The Impact of a Yearlong Diabetes Prevention Program-Based Lifestyle Intervention on Cardiovascular Health Metrics

Susan M. Devaraj1, Bonny Rockette-Wagner1, Rachel G. Miller1, Vincent C. Arena1, Jenna M. Napoleone1, Molly B. Conroy2, and Andrea M. Kriska1

Abstract

Introduction: The American Heart Association created “Life’s Simple Seven” metrics to estimate progress toward improving US cardiovascular health in a standardized manner. Given the widespread use of federally funded Diabetes Prevention Program (DPP)-based lifestyle interventions such as the Group Lifestyle Balance (DPP-GLB), evaluation of change in health metrics within such a program is of national interest. This study examined change in cardiovascular health metric scores during the course of a yearlong DPP-GLB intervention. Methods: Data were combined from 2 similar randomized trials offering a community based DPP-GLB lifestyle intervention to overweight/obese individuals with prediabetes and/or metabolic syndrome. Pre/post lifestyle intervention participation changes in 5 of the 7 cardiovascular health metrics were examined at 6 and 12 months (BMI, blood pressure, total cholesterol, fasting plasma glucose, physical activity). Smoking was rare and diet was not measured. Results: Among 305 participants with complete data (81.8% of 373 eligible adults), significant improvements were demonstrated in all 5 risk factors measured continuously at 6 and 12 months. There were significant positive shifts in the “ideal” and “total” metric scores at both time points. Also noted were beneficial shifts in the proportion of participants across categories for BMI, activity, and blood pressure. Conclusion: AHA-metrics could have clinical utility in estimating an individual’s cardiovascular health status and in capturing improvement in cardiometabolic/behavioral risk factors resulting from participation in a community-based translation of the DPP lifestyle intervention.

Keywords

health promotion, lifestyle change, obesity, physical activity, community health, prevention

Introduction

The American Heart Association (AHA) set a goal of improving the cardiovascular health of all Americans by 20% by the year 2020 in an effort to reduce the burden of cardiovascular disease (CVD). In order to measure progress toward this goal, the AHA created Life’s Simple Seven (LS7) metrics to estimate cardiovascular health status. These 7 metrics include BMI, physical activity, diet, smoking, blood pressure, total cholesterol, and fasting plasma glucose. The AHA established criteria classifying each metric as “ideal,” “intermediate,” or “poor” based on evidence in line with clinical practice and public health guidelines for promoting CVD free survival. By including both behavioral and cardiometabolic factors, the LS7 concept captures a comprehensive picture of modifiable CVD risk while providing straightforward standardized definitions of optimal status. The LS7 could be a useful approach to identifying individuals who may be

1University of Pittsburgh Graduate School of Public Health, Pittsburgh, PA, USA
2University of Utah School of Medicine, Salt Lake City, UT, USA

Corresponding Author:
Bonny Rockette-Wagner, University of Pittsburgh Graduate School of Public Health, 5135 Public Health, 130 De Soto Street, Pittsburgh, PA 15261, USA.
Email: bjr26@pitt.edu

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This project aimed to assess changes in cardiovascular health metrics based on AHA criteria resulting from participation in this yearlong CDC-recognized intervention program. It was hypothesized that participants of the DPP-GLB would demonstrate an improvement in cardiovascular health metrics after 6 months and improvement would be maintained after 12 months of intervention.

**Methods**

This project is a secondary data analysis of 2 NIH funded intervention trials evaluating the DPP-GLB in the community setting with almost identical eligibility criteria and study design. The Healthy Lifestyle Project (GLB-Healthy) was conducted from March 2010 through February 2014. The Physical Activity and Sedentary Behavior Change study (GLB-Moves) was conducted from September 2014 through July 2019. Both studies received Institutional Review Board approval and all subjects provided written informed consent.

**Sample**

Eligibility criteria for these studies included age ≥18 years of age (GLB-Healthy) or ≥40 years of age (GLB-Moves), BMI >24 kg/m² (>22 kg/m² for Asian persons, consistent with the DPP BMI eligibility criteria), evidence of prediabetes defined as fasting glucose ≥100 to <126 and/or hemoglobin A1c 5.7% to 6.4%, and/or metabolic syndrome defined by National Cholesterol Education Program Adult Treatment Panel III criteria or hyperlipidemia and 1 component of metabolic syndrome. Participants were ineligible if they had ever had diagnosed diabetes, planned to move away in the 18 months following screening, were taking metformin, had an initiation or change in blood pressure or lipid medication within the past 3 months, or were pregnant or breastfeeding. Recruitment and screening efforts were conducted for GLB-Healthy from September 2010 to November 2011, and for GLB-Moves from October 2014 through March 2017.

