A Worksite Translation of the Diabetes Prevention Program among Employees with Prediabetes

by

Kellie R. Weinhold, MS, RD, LD[1]

OSU Interdisciplinary PhD Program in Nutrition

The Ohio State University

[1] With special appreciation for contributing author Carla K. Miller, PhD.

ABSTRACT

INTRODUCTION: Type 2 diabetes mellitus (T2DM) is a serious medical condition affecting over 12% of Americans and is associated with $58 billion in work-related annual costs. Prediabetes increases risk for T2DM, and is estimated to affect over one third of U.S. adults. There is an evident need to prevent the development of T2DM in at-risk individuals. Adults spend a significant portion of their time at the workplace, suggesting its utility for efforts at health promotion and disease prevention. The Diabetes Prevention Program (DPP) is a lifestyle intervention program that has demonstrated efficacy in preventing or delaying T2DM in at-risk adults, however there is a lack of well-designed research studies evaluating the efficacy of the DPP in the workplace. The primary aim of this study was to implement and evaluate the efficacy of the group-based DPP intervention at The Ohio State University (OSU).

METHODS: Seventy-eight employees with prediabetes recruited from OSU were randomized to the 16-week group-based DPP intervention group or a usual care control group. Sixty-eight participants completed data collection at baseline and post-intervention. Clinical and anthropometric measures included body weight, waist circumference, fasting blood glucose and lipids, and blood pressure. Statistical analyses included Pearson chi-square tests for baseline demographic characteristics and Student t-tests within an ANOVA for between and within-group analyses. For data not meeting normality assumptions, Wilcoxon signed rank tests were used for within-group and Wilcoxon rank sum 2-sample test for between-group comparisons. Multivariate analyses between variables were completed using Spearman nonparametric correlations.

RESULTS: There were no significant differences in primary outcomes between treatment groups at baseline except for occupation. Mean (±SE) change in body weight for experimental versus control groups was -5.25 kg (±0.55) vs. -0.37 kg (±0.56), ($p<0.0001$). Fasting glucose was reduced by a mean (±SE) of -8.56 mg/dL (±1.52) and -4.48 mg/dL (±1.79), ($p=0.0293$), for the experimental versus control groups, respectively.

CONCLUSIONS: The worksite was an effective setting to implement the DPP intervention, and facilitated significant reductions in body weight and blood glucose. Evaluation of cost-effectiveness of the intervention for employers and long-term maintenance of weight loss and prevention of T2DM are warranted.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a major medical concern in the U.S. that has increased at alarming rates in recent decades. National Health and Nutrition Examination Survey (NHANES) data indicates there has been an estimated relative increase of 45% in combined diagnosed & undiagnosed T2DM from 1988-1994 to 2005-2010, with the present estimated prevalence at 12.1%.[1] Undiagnosed T2DM has been shown to comprise 19-40% of diabetes cases, suggesting that there is a growing need for T2DM screening and prevention efforts.[2-4]

With rates continuing to increase, there are numerous fiscal and social costs associated with T2DM. The total national cost of diabetes in the U.S. in 2007 was estimated at $174 billion, with $58 billion in reduced productivity from work-related absenteeism, reduced productivity at work and at home, unemployment from chronic disability, and premature mortality.[5] There is reported to be an annual incremental cost to employers of $4413 for employees with T2DM compared to those without T2DM, and greater than 30% of costs associated with diabetic employees are attributable to medically related work absences and disability.[6] The American Diabetes Association (ADA) reports that of the roughly 16 million people in 2007 who were unemployed or on disability, over 1 million had T2DM and over 445,000 cases of unemployment were attributed to T2DM, resulting in a total of 107 million lost work days at a national cost of $7.9 billion.[5] In addition to national and employer fiscal costs, there are also fiscal costs incurred by individuals with T2DM. About half of all doctor office, emergency, and hospital outpatient visits in addition to outpatient prescriptions incurred by people with T2DM are attributable to their diabetes.[5] Beyond fiscal costs, T2DM also imposes

unquantifiable costs on society in terms of reduced quality of life as well as pain and suffering experienced by people with T2DM and their family.[5]

