Journal of Epidemiology and Public Health (2024), 09(01): 129-137
Masters Program in Public Health, Universitas Sebelas Maret

Research

Open Access

Using Trends in Biometric Data to Predict Interest in Enrolling in an Employer-Sponsored National Diabetes Prevention Program Focusing on Diet and Exercise: A Retrospective Cohort Study

Victoria Zigmont[1,2)], Abigail Shoben[3)], Gail Kaye[4)], Steven Clinton[5)], Randall Harris[2)], Susan Olivo-Marston[2,6)]

[1)]Department of Health, Exercise Science and Recreation Management, University of Mississippi, USA
[2)]Division of Epidemiology, College of Public Health, The Ohio State University, USA
[3)]Division of Biostatistics, College of Public Health, The Ohio State University, USA
[4)]Division of Health Promotion, College of Public Health, The Ohio State University, USA
[5)]Department of Internal Medicine, Division of Medical Oncology, College of Medicine, The Ohio State University, USA
[6)]Medical Microbiology, Immunology and Cell Biology Springfield, Southern Illinois University School of Medicine, USA

Received: 4 August 2023; Accepted: 30 October 2023; Available online: 16 January 2024

ABSTRACT

Background: Evidence-based lifestyle programs including the Diabetes Prevention Program can delay an individual's risk of developing type 2 diabetes. Identifying which individuals are less likely to enroll in these programs and tailoring recruitment approaches to encourage participation among those with perceived barriers is an effective strategy to increase engagement in health promotion. This study aimed to identify the pre-enrollment differences in biometric trends between individuals with prediabetes who did and did not express interest in free worksite diabetes prevention program.
Subjects and Method: This retrospective cohort study was conducted among individuals in the Midwest enrolled in a private insurance plan from 2011 to 2014. Data was combined from annual bio metric screenings and a health survey. Demographic characteristics were summarized for the study population (n=2,066). The dependent variable for this study was interest in the DPP, while the independent variables included body mass index, waist circumference, body weight, lipid measurements, and blood pressure. Linear mixed models with random intercepts were used to compare biometric trajectories for body mass index, waist circumference, body weight, lipid measurements (triglycerides and cholesterol), and blood pressure for the two groups.
Results: No differences were observed in biometric trends for those who did and did not choose to enroll in the free worksite program.
Conclusion: Examining pre-enrollment biometric trend data is a relatively novel approach to evaluating engagement in health programs. More research is needed to understand how this information can be used to identify an individual's interest in enrolling in health programming.

Keywords: Diabetes mellitus, diabetes prevention, worksite health, health promotion, prediabetes, biometric data

Correspondence:
Victoria Zigmont. Department of Health, Exercise Science and Recreation Management, University of Mississippi. 642 All-American Drive (Suite-215 Turner Center), USA, MS 38677. Email: VZigmont42@gmail.com. Mobile: 203-561-0683.

Cite this as:
Zigmont V, Shoben A, Kaye G, Clinton S, Harris R, Olivo-Marston S (2024). Using Trends in Biometric Data to Predict Interest in Enrolling in an Employer-Sponsored National Diabetes Prevention Program Focusing on

Diet and Exercise: A Retrospective Cohort Study. J Epidemiol Public Health. 09(01): 129-137. https://doi.org-/10.26911/jepublichealth.2024.09.01.12.

BACKGROUND

Employer-sponsored health programming provides employees with opportunities to improve their health, thus reducing healthcare costs (Baicker et al., 2010; Tice et al., 2016). Employer-based biometric screening has become a common approach to maximize the return on investment by identifying which individuals would benefit from specific wellness programming. Type II diabetes mellitus (T2DM) affects over 34 million Americans (US Department of Health and Human Services, 2020). The evidence-based Diabetes Prevention Program lowers the risk of T2DM for individuals with prediabetes through the adoption of healthy lifestyle behaviors (The Diabetes Prevention Program Research Group, 1999).

