Preventive Medicine Reports 2 (2015) 591–594

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: http://ees.elsevier.com/pmedr

Concurrent healthy behavior adoption and diabetic retinopathy in the United States

Paul D. Loprinzi *

Center for Health Behavior Research, Department of Health, Exercise Science, and Recreation Management, The University of Mississippi, 229 Turner Center, University, MS 38677, United States

ARTICLE INFO

Available online 18 July 2015

Keywords:
Epidemiology
Diabetes
Diet
Physical activity
Retinopathy

ABSTRACT

Objective. Emerging work suggests an independent association of physical activity and healthy eating on diabetic retinopathy. No study, however, has examined whether physical activity and healthy eating have an additive and/or additive interaction effect on diabetic retinopathy.

Methods. Data from 2005–2006 NHANES were used (N = 223). Physical activity was assessed via accelerometry; healthy eating was assessed from an interview with the Healthy Eating Index calculated to represent healthy eating; and diabetic retinopathy was assessed from the Canon Non-Mydratic Retinal Camera CR6-45NM.

Results. Physical activity (OR = 0.70, p = 0.42) and healthy eating (OR = 0.36, p = 0.16) were not independently associated with moderate-to-severe retinopathy. However, individuals with both health behaviors, compared to none, had a reduced odds of moderate-to-severe retinopathy (OR = 0.03, p = 0.02). Further, the attributable proportion (AR = 0.57, 95% CI 0.02–1.12, p < 0.05) was significant, suggesting that a significant proportion of retinopathy may be attributed to the additive interaction between inactivity and unhealthy eating.

Conclusion. The concurrent presence of physical activity and healthy eating was associated with reduced odds of diabetic retinopathy, with the additive interaction effects suggesting that this observed association is more than summation.

Introduction

Emerging research suggests that regular participation in physical activity may be associated with reduced odds of having diabetic retinopathy (Dirani et al., 2014; Loprinzi et al., 2014a), as well as other ocular-related parameters, such as visual impairment (Loprinzi et al., 2014b) and age-related macular degeneration (Loprinzi et al., 2015; Knudtson et al., 2006). Although the mechanisms are unknown at this point, potential reasons to explain this potential relationship include physical activity-induced modulation of parameters (e.g., glycemic control and blood pressure) known to increase the risk of developing diabetic retinopathy (Ding & Wong, 2012). Through similar potential mechanisms, emerging work is also demonstrating that the broad consumption of a healthy diet (e.g., greater adherence to dietary guidelines) is associated with reduced odds of diabetic retinopathy (Cundiff & Nigg, 2005; Mahoney & Loprinzi, 2014). (See Tables 1 and 2.)

Taken together, this emerging work suggests that both physical activity and healthy eating are associated with diabetic retinopathy. Although it is plausible to suggest that physical activity and diet would have an additive and/or additive interaction effect on diabetic retinopathy, no studies to date have examined this possibility, but rather, just examined their independent effects. As a result, the purpose of this study was to examine the potential additive and additive interaction effects of physical activity and healthy eating on the odds of diabetic retinopathy.

Methods

Study design and participant

Data were restricted to the 2005–2006 NHANES cycle because this is the only wave with objectively-measured physical activity (i.e., accelerometry) and retinopathy data. The NHANES is an ongoing survey conducted by the Centers for Disease Control and Prevention that uses a representative sample of non-institutionalized United States civilians selected by a complex, multistage, stratified, clustered probability design. In brief, participants were interviewed in their homes and then subsequently examined in a mobile examination center (MEC) by NHANES personnel. Further details about NHANES can be found elsewhere. NHANES study procedures were approved by the National Center for Health Statistics ethics review board, with informed consent obtained from all participants prior to data collection.

In the 2005–2006 NHANES, 521 participants had a physician diagnosis of diabetes, with 513 providing data on their diabetes duration. Only those ≥40 yrs were eligible for retinopathy assessment, which included 461 adults above or equal to this age. Among these 461 participants, 347 provided retinopathy data. After excluding participants with missing

* Fax: +1 662 915 5525.
E-mail address: pdloprin@olemiss.edu.

http://dx.doi.org/10.1016/j.pmedr.2015.07.002

Table 1
Weighted characteristics of the analyzed sample of U.S. diabetics, NHANES 2005–2006 (N = 223).