An increased risk for developing T2DM is associated with prediabetes, obesity, and lack of physical activity.[7-10] Prediabetes is defined as having impaired fasting plasma glucose levels of 100-125 mg/dl, impaired glucose tolerance following 2-hour oral glucose tolerance test with plasma glucose levels of 140-199 mg/dl, or hemoglobin A1c of 5.7-6.5%.[7] NHANES data indicates that there has been a significant increase in prediabetes prevalence for adults from 30.2% in 1999-2002 to 36.5% in 2007-2010.[11] It has been reported that prediabetes itself is associated with greater prevalence of microvascular and macrovascular complications that are commonly associated with T2DM.[12-15] Additionally, among full-time employees in the U.S., obesity-related medical costs are estimated at $73.1 billion, with $30.0 billion attributable to presenteeism, $12.8 billion attributable to absenteeism, and $30.3 billion attributable to medical expenditures.[16, 17] With prediabetes rates on the rise and costs associated with obesity and T2DM well documented, there is an evident need for continued efforts to prevent the development of T2DM in at-risk individuals.

Numerous randomized control trials in multiple countries have demonstrated the efficacy of intensive lifestyle interventions in preventing or delaying the development of T2DM in at-risk populations.[8, 18-20] The lifestyle interventions have primarily focused on achieving weight loss through improving dietary habits and increasing physical activity levels. Results from the Diabetes Prevention Program (DPP), which is a goal-based individual behavioral intervention providing nutrition and physical activity education and emphasizing self-monitoring, indicate that weight loss through intensive lifestyle intervention is more effective in reducing incidence of

T2DM in adults with prediabetes than pharmacotherapy, although both are effective interventions.[8] For every kilogram of weight loss achieved in the DPP, there was found to be a 16% reduction in diabetes risk, adjusting for changes in diet and activity.[21] Ten-year follow-up of participants in the DPP showed that diabetes incidence was lowest for participants in the lifestyle intervention group.[22]

Adults spend a significant portion of their time at work, which makes the worksite an ideal setting to provide opportunities for health promotion and disease prevention for employees. There has recently been increasing interest among employers to provide programs at the worksite that are focused on improving the health of employees. Employers have an incentive to offer wellness programs, as the potential exists for cost-savings if employees' medical costs and absenteeism are reduced through improvements to their health. Reviews of studies evaluating worksite programs for weight loss and obesity prevention have revealed evidence of success.[23-25] There is strong evidence of the efficacy of weight reduction through worksite health promotion programs aimed at improving nutrition, physical activity, or both.[24] The workplace can be a unique setting to identify individuals at risk for developing T2DM and provide opportunities to reduce their risk while also saving employers the potential future costs they could incur if those employees develop T2DM.[6]

There have been recent translations of the DPP to a variety of community settings such as churches, hospitals, and worksites.[26, 27] While many of these settings have been shown to be effective for the general community, few studies have examined the efficacy of implementing the DPP in the worksite.[26, 28-31] Adaptations to the format of the DPP intervention for utilization in worksites have varied, including providing the intervention via self-study, weekly group

sessions, one-on-one sessions, modifying the number and frequency of sessions, and a combination of the above.[28-31] Of the articles identified that utilized the DPP for a worksite intervention, only one employed a randomized controlled trial study design[28]; one refined inclusionary criteria to only those at risk for T2DM[29]; two assessed clinical indicators of diabetes risk before and after the intervention[28, 29]; and only utilized an intervention format consistent with prior adaptations[29]. Clearly, there is a lack of well-designed studies evaluating the efficacy of implementing the DPP in the worksite in efforts to improve health and reduce diabetes risk.

METHODS

Research Design

A randomized controlled trial design was utilized for this efficacy study with the purpose of evaluating the DPP intervention for diabetes prevention in the worksite setting at The Ohio State University (OSU). Approval for the study was obtained from the Institutional Review Board (IRB) at OSU and all participants provided written, informed consent. Eligible participants were randomized to receive either the 16-week healthy lifestyle treatment or to receive usual care from their health care providers, which served as the control. Data was collected at baseline, post-intervention, and at 3-month follow-up.

