Factors Associated with Diabetic Retinopathy Among us Adults 40 years and Above with Diabetes

ABSTRACT

Background: Diabetic Retinopathy (DR) is one of the complications of diabetes and the primary cause of blindness among adults, and the third leading cause of all cases of blindness in the United States. DR is also the leading cause of vision loss, affecting over 100 million people worldwide. It accounts for 10,000 new cases of vision loss every year in the United States. Understanding the risk factors of diabetic retinopathy is crucial to the development of effective prevention strategies.

Aim: This study is designed to investigate the relationship between the selected independent variables and the risk of diabetic retinopathy among U.S. adults aged 40 years and above with diabetes.

Methods: Dataset from the 2017-2018 National Health and Nutrition Examination Survey (NHANES) was used for this study. The final sample comprised 893 adults aged 40 years and above with diabetes. Logistic regression analysis was used to determine the association between selected risk factors among those with diabetes and the risk of diabetic retinopathy.

Results: Approximately 20% of the sample reported a diagnosis of DR Increased age (AOR=2.19, 95% CI:0.69 -7.06), female gender (AOR=1.81, 95% CI:0.71-4.41), and increased total cholesterol (AOR=2.83, 95% CI:1.030-27.3), Increase in BMI (AOR=1.71, 95% CI:0.23-12.88), blood pressure (AOR=1.40, 95% CI:0.41-4.75), Physical activity (AOR=1.37, 95% CI:0.41-4.60) and Non- Hispanic White(AOR=1.32, 95% CI:0.37-4.67) were found to be associated with greater odds of diabetic retinopathy after controlling for covariates.

Conclusion: Though not statistically significant, diabetic retinopathy was related to elevated total cholesterol, high BMI, an increase in age, and duration of diabetes. This study warrants the need for powered research to inform their relationship because of the lack of statistically significant association between the selected risk factors of diabetes and the risk of diabetic retinopathy.

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By

CHIOMA AGBO

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by

CHIOMA AGBO

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ATLANTA, GEORGIA
30303

APPROVAL PAGE

FACTORS ASSOCIATED WITH DIABETIC RETINOPATHY AMONG US ADULTS 40 YEARS AND ABOVE WITH DIABETES

by

CHIOMA AGBO

Approved:

Dr Ike Okosun
Committee Chair

Dr Reynolds Morrison
Committee Member

December 15, 2020
Date

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Author’s Statement Page

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CHIOMA AGBO

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Table 4.2 Bivariate and multivariate association between diabetic retinopathy, sociodemographic, metabolic, and clinical characteristics

CHAPTER I

INTRODUCTION

1.1Background

Diabetes Mellitus is the seventh out of the top ten leading causes of morbidity and mortality in the United States. Globally, 463 million adults live with diabetes mellitus, and it has been projected that by 2030 there will be 578 million adults with diabetes and 700 million by 2045 (International Diabetes Federation, 2019). This global increase in the incidence of diabetes has an important impact on the prevalence of complications of diabetes, such as diabetic retinopathy. Almost half of the people living with diabetes are undiagnosed. They are at greater risk of diabetes-related complications due to inadequate control of diabetes, leading to severe health conditions, including diabetic retinopathy.

Diabetic retinopathy is a typical microvascular complication of diabetes mellitus. It is the third leading cause of all cases of blindness in the United States and the leading cause of new cases in adults. It is the leading cause of vision loss globally, affecting over 100 million people worldwide with 10,000 new vision loss every year in the US (Canto et al., 2019). The prevalence rate of diabetic retinopathy varies across countries. Diabetic retinopathy and other microvascular and macrovascular complications of diabetes cause considerable morbidity, mortality, and an enormous economic impact. Diabetic retinopathy and other microvascular complications are attributed to chronic hyperglycemia, vascular damage and leakage, edema, capillary basement member thickening, neovascularization, hemorrhage, and ischemia.

There are two categories of diabetic retinopathy: Proliferative diabetic retinopathy (PDR) and Non-proliferative diabetic retinopathy (NPDR). NPDR usually progresses into mild, moderate, and severe diabetic retinopathy. There are many risk factors associated with diabetic retinopathy, including a longer duration of diabetes, inadequate blood sugar control, and elevated Hemoglobin A1C (HbA1c) (Lachin et al., 2000). Additionally, the prevalence of coexisting conditions like hypertension, hyperlipidemia, and obesity in the general population are associated with risk factors for diabetic retinopathy (Liu *et al*., 2015). Understanding the role of manageable risk factors for diabetic retinopathy is critical for informing prevention interventions.