Variables	Mean/proportion (95% CI)
Non-proliferative diabetic retinopathy, %	
No retinopathy	63.3 (56.6–70.1)
Mild retinopathy	24.5 (20.6–28.4)
Moderate-to-severe retinopathy [a]	12.1 (7.1–17.1)
Health behaviors, mean	
Total MVPA, min/day	11.07 (8.08–14.06)
Mean MVPA for those ≥60th percentile	21.3 (17.1–25.5)
Mean MVPA for those <60th percentile	2.8 (2.4–3.1)
HEI	57.4 (55.8–58.9)
Mean HEI for those ≥60th percentile	67.4 (65.6–69.2)
Mean HEI for those <60th percentile	49.7 (48.3–51.1)
Concurrent healthy behavior index, mean	0.88 (0.75–1.00)
% 0 health behaviors	32.7 (27.6–37.9)
% 1 health behaviors	46.4 (40.1–52.6)
% 2 health behaviors	20.8 (12.6–28.9)
Age, yr	62.6 (60.5–64.6)
Race-ethnicity, %	
Mexican American	7.7 (3.5–12.0)
Non-Hispanic White	67.9 (58.2–77.7)
Non-Hispanic Black	16.2 (8.6–23.8)
Other	8.0 (1.7–14.2)
Gender, %	
Male	46.3 (37.5–55.1)
Female	53.6 (44.8–62.4)
Coronary heart disease, %	12.5 (7.4–17.7)
Stroke, %	10.4 (6.0–14.8)
Hypertension, %	65.1 (57.7–72.4)
Cotinine, ng/mL	37.2 (24.1–50.2)
Vision, logMAR	0.59 (0.39–0.78)
HgbA1c, %	6.95 (6.6–7.2)
Total cholesterol, mg/dL	188.4 (179.5–197.3)
BMI, kg/m^2	32.3 (30.9–33.8)
Diabetes duration, yrs	10.0 (8.3–11.6)

MVPA = moderate-to-vigorous physical activity.
HEI = Healthy Eating Index.
[a] As noted in the methods section, the 5 participants who had proliferative retinopathy were recoded into the moderate-to-severe non-proliferative group.

Table 2
Polytomous model describing the association between the Health Behavior Index[b] variable (independent variable) and the presence of either mild or moderate/severe diabetic retinopathy, compared to no retinopathy, NHANES 2005–2006 (N = 223).

Health Behavior Index [b]	Odds ratio (95% CI) [a]	
	Mild NPDR	Moderate-to-severe NPDR
1 vs. 0	0.28 (0.07–1.13)	0.84 (0.17–4.07)
2 vs. 0	0.61 (0.10–3.40)	**0.03 (0.02–0.60)**
Covariates		
Age, 1 yr	1.01 (0.98–1.05)	0.96 (0.92–1.01)
Race-ethnicity		
Mexican American vs. Non-Hispanic White	1.12 (0.22–5.63)	0.59 (0.03–9.29)
Non-Hispanic Black vs. Non-Hispanic White	0.96 (0.28–3.28)	1.02 (0.21–4.89)
Other vs. Non-Hispanic White	1.62 (0.41–6.34)	0.49 (0.04–4.87)
Female vs. male	0.47 (0.18–1.21)	**0.29 (0.09–0.92)**
Coronary heart disease vs. none	1.50 (0.29–7.69)	1.09 (0.27–4.40)
Stroke vs. no stroke	1.11 (0.13–9.03)	0.88 (0.16–4.67)
Hypertension vs. none	1.77 (0.66–4.69)	1.25 (0.33–4.71)
Cotinine, 1 ng/mL	1.00 (0.99–1.00)	1.00 (0.99–1.01)
Vision, 0.1 logMAR units	0.96 (0.53–1.74)	**1.45 (1.01–2.08)**
HgbA1c, 1%	**1.73 (1.19–2.52)**	**2.26 (1.33–3.82)**
Total cholesterol, 1 mg/dL	0.99 (0.98–1.01)	0.99 (0.98–1.01)
BMI, 1 kg/m^2	0.99 (0.92–1.06)	1.03 (0.96–1.12)
Diabetes duration, 1 yr	1.07 (0.98–1.17)	**1.08 (1.00–1.17)**

