



Lifestyle-related education and counseling resource utilization and cardiovascular biomarkers in midlife women with low physical activity

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ABSTRACT

Health plan-based resources are promising avenues for decreasing cardiovascular disease risk. This study examined associations of lifestyle-related resource utilization within a healthcare delivery system and cardiovascular biomarkers among midlife women with low physical activity. Midlife women (45–55 years old) with <10 min/week of reported physical activity at a primary care visit within a large integrated healthcare delivery system in Northern California in 2015 (n = 55,393) were identified. Within this cohort, subsequent lifestyle-related health education and individual coaching resource utilization, and the next recorded physical activity, weight, systolic blood pressure, plasma glucose, HDL and LDL cholesterol measures up to 2 years after the index primary care visit were identified from electronic health records. We used a multilevel linear model to estimate associations. About 3% (n = 1587) of our cohort had ≥1 lifestyle-related resource encounter; 0.3% (n = 178) had ≥4 encounters. Participation in ≥4 lifestyle-related resource encounters (compared to none) was associated with 51 more minutes/week of physical activity (95% CI: 33,69) at the next clinical measurement in all women, 6.2 kg lower weight (95% CI: –7.0,–5.5) at the next measurement in women with obesity, and 8–10 mg/dL lower plasma glucose (95% CI: –30,14 and –23,2, respectively) at the next measurement in women with diabetes or prediabetes. Our results support the sustained utilization of health plan-based lifestyle-related resources for improving physical activity, weight, and plasma glucose in high-risk midlife women. Given the observed low utilization, health system-wide efforts may be warranted to increase utilization of lifestyle-related resources in this population.

1. Introduction

Midlife is a time of increased cardiovascular disease (CVD) risk for women. The combined effects of aging and the menopause transition result in adverse changes in several CVD risk factors, including higher fat mass (Matthews et al., 2009; Abdunour et al., 2012), higher blood pressure (Matthews et al., 2009, 2013), reduced glucose tolerance (Abdunour et al., 2012), greater insulin resistance (Matthews et al., 2009), and risk-enhancing changes to the quality of HDL and LDL cholesterol particles across midlife (El Khoudary et al., 2018). Low levels of physical activity further increase CVD risk (Aune et al., 2015; Diaz and Shimbo, 2013; Chomistek et al., 2013; Sternfeld et al., 2004), therefore midlife women with low physical activity levels are a particularly high-risk group.

Intensive lifestyle counseling can increase physical activity and

improve diet quality, resulting in beneficial changes in CVD risk factors (Melvin et al., 2017; Lin et al., 2014). Lifestyle counseling within primary care is recommended, especially for adults with CVD risk factors (LeFevre, 2014); however, primary care providers encounter several barriers to lifestyle counseling within their practices. Lifestyle behaviors are often not priority topics during primary care visits, with low screening and documentation of these behaviors, and primary care providers lack sufficient time and training for lifestyle counseling (Hébert et al., 2012; Parker et al., 2011). Health plan-based resources outside of primary care, such as health education classes and individual lifestyle-related counseling, are promising avenues for a population-based approach to lifestyle counseling; however, the effectiveness of such resources for improving lifestyle behaviors and improving cardiovascular biomarkers in midlife women in a healthcare delivery system context has not been studied.

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The goal of this study was to determine whether utilization of existing lifestyle-related education and counseling resources within a healthcare delivery system was associated with greater physical activity and improved cardiovascular biomarkers among midlife women with low physical activity levels.

2. Methods

2.1. Study setting

This study was conducted within Kaiser Permanente Northern California (KPNC), an integrated healthcare delivery system that provides medical care for about 4.3 million people in Northern California. KPNC members are representative of the underlying population of this region (Gordon, 2012). Within the KPNC health care system, trained medical assistants collect structured physical activity data and record total weekly minutes of moderate-to-vigorous-intensity physical activity in the Vital Signs section of the electronic health record (EHR) as part of the Exercise as a Vital Sign screening program in primary care settings (Coleman et al., 2012; Grant et al., 2014). KPNC offers health education classes and a telephone-based wellness coaching program to its members to support behavior change related to healthy lifestyle, including weight management, healthy eating, physical activity, tobacco cessation, chronic disease management, and stress reduction (Schmittiel et al., 2013). Although these resources are accessible by self-referral, primary care providers can also refer patients to these resources.