Sample

Employees were recruited for this research study between August 2012 and May 2013. A variety of recruitment methods were utilized, including a health fair table, letters of invitation through The OSU Health Plan, various advertisement formats including OSUToday, and recruitment websites including ResearchMatch and StudySearch. Inclusion criteria included OSU employees between the ages of 18 to 65 years old with prediabetes (fasting blood glucose values between 100-125 mg/dl) who were overweight or obese, as defined by a BMI of 25 to 50 kg/m^2. Exclusion criteria were established as factors that could potentially interfere with study participation, weight loss rates, and fasting blood sugar levels. Participants could not have a current diagnosis of T2DM or type 1 diabetes mellitus (T1DM). Participants could not be pregnant, breastfeeding, or trying to become pregnant for the duration of the study due to the changes to energy requirements and weight status associated with these states. Participants could not be pursuing bariatric surgery or have recently had bariatric surgery, as weight loss rates are

much greater following surgery than without. Participants also could not be participating in any other weight management programs as the effects of those programs could confound study results. Participants could not be taking any medications that modify blood glucose levels, such as Metformin or steroids. Additionally, participants could not be planning to leave their employment at OSU within one year of enrollment in the study.

Intervention Group

The participants who were randomized to the intervention group received the manualized 16-week DPP intervention. Groups met either during the lunch hour or in the evening after work for 60 minutes each week. A registered dietitian employed by the OSU Health Plan served as the interventionist for the lunch hour groups, and a registered dietitian graduate student served as the interventionist for the evening group. Both interventionists completed the two-day training sessions for DPP lifestyle coaches conducted by Dr. David Marrero, a principal investigator with the original DPP intervention. The behavioral goals for the program were consistent with those of the original DPP, and included achieving 7% weight loss at the end of the intervention program, completing at least 150 minutes per week of moderate to vigorous intensity physical activity, and meeting a personal recommended daily fat gram goal equivalent to 25% of total energy intake.[8]

Participants were provided intervention materials, a Carbohydrate, Fat & Calorie Guide, and weekly food and exercise trackers.[32] Participants received their program goals at the first session, and were encouraged to set smaller, specific goals each week relating to the weekly session topics. They engaged in group discussions and completed individual and group activities each week during the 60-minute sessions, establishing support networks with their fellow group

members. They were expected to track their diet and physical activity each day in their weekly tracker booklets and submit them each week to be reviewed by the interventionist, who returned them the following week with individualized feedback. Daily self-monitoring of diet and physical activity allowed participants to be more accountable to their goals and receive support as they made changes to their lifestyles. While missing any of the weekly group sessions was discouraged, efforts were made to provide individual make-up sessions and collect weight measurements for any participants who missed a regularly scheduled group session. Methods were employed to enhance treatment fidelity for this research study.[33] The principal investigator (PI) for the study observed >20% of intervention sessions and found no serious departures from the curriculum as planned.

Control Group

Following randomization, participants in the control group were provided with the "*Small Steps. Big Rewards. Your GAME PLAN to Prevent Type 2 Diabetes: Information for Patients"* booklet that was based on the lifestyle modification strategies used in the DPP (http://ndep.nih.gov/publications/PublicationDetail.aspx?PubId=71). These participants were advised to utilize the information in booklet on their own, and were encouraged to continue receiving usual care from their health care providers for the duration of the research study. They were discouraged from participating in any weight management programs in order to limit confounding variables. Following all data collection, participants in the control group were invited to attend a 1-hour session which addressed key principles to promote weight loss in the DPP intervention.

Study Measures

All study measures were collected at baseline, post-intervention, and at 3-month follow-up. Body weight was measured using a calibrated Health-O-Meter Professional® digital scale. Height was collected only at the initial screening visit, and was measured using a Perspective Enterprises® standing stadiometer. For both height and weight, participants were measured with shoes and excess clothing removed. Waist circumference measurements were obtained using the procedure identified in the National Health and Nutrition Examination Survey (NHANES).[34] All anthropometric measurements were collected twice at each visit and mean values were determined for each. BMI (kg/m^2) was calculated from mean values for body weight and height.

Fingerstick whole blood samples were collected from study participants after a minimum 8-hour fast at both the initial screening and post-intervention visits. The Alere Cholestech LDX® System was utilized to complete point-of-care analysis of the whole blood samples for glucose, total and HDL cholesterol, and triglycerides. LDL cholesterol was calculated by the system using the Friedewald formula.[35] The Alere Cholestech LDX® System has been certified as accurate and reproducible by the CDC's Lipid Standardization Program (LSP) and Cholesterol Reference Method Laboratory Network (CRMLN).[36] Additionally, two blood pressure readings were collected from seated participants at each data collection visit with an Omron Healthcare, Inc. 7-Series™ home blood pressure cuff, which meets the protocol criteria for validation standards of the European Society of Hypertension (ESH).[37]