Obesity is a crucial health indicator that plays a pivotal role in developing many chronic conditions, including diabetes. Diabetic retinopathy is a systemic microvascular sequela of diabetes. Despite the documented research on diabetes and its associated risk factors for diabetic retinopathy, there is still limited data, especially in the United States. Several other studies have reported factors associated with diabetic retinopathy, but these studies were done in other countries, including Asia, Indian, Germany, etc. These studies' findings were inconclusive, which may be due to data collection, geographic, environmental, and nutritional factors associated with obesity and risk factors in the global populations. Hence, this study's principal aim is to carry out a most current survey on the relationship between the selected risk factors of diabetes and risk of diabetic retinopathy among U.S. adults 40 years and above with diabetes using NHANES 2017-2018.

1.2 Purpose of the Study

This study investigates the relationship between the selected risk factors of diabetes and the risk of diabetic retinopathy among US adults aged 40 years and above with diabetes.

1.3 Research Question

What are the factors that increase the likelihood of diabetic retinopathy in subjects with diabetes?

CHAPTER II

REVIEW OF LITERATURE

This section of the study reviews what is known about factors that are related to diabetes such as; duration of diabetes, age, race, high BMI, hypertension, elevated HbA1c, elevated total cholesterol, and other associated factors and their risk for diabetic retinopathy among diabetes. The relationship between diabetes-related factors and the risk of diabetic retinopathy remains inconclusive. Various studies report varying opinions, which may be due to the different methodology used, the environmental factors specific to the study area, and the low sample size for clinical analysis and anthropometric measurement.

The incidence and prevalence of diabetic retinopathy have been documented in previous research (Klein R et al., 2008, Sanders B et al., 2013). To understand the significance of age in the development of diabetic retinopathy, the Singapore Malay Eye Study conducted between 2004-2012 was reviewed. It was found that obese patients were less likely to have diabetic retinopathy (Rooney et al., 2015). The study was conducted on a multiethnic group in Singapore that included 10,033 Malay, Chinese, and Indian adults. Their results showed some association among the >65years age group who also had hypertension, had previously been diagnosed with diabetes, and those using insulin. This multiethnic study then concluded by reporting an inverse association between obesity and diabetic retinopathy, independent of age, insulin use, and duration of a diabetes diagnosis.

The rate of diabetic retinopathy varies across diverse populations. Racial and ethnic minorities are disproportionately affected by diabetes and its complications, including diabetic retinopathy. According to the study conducted by Harris *et al*.1998, these high-risk populations are not adequately screened or treated for this sight-threatening condition making it difficult to compare the risk for diabetic retinopathy in non-Hispanic whites, non-Hispanic blacks, and Mexican American adults with type 2 diabetes in the US. Harris et al. 1998 found that both Hispanics and non-Hispanic blacks have a higher prevalence of diabetic retinopathy than non-Hispanic whites. The rate was reported to be 84% higher in Hispanics and 46% higher in non-Hispanic blacks. They further linked the risk of diabetic retinopathy in people with diabetes associated with elevated systolic blood pressure, high level of HbA1c, poor glycemic control, and duration of diabetes. (Harris *et al*., 1998).

Furthermore, a literature review by Nsiah-Kumi et al. investigated disparities in diabetic retinopathy screening and disease for racial and ethnic minority populations. They found that the prevalence of vision-threatening diabetic retinopathy in diagnosed diabetes patients was 190% higher in non-Hispanic blacks and 130% higher in Hispanic American individuals than in non-Hispanic whites. However, the study suggested that the higher prevalence in both races might be due to inadequate glycemic control, less likelihood of being screened and treated for diabetic retinopathy, and less healthcare access.

Another study was conducted in Croatia by Kastelan *et al*. 2013, where 545 individuals with type2 diabetes were examined to determine whether obesity or other factors are associated with diabetic retinopathy. They found that the development of diabetic retinopathy in diabetes patients was highly severe among those with prolonged duration of diabetes and that diabetic retinopathy development had an association with duration of diabetes, BMI, HbA1c, hypertension, and high cholesterol level. The study showed that the development of diabetic retinopathy increased significantly with higher BMI. They suggested that high BMI in connection with hypertension, high cholesterol, and HbA1c were associated with diabetic retinopathy in type2 diabetes. They further stated that this might serve as a predictive factor for diabetic retinopathy in diabetes. (Kastelan et al., 2013).