2.2. Study design

This study was a retrospective cohort study of midlife women (45-55 years old) who reported low physical activity on Exercise as a Vital Sign screening at KPNC. We identified the first eligible primary care visit (index primary care visit) in 2015 and subsequent lifestyle-related resource utilization in the 6 months following the index primary care visit. We followed women up to 2 years for cardiovascular biomarker outcomes.

This study was approved by the KPNC institutional review board. The requirement for informed consent was waived.

2.3. Index primary care visit

Using the KPNC EHR database, we identified all primary care visits with < 10 min of weekly moderate-to-vigorous-intensity physical activity on Exercise as a Vital Sign screening ($n = 80,687$ visits) in 2015 among female midlife KPNC members. We excluded visits among women with < 2 years of continued enrollment in KPNC after the primary care visit ($n = 13,344$ visits), visits among women who were pregnant ($n = 117$), and visits among women with conditions that likely result in a limited capacity for physical activity—advanced liver disease diagnosis ($N = 2,329$), advanced CVD diagnosis ($N = 630$), cancer diagnosis ($N = 341$), dementia diagnosis ($N = 150$), advanced renal disease diagnosis ($N = 53$), and Parkinson's disease diagnosis ($N = 5$)—for a total of 63,905 primary care visits among 55,393 midlife women. We identified the first visit for each woman in 2015 as the index primary care visit in our final analytic dataset ($N = 55,393$ index primary care

visits).

2.4. Data collection and measures

Fig. 1 shows the timeline for measures used in this study.

2.4.1. Utilization of lifestyle-related resources

We identified utilization of lifestyle-related resources at KPNC using the EHR. Encounters with the Health Education department (in-person health education classes) and completed wellness coaching sessions (telephone-based) that were related to healthy lifestyle were identified by filtering on key words relevant to diabetes prevention and management, diet/nutrition, hypertension management, physical activity, lipid management, weight management, and wellness coaching. The total number of encounters with Health Education or completed wellness coaching sessions that matched any of the relevant key words (Appendix Table 1) in the 6 months after the index primary care visit were summed and categorized into 0 encounters (no utilization), 1 encounter, 2 encounters, 3 encounters, and 4 or more encounters.

2.4.2. Cardiovascular biomarker outcomes

Minutes of moderate-to-vigorous-intensity physical activity, weight, systolic blood pressure, plasma glucose, HDL cholesterol, and LDL cholesterol were collected from recorded measurements in the EHR for any clinical encounter within 2 years after the index primary care visit. For women in our cohort with no utilization of lifestyle-related resources, we identified the next measurements after the index primary care visit. For women with at least one encounter with a lifestyle-related resource, we collected the next measurements after the last encounter with a lifestyle-related resource after the index primary care visit.

2.4.3. Covariates

Information on covariates at the index primary care visit was ascertained from the EHR.

Sociodemographic characteristics included were age, self-reported race/ethnicity (categorized as Hispanic, non-Hispanic white, non-Hispanic Asian, non-Hispanic Black, and non-Hispanic other race), Medicaid status, and neighborhood deprivation index (Kind et al., 2014; Area Deprivation Index v2.0) for census tract of address (categorized according to quartiles of its distribution).

Health behaviors included were smoking status, alcohol use, and other drug use.