The National DPP is currently being implemented in worksite settings across the country, yet it is unclear if individuals expressing interest in these programs are those who would most benefit. Evaluating the reach of health programs identifies if patients who enroll are different than those who do not enroll (Beck et al., 2016; Ritchie et al., 2017; Taradash et al., 2015; Venkataramani et al., 2019; Zigmont et al., 2017).

Based on preliminary studies, there is no previous studies have examined program reach using biometric risk trajectories. The health belief model (Janz and Becker, 1984; Joiner et al., 2022), posits that individuals who consider their biometric values to put them at risk (increased perceived susceptibility and severity), are more likely to engage in health-promoting behaviors. Being in a structured program may increase knowledge, skills, and self-efficacy to adopt positive health behaviors. As employer-sponsored health insurance programs require their employees to complete annual biometric screening, it is currently unclear what utility this longitudinal data could contribute to enrolling and engaging participants in health programming. The objective of this study was to identify differences in biometric risk trajectories between individuals with prediabetes who did and did not express interest in enrolling in a free worksite diabetes prevention program. We hypothesized that individuals with declining biometric trajectories would be more likely to enroll in the free diabetes prevention program, and males may require larger declining changes than females to enroll in the program. The goal of this study was to understand the utility of biometric screening data to identify groups who were likely to enroll in the free diabetes prevention program.

SUBJECTS AND METHOD

1. Study Design

This is a retrospective cohort study that was conducted among individuals in the Midwest enrolled in a private insurance plan from 2011 to 2014.

2. Population and Sample

This study sample and the data sources were previously described(Zigmont et al., 2017). This cohort was limited to health plan participants (employees and spouses) who were enrolled in a health plan for 6 months or more, were at least 18 years old, and participated in the 2014 biometric screening. The study was restricted to individuals with prediabetes using glycosylated hemoglobin levels between 5.7 to 6.4 and a body mass index of at least 24 (CDC, 2015). Participants were excluded from the study if they had a previous diagnosis of T2DM. Glycosylated hemoglobin was measured in 2013 and 2014. Individuals with prediabetes who met the diabetes prevention program inclusion criteria in 2014 discussed their test results with a healthcare provider and received mailed and in-person recruitment materials for the free work site program as well as up to two phone calls encouraging them to participate in the diabetes prevention program. The program was advertised to employees on the company intranet and around the work site. Diabetes prevention program interest was quantified using a list of patients who contacted the worksite diabetes prevention program office to enroll in the program.

3. Study Variables

A health survey was used to collect information about participants' demographic characteristics, including age, gender, Race/ethnicity, and education level. Annual biometric measurements were collected from 2011 to 2014 and included body mass index, waist circumference, body weight, systolic and diastolic blood pressures, lipids, and cholesterol (high-density lipoprotein, low-density lipoprotein, and total cholesterol) levels.

4. Definition Operational of Variables

Interest in the diabetes prevention program: was dichotomized as interested or not interested in the program.

Biometric data: information resulting from the measurement or analysis of physical characteristics including BMI (Body Mass Index) waist circumference (inches), body weight (pounds), systolic and diastolic blood pressures, and lipids (triglyceride) and cholesterol HDL (high-density lipoprotein), LDL (low-density lipoprotein) and total cholesterol levels were analyzed as continuous variables. Measurement dates were included to account for changes over time.

5. Study Instruments

The health survey asked participants to provide their date of birth, gender, and Race/ethnicity. Education level was also obtained by asking participants to indicate the highest level of education they completed. The biometric screening data included measurements for height, body weight, waist circumference, blood pressure (SBP and DBP), lipids (triglycerides and cholesterol), and glycosylated hemoglobin. Height was measured using a stadiometer and recorded in inches. Weight was measured using a high-capacity scale (Siltec; Bradford, Massachusetts) and recorded in pounds. Body mass index was calculated using the CDC guidelines.