In both study efforts, investigators partnered with community organizations in Allegheny County, Pennsylvania (ie, the greater Pittsburgh area) to recruit in the geographic area around community centers. In GLB-Healthy, investigators also partnered with a worksite in the Pittsburgh metropolitan area, to recruit employees. The lifestyle intervention and clinic assessment visits were conducted at the community centers and worksite.

**Design**

Both studies had a randomized controlled design with participants assigned to begin the intervention program immediately or after a 6-month delay with randomization stratified by site location. Participants who were randomized to the
delayed intervention arm received an identical yearlong intervention program but started 6 months later (Supplemental Figure 1). Baseline was considered to be the clinic visit immediately preceding the start of the lifestyle program sessions (ie, month 6 for delayed participants).

The focus of this analysis is change during the course of a yearlong DPP-GLB intervention that is currently widely used in community settings. For this reason, pre/post intervention assessments were examined to capture the time period of interest for these national programs. Randomized controlled trial results for DPP-GLB have been published previously.21,22

One of the intervention arms in the GLB-Moves study involved an alternative intervention with a focus on reducing time spent sitting. Participants from that study arm were excluded from this analysis due to the experimental nature of that intervention, and because it is a significant departure from the current CDC-recognized GLB curriculum. Although participants and lifestyle coaches could not be blinded to randomization assignment due to the nature of the intervention, lifestyle coaches were not involved in any outcome assessments.

**Intervention**

The DPP-GLB lifestyle intervention used in both studies was adapted from the lifestyle intervention of the DPP to be a 22 session, year-long, group-based program, developed by individuals who helped direct both the DPP lifestyle intervention and the resulting translation efforts.27 The first 12 sessions occurred weekly, followed by 4 biweekly sessions and 6 monthly maintenance sessions. All lifestyle coaches received standard training in the DPP-GLB curriculum.

The primary goals of the DPP-GLB lifestyle intervention were to achieve and maintain a 7% weight loss and to safely progress to 150 minutes per week of moderate physical activity, with an intensity similar to a brisk walk. The program curriculum consisted of group discussion and education surrounding topics encouraging activity, balanced diet and caloric restriction to promote weight loss, and behavioral strategies to support program goals. Delayed participants received the same program starting 6 months after randomization. During the delay, those participants randomized to this arm received occasional health-related handouts to promote retention. Attendance included both in-person small group sessions and make-up sessions, which were completed as needed.

**Measures**

Five of the 7 AHA cardiovascular health metrics were analyzed in this study. Direct measures of diet were not collected in these 2 studies, and smoking prevalence was rare (4.9%) at baseline and therefore not collected beyond that point. All metric calculations are based on measures taken at clinic assessment visits that took place at intervention baseline, and after 6 months, and 12 months of intervention. The protocols for outcome measures were the same in both study cohorts.

Body mass index (BMI) was determined by measured height and weight. A BMI below 25 was considered ideal, 25 to <30 intermediate and ≥30 poor, in accordance with AHA criteria.1 Asian participants with a BMI <23 were classified as ideal, 23 to 27.5 intermediate, and ≥27.5 poor, per the greater risk associated with lower BMI cut points in this demographic.28,29

Leisure physical activity was assessed using a past month version of the Modifiable Activity Questionnaire, which has been shown to be reliable and valid in adults,30,31 and quantified as Metabolic Equivalent of Task (MET) hours per week. Activity of ≥7.5 MET hours/week was considered ideal, >0 to <7.5 MET hours/week intermediate, and no reported activity poor. The ideal cut point of 7.5 MET hours/week is roughly equivalent to the AHA criteria promoting 150 minutes or more of moderate intensity or 75 minutes or more of vigorous intensity activity each week,1 as has been shown in previous literature,32 and is consistent with commonly accepted physical activity guidelines.