Medical characteristics included were body mass index (BMI; calculated using weight and height, kg/m^2 ; categorized using standard cut-points (About Adult BMI, 2014): underweight: $<18.5 \text{ kg}/\text{m}^2$, normal weight: $18.5\text{--}24.9 \text{ kg}/\text{m}^2$, overweight: $25\text{--}29.9 \text{ kg}/\text{m}^2$, obese: $\geq 30 \text{ kg}/\text{m}^2$), hypertension diagnosis, cholesterol disorder diagnosis, depression diagnosis, prediabetes diagnosis, diabetes diagnosis (based on date of diabetes diagnosis obtained from the KPNC diabetes registry (Selby et al., 1997), and CVD diagnosis. Active diagnoses were identified in the 12 months prior to the index primary care visit through 7 days after the index primary care visit to capture existing and new diagnoses. Diagnosis codes used are presented in Appendix Table 2.

The most recent weight, systolic blood pressure, plasma glucose, HDL cholesterol, and LDL cholesterol measurements within the 6

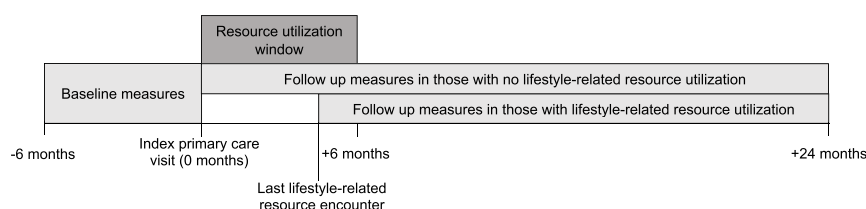


Fig. 1. Timeline for measures used.

months prior to the index primary care visit were considered baseline measures.

Prescription medication use included antihypertensive medication use, diabetes medication use, and cholesterol medication use. Medications used for each indication are listed in [Appendix Table 3](#). We calculated days supply of medications accounting for 80% medication adherence and stockpiling. Women were considered to be using a medication from the date of their medication fill to the end of their medication supply days.

2.5. Statistical analyses

Descriptive statistics are presented for the overall cohort and stratified by number of encounters with a lifestyle-related resource. Mean and standard deviation are used to describe the distribution of continuous variables. Frequency and percent are used to describe categorical variables.

For women with missing data, we used multiple imputation using the Markov Chain Monte Carlo method under the assumption of multivariate normality with 100 imputations to impute covariates (BMI category, neighborhood deprivation index quartile) and cardiovascular biomarkers (weight, systolic blood pressure, plasma glucose, HDL cholesterol, and LDL cholesterol) at baseline and at follow-up measurement. This method is robust to violations of the multivariate normality assumption ([Demirtas et al., 2008](#)). We compared characteristics of women in the overall cohort with those of women with complete data for each outcome in [Appendix Table 4](#).

We used a multilevel linear model with a random effect for primary care provider to estimate mean differences and 95% confidence intervals for each lifestyle-related resource utilization category (with no utilization as the referent) for each cardiovascular health outcome. Inclusion of a random effect for primary care provider in the model accounted for clustering of women within primary care providers. For weight, systolic blood pressure, plasma glucose, HDL cholesterol, and LDL cholesterol outcomes, models were run stratified by diagnosis of associated conditions at the index primary care visit.

Regression models were adjusted for patient race/ethnicity, Medicaid status, neighborhood deprivation index quartile, current smoking, current alcohol use, current other drug use, depression diagnosis, CVD diagnosis, BMI category (by covariate adjustment or stratification), diabetes diagnosis (by covariate adjustment or stratification), prediabetes diagnosis (by covariate adjustment or stratification), cholesterol disorder diagnosis (by covariate adjustment or stratification), and hypertension diagnosis (by covariate adjustment or stratification). For weight, the model was additionally adjusted for baseline weight. For systolic blood pressure, plasma glucose, HDL cholesterol, and LDL cholesterol, the model was additionally adjusted for the corresponding baseline measurement and corresponding medication use at baseline and follow up measurement. Regression models were run using each imputed dataset. Results were combined using Rubin's rules ([Rubin, 1987](#)).

Because of the large proportion of data imputed for plasma glucose (78% of cohort), HDL cholesterol (84% of cohort), and LDL cholesterol (81% of cohort), sensitivity analyses were conducted using complete

Table 1

Characteristics of 55,393 midlife women with primary care visits with low reported physical activity overall and by lifestyle-related resource utilization.