Blood pressure was measured from a sitting position using an automated blood pressure cuff. For abnormal readings, the blood pressure measurement was repeated with a manual cuff, and the new measurement was recorded. Waist circumference was measured in inches using a flexible tape measure. A blood sample was obtained via a finger-stick and then used for both lipid, cholesterol, and glycosylated hemoglobin testing. The "CardioCheck System" test (Polymer Technical Systems, Indianapolis, Indiana) was used to obtain total cholesterol, HDL cholesterol, LDL cholesterol, and triglyceride values. HbA1c results were obtained using the "Bayer A1C Now" test (Bayer HealthCare LLC, Diabetes Care, Tarrytown, New York). Quality controls were used to ensure that the test values obtained were accurate and precise.

6. Data Analysis

Demographic characteristics (age, gender, Race/ethnicity, and education level) were summarized for participants using the mean and standard deviation for normally distributed continuous variables, and percentages for categorical variables. Biometric measurements were evaluated to test if there was a difference in biometric trends over time-based on group membership. A power calculation and adjustment for multiple tests were not provided due to the hypothesis-generating and exploratory nature of this study. Linear mixed models with a random intercept were fit, time was modeled categorically (time of follow-up), and the outcome variable was the biometric measurement. To examine the effect of time, the multivariate Wald test was used to test the significance of the interaction terms (group and time) in the full model. SAS version 9.4(Cary, NC: SAS Institute Inc.) and Stata 14 (StataCorp. 2015. College Station, TX) were used.

7. Research Ethics

IRB approval was obtained at the university and hospital where this research was conducted. [This study was approved by the Institutional Research Board at OhioHealth (OhioHealth IRB# OH1-15-0599; Federalwide Assurance#:FWA00014752) and Ohio State University (Federalwide Assurance #: FWA00006378) ceded review to OhioHealth's IRB].

RESULTS

1. Sample Characteristics

A total of 2,066 individuals met the inclusion criteria for this study and 217 (10%) were interested in the diabetes prevention program. The average participant age was 50.19 (SD=10.64), and the majority of participants were female (63.2%). The ethnic distribution was comprised of 79.4% White, 15.6% Black or African-American, and 5% other ethnicities. Education levels in the sample included those who had completed high school or less (16%), some college (42.6%), college graduates (27.7%), and post-graduates (13%).

2. Longitudinal Analysis

The longitudinal analysis did not observe any significant differences in the biometric trajectories based upon group membership for adiposity (body mass index (BMI), body weight or waist circumference), cholesterol (total cholesterol, LDL cholesterol, or HDL cholesterol), blood pressure (SBP or DBP) or triglycerides. Overall, there was a pattern of those interested in the DPP having less healthy biometric values for BMI, total LDL, and HDL cholesterol. Table 1 shows Differences in biometric trends between those interested and not interested in enrolling in the DPP overall and stratified by gender. Figure 1 shows annual biometric trends for average BMI, body weight, waist circumference, total cholesterol, LDL cholesterol, HDL cholesterol, systolic BP, diastolic BP, and triglycerides over time for those who were and were not interested in the DPP. Although these patterns were visually apparent, they were not statistically significant.

Table 1. Differences in biometric trends between those interested (I) and not interested (NI) in enrolling in the DPP overall and stratified by gender

Biometric Measure	Measures	Years				p
		2011	2012	2013	2014	
Body Mass Index						
Overall	I/N	136/1090	158/1235	166/1441	225/2067	0.986
	Difference	0.85	0.95	0.92	0.89	
	95% CI	(-0.09 to 1.79)	(0.03 to 1.88)	(0.00 to 1.84)	(0.00 to 1.78)	
Males	I/N	19/394	26/453	28/533	40/808	0.776
	Difference	-0.69	-0.49	-0.37	-0.16	
	95% CI	(-2.55 to 1.16)	(-2.28 to 1.30)	(-2.14 to 1.41)	(-1.87 to 1.55)	
Females	I/N	117/696	132/782	138/908	185/1259	0.469