Blood pressure was measured using the average of 2 readings taken after a 5-minute rest with an automatic digital sphygmomanometer. If measures differed by greater than 5 mmHg, a third measure was taken. Ideal blood pressure was defined as <120/80 mmHg without treatment, intermediate as 120 to 139 systolic or 80 to 89 mmHg diastolic or treated to ideal range, and poor as ≥140 systolic or ≥90 mmHg diastolic, as outlined by AHA criteria.1

Total cholesterol and fasting plasma glucose were determined using a fasting blood draw. Ideal total cholesterol was defined as <200 mg/dL, intermediate as 200 to 239 mg/dL or treated to ideal range, and poor as ≥240 mg/dL. Fasting plasma glucose was considered ideal with a level of <100 mg/dL, intermediate with 100 to 125 mg/dL or treated to ideal range, and poor was ≥126 mg/dL. Blood value cut points were consistent with AHA criteria.1 Treatment for blood pressure, total cholesterol, and fasting plasma glucose was ascertained using a medication questionnaire.

**Analysis**

Differences in demographic characteristics between those who were included in the analysis and those who were excluded were tested using chi-square, Fisher’s exact, and t-tests.

Significant continuous change in each metric at 6 and 12 months was tested using Wilcoxon signed-rank tests due
to the non-normal distribution of change variables. Since study participants had individual variability in their cardio-
metabolic risk profiles at baseline, for any 1 health metric, some participants were in need of improvement while oth-
ers may have already met the ideal criteria for that metric per the definitions previously described. For that reason,
additional separate analyses were done for continuous change for each metric, limited to only those participants at
“high risk” for that metric (defined as having baseline val-
ues falling within the intermediate or poor range).

Differences in the proportion of metrics within each cat-
egory (ideal, intermediate, and poor) were determined using a marginal homogeneity test of symmetry to assess whether there was a significant shift in off-diagonal terms from baseline to 6 months and from baseline to 12 months. A “total metric score” was calculated as the sum of the categories of each metric (poor = 0, intermediate = 1, ideal = 2; possible “total metric score” range 0-10). “Ideal metric score” was calculated as a count of metrics falling within the ideal range (possible “ideal metric score” range 0-5). Within group change for all participants from baseline to 6 months and baseline to 12 months was determined using the Wilcoxon signed-rank test, again due to the non-normal dis-
tribution of pairwise differences between timepoints. StatXact version 11.1 (Cytel Inc.) was used for the marginal homogeneity test. All other analyses were conducted in SAS version 9.4 (SAS Institute, Inc.).

Two sensitivity analyses were conducted to examine out-
comes for stratified groups (1) study cohort: GLB-Healthy and GLB-Moves and (2) delivery site type: community cen-
ter and worksite. Additionally, we assessed the impact of restricting our analyses to those with complete data by repeating our analyses using last observation carried forward (LOCF), an imputation method that can be used when repeated measures have been taken per subject by time point in which the last observed nonmissing value is used to fill in missing values.

Results

Of the 373 participants eligible for this analysis in the com-
bined cohorts, 305 participants (81.8%) had data available for 6- and 12-month pre/post intervention comparison (182 of 223 in GLB-Healthy, 123 of 150 in GLB-Moves). Screening and enrollment in both studies is shown in Supplemental Figure 1 but was described previously for the GLB-Healthy study only.\textsuperscript{21,22} Median participant attendance was 21 out of 22 sessions.

Demographic characteristics for the combined cohorts used in pre/post analysis are shown in Table 1. The majority of participants were female (74.3%), and the mean age was 60.4 years. Nearly half of the participants indicated they were working full time (48.9%) and more than half had completed at least some college education. Participants identifying as Black were slightly more likely to have incomplete data than individuals self-identifying as White, Asian, or another race. When comparing the study cohorts (data not shown), the GLB-Moves study had significantly more females (82.1% vs 60.1%), was more diverse (87.0% White vs 92.9% White), had a higher percentage with some college education and a lower percentage with graduate degrees, and had more retired participants compared to GLB-Healthy.

Confirmation of Lifestyle Intervention Success

When measured continuously, all of the outcome variables that form the basis of the cardiovascular health metrics for this study (Table 2) demonstrated significant improve-
ment at 6 and maintenance at 12 months ($P < .01$), with the exception of total cholesterol at 12 months. In the additional “high risk” analysis (as defined in the meth-
ods), which examined continuous change in each metric, total cholesterol demonstrated a significant improvement ($P < .01$) at both 6 and 12 months (n = 127, median [IQR]: −11.5 mg/dL [−28.5, 5.5] and −4.0 [−24.0, 10.0], respectively). All other metrics also demonstrated a greater magnitude of improvement when measured continuously for those at “high risk” (data not shown). Participants with medication changes related to a metric over the course of the intervention study were excluded from the continuous change analysis of that metric, although all significant changes remained consistent when these participants were included.