Statistical Analysis

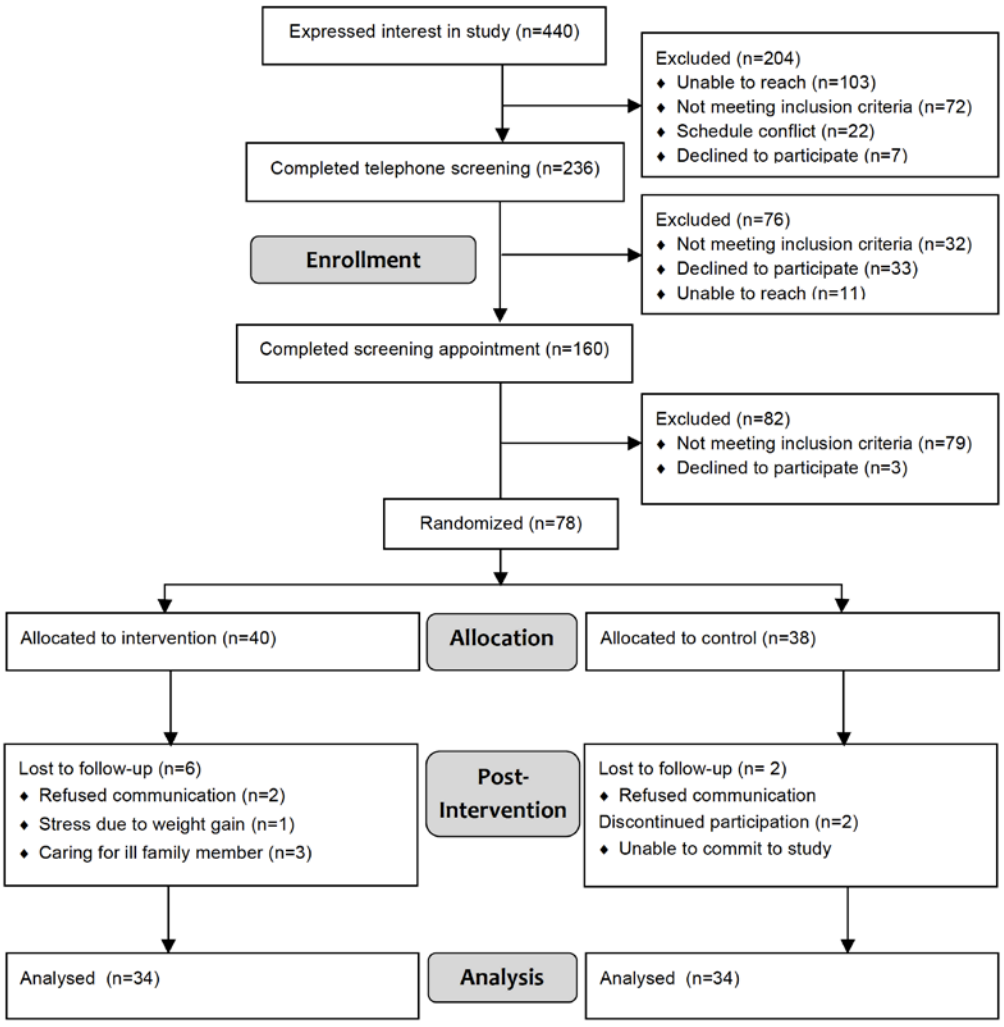
Baseline demographic characteristics were assessed using Pearson chi-square tests for categorical data. The continuous variable age was assessed using a 2-sample t-test.

Anthropometric and clinical outcome variables with normally distributed residuals were assessed using student t-tests within an ANOVA for between group comparisons of mean values at baseline, and between group and within-group change from baseline to post-intervention. The clinical outcome variables glucose, HDL cholesterol, and triglycerides had residuals that were not normally distributed, and were assessed using Wilcoxon Rank Sum 2-Sample tests for between group comparisons at baseline and between-group change from baseline to post-intervention. Wilcoxon Signed Rank Tests were used for within-group changes from baseline to post-intervention for these variables. Multivariate analyses of correlation between variables were completed using Spearman nonparametric tests. Statistical analyses were completed using SAS JMP® Pro (version 10.0.2, 2012, SAS Institute, Cary, NC). P-values of < 0.05 were used for statistical significance.

RESULTS

A total of 440 individuals expressed initial interest in the research study, 236 of which were screened over the phone for potential eligibility (see figure 1). In-person screening appointments were completed by 160 potentially eligible individuals, and 78 met inclusion criteria and were enrolled in the study. Random assignment allocated 40 participants to the intervention group and 38 to the control group. Post-intervention data were obtained for 68 participants (34 in each group), indicating 87% retention.