Biometric Measure	Measures	Years 2011	2012	2013	2014	p
	Difference	1.15	0.91	0.67	0.83	
	95% CI	(0.08 to 2.23)	(-0.15 to 1.97)	(-0.39 to 1.73)	(-0.19 to 1.86)	
Body Weight						
Overall	I/N	136/1090	158/1235	166/1441	225/2067	
	Difference	0.24	-0.59	-0.54	0.61	0.730
	95% CI	(-6.15 to 6.64)	(-6.93 to 5.75)	(-6.86 to 5.77)	(-5.62 to 6.83)	
Males	I/N	19/394	26/453	28/533	40/808	
	Difference	-1.84	-2.09	-1.50	0.80	0.738
	95% CI	(-16.18 to 12.49)	(-16.13 to 11.95)	(-15.46 to 12.47)	(-12.90 to 14.50)	
Females	I/N	117/696	132/782	138/908	185/1259	
	Difference	7.17	6.18	6.05	6.74	0.882
	95% CI	(0.17 to 14.18)	(-0.78 to 13.14)	(-0.87 to 12.98)	(-0.10 to 13.57)	
Waist Circumference						
Overall	I/N	129/998	153/1158	158/1355	217/1965	
	Difference	0.26	-0.06	0.30	0.47	0.595
	95% CI	(-0.74 to 1.27)	(-1.03 to 0.90)	(-0.65 to 1.26)	(-0.42 to 1.36)	
Males	I/N	18/352	26/428	27/497	38/755	
	Difference	-0.47	-0.28	0.65	0.72	0.494
.	95% CI	(-2.75 to 1.81)	(-2.36 to 1.79)	(-1.40 to 2.70)	(-1.16 to 2.59)	
Females	I/N	111/646	127/730	131/858	179/1210	
	Difference	0.75	0.40	0.58	0.78	0.838
	95% CI	(-0.41 to 1.90)	(-0.72 to 1.52)	(-0.53 to 1.69)	(-0.25 to 1.81)	
Total Cholesterol						
Overall	I/N	127/1100	158/1236	166/1444	224/2064	
	Difference	2.94	1.62	2.51	0.34	0.758
	95% CI	(-3.17 to 9.04)	(-4.26, 7.50)	(-3.27 to 8.29)	(-4.97 to 5.66)	
Males	I/N	19/399	26/454	28/536	40/807	
	Difference	-1.88	-0.83	-3.67	-7.52	0.701
.	95% CI	(-16.62 to 12.87)	(-14.31 to 12.65)	(-16.84 to 9.50)	(-19.37 to 4.33)	
Females	I/N	118/701	132/782	138/908	184/1257	
	Difference	3.05	0.44	2.27	-1.17	0.469
	95% CI	(-3.76 to 9.86)	(-6.17 to 7.05)	(-4.24 to 8.77)	(-7.18 to 4.84)	
LDL-Cholesterol						
Overall	I/N	135/1095	158/1235	166/1441	214/1987	
	Difference	2.49	0.92	2.27	0.68	0.804
	95% CI	(-2.79 to 7.77)	(-4.16 to 5.99)	(-2.71 to 7.26)	(-3.98 to 5.33)	
Males	I/N	19/396	26/454	28/534	36/777	
	Difference	-1.36	-3.08	-4.09	-5.22	0.924
.	95% CI	(-14.04 to 11.32)	(-14.73 to 8.57)	(-15.49 to 7.30)	(-15.81 to 5.37)	
Females	I/N	116/699	132/781	138/907	178/1210	
	Difference	3.85	1.73	3.86	1.37	0.643
	95% CI	(-2.09 to 9.79)	(-4.02 to 7.48)	(-1.79 to 9.52)	(-3.92 to 6.65)	
HDL-Cholesterol						
Overall	I/N	137/1100	158/1236	166/1444	224/2066	
	Difference	2.23	2.22	1.45	0.84	0.347
	95% CI	(-0.20 to 4.66)	(-0.14 to 4.58)	(-0.88 to 3.78)	(-1.35 to 3.03)	
Males	I/N	19/399	26/454	28/536	40/807	
	Difference	0.95	-2.39	-1.96	-3.00	0.301
.	95% CI	(-4.00 to 5.89)	(-6.97 to 2.18)	(-6.44 to 2.53)	(-7.10 to 1.10)	
Females	I/N	118/701	132/782	138/908	184/1259	
	Difference	-0.28	0.21	-0.71	-1.64	0.319
	95% CI	(-2.99 to 2.42)	(-2.43 to 2.85)	(-3.32 to 1.90)	(-4.09 to 0.80)	
Systolic Blood Pressure						
Overall	I/N	134/1090	158/1224	166/1439	225/2066	
	Difference	1.33	0.78	0.64	-1.61	0.096
	95% CI	(-1.22 to 3.88)	(-1.62 to 3.17)	(-1.71 to 2.98)	(-3.68 to 0.45)	
Males	I/N	19/395	26/445	28/533	40/808	0.063