Examining the Impact of the Intervention on the AHA Cardiovascular Health Metrics

The percentages of participants within each metric category (poor, intermediate, ideal) showed improvement over the course of the intervention, as shown in Figure 1. Shifts in the ordered proportion of participants across categories for BMI, physical activity, and blood pressure were statistically significant from baseline to 6 months and from baseline to 12 months ($P < .05$), with a higher percentage of participants moving into the ideal range and a lower percentage of participants in the poor range after receiving the intervention. A favorable, but not statistically significant, shift was seen with the fasting plasma glucose metric. The proportion of participants within each category of total cholesterol did not change significantly.

Total” and “ideal” metric scores at each time point, and changes in metric scores are shown in Table 3. There was a significant positive shift in the distribution of the “total metric score” at both 6 ($P < .01$) and 12 months ($P < .01$) compared to baseline. There was also a significant positive shift in the distribution of “ideal metric score” at both 6 ($P < .01$) and 12 months ($P < .01$).
These findings were largely consistent when looking at the 2 study cohorts separately, and when examining all community sites and the worksite setting separately (not shown). While results were generally similar to those observed overall, the smaller sample sizes in the subgroup analysis led to reduced power, thus continuous change in fasting plasma glucose did not reach statistical significance in the worksite only sample. Also, the shift in the percentage of participants within each blood pressure category did not reach statistical significance at either time point at the worksite and community sites when analyzed separately. All findings for LOCF analysis were consistent with the complete case analysis.

**Discussion**

American Heart Association defined health metrics captured improvement in behavioral and cardiometabolic risk factors that occurred as the result of the effective DPP-GLB behavioral lifestyle intervention. This improvement was of substantial public health significance as it indicated that several metrics reached clinically meaningful cut points associated with lower CVD risk. In addition, it demonstrated the potential utility of the AHA-defined approach for monitoring progress during and after lifestyle intervention participation.

In this effort, continuous measures of the CVD risk factors of interest improved significantly at both 6 and 12 months, although total cholesterol change was only significant for initially “high risk” participants at the 12 month assessment. Continuous change in CVD risk factors was mirrored by beneficial shifts toward ideal metric status for BMI, blood pressure and physical activity and significant improvement in “total” and “ideal” composite scores. Positive changes in BMI, physical activity, and blood pressure appeared to contribute most to the shifts toward more favorable “total” and “ideal” composite scores of cardiovascular health metrics. Although the metrics of total cholesterol and glucose levels appeared to be less influenced by the intervention in this cohort, it should be noted that the lack of a visible significant change in the total cholesterol metric may be due to the high percentage (44%) of participants reporting use of medication for lipid management, which could mask the effects of the program on lipid

| Table 1. Demographic Characteristics of Combined GLB Cohort Pre/Post Analysis Sample n (%) or mean (SD), Samples with Complete Metric Data Versus Missing Metric Data. |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Complete data (n = 305) | Missing metric data (n = 68) | Between group P-value |
| Female | 165 (74.3) | 49 (72.1) | .68 |
| Age | 60.4 (10.3) | 57.9 (11.4) | .08 |
| Race/ethnicity | | | |
| White | 276 (90.5) | 57 (83.8) | .04 |
| Black | 17 (5.6) | 10 (14.7) | |
| Asian | 7 (2.3) | 0 (0) | |
| Other | 5 (1.6) | 1 (1.5) | |
| Spanish/Hispanic/Latino | 5 (1.6) | 1 (1) | .99 |
| Smoking status | | | |
| Current | 15 (4.9) | 2 (2.9) | .78 |
| Former | 101 (33.1) | 23 (33.8) | |
| Never | 189 (62.0) | 43 (63.2) | |
| Employment | | | |
| Working full-time | 149 (48.9) | 44 (64.7) | .19 |
| Working part-time | 33 (10.8) | 5 (7.4) | |
| Unemployed | 6 (2.0) | 0 (0) | |
| Homemaker | 8 (2.6) | 2 (2.9) | |
| Retired | 102 (33.4) | 14 (20.6) | |
| Disabled/unable to work | 7 (2.3) | 3 (4.4) | |
| Education | | | |
| 8th Grade or less | 1 (0.3) | 0 (0) | .06 |
| Some high school | 1 (0.3) | 1 (1.5) | |
| High school graduate | 29 (9.5) | 7 (10.3) | |
| Some college | 92 (30.2) | 28 (41.2) | |
| College graduate | 98 (32.1) | 11 (16.2) | |
| Graduate degree | 84 (27.5) | 21 (30.9) | |