Figure 1. Consort Flow Diagram



Baseline results

Baseline demographic information is reported in Table 1. There were no significant differences between groups at baseline for demographic characteristics except occupation category. All remaining baseline comparisons of intervention and control groups are shown in tables 3 and 4. For anthropometric and clinical outcomes, only diastolic blood pressure approached significance at baseline (p=0.0571) (see table 3).

Table 1. Demographic characteristics of participants by treatment group at baseline

	Experimental Group (n=34)	Control Group (n=34)	
	Mean (± SD)	**Mean (± SD)**	**P-value**
Age (years)	51.71 (±9.63)	51.00 (±8.07)	0.7442
	n (%)	**n (%)**	**P-value**
Race			
White	27 (79.41)	30 (88.24)	0.3232
Non-White (Black and Asian)	7 (20.59)	4 (11.76)	
Ethnicity			
Non-Hispanic/Latino	34 (100.00)	33 (97.06)	0.3137
Hispanic/Latino	0 (0.00)	1 (2.94)	
Gender			
Male	7 (20.59)	7 (20.59)	1.0000
Female	27 (79.41)	27 (79.41)	
Education			
Less than Bachelor's Degree	14 (41.18)	9 (26.47)	0.3950
Bachelor's Degree	11 (32.35)	12 (35.29)	
Advanced Degree	9 (26.47)	13 (38.24)	
Employment			
Full-time	31 (91.18)	33 (97.06)	0.3026
Part-time	3 (8.82)	1 (2.94)	
Marital Status			
Married	24 (70.59)	26 (76.47)	0.5825
Not Married	10 (29.41)	8 (23.53)	
Occupation [a]			
Professional	12 (36.36)	19 (55.88)	0.0167
Clerical	10 (30.30)	13 (38.24)	
Other (i.e. clinical, technology, physical labor)	11 (33.33)	2 (5.88)	
Years at Current Job			
1-5 years	13 (38.24)	11 (32.35)	0.3230
6-10 years	12 (35.29)	7 (20.59)	
11-15 years	3 (8.82)	6 (17.65)	
20+ years	6 (17.65)	10 (29.41)	
Current Student			
No	30 (88.24)	32 (94.12)	0.3562
Yes, full-time student	2 (5.88)	0 (0.00)	
Yes, part-time student	2 (5.88)	2 (5.88)	
Number of people at home			
1	5 (14.71)	2 (5.88)	0.6520
2	17 (50.00)	16 (47.06)	
3	5 (14.71)	5 (14.71)	
4	5 (14.71)	9 (26.47)	
5+	2 (5.88)	2 (5.88)	
Annual Household Income [a]			
$20,000-39,999	7 (21.21)	3 (8.82)	0.2777
$40,000-59,999	4 (12.12)	4 (11.76)	
$60,000-79,999	6 (18.18)	6 (17.65)	
$80,000-99,999	9 (27.27)	6 (17.65)	
≥$100,000	7 (21.21)	15 (44.12)	

[a] One participant in intervention group did not provide this information

Between-group comparisons and outcomes

The experimental group had significantly greater decreases in body weight, BMI, waist circumference, fasting blood glucose, and blood pressure than the control group (see table 3). When divided by sex, change in body weight and BMI were not significantly different between men but remained significant between women in the experimental and control groups, and change in waist circumference was not significantly different between women but remained significant between men in the experimental and control groups. More participants in the experimental than control groups lost at least 5% of their body weight following the intervention ($p<0.0001$) (see table 2). There was no significant difference between groups in the change in total, HDL and LDL cholesterol, and triglycerides. For clinical outcomes, LDL and total cholesterol were both significantly lower post-intervention compared to baseline within the experimental group (see table 3). Within the control group, glucose was the only post-intervention clinical outcome found to be significantly different from baseline.