A cross-sectional study was conducted in Saudi Arabia by Magliah S.F. *et al*. on the prevalence and risk factors of diabetic retinopathy in diabetes. An association was found between the duration of diabetes, hemoglobin A1c level, uncontrolled diabetes, hypertension, and age to be a risk factor for diabetic retinopathy. They also performed the chi-square statistical test, and they found that the duration of diabetes mellitus (p-value=0.005), HbA1c level (p-value=0.0005), uncontrolled diabetes (p-value=0.0005, hypertension(p-value=0.0005), and insulin treatment (p-value=0.0005) were all significantly associated with diabetic retinopathy.

Another study conducted by Sharma *et al.*2016, among 158 type-2 diabetes patients in India on the risk factors associated with diabetic retinopathy. Here, the duration of diabetes was also found to be significantly associated with diabetic retinopathy, and after Univariate analysis was carried out, the duration of diabetes (p-value<0.0001), HbA1c (p-value<0.001), associated hypertension (p-value<0.001) were found to be significant in the presence of diabetes. In the multivariate analysis, after controlling for other variables from the univariate model, the duration of diabetes (p-value=0.000) was once again found to be significantly associated with the presence of diabetic retinopathy (Sharma A. *et al.,* 2016).

A study conducted by Lima *et al*. among 222 diabetes individuals showed a significant association between the duration of diabetes and other risk factors in the diagnosis of diabetic retinopathy. The study used data for patients at an outpatient specialty clinic at the University of South Santa Catarina. In this study, those who had diabetes for 11-15 years had seven times greater odds of developing diabetic retinopathy than those who had the disease for a shorter duration. Those with longer diabetes duration (>15 years) had nine times greater chances of developing diabetic retinopathy. The bivariate analysis conducted showed an association between diabetic retinopathy and the following risk factors; HbA1c (>7%), the duration of diabetes for those who had diabetes for over 11 years, and Insulin use. After logistic regression, an association was lost with Insulin use, but diabetes duration and glycemic control maintained the association.

In another study conducted by Zelia in Brazil, 81 patients were selected to investigate the risk factors related to the severity of diabetic retinopathy. The analysis showed a strong association between the severity of retinopathy and the following: higher fasting blood sugar (p-value= 0.11), HbA1c (p-value=0.001), total serum cholesterol (p-value=0.019), and longer duration of diabetes. The study also reported no statistical correlation between the severity of diabetic retinopathy and age, high blood pressure, and triglycerides.

The relationship between diabetes-related factors and the risk of diabetic retinopathy remains inconclusive. Various studies report varying opinions, which may be due to the different methodology used, the environmental factors specific to the study area, and the low sample size for clinical analysis and anthropometric measurement.

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CHAPTER III

METHODS AND PROCEDURE

3.1 Data Source

The dataset used in this study was obtained from the 2017-2018 cycle of the National Health and Nutrition Examination Survey (NHANES), an open dataset from the National Center for Health Statistics. The NHANES is administered to a representative sample of U.S. non-institutionalized civilians. Data was collected through a questionnaire, a physical examination, and laboratory testing. The participants were interviewed in their homes while the physical examination and laboratory components were conducted in the Mobile Examination Center (MEC.). Diabetes diagnosis was based on responses to the following question: "Have you ever been told by a doctor that you have diabetes or sugar disease? " Participants who responded "Yes" were categorized as having diabetes.

3.2 Variables

3.21 Dependent variable

Diabetic retinopathy

Two NHANES questions were used to define diabetic retinopathy; (a) Has a doctor ever told you that you had Retinopathy? (b) Has diabetes affected your eye? Participants who responded yes to either question were classified as having Retinopathy.

3.22 Independent Variables

This study's independent variables include age, gender, race/ethnicity, education, health insurance, height, weight, fasting blood glucose, blood pressure, glycated hemoglobin, total cholesterol, smoking, and physical activity status. In NHANES, age, gender, race/ethnicity, health insurance, smoking, and physical activity status were bi participants' self-reports. Fasting blood glucose, total cholesterol, and HbA1c values were obtained by NHANES staff in the mobile examination unit. Blood pressure was also determined by NHANES staff in the mobile examination unit.