Patient characteristics at index primary care visit	Total (n=55,393)	No utilization (n=53,806)	1 encounter (n=1,001)	2 encounters (n=306)	3 encounters (n=102)	4+ encounters (n=178)
Age, mean (SD)	50.1 (3.2)	50.7 (3.2)	50.9 (3.1)	51.1 (3.2)	50.7 (3.0)	50.9 (3.1)
Race/ethnicity, n (%)						
Non-Hispanic white	22,682 (41)	22,065 (41)	344 (34)	125 (41)	40 (39)	108 (61)
Hispanic	13,334 (24)	12,892 (24)	316 (32)	78 (25)	28 (27)	20 (11)
Non-Hispanic Asian	11,682 (21)	11,494 (21)	125 (12)	33 (11)	15 (15)	15 (8)
Non-Hispanic Black	5,183 (9)	4,907 (9)	170 (17)	58 (19)	15 (15)	33 (19)
Non-Hispanic other	2,512 (5)	2,448 (5)	46 (5)	12 (4)	4 (4)	2 (1)
Racial/ethnic concordance with primary care provider, n (%)	20,210 (36)	19,753 (37)	268 (27)	98 (32)	29 (28)	62 (35)
Medicaid recipient, n (%)	3,002 (5)	2,905 (5)	65 (6)	14 (5)	6 (6)	12 (7)
Neighborhood deprivation index quartile, n (%)						
Quartile 1 (-2.16 to -0.65)	14,159 (26)	13,841 (26)	184 (18)	63 (21)	27 (26)	44 (25)
Quartile 2 (-0.66 to -0.20)	13,957 (25)	13,559 (25)	234 (23)	84 (28)	23 (23)	57 (32)
Quartile 3 (-0.19 to 0.49)	13,665 (25)	13,265 (25)	261 (26)	80 (26)	25 (25)	34 (19)
Quartile 4 (0.50 to 4.58)	13,513 (24)	13,046 (24)	319 (32)	78 (26)	27 (26)	43 (24)
Missing	99	95	3	1	0	0
Current smoker, n (%)	5,448 (10)	5,321 (10)	89 (9)	24 (8)	4 (4)	10 (6)
Current alcohol use, n (%)	19,275 (35)	18,706 (35)	362 (35)	98 (32)	36 (35)	73 (41)
Current other drug use, n (%)	916 (2)	892 (2)	15 (2)	5 (2)	1 (1)	3 (2)
BMI category, n (%)						
Underweight (<18.5 kg/m ²)	460 (1)	456 (1)	2 (0.2)	1 (0.4)	0 (0)	1 (1)
Normal weight (18.5-24.9 kg/m ²)	13,006 (25)	12,926 (26)	48 (5)	20 (7)	5 (5)	7 (4)
Overweight (25-29.9 kg/m ²)	15,018 (29)	14,792 (29)	153 (16)	41 (14)	19 (20)	13 (8)
Obese (≥30 kg/m ²)	23,322 (45)	22,128 (44)	752 (79)	222 (78)	73 (75)	147 (88)
Missing	3,587	3,504	46	22	5	10
Diagnoses at index primary care visit						
Hypertension, n (%)	14,668 (26)	14,025 (26)	413 (41)	123 (40)	39 (38)	68 (38)
Cholesterol disorder, n (%)	13,018 (24)	12,481 (23)	355 (35)	89 (29)	30 (29)	63 (35)
Depression, n (%)	8,611 (16)	8,278 (15)	199 (20)	74 (24)	15 (15)	45 (25)
Diabetes, n (%)	6,104 (11)	5,738 (11)	230 (23)	78 (25)	26 (25)	32 (18)
Prediabetes, n (%)	3,590 (6)	3,411 (6)	108 (11)	33 (11)	17 (17)	21 (12)
Cardiovascular disease, n (%)	319 (1)	308 (1)	3 (0.3)	6 (2)	1 (1)	1 (1)
Medication use at index primary care visit						
Antihypertensive use, n (%)	3,156 (6)	3,014 (6)	95 (9)	29 (9)	7 (7)	11 (6)
Diabetes medication use, n (%)	1,010 (2)	919 (2)	59 (6)	17 (6)	9 (9)	6 (3)
Cholesterol medication use, n (%)	1,151 (2)	1,082 (2)	48 (5)	13 (4)	2 (2)	6 (3)
Referral at primary care visit, n (%)	859 (2)	541 (1)	201 (20)	67 (22)	21 (21)	29 (16)