Table 2. Post-intervention percent weight change

	Intervention Group (n=34)	**Control Group (n=33)**
Weight Loss (%)	n (%)	n (%)
≤ 0%	2 (5.88)	17 (51.52)
0 – 4.9%	14 (41.18)	15 (45.46)
5 – 6.9%	7 (20.59)	0 (0.00)
7 – 9.9%	7 (20.59)	0 (0.00)
≥ 10%	4 (11.77)	1 (3.03)

Table 3. Mean (± SE) value and change in anthropometric & clinical outcomes by treatment group and time point

	Baseline (T1)			Post-Intervention (T2)[a]		Change Scores (T2-T1)		
	Experimental Group (n=34)	Control Group (n=33)[b]	P-value[c]	Experimental Group (n=34)	Control Group (n=33)[b]	Experimental Group (n=34)	Control Group (n=33)[b]	P-value[c]
Percent weight change (%)	-	-	-	-	-	-5.50 (±0.56)	-0.35 (±0.57)	<0.0001
Body weight (kg)	95.74 (±2.93)	101.68 (±2.98)	0.1597	90.49 (±2.93)***	101.31 (±2.98)	-5.25 (±0.55)	-0.37 (±0.56)	<0.0001
Men	102.94 (±6.21)	107.44 (±6.21)	0.6175	97.23 (±6.21)**	104.44 (±6.21)	-5.71 (±1.38)	-2.71 (±1.38)	0.1514
Women	93.87 (±3.32)	100.13 (±3.38)	0.1919	88.74 (±3.32)***	100.39 (±3.38)	-5.13 (±0.57)	0.26 (±0.59)	<0.0001
BMI (kg/m^2)	35.10 (±0.99)	35.94 (±1.01)	0.5572	33.20 (±0.99)***	35.82 (±1.01)	-1.91 (±0.19)	-0.11 (±0.20)	<0.0001
Men	32.22 (±1.66)	32.85 (±1.66)	0.7908	30.48 (±1.66)**	32.03 (±1.66)	-1.74 (±0.41)	-0.82 (±0.41)	0.1425
Women	35.85 (±1.14)	36.77 (±1.16)	0.5737	33.85 (±1.14)***	36.85 (±1.16)	-1.95 (±0.21)	0.08 (±0.22)	<0.0001
Waist circumference (cm)	107.27 (±2.08)	110.83 (±2.11)	0.2335	102.39 (±2.08)***	109.63 (±2.11)	-4.88 (±1.01)	-1.20 (±1.02)	0.0127
Men	109.63 (±4.97)	109.19 (±4.97)	0.9508	102.87 (±4.97)***	108.64 (±4.97)	-6.76 (±1.23)	-0.54 (±1.23)	0.0037
Women	106.66 (±2.33)	111.28 (±2.37)	0.1697	102.26 (±2.33)***	109.90 (±2.37)	-4.40 (±1.23)	-1.38 (±1.25)	0.0919
Glucose (mg/dL)	109.41 (±1.37)	111.64 (±1.96)	0.6422[d]	100.85 (±1.80)[e]***	107.15 (±2.11)[e]*	-8.56 (±1.52)	-4.48 (±1.79)	0.0293[d]
Total cholesterol (mg/dL)	195.74 (±4.96)	197.06 (±5.03)	0.8515	183.65 (±4.96)*	196.85 (±5.03)	-12.09 (±4.73)	-0.21 (±4.80)	0.0825
LDL cholesterol (mg/dL)[f]	114.36 (±4.20)	113.84 (±4.26)	0.9309	104.24 (±4.25)*	115.07 (±4.32)	-10.12 (±4.26)	1.22 (±4.32)	0.0662
HDL cholesterol (mg/dL)[g]	50.88 (±2.35)	50.42 (±3.07)	0.3866[d]	50.82 (±2.00)[e]	49.03 (±2.54)[e]	-0.06 (±1.73)	-0.19 (±1.38)	0.9284[d]
Triglycerides (mg/dL)[h]	166.79 (±15.11)	165.31 (±12.37)	0.7974[d]	160.88 (±15.28)[e]	161.22 (±13.38)[e]	-8.39 (±10.14)	-4.09 (±7.47)	0.8133[d]
Systolic blood pressure (mmHg)	128.91 (±2.54)	124.68 (±2.58)	0.2459	120.50 (±2.54)***	124.27 (±2.58)	-8.41 (±2.22)	-0.41 (±2.25)	0.0137
Diastolic blood pressure (mmHg)	90.84 (±1.57)	86.52 (±1.60)	0.0571	82.19 (±1.57)***	84.64 (±1.60)	-8.65 (±1.23)	-1.88 (±1.25)	0.0003

