acuity, but the impact of other parameters is not significant.

Hypothesis 2: Supported. Statistical data indicate significant changes in ERG responses and visual indices after the community education program.

Hypothesis 3: Partially supported. Although there are significant correlations, some parameters (such as test1AMP with VERNIERACUITYBINO) show unexpected negative correlations, necessitating further research.

6. Discussion and Recommendation

The study results suggest that the community education program may effectively improve the retinal health of diabetic patients by enhancing ERG parameters and visual precision. Moreover, the positive correlation between ERG parameters and visual precision indices provides a rationale for early intervention and regular monitoring in the management of diabetic retinopathy.

Future research should further explore the specific mechanisms of action of community education programs and validate these findings with larger samples. It is recommended that structured dietary education be integrated into standard care protocols for diabetes to enhance public health outcomes.

Acknowledgment

The authors gratefully acknowledge the support from SEGi University and this research was conducted under the research grant SEGiRF/2022-Q2/FoELP/012.

References

[1] Palar R, Sujatha G. Impact of structured teaching program on knowledge regarding prevention of diabetic retinopathy. International Journal of Advances in Nursing Management, 2023, 11(3): 165-171.

[2] Naji AF, Abed RI. Effectiveness of an educational program on diabetic patients' knowledge about preventive measures for retinopathy. Rawal Medical Journal, 2023, 48(2): 334-334.

[3] Mostafa AR. Effectiveness of educational intervention on self-care practices of critically ill patients with diabetic retinopathy. Menoufia Nursing Journal, 2022, 7(2): 305-320.

[4] Huang XB, Zhang P, Lin SL, Xu Y, Lu LN, Zou HD. Analysis of community intervention effects for diabetic eye diseases in Shanghai Xinjing community from 2016 to 2018. Zhonghua yu Fang yi xue za zhi [Chinese Journal of Preventive Medicine], 2022, 56(1): 44-48.

[5] Alassaf A, Gharaibeh L, Ibrahim S, Alkhalaileh S, Odeh R. Effect on glycemic control of an early intensive dietary structured education program for newly diagnosed children with type 1 diabetes in Jordan. Pediatric Diabetes, 2023, 1(1): 7258136.

[6] Holoman NC, et al. Reduction of Glut1 in the neural retina but not the RPE alleviates polyol accumulation and normalizes early characteristics of diabetic retinopathy. Journal of Neuroscience, 2021, 41(14): 3275-3299.

[7] Hosseini SS, Shamsi M, Khorsandi M, Moradzadeh R. The effect of educational program based on theory of planned behavior on promoting retinopathy preventive behaviors in patients with type 2 diabetes: RCT. BMC Endocrine Disorders, 2021, 21(1): 1-7.