BMI, body mass index; SD, standard deviation

case data for comparison. We also adjusted complete case analyses for days between index primary care visit and follow-up measurement to account for differences in timing of outcome measurements by lifestyle-resource utilization.

Analyses were conducted in SAS version 9.4 (SAS Institute Inc, Cary NC).

3. Results

Our study cohort of 55,393 midlife women with low physical activity was 41% non-Hispanic white, 24% Hispanic, 21% Asian, 9% non-Hispanic Black, and 5% non-Hispanic other race (Table 1). Ten percent reported being current smokers at the primary care visit, and 35% reported currently using alcohol. Almost half (45%) of the cohort had obesity.

Table 2
Associations of lifestyle-related resource utilization and cardiovascular health outcomes in midlife women.

Outcome	No utilization		1 encounter		2 encounters		3 encounters		4+ encounters	
	N	Mean difference in outcome (95% CI)	N	Mean difference in outcome (95% CI)	N	Mean difference in outcome (95% CI)	N	Mean difference in outcome (95% CI)	N	Mean difference in outcome (95% CI)
Physical activity (minutes/week) ^a	53,806	Referent	1,001	1 (-7, 9)	306	13 (-1, 27)	102	-2 (-26, 22)	178	51 (33, 69)
Weight (kg) ^b										
Women with underweight	456	Referent	2	0.1 (-3.3, 3.4)	1	-2.8 (-7.6, 2.1)	0	-	1	0.1 (-4.6, 4.8)
Women with normal weight	12,926	Referent	48	-0.6 (-1.4, 0.1)	20	-0.4 (-1.7, 0.8)	5	-1.0 (-3.2, 1.2)	7	-0.3 (-2.1, 1.6)
Women with overweight	14,792	Referent	153	-0.4 (-0.9, 0.1)	41	-0.9 (-1.8, 0.1)	19	-1.6 (-3.0, -0.2)	13	-0.2 (-1.9, 1.5)
Women with obesity	22,128	Referent	752	-0.2 (-0.6, 0.1)	222	-1.1 (-1.7, -0.5)	73	-1.1 (-2.1, 0.0)	147	-6.2 (-7.0, -5.5)
Systolic blood pressure (mmHg) ^c										
Women with hypertension	14,025	Referent	413	-1 (-3, 0)	123	-1 (-4, 2)	39	4 (-1, 8)	68	0 (-3, 3)
Women without hypertension	39,781	Referent	588	0 (-1, 1)	183	-1 (-2, 1)	63	0 (-3, 3)	110	-3 (-5, -1)
Plasma glucose (mg/dL) ^d										
Women with diabetes	5,738	Referent	230	1 (-7, 9)	78	-1 (-15, 13)	26	-11 (-36, 14)	32	-8 (-30, 14)
Women with prediabetes	3,411	Referent	108	6 (0, 12)	33	4 (-7, 14)	17	9 (-6, 23)	21	-10 (-23, 2)
Women without diabetes or prediabetes	44,657	Referent	663	3 (1, 5)	195	6 (2, 10)	59	9 (2, 16)	125	-2 (-6, 3)
HDL cholesterol (mg/dL) ^e										
Women with cholesterol disorder	12,481	Referent	355	0 (-1, 2)	89	1 (-1, 3)	30	3 (-1, 7)	63	0 (-2, 3)
Women without cholesterol disorder	41,325	Referent	646	0 (-1, 1)	217	1 (-1, 2)	72	0 (-2, 3)	115	1 (-1, 3)
LDL cholesterol (mg/dL) ^e										
Women with cholesterol disorder	12,481	Referent	355	-4 (-8, -1)	89	-4 (-11, 2)	30	-7 (-19, 4)	63	-2 (-10, 5)
Women without cholesterol disorder	41,325	Referent	646	-2 (-5, 0)	217	-3 (-7, 1)	72	-7 (-13, 0)	115	-4 (-9, 1)

CI, confidence interval

Statistically significant associations are bolded.