Biometric Measure	Measures	Years				p
		2011	2012	2013	2014	
	Difference	4.70	3.47	3.24	-2.98	
.	95% CI	(-1.79 to 11.19)	(-2.23 to 9.18)	(-2.35 to 8.84)	(-7.81 to 1.74)	
Females	I/N	115/695	132/779	138/906	185/1258	
	Difference	1.92	1.45	1.25	0.12	0.612
	95% CI	(-0.84 to 4.68)	(-1.18 to 4.07)	(-1.32 to 3.82)	(-2.16 to 2.40)	
Diastolic Blood Pressure						
Overall	I/N	134/1090	158/1224	166/1439	225/2066	
	Difference	-0.27	-1.14	-0.36	-1.76	0.294
	95% CI	(-1.98 to 1.43)	(-2.74 to 0.45)	(-1.91 to 1.20)	(-3.12 to -0.40)	
Males	I/N	19/395	26/445	28/533	40/808	
	Difference	-0.72	-0.12	2.13	-4.38	0.007
.	95% CI	(-4.82 to 3.38)	(-3.72 to 3.51)	(-1.36 to 5.62)	(-7.38 to -1.39)	
Females	I/N	115/695	132/779	138/906	185/1258	
	Difference	0.70	-0.41	-0.12	-0.32	0.758
	95% CI	(-1.20 to 2.60)	(-2.20 to 1.38)	(-1.87 to 1.63)	(-1.85 to 1.22)	
Triglycerides						
Overall	I/N	137/1097	158/1227	166/1439	224/2060	
	Difference	-10.46	-5.82	-8.52	-2.57	0.557
	95% CI	(-23.16 to 2.23)	(-18.00, 6.36)	(-20.46, 3.41)	(-13.38, 8.25)	
Males	I/N	19/397	26/448	28/532	40/803	
	Difference	-8.79	28.78	8.39	8.27	0.183
.	95% CI	(-43.25 to 25.67)	(-2.45 to 60.01)	(-22.03 to 38.82)	(-18.80 to 35.33)	
Females	I/N	118/700	132/779	138/907	184/1257	
	Difference	-5.30	-7.80	-7.01	-1.07	0.669
	95% CI	(-18.51 to 7.91)	(-20.58 to 4.98)	(-19.54 to 5.51)	(-12.44 to 10.30)	

I/N = n interested/ n not interested

3. Differences in Gender

After stratifying by gender, a difference was observed in the rate of change in DBP blood pressure for males based on program interest (p=0.007) (Table 1 and Figure 2). Figure 2 in this study shows annual biometric trends by gender for participants who were and were not interested in the DPP by gender over time. Several patterns were observed; however, none were statistically significant. Males interested in the DPP appeared to also have higher SBPs, however, these differences were not statistically significant. There were no statistically significant differences observed for the other eight biometric trajectories. Patterns were observed that males who were interested in the diabetes prevention program had a greater increase in their BMI before expressing their interest, and females who were interested in the diabetes prevention program had higher BMIs than uninterested females were observed but these were not statistically significant.