Allegheny County, PA, USA. Study date: 2010 to 2019. Eligible population: overweight with prediabetes and/or metabolic syndrome.
levels. Additionally, we had a low prevalence of individuals with poor and intermediate glucose status which may account for the relatively lower impact of the intervention on changes in glucose as measured by the metric scores. However, in general, the beneficial impact of this DPP-based lifestyle intervention on cardiovascular risk factors in need of change specific to this cohort of individuals with prediabetes and/or metabolic syndrome as quantified by the AHA cardiovascular health metrics is encouraging.

Assessment and promotion of health behaviors and approaches to identifying appropriate lifestyle intervention candidates remain limited in clinical care, making screening tools desirable. The AHA metrics provide both a standard assessment tool and goal-based guidance in addressing health behaviors and associated cardiometabolic risk, serving as a natural complement to a lifestyle intervention program. In addition, prevalence estimates of cardiovascular health metrics in the general population show room for improvement, with projections suggesting a relative increase in cardiovascular health metric scores of about 6% in 2020, far lower than the 20% goal. Given the improvement in AHA metrics demonstrated in the current analysis, referral to and coverage for DPP-GLB programs...
based on initial cardiovascular health metric score status could meaningfully improve risk profiles in those in need of change.

Among the limitations of this effort, the lack of direct diet measures and low prevalence of smokers limited the ability to capture change in the entire AHA cardiovascular health metrics framework which includes 7 components. Changes in diet quality were not primary behavioral goals of these DPP-GLB study efforts, which focused primarily on weight loss and physical activity. In general, diet quality is not typically measured in these community-based programs. However, balanced heart healthy eating was discussed and encouraged during the course of the intervention. In a post-intervention survey conducted in the GLB-Moves study, 94% of participants said they made healthier food choices as a result of the program. Also, although diet quality is not routinely assessed as part of these intervention efforts, the AHA LS7 framework could potentially serve as a screening tool to assess and monitor diet quality in future intervention efforts.

While significant effort was made to sample communities to maximize diversity in these study cohorts, participation by non-white individuals was constrained by the fact that the greater Pittsburgh area has limited racial/ethnic diversity. Although previous research has suggested that the DPP-GLB program is effective among older adults of varying socioeconomic status, future studies should focus on other geographic regions with much more diverse populations.

A notable strength of this study is the consistent findings across 2 different study cohorts, spanning a period of 8 years, and across worksite and community settings. The consistency of the results across studies and sites justified the combination of these cohorts, in turn providing a more robust sample to examine effectiveness of the DPP-GLB program in improving cardiovascular health factors. In addition, the DPP-GLB programs demonstrated excellent adherence, with median attendance of 21 out of 22 sessions. Finally, post-intervention surveys reflected positive perceptions of the program among participants, with 95% of community participants and 99% of worksite participants surveyed in GLB-Healthy reporting they would recommend the DPP-GLB program to others. Similarly, 94% of GLB-Moves participants surveyed reported that the program helped them achieve a healthier lifestyle.

Conclusions

Participation in the highly successful, CDC-recognized and CMS funded, DPP-GLB resulted in improvement in several of the AHA cardiovascular health metrics, a composite of behavioral and cardiometabolic CVD risk factors. Each of the included AHA metrics improved significantly when measured continuously, confirming previous findings regarding participation in the DPP-GLB, and benefits to the cardiovascular risk profile. Improvement in “ideal” and “total” composite metric scores, as well as shifts toward more favorable individual cardiovascular health metric categories, mirrored this continuous change, signifying risk factor progression toward clinically desirable values. Given these metric improvements, the AHA metrics approach could have great utility in streamlining referral to and monitoring of success in behavioral lifestyle interventions, all of which would have important implications for CVD prevention.