HgbA1c = hemoglobin A1C.
logMAR = logarithm of the minimum angle of resolution.
NPDR = non-proliferative diabetic retinopathy.
Bold = statistical significant association ($p < 0.05$).
[a] Not having diabetic retinopathy served as the referent group. All results are weighted.
[b] Participants were classified as having 0–2 positive health behaviors by summing the number of health behaviors they had, with having a positive health behavior being defined as at or above the 60th percentile for that behavior; for example those above the 60th percentile for both HEI (healthy eating index) and MVPA (moderate-to-vigorous physical activity) were considered to have 2 positive health behaviors.

data on the covariates, 319 remained. After excluding those with missing dietary data, 312 remained. Lastly, after excluding those with insufficient accelerometry data (<4 days or 10+ h/day of monitoring), 223 participants remained, which constituted the analytic sample.

Previous studies have shown that adults with invalid accelerometry data have different demographic, behavioral and health characteristics than their counterparts who provide valid accelerometry data (i.e., wear the monitor for at least 4 days of 10+ h/day) (Loprinzi et al., 2013). When comparing the 89 participants who were excluded due to missing or insufficient accelerometry data to the 223 analyzed participants, there were no differences in any of the study variables with the exception of age and body mass index (BMI); excluded participants were younger (59.9 yrs vs. 64.1 yrs, $p = 0.001$) and had a higher BMI (32.9 kg/m^2 vs. 31.1 kg/m^2, $p = 0.04$). These are unweighted estimates.

Assessment of diabetic retinopathy

Participants aged 40 years and older were eligible for the retinal imaging exam unless they were unable to see light with both eyes open or had an eye infection. Detailed procedures of the retinal imaging exam performed in the NHANES 2005–2006 cycle can be found elsewhere (Zhang et al., 2010). Briefly, retinal imaging was performed using the Canon Non-Mydratic Retinal Camera CR6-45NM (Canon, Tokyo, Japan). Two forty-five degree non-mydriatic digital images were obtained on both eyes. Diabetic retinopathy was defined as the presence of 1 or more retinal microaneurysms or retinal blot hemorrhages using the Early Treatment Diabetic Retinopathy Study (ETDRS) grading criteria, and was further classified as *no retinopathy*, *mild non-proliferative retinopathy*, *moderate-to-severe non-proliferative retinopathy*, *or proliferative retinopathy* according to ETDRS standards applied to the worse eye. Notably, after exclusions, only 5 participants had proliferative retinopathy. Analyses were computed when these 5 participants were excluded and when they were collapsed into the moderate-to-severe non-proliferative group. Results were similar (data not shown); therefore, results are presented with these 5 participants included into the moderate-to-severe non-proliferative group.

Measurement of physical activity

While attending the MEC, participants were instructed to wear an ActiGraph 7164 accelerometer during all activities, except water-based activities and while sleeping. The accelerometer measured the frequency, intensity, and duration of physical activity by generating an activity count proportional to the measured acceleration. Detailed information on the ActiGraph accelerometer can be found elsewhere (Chen & Bassett, 2005). Estimates for moderate-to-vigorous physical activity (MVPA) were summarized in 1-minute time intervals. Activity counts/min greater than or equal to 2020 were classified as MVPA (Troiano et al., 2008). For the analyses described here, and to represent habitual physical activity patterns, only those participants with activity patterns for at least 4 days of 10 or more hours per day of monitoring data were included in the analyses (Troiano et al., 2008). To determine the amount of time the monitor was worn, nonwear was defined by a period of a minimum of 60 consecutive minutes of zero activity counts, with the allowance of 1–2 min of activity counts between 0 and 100 (Troiano et al., 2008).

The SAS (version 9.2) was used to reduce the accelerometry data using the SAS code provided the National Cancer Institute. Using the SAS code, the average time each participant spent per day in physical activity was analyzed from valid individual data.