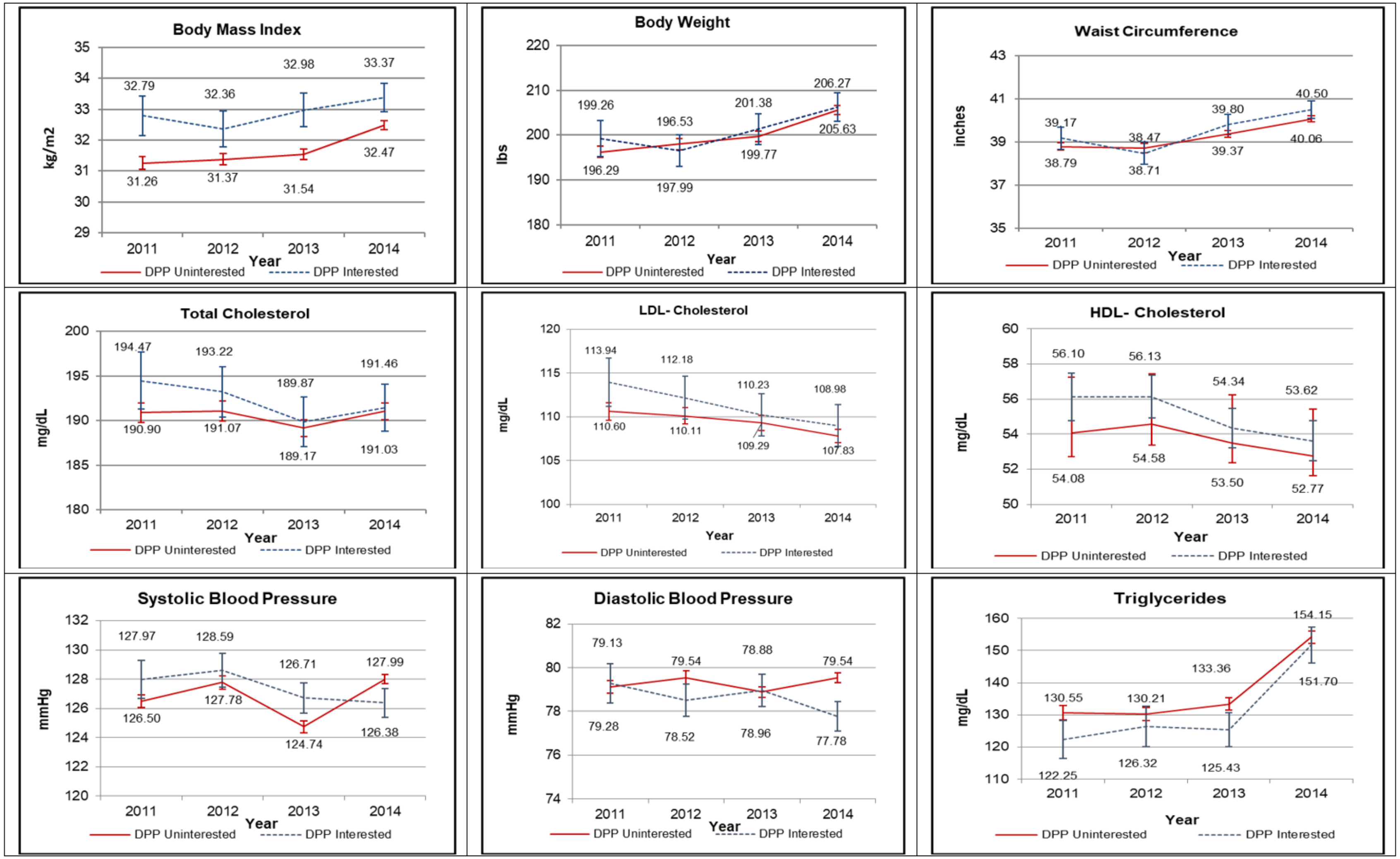

Figure 1. Annual biometric trends for average BMI, body weight, waist circumference, total cholesterol, LDL cholesterol, HDL cholesterol, systolic BP, diastolic BP and triglycerides over time for those who were and were not interested in the DPP.