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Declaration of Conflicting Interests

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**Ethical Approval and Approval Number**

Both clinical trials included in this current effort were conducted in accordance with the 1964 Declaration of Helsinki and received ethical approval from the University of Pittsburgh Institutional Review Board. All subjects provided written informed consent.

**ORCID iDs**

Susan M. Devaraj [https://orcid.org/0000-0002-3702-2874](https://orcid.org/0000-0002-3702-2874)

Vincent C. Arena [https://orcid.org/0000-0002-1634-7207](https://orcid.org/0000-0002-1634-7207)

**Availability of Data and Materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Supplemental Material**

Supplemental material for this article is available online.

**References**

1. Lloyd-Jones DM, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: The american heart association’s strategic impact goal through 2020 and beyond. *Circulation*. 2010;121(4):586-613.

2. Enserro DM, Vasan RS, Xanthakis V. Twenty-year trends in the American heart association cardiovascular health score and impact on subclinical and clinical cardiovascular disease: the framingham offspring study. *J Am Heart Assoc*. 2018;7(11):e008741.

3. Folsom AR, Yatsuya H, Nettleton JA, et al. Community prevalence of ideal cardiovascular health, by the American heart association definition, and relationship with cardiovascular disease incidence. *J Am Coll Cardiol*. 2011;57(16):1690-1696.

4. Younus A, Aneni EC, Spatz ES, et al. Trends in cardiovascular health metrics and associations with all-cause and CVD mortality among us adults. *Circulation*. 2016;307(12):1273-1283.

5. Aneni EC, Crippa A, Osondu CU, et al. Estimates of mortality benefit from ideal cardiovascular health metrics: the atherosclerosis risk in communities study. *J Am Heart Assoc*. 2013;2(6):e000430.

6. Artero EG, España-Romero V, Lee D, et al. Ideal cardiovascular health and incident cardiovascular disease and cancer: the women’s health initiative. *Am J Prev Med*. 2016;50(2):236-240.

7. Foraker RE, Abdel-Rasoul M, Kuller LH, et al. Cardiovascular health and incident cardiovascular disease and cancer: the women’s health initiative. *Am J Prev Med*. 2016;50(2):236-240.

8. Ogaguru ER, Lutsey PL, Klein R, et al. Association of ideal cardiovascular health metrics and retinal microvascular findings: the atherosclerosis risk in communities study. *J Am Heart Assoc*. 2013;2(6):e000430.

9. Frets AM, Howard BV, McKnight B, et al. Life’s simple 7 and incidence of diabetes among American Indians: the strong heart family study. *Diabetes Care*. 2014;37(8):2240-2245.

10. Brewer LC, Ballis-Berry JE, Dean P, et al. Fostering African-American improvement in total health (FAITH): an application of the American heart association’s life’s simple 7™ among Midwestern African-Americans. *J Racial Ethn Heal Disparities*. 2017;4(2):269-281.

11. Murphy MP, Coke L, Staffileno BA, et al. Improving cardiovascular health of underserved populations in the community with life’s simple 7. *J Am Assoc Nurse Pract*. 2015;27(11):615-623.

12. Al Mheid I, Kelli HM, Ko YA, et al. Effects of a health-partner intervention on cardiovascular risk. *J Am Heart Assoc*. 2016;5(10):e004217.

13. Tettey NS, Duran PA, Andersen HS, et al. Evaluation of heartsmarts, a faith-based cardiovascular health education program. *J Relig Health*. 2017;56(1):320-328.

14. Gruss SM, Nhim K, Gregg E, et al. Public health approaches to type 2 diabetes prevention: the US national diabetes prevention program and beyond. *Curr Diab Rep*. 2019;19(9):78.

15. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med*. 2002;346(6):393-403.

16. Orchard TJ, Temprosa M, Goldberg R, et al. The effect of metformin and intensive lifestyle intervention on the metabolic syndrome: the diabetes prevention program randomized trial. *Ann Intern Med*. 2005;142(8):611-619.

17. Ratner R, Goldberg R, Haefner S, et al. Impact of intensive lifestyle and metformin therapy on cardiovascular disease risk factors in the diabetes prevention program. *Diabetes Care*. 2005;28(4):888-894.