[a] Student t-test within an ANOVA to compare within-group change from baseline to post-intervention; *(p<0.05); **(p<0.01); ***(p<0.001)
[b] One subject excluded due to post-intervention measures collected immediately post-knee surgery while subject was on Metformin and unable to travel.
[c] Student t-test within an ANOVA for between-group comparison at baseline and change from baseline to post-intervention; P-value < 0.05 used for statistical significance.
[d] Wilcoxon Rank Sum 2-Sample Test for between group comparisons at baseline and between-group change from baseline to post-intervention; P-value < 0.05 used for statistical significance.
[e] Wilcoxon Signed Rank Test for within-group comparisons from baseline to post-intervention; *(p<0.05); **(p<0.01); ***(p<0.001)
[f] LDL could not be calculated due to triglycerides or HDL outside of acceptable range for one participant in each group at baseline and for two participants in each group post-intervention.
[g] HDL outside of detectable levels (>100 mg/dL) for one participant in control group post-intervention.
[h] Triglycerides were below detectable levels (<45 mg/dL) for one participant in control group at baseline and for one participant in each group post-intervention.

The percent of participants in each group who met the recommended guidelines for the clinical health outcomes revealed no significant differences at baseline or post-intervention between groups for any of the health outcomes. However, there was a greater percentage of participants in the experimental than control group who met the clinical guidelines following the intervention (see table 4).

Table 4. Percent of participants meeting recommended health outcomes by time point

	Baseline			Post-Intervention		
	Experimental Group (n=34)	Control Group (n=33)		Experimental Group (n=34)	Control Group (n=33)	
Optimal Health Outcome	**n (%)**	**n (%)**	P-Value	**n (%)**	**n (%)**	P-Value
Glucose < 100 mg/dL	4 (11.77)	1 (3.03)	0.1738	16 (47.01)	11 (33.33)	0.2522
Total cholesterol < 200 mg/dL	18 (52.94)	17 (51.52)	0.9070	26 (76.47)	20 (60.61)	0.1617
LDL cholesterol < 100mg/dL	9 (26.47)	9 (27.27)	0.9410	13 (38.24)	6 (18.18)	0.0687
HDL cholesterol > 40 mg/dL (men) or > 50 mg/dL (women)	17 (50.00)	14 (42.42)	0.5341	18 (52.94)	15 (45.46)	0.5400
Triglycerides < 150 mg/dL	19 (55.88)	19 (57.58)	0.8888	19 (55.88)	15 (45.46)	0.3934
Systolic blood pressure <120 mmHg	7 (20.59)	9 (27.27)	0.5211	16 (47.06)	11 (33.33)	0.2522
Diastolic blood pressure < 80 mmHg	3 (8.82)	6 (18.18)	0.2614	13 (38.24)	11 (33.33)	0.6757

Associations among intervention participation and changes in body weight

Within the experimental group, the change in body weight post-intervention was negatively associated with total days of self-monitoring food intake, total minutes of self-monitoring physical activity, and total number of sessions attended during the 16-week intervention program (see table 5).

Table 5. Spearman correlations among intervention attendance, self-monitoring, and change in body weight

Intervention outcomes (n=32)	Correlation coefficient	P-Value
Days self-monitoring food intake and change in body weight	-0.6223[a]	0.0001
Minutes self-monitoring physical activity and change in body weight	-0.4945[a]	0.0040
Total sessions attended and change in body weight	-0.5997[a]	0.0002

[a] Two subjects from experimental group completed 0 days and 0 minutes of self-monitoring, and were excluded from the analysis.

DISCUSSION & CONCLUSION

The results from this study indicate that the 16-week group-based DPP intervention provided in a worksite setting was effective in reducing body weight and fasting blood glucose among intervention participants, which is associated with reduced risk for T2DM.[8] These results support the DPP intervention as an effective disease risk reduction program, and provide promising evidence for its utility in a worksite setting. In the present study, 32.4% of participants in the experimental group achieved the weight loss goal of 7% or more of body weight at the end of the group-based intervention (table 2), compared with 50% of participants who received the original 24-week one-on-one DPP intervention.[8] The smaller percentage of participants meeting the program weight loss goal in the present study may be a result of the use of a shorter intervention period, in addition to less individualized attention. Over 50% of participants in the experimental group for the present study successfully achieved clinically significant weight loss of at least 5% of their body weight, which is associated with a reduction in morbidity and mortality.[38-40] The group-based format of the intervention was more appropriate for a worksite-based intervention because of the significant reduction in resources and time required to offer a program to multiple people at once versus individually.