In this analysis, age was classified into 40-59years, 60-79years, and >80years. Gender was categorized as either male or female. Race/Ethnicity was recorded as either white, black, and others. Educational level was among the socioeconomic characteristics and was classified as either having less than high school or greater than high school. Health insurance was classified as a dichotomous outcome of "Yes or No." BMI was classified as normal/underweight (BMI $<25kg/mg^2$) and overweight/obese (BMI $>25kd/mg^2$). Blood Pressure was classified as "Yes or No" to the question; "has the doctor ever told you that you have hypertension"? In NHANES, fasting blood glucose was recorded in mg/dL and classified as having high fasting blood glucose if greater than or equal to 126 mg/dL and normal if less than 126mg/dl in this analysis. Total cholesterol was also measured in mg/dl in NHANES and classified as less than 240mg/dl and greater than or equal to 240mg/dl in this analysis. In this analysis, glycated HbA1c was measured in percent and classified as <6.5% and >6.5%.

The variables used to describe behavioral characteristics in this analysis were cigarette smoking and physical activity. A cigarette smoker was defined as an individual who responded "Yes" to the question if they had smoked up to 100 cigarettes in their lifetime. Physical activity was also noted by participants saying "Yes or No" to participating in moderate to vigorous physical activity.

3.3 Statistical Procedure

Statistical analysis was performed using SAS 9.4 software. To target for imbalance probabilities of selection, oversampling, and non-response, appropriate sample weights were used for these analyses. An estimate of the prevalence of diabetic retinopathy across other independent variables was determined. Chi-square and p-value were also used. The association between Diabetic retinopathy and other predictors was determined using the prevalence odds ratio from logistic regression.

CHAPTER IV

RESULTS

The final sample included 893 diabetes U.S. adults aged 40 years and older. About 18.8% of the sample were non-Hispanic white, and 22.6% were non-Hispanic black. Among the study sample, 18.9% were male, and the most common age group were those between 60-79 years old (20.0%). Nearly 19.0% of the sample were overweight/obese, and 19.95% had been diagnosed with diabetic retinopathy.

Table 1 presents the proportion of diabetic retinopathy by the various demographic and clinical characteristics. The proportion of diabetic retinopathy increased with age, from 23.7% among adults aged 40-59 years to 60.4% among 60-79 years and declined to 16.0% among those 80 years and older. Diabetic retinopathy proportion was higher in males than females (52.0% vs. 48.0%%). The prevalence of diabetic retinopathy among other races was (41.1%) higher than the non-Hispanic white (32.6%) and (26.3%) among non-Hispanic blacks. The percentage of diabetic retinopathy was 72.6% among those with high school education and 27.4% in those with less than high school.

Table 2 presents the result of the analysis of the association between diabetic retinopathy and various demographic and clinical characteristics. In the bivariate analysis, age, gender, total cholesterol, HbA1c, duration of diabetes, oral hypoglycemic medication, blood pressure, and physical activity were associated with increased odds of diabetic retinopathy.

After adjusting for all the independent variables, those aged 60-79 were two times more likely to have diabetic retinopathy (AOR=2.19, 95% CI:(0.69-7.06) than those between 40-59 years. Participants who had elevated total cholesterol (AOR=2.83, 95% CI:0.30-27.3), longer duration of diabetes (AOR=1.73, 95% CI:0.60-4.97), and high blood pressure (AOR=1.40, 95% CI:0.41-4.75) were found to be more likely to have diabetic retinopathy when compared to the various comparison groups. Similarly, females were more likely than males to have diabetic retinopathy (AOR=1.81, 95% CI:0.71-4.64). Non-Hispanic whites were also found to be more likely to have diabetic retinopathy than their counterparts (AOR=1.32, 95% CI:0.37-4.67). Those who were overweight/obese had greater odds of diabetic retinopathy (AOR:1.71, 95% CI: 0.23 - 12.88) compared to those with average weight. Participants who did not engage in physical activity were more likely to have diabetic retinopathy than those physically active (A.O.R.;1.37, 95% CI:0.41-4.60).

Table 1: Distribution Of demographic and clinical characteristics of study participants by diabetic retinopathy diagnosis status. (N=893)