^aMixed model with patient and provider levels adjusted for patient race/ethnicity, Medicaid, neighborhood deprivation index quartile, current smoking, current alcohol use, current other drug use, BMI category, diabetes diagnosis, prediabetes diagnosis, cholesterol disorder diagnosis, hypertension diagnosis, depression diagnosis, cardiovascular disease diagnosis.

^bMixed model with patient and provider levels adjusted for patient race/ethnicity, Medicaid, neighborhood deprivation index quartile, current smoking, current alcohol use, current other drug use, diabetes diagnosis, prediabetes diagnosis, cholesterol disorder diagnosis, hypertension diagnosis, depression diagnosis, cardiovascular disease diagnosis, and weight at index visit.

^cMixed model with patient and provider levels adjusted for patient race/ethnicity, Medicaid, neighborhood deprivation index quartile, current smoking, current alcohol use, current other drug use, BMI category, diabetes diagnosis, prediabetes diagnosis, cholesterol disorder diagnosis, depression diagnosis, cardiovascular disease diagnosis, systolic blood pressure at index visit, and antihypertensive use at index visit and follow up.

^dMixed model with patient and provider levels adjusted for patient race/ethnicity, Medicaid, neighborhood deprivation index quartile, current smoking, current alcohol use, current other drug use, BMI category, cholesterol disorder diagnosis, hypertension diagnosis, depression diagnosis, cardiovascular disease diagnosis, plasma glucose at index visit, and diabetes medication use at index visit and follow up.

^eMixed model with patient and provider levels adjusted for patient race/ethnicity, Medicaid, neighborhood deprivation index quartile, current smoking, current alcohol use, current other drug use, BMI category, diabetes diagnosis, prediabetes diagnosis, hypertension diagnosis, depression diagnosis, cardiovascular disease diagnosis, cholesterol at index visit, and cholesterol medication use at index visit and follow up.

Of the 55,393 midlife women in our study cohort, 2.9% had at least one lifestyle-related education or counseling resource encounter after the index primary care visit. The most common lifestyle-related resources that women participated in were related to weight management (68% of encounters), diabetes prevention or management (20% of encounters), or general wellness (18% of encounters) (Appendix Table 5). Sixty-three percent of women who had at least one lifestyle-related resource encounter had only one encounter, 19% had two encounters, 6% had three encounters, and 11% had four or more encounters (Table 1).

Women with at least one lifestyle-related resource encounter were more likely to be non-Hispanic Black, live in a neighborhood with high neighborhood deprivation, have obesity, hypertension, a cholesterol disorder, depression, diabetes, or prediabetes, and have received a referral to a lifestyle-related resource than women who did not have a lifestyle-related resource encounter. Women who had four or more lifestyle-related resource encounters were more likely to be non-Hispanic white, report current alcohol use, and have obesity than women with one to three encounters.

In adjusted analyses, participation in four or more lifestyle-related resource encounters was associated with 51 more minutes per week of moderate-to-vigorous-intensity physical activity (95% CI: 33,69) at the follow-up measurement compared to no utilization of lifestyle-related resources (Table 2). In women with obesity, participation in two or three lifestyle-related resource encounters was associated with 1.1 kg lower weight (95% CI: -1.7, -0.5 and -2.1, 0.0, respectively) at the follow-up measurement compared to no utilization; participation in four or more lifestyle-related resource encounters was associated with 6.2 kg lower weight (95% CI: -7.0, -5.5) at the follow-up measurement compared to no utilization.