The original DPP study identified a 16% reduction in diabetes risk for every kilogram of body weight loss.[21] The mean (±SE) post-intervention body weight loss achieved in this study was -5.25 kg (±0.55), comparable to the amount of weight loss achieved in the Diabetes Education & Prevention with a Lifestyle Intervention Offered at the YMCA (DEPLOY) community trial of the DPP intervention (-5.7 kg).[27] Participation in the intervention program, as evidenced by attendance and completion of diet and physical activity self-monitoring, was strongly associated with post-intervention weight loss (table 5). This association is similar to

that of the original DPP study, in which self-monitoring was related to achieving and sustaining weight loss.[41] Further, the mean weight loss achieved in this study was far exceeded that of any of the previously examined studies using the DPP in a worksite setting (-0.94 kg to -2.58 kg).[28-31] Clearly, the DPP intervention administered in a group-based worksite setting is effective in producing weight loss compared to other intervention settings and formats.

The intervention in this study was also effective in helping a greater percent of participants meet clinical guidelines for recommended health outcomes for glucose, lipids, and blood pressure compared to the standard care received by the control group (table 4). These findings suggest that there may be additional health benefits of the DPP intervention beyond diabetes prevention when provided to individuals in a worksite setting. An evaluation of the DPP on cardiovascular risk factors found that after an average of 10 years' follow-up of intervention participants, there were considerable reductions for systolic and diastolic blood pressure, LDL cholesterol and triglycerides, and an increase for HDL cholesterol.[42]

The cost-effectiveness and sustainability of worksite programs is an important consideration. Ten-year follow-up data from the original DPP study found that the total cumulative per-participant cost of the individual lifestyle intervention was $4,601, compared to $769 for the placebo intervention.[43] In addition, the estimated cumulative per-participant cost of the DPP group lifestyle intervention was $3,023, about a third the cost of the individual intervention. Direct medical costs of non-intervention related medical care were also analyzed and found to be greater by $2,905 for the placebo compared to lifestyle intervention group. Future research is needed to determine whether the group-based DPP intervention is cost-effective for U.S. employers.

Conclusions

Prediabetes is a growing problem that currently affects over a third of adults in the U.S. and places individuals at an increased risk for developing T2DM.[11] Additionally, prediabetes is associated with a number of costs to individuals and to employers with regards to health care and productivity related costs.[12-17] T2DM can be delayed or prevented in at-risk adults through lifestyle interventions targeting weight loss such as the DPP.[44] The lifestyle intervention in the DPP previously reduced the incidence of T2DM by 58% over a 3 year period, compared with placebo.[8] The beneficial long-term reduction in diabetes risk following lifestyle intervention can persist for at least 10 years.[22] The present study suggests that a worksite diabetes prevention program can be feasible to offer to employees without interfering with work schedules or productivity, and can be an effective intervention to promote improvements to employees' health with a potential for long-term health implications, if results are sustained.

Limitations

Despite efforts to reach a diverse study population, participants in this study were primarily women (79.4%), and white (83.8%). While this does not accurately represent the employee population at The Ohio State University, it is a common limitation of weight loss studies to experience difficulty recruiting men and individuals from minority populations.

The post-intervention retention rate was 87.2%, which is comparable to that of the previous studies which implemented the DPP intervention (57-91% retention).[28-31] Nevertheless, efforts to retain participants are crucial to obtaining strong study results, and thus the attrition in the present study is a limitation.

Future Directions

Recent evidence suggests that men may benefit from gender-tailored programs with minimal contact.[45] Further research into how best to reach these under-served populations and offer wellness programs that appeal to their interests and perceived needs is needed.

In order for the group-based DPP to be adopted at a worksite, it will need to be cost-effective, sustainable, and able to work with existing healthcare systems. The original DPP intervention was found to be cost-effective from a health system and societal perspective.[43] Future research will need to evaluate the cost-effectiveness of a group-based DPP intervention in the worksite setting, in addition to the long-term sustainability of the program considering the worksite resources and systems for employee health. The potential for diabetes prevention programs to be offered at the worksite exists with the recent Affordable Care Act emphasizing prevention and wellness through cost-effective manners in the workplace.[46]

While the results from this study are promising, a larger, multi-site translational study is needed to further evaluate the effectiveness of the DPP intervention in the worksite. Attempting to reach males and minorities will be of utmost importance in future worksite trials, and monitoring progression to T2DM will confirm whether or not the intervention is effective in reducing risk for T2DM.

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