	RETINOPATHY		
CHARACTERISTIC	YES n (%)	NO n (%)	P-VALUE
Age (in years) 40 - 59 60 - 79 ≥80	 40(23.7) 102(60.4) 27(16.0)	 187(28.3) 392(59.2) 83(12.5)	0.3222
Gender Male Female	 91(52.0) 84(48.0)	 387(55.1) 315(44.9)	0.4572
Race Others White Black	 72(41.1) 57(32.6) 46(26.3)	 292(41.6) 252(35.9) 158(22.5)	0.5203
Educational Level > High School < High School	 48(27.4) 127(72.6)	 187(27.1) 503(72.9)	0.9308
BMI ≤ 25kg/m² > 25kg/m²	 26(16.1) 136(84.0)	 80(12.2) 575(87.8)	0.1933
Fasting Blood Glucose mg/dl ≤ 126mg/dl > 126mg/dl	 27(33.8) 53(66.3)	 107(32.2) 225(67.8)	0.7943
HbA1c ≤ 6.5% > 6.5%	 42(26.1) 119(73.9)	 210(32.7) 435(67.4)	0.1131
Total Cholesterol mg/dl ≤ 240mg/dl > 240mg/dl	 143(89.9) 16(10.1)	 590(92.9) 45(7.09)	0.2076
Duration of Diabetes ≤ 10years > 10years	 49(56.3) 38(43.7)	 90(58.8) 63(41.2)	0.7059
Are you now taking oral hypoglycemic? Yes No	 126(72.0) 49(28.0)	 512(72.9) 190(27.1)	0.8038
Blood Pressure mmHg Yes No	 124(71.7) 49(28.3)	 475(68.3) 221(31.8)	0.3831
Age first told that you had diabetes. ≤ 40years > 40years	 48(27.4) 127(72.6)	 120(17.1) 582(82.9)	0.0019
Physical Activity Yes No	 27(15.5) 147(84.5)	 123(17.8) 569(82.2)	0.4818
Smoking Yes No	 80(45.7) 95(54.3)	 353(50.9) 341(49.1)	0.2233

Table 2: Bivariate and multivariate association between diabetic retinopathy, sociodemographic, metabolic, and clinical characteristics

CHARACTERISTIC	COR (95%)	AOR (95%)
Age (in years)		
40 - 59	REF	REF
60 - 79	1.22 (0.81 - 1.82)	2.19 (0.69- 7.06)
≥80	1.52 (0.88 2.64)	2.05 (0.37- 11.34)
Gender		
Male	REF	REF
Female	1.13 (0.81 - 1.58)	1.81 (0.71- 4.64)
Race		
Others	0.85 (0.56 - 1.29)	1.00 (0.30- 3.42)
White	0.78 (0.50 - 1.20)	1.32 (0.37- 4.67)
Black	REF	REF
Educational Level		
> High School	REF	REF
< High School	0.98 (0.68 - 1.43)	0.78 (0.30- 2.04)
BMI		
≤ 25kg/m²	REF	REF
> 25kg/m²	0.73 (0.45 - 1.18)	1.71 (0.23 -12.88)
Fasting Blood Glucose mg/dl		
≤ 126mg/dl	REF	REF
> 126mg/dl	0.93 (0.56 - 1.57)	0.68 (0.21- 2.15)
HbA1c		
≤ 6.5%	REF	REF
> 6.5%	1.37 (0.93 - 2.02)	0.50 (0.15- 1.69)
Total Cholesterol mg/dl		
≤ 240mg/dl	REF	REF
> 240mg/dl	1.47 (0.81 - 2.67)	2.83 (0.30- 27.3)
Duration of Diabetes		
≤ 10years	REF	REF
> 10years	1.11 (0.65 - 1.89)	1.73 (0.60 - 4.97)
Are you now taking oral hypoglycemic medication?		
Yes	REF	REF
No	1.05 (0.72 - 1.52)	0.36 (0.13 -1.02)
Blood Pressure mm/Hg		
Yes	1.18 (0.82 -1.70)	1.40 (0.41 -4.75)
No	REF	REF
Age first told that you have diabetes.		
≤ 40years	REF	REF
> 40years	0.55 (0.37 - 0.80)	0.35 (0.11 -1.11)
Physical Activity		
Yes	REF	REF
No	1.18 (0.75 - 1.85)	1.37 (0.41 4.60)
Smoking		
Yes	0.81 (0.58 1.13)	0.48 (0.18 -1.27)
No	REF	REF

CHAPTER V

DISCUSSION

This study investigated the association between selected independent variables and their risk of diabetic retinopathy in subjects with diabetes. Prevention and managing diabetic retinopathy is a fundamental goal of reducing blindness. Many epidemiological studies have been conducted on the relationship between diabetic retinopathy and several risk factors, but the results have been contradictory.

The findings of this study showed a 20% prevalence of diabetic retinopathy among the 893 diabetes participants. This study found that the prevalence odds of diabetic retinopathy increased with an increase in age, being a non-Hispanic white, being a female, elevated total cholesterol, high blood pressure, increase in the duration of diabetes, high BMI, and lack of physical activity.