In women with diabetes, participation in four or more lifestyle-related resource encounters was associated with 8 mg/dL lower plasma glucose (95% CI: -30, 14) at the follow-up measurement compared to no utilization, though confidence intervals were wide. In women with prediabetes, participation in four or more lifestyle-related resource encounters was associated with 10 mg/dL lower plasma glucose (95% CI: -23, 2) at the follow-up measurement compared to no utilization.

Utilization of lifestyle-related resources was not associated with systolic blood pressure, HDL or LDL cholesterol.

More time elapsed, on average, between the index primary care visit and follow-up measurements in women with at least one lifestyle-related resource encounter compared to those with no utilization (range: 8–121 days later; Appendix Table 6).

3.1. Sensitivity analyses

Results from complete case analyses for all outcomes were similar to those from analyses using multiply imputed data (Appendix Table 7). Additional adjustment for days between index primary care visit and follow-up measurement in complete case analyses did not meaningfully change results (data not shown).

4. Discussion

In our cohort of midlife women with low physical activity levels, sustained utilization (four or more encounters) of health system-based lifestyle-related resources was associated with greater physical activity in all women, lower weight in women with obesity, and lower plasma glucose in women with diabetes or prediabetes. However, only a small fraction (3%) of our cohort participated in available lifestyle-related resources.

Previous studies of individual lifestyle counseling interventions among midlife women administered by research nurses as part of randomized controlled trials have successfully increased physical activity and reduced cardiovascular biomarkers. A 12-week telephone-based

lifestyle modification program among midlife women in Taiwan increased total, moderate-intensity, and vigorous-intensity physical activity and decreased the prevalence of several metabolic syndrome components: elevated fasting plasma glucose, reduced HDL cholesterol, and central obesity (Lin et al., 2016). In a study comparing modes of administration of a 12-week lifestyle counseling intervention in midlife women in Australia, both web-based and face-to-face lifestyle counseling increased total and moderate-to-vigorous-intensity physical activity (McGuire et al., 2019). Building upon these previous studies, where interventions were not health system-based, our study found that utilization of health education and lifestyle counseling resources available within the healthcare delivery system was associated with greater moderate-to-vigorous intensity physical activity, lower weight, and lower plasma glucose in midlife women, although we did not find associations with HDL cholesterol. Greater intensity of lifestyle intervention may be necessary to impact cholesterol levels.

Although individual lifestyle counseling through an established wellness coaching program made up a small (3%) portion of the total encounters with lifestyle-related resources in our cohort of midlife women, our results are consistent with previous research indicating that individual lifestyle coaching was associated with reduced BMI in the 12 months after the initial wellness coaching encounter in adult KPNC members (mean age 52 years) (Schmittiel et al., 2017). Group-based health education classes focused on weight management, diabetes prevention and management, and general wellness, which were more highly utilized in our cohort, present similar information and strategies for behavior change as individual lifestyle coaching.

Our results indicate that sustained engagement with lifestyle-related resources was most strongly associated with substantial improvements in cardiovascular biomarkers in midlife women. Health behavior change and habit formation takes time. Sustained engagement with lifestyle-related resources allows for reinforcement of effective behavior change strategies and greater accountability for behavior change (Coleman and Pasternak, 2012). Our results are consistent with research among KPNC members which found that members who completed two or more sessions of individual lifestyle coaching were more likely to report that lifestyle coaching helped them improve lifestyle behaviors (eating more healthfully, increasing physical activity) and reduce their risk of disease than members who completed only one session of individual lifestyle coaching (Adams et al., 2013 Oct). Our results are also consistent with results from a study among adults with type 2 diabetes indicating greater weight loss with more completed telephone intervention sessions (Goode et al., 2015), though our study did not assess weight changes by diabetes status. However, sustained engagement with lifestyle-related resources may also be an indicator of high motivation or social support for behavior change, which we were not able to measure in our study.