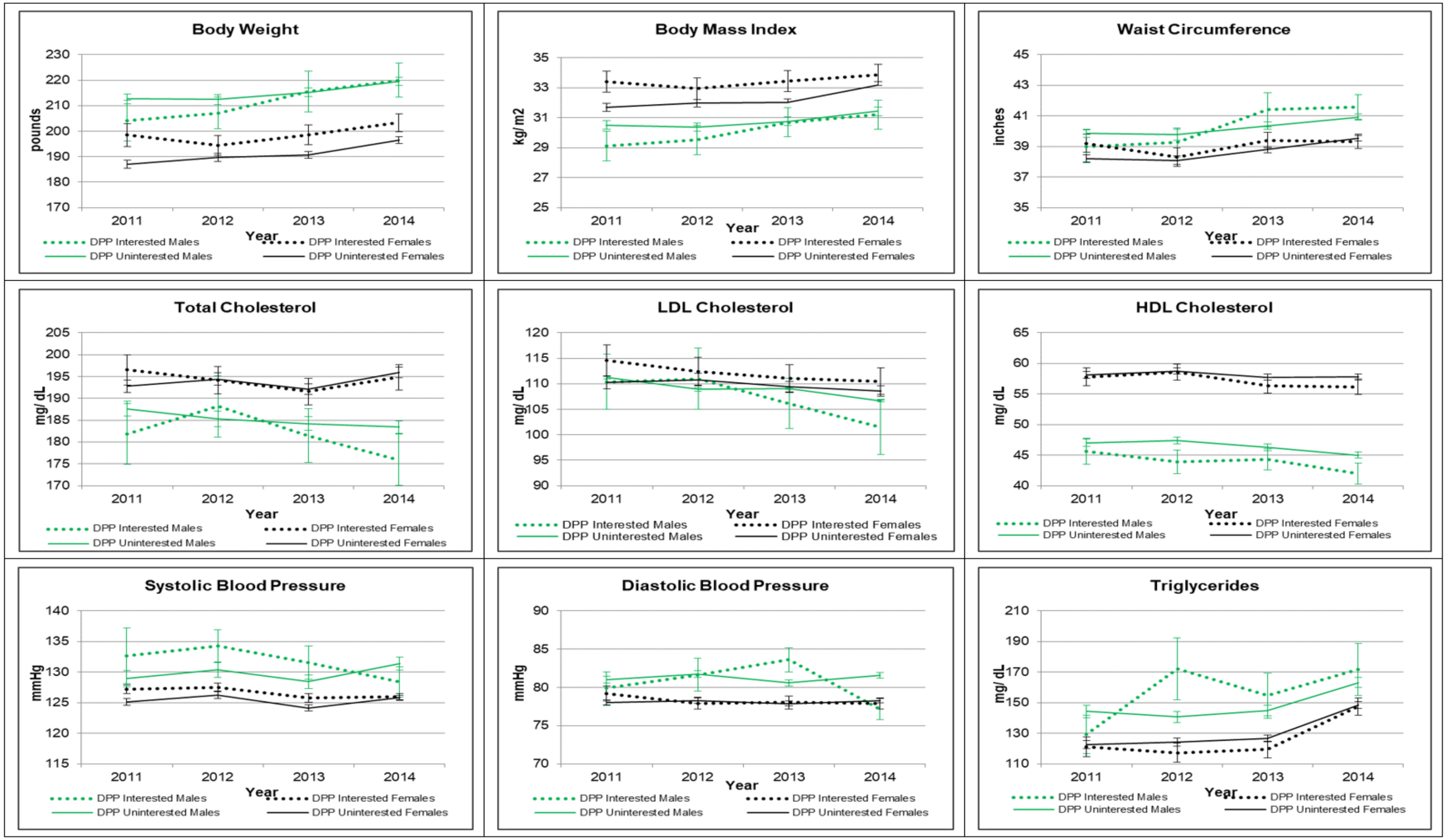

Figure 2. Annual biometric trends by gender for participants who were and were not interested in the DPP by gender over time

DISCUSSION

This study examines biometric trajectories to study the impact of weight gain or declining health on interest in enrollment in a health program. Males with greater changes in their DBP were more likely to express interest in the diabetes prevention program (DPP). However, no clear pattern for these DBPs was identified that was likely to influence program interest. This study did not find any significant differences in biometric trajectories overall. It is possible that the individuals in this study did not notice their incrementally declining health, which was the reason we did not observe any significant differences between those who did and did not express interest in the DPP. We hypothesized that individuals with declining biometric trajectories would be more likely to enroll in the free DPP; it is possible that individuals already working on improving their health may be interested in enrolling in the program (Zigmont et al., 2017) (that are further along in the stages of change), which could account for some of the null findings.

Studies examining health program reach have focused on the cross-sectional evaluation of participants (Beck et al., 2016; Ritchie et al., 2017; Taradash et al., 2015; Venkataramani et al., 2019; Zigmont et al., 2017). Several studies have focused specifically on DPPs (Joiner et al., 2022; Ritchie et al., 2017; Venkataramani et al., 2019; Zigmont et al., 2017). Individuals who participate or elect to enroll in programming have a greater biological risk including older age (Herman et al., 2023; Joiner et al., 2022; Ritchie et al., 2017; Venkataramani et al., 2019; Zigmont et al., 2017), hyperlipidemia (Beck et al., 2016), hypertension (Beck et al., 2016; Herman et al., 2023; Zigmont et al., 2017), higher BMI (Joiner et al., 2022), or greater waist circumference (Zigmont et al., 2017).