This study's overall prevalence was consistent with a study conducted in Saudi Arabia by Al-Rubeaan et al. 2014, which reported a 19.7% prevalence of diabetic retinopathy. An increase in age and duration of diabetes were also found to be the most significant risk factors of diabetic retinopathy (OR=2.65, 95% CI:1.85-3.78), (OR=5.76, 95% CI;5-10-6.55). However, the study also found that high pressure is another risk factor for diabetic retinopathy. Another study by Al-Adsani et al. 2007 found that an increase in age is a risk factor for diabetic retinopathy.

This study found increased odds of diabetic retinopathy in high BMI, total cholesterol, high blood pressure, and duration of diabetes. These findings were consistent with the reports from the study conducted by Kastelan et al. 2013 in Croatia to investigate if BMI independently or in correlation with other risk factors are associated with diabetic retinopathy progression. They found that high blood pressure, total cholesterol, elevated glycosylated hemoglobin A1c, and BMI were statistically significant with diabetic development. However, this study was unable to find HbA1c association with diabetic retinopathy.

Regarding hypertension, this study found high blood pressure with increased odds of diabetic retinopathy. The findings of this study are in line with those of the study conducted by Jin et al. 2014, to determine the rate and risk factors of diabetic retinopathy. They found that hypertension is an independent risk factor associated with diabetic retinopathy. Their data indicated that participants with high blood pressure were more likely to be diagnosed with diabetic retinopathy (OR=1.80, 95% CI;1.14-2.86, P=< 0.01). This finding is consistent with previous research conducted in different populations (UKPDS, Joanne, et al., 2012). The United Kingdom Prospective Diabetes Study (UKPDS) and Appropriate Blood Pressure Control in Diabetes (ABCD Study) found that strict blood pressure control can slow down DR and visual loss progression and progression. On the other hand, Western studies such as VanLeiden et al. 2002, and Dirani et al. 2011 have reported an association between higher BMI and the risk of Diabetic retinopathy. The different findings from the studies and the results of this study give room for more research.

Good glycemic and hypertensive management highly reduces the risk of diabetic retinopathy and other microvascular complications of diabetes. It is the best available management intervention to prevent or reduce the development and progression of diabetic retinopathy. (Turner, R., Cull, C., & Holman, R., 1996). In addition to these, other risk factors discovered in this study for diabetic retinopathy, obesity intervention should be put in place because of its interrelationship with many chronic diseases in which diabetes and its complications are included.

Additionally, lack of physical activity was found to be related to diabetic retinopathy in this study. Physical activity and weight loss programs as lifestyle intervention factors show a relationship between high BMI and diabetic retinopathy. However, weight loss has been seen to delay diabetic complications, including diabetic retinopathy (Khavandi. et al., 2013). Yes, this study has found a more likely relationship between physical inactivity and diabetic retinopathy risk. Lifestyle interventions like weight loss and physical activity have been advocated as a critical factor in preventing diabetes and delaying its complications, especially diabetic retinopathy (Cheung, N., & Wong, T. Y. (2007).

Furthermore, this study's main finding has shown that high BMI, high blood pressure, total cholesterol, age, duration of diabetes, and lack of physical inactivity are independent risk factors for diabetic retinopathy.

5.1 Strength and Limitation of the study

This study's strength is using the right well-known, examined secondary data from NHANES 2017-2018 dataset. As this study is cross-sectional, it does not allow causal effect but only the association. The study's limitation is the self-reported or recall bias from the responses used in diagnosing the diabetic retinopathy from questionnaires interviews: Ever told by a doctor that diabetes has affected your eyes, or you had retinopathy? Screening and testing the retinal image would have been better to be genuinely diagnostic. Another limitation is that NHANES data provided a nationally representative sample, but the results might not represent the general population due to the sampling methods. Additionally, interpretation of this study result should be made with caution due to the lack of confounding variables such as diet, alcohol, triglyceride, and HDL-cholesterol, which were not examined. Furthermore, a relatively small number of individuals with diabetic retinopathy (n=162) resulted in high imprecision of our estimate.

5.2 Conclusion

Though not statistically significant, diabetic retinopathy was related to elevated total cholesterol, high BMI, an increase in age, and duration of diabetes. The lack of statistically significant association between diabetic retinopathy and risk factors in this study warrants the need for powered research to inform their relationship. Understanding the association between diabetic retinopathy and its risk factors can inform a more appropriate public health intervention to reduce diabetic retinopathy risk among diabetic patients.

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