Given the beneficial associations of sustained engagement with lifestyle-related resources and cardiovascular biomarkers but low utilization of these resources, barriers to utilization and engagement with these resources in midlife women need to be better understood. Lifestyle-related education and counseling resources are available at no cost to members of the KPNC integrated healthcare delivery system, however awareness about available lifestyle-related resources may be low within this population. Our results suggest that referral to these resources by primary care providers is associated with utilization, though referral is not required to access these resources. Patients prefer to receive health information directly from their health care providers (Gaglio et al., 2012). However, referral was also low; only 2% of our cohort was referred to a lifestyle-related resource. Referral is likely to be accompanied by lifestyle counseling by the primary care provider, but we did not have information on primary care provider lifestyle counseling in our study. Incorporating referral to lifestyle-related resources within primary care clinical workflows — either during in-person visits or using automated secure email messaging (Xiao et al., 2015) — to address low physical activity and other CVD risk factors may help

increase awareness and utilization of available lifestyle-related resources in high-risk populations, such as midlife women. Centralized, population-management approaches to increase awareness and promote use of lifestyle-related resources may also help increase utilization. Telehealth options (online classes) may also help address practical barriers to utilization of these resources; however, it is important to continue offering in-person resources as not all individuals have phone or internet access.

4.1. Strengths and limitations

Strengths of our study include our ability to identify and characterize utilization of lifestyle-related resources within a real-world healthcare delivery system among a diverse high-risk population of midlife women with low physical activity levels. However, several limitations should be considered when interpreting our results. The keywords we used to identify lifestyle-related resource utilization were compiled after reviewing names of available lifestyle-related resources, but we may not have captured all lifestyle-related resources available within the healthcare delivery system. Also, we may not have captured all relevant medication use in this population. We did not have any data on motivation for behavior change or social support, which may explain observed associations between sustained utilization of lifestyle-related resources and physical activity, weight, and plasma glucose. We also do not have any data on several important and emerging factors related to cardiovascular risk in women, including reproductive and pregnancy history, age at menopause, and use of hormone replacement therapy. There was a large amount of missing data for plasma glucose, HDL, and LDL cholesterol outcomes as we used clinically collected data, where these biomarkers are not as routinely collected as physical activity, weight, and blood pressure. Women who had multiple measurements of these biomarkers during the study period were more likely to have a chronic condition (hypertension, cholesterol disorder, diabetes, or prediabetes) than women in the overall study cohort (Appendix Table 4), which is expected given that women with chronic conditions are more closely monitored. However, we used multiple imputation to address missing data. Because outcome measurements in women with utilization of lifestyle-related resources in our cohort were generally later than those in women without utilization of these resources, women with utilization of lifestyle-related resources had a longer opportunity for behavior change and subsequent impact of behavior change on CVD risk factors. Adjustment for days between the index primary care visit and outcome measurement in additional analyses did not change results. Results should be generalized cautiously as lifestyle-related resources may differ in other health plans.

5. Conclusions

Among midlife women with low physical activity levels, sustained utilization of lifestyle-related resources was associated with greater physical activity in all women, lower weight in women with obesity, and lower plasma glucose in women with diabetes or prediabetes. Our results support the effectiveness of lifestyle-related resources within healthcare delivery systems for improving healthy behaviors and CVD risk factors in high-risk midlife women. Considering only a small portion of this population took advantage of available lifestyle-related resources, healthcare delivery systems may consider strategies that promote primary care provider referral to increase utilization of lifestyle-related resources.

CRediT authorship contribution statement

Sylvia E. Badon: Conceptualization, Formal analysis, Funding acquisition, Writing - original draft, Writing - review & editing, Supervision. **Nerissa Nance:** Data curation, Writing - review & editing. **Renee Fogelberg:** Conceptualization, Writing - review & editing. **Charles**

Quesenberry: Conceptualization, Writing - review & editing. **Monique M. Hedderson:** Conceptualization, Writing - review & editing. **Lyndsay A. Avalos:** Conceptualization, Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Previous Presentation

The results presented here have not been previously presented elsewhere.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2021.101401>.

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