18. Ali MK, Echouffo-Tcheugui J, Williamson DF. How effective were lifestyle interventions in real-world settings that were modeled on the diabetes prevention program? *Health Aff (Millwood)*. 2012;31(1):67-75.

19. Centers for Medicare and Medicaid Services. Medicare diabetes prevention program (MDPP) expanded model. 2019. Accessed August 21, 2019. [https://innovation.cms.gov/initiatives/medicare-diabetes-prevention-program/](https://innovation.cms.gov/initiatives/medicare-diabetes-prevention-program/)

20. Kramer MK, McWilliams JR, Chen HY, et al. A community-based diabetes prevention program: evaluation of the group lifestyle balance program delivered by diabetes educators. *Diabetes Educ*. 2011;37(5):659-668.

21. Kramer MK, Molenaar DM, Arena VC, et al. Improving employee health: evaluation of a worksite lifestyle change program to decrease risk factors for diabetes and cardiovascular disease. *J Occup Environ Med*. 2015;57(3):284-291.

22. Kramer MK, Vanderwood KK, Arena VC, et al. Evaluation of a diabetes prevention program lifestyle intervention in older adults: a randomized controlled study in three senior/community centers of varying socioeconomic status. *Diabetes Educ*. 2018;44(2):118-129.

23. Ma J, Yank V, Xiao L, et al. Translating the diabetes prevention program to decrease risk factors for diabetes and cardiovascular disease. *JAMA Intern Med*. 2013;173(2):113-121.

24. Kramer MK, Kriska AM, Venditti EM, et al. A novel approach to diabetes prevention: evaluation of the Group
Lifestyle Balance program delivered via DVD. *Diabetes Res Clin Pract*. 2010;90(3):e60-e63.

25. Venditti EM, Kramer MK. Diabetes Prevention Program community outreach: perspectives on lifestyle training and translation. *Am J Prev Med*. 2013;44(4 Suppl 4):S339-S345.

26. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III). *JAMA*. 2001;285(19):2486-2497. doi:10.1001/jama.285.19.2486

27. Kramer MK, Kriska AM, Venditti EM, et al. Translating the diabetes prevention program: a comprehensive model for prevention training and program delivery. *Am J Prev Med*. 2009;37(6):505-511.

28. Fang J, Zhang Z, Ayala C, et al. Cardiovascular health among non-hispanic Asian Americans: NHANES, 2011-2016. *J Am Heart Assoc*. 2019;8(13):e011324.

29. Hsu WC, Araneta MRG, Kanaya AM, et al. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. *Diabetes Care*. 2015;38(1):150-158.

30. Schulz LO, Harper IT, Smith CJ, et al. Energy intake and physical activity in Pima Indians: comparison with energy expenditure measured by doubly-labeled water. *Obes Res*. 1994;2(6):541-548.

31. Kriska AM, Knowler WC, LaPorte RE, et al. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. *Diabetes Care*. 1990;13(4):401-411.

32. Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults: recommendation from the American college of sports medicine and the American heart association. *Circulation*. 2007;116(9):1094-1105.

33. Kushner RF, Ryan DH. Assessment and lifestyle management of patients with obesity: clinical recommendations from systematic reviews. *JAMA*. 2014;312(9):943-952.

34. Dash S, Delibasic V, Alsaeed S, et al. Knowledge, attitudes and behaviours related to physician-delivered dietary advice for patients with hypertension. *J Community Health*. 2020;45:1067-1072.

35. Tseng E, Greer RC, O’Rourke P, et al. Survey of primary care providers’ knowledge of screening for, diagnosing and managing prediabetes. *J Gen Intern Med*. 2017;32(11):1172-1178.

36. Tseng E, Greer RC, O’Rourke P, et al. National survey of primary care physicians’ knowledge, practices, and perceptions of prediabetes. *J Gen Intern Med*. 2019;34(11):2475-2481.

37. Huffman MD, Capewell S, Ning H, et al. Cardiovascular health behavior and health factor changes (1988–2008) and projections to 2020. *Circulation*. 2012;125(21):2595-2602.

38. Virani SS, Alonso A, Benjamin EJ, et al. Heart disease and stroke statistics-2020 update: a report from the American Heart Association. *Circulation*. 2020;141(9):e139-e596.

39. United States Census Bureau. United States census bureau quickfacts: Allegheny County, Pennsylvania. 2019.