This study was limited by the small proportion of males expressing interest in the DPP, which may be one reason differences were not observed when stratifying by gender. Gender-specific recruitment materials may be needed to encourage male interest in the DPP (Zigmont et al., 2017). This study compared program interest and not actual enrollment; 68% of those who expressed interest enrolled in the DPP. Reasons for non-enrollment were not collected for the current study. The participants in this study are insured through their employers, and these findings may not be generalizable to other groups with different insurance statuses, or those who are unemployed.

Strengths of this study included a large sample size (N= 2,066) with four years of longitudinal data. This cohort had a high adherence to biometric screenings (overall, 86% of the eligible workforce population participated). The availability of biometric data ensured the reliable identification of individuals with prediabetes, and accurate measurement for changes in the nine values observed over the study period. Suggestions for future research include exploring reasons for non-enrollment which were not collected in the current study, which was retrospective in nature. Further research is needed to understand the utility of biometric data to understand participant's decisions to enroll in health programs.

AUTHOR CONTRIBUTION

V.Z. wrote the manuscript, conducted the analysis, and researched data; S.O.M., R.H., G.K., and S.C. reviewed/edited the manuscript; and A.S. contributed to the methods and reviewed/edited the manuscript.

ACKNOWLEDGMENT

We thank the participants for the use of their data in this study.

FUNDING AND SPONSORSHIP

No funding was available for this study.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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