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A translational worksite diabetes prevention trial improves psychosocial status, dietary intake, and step counts among employees with prediabetes: A randomized controlled trial

Carla K. Miller [a,*], Kellie R. Weinhold [b], David G. Marrero [c], Haikady N. Nagaraja [d], Brian C. Focht [e]

[a] Department of Human Sciences, Human Nutrition, Ohio State University, 1787 Neil Ave., 325 Campbell Hall, Columbus, OH 43210, USA
[b] Department of Human Sciences, Human Nutrition, Ohio State University, Columbus, OH, USA
[c] Indiana University School of Medicine, 410 W. 10th Street, Room 1140, Indianapolis, IN 46202, USA
[d] Division of Biostatistics, College of Public Health, Ohio State University, Columbus, OH, USA
[e] Department of Human Sciences, Kinesiology, Ohio State University, Columbus, OH, USA

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ABSTRACT

Objective. Few worksite trials have examined the impact of diabetes prevention interventions on psychological and behavioral outcomes. Thus, the impact of a worksite lifestyle intervention on psychosocial outcomes, food group intake, and step counts for physical activity (PA) was evaluated.

Method. A randomized pretest/posttest control group design with 3-month follow-up was employed from October 2012 to May 2014 at a U.S. university worksite among employees with prediabetes. The experimental group (n = 35) received a 16-week group-based intervention while the control group received usual care (n = 33). Repeated measures analysis of variance compared the change in outcomes between groups across time.

Results. A significant difference occurred between groups post-intervention for self-efficacy associated with eating and PA; goal commitment and difficulty; satisfaction with weight loss and physical fitness; peer social support for healthful eating; generation of alternatives for problem solving; and intake of fruits, meat, fish, poultry, nuts, and seeds (all ps < .05). The experimental group significantly increased step counts post-intervention (p = .0279) and were significantly more likely to report completing their work at study end (p = .0231).

Conclusion. The worksite trial facilitated improvement in modifiable psychosocial outcomes, dietary patterns, and step counts; the long-term impact on diabetes prevention warrants further investigation.

Trial Registration. ClinicalTrials.gov identifier: NCT01682954

Introduction

The prevalence of prediabetes among U.S. adults was 36.2% in 2007–2010 (Bullard et al., 2013), placing them at high risk for type 2 diabetes. Findings from the Diabetes Prevention Program (DPP) and other studies showed that type 2 diabetes can be delayed or prevented among adults with elevated glucose levels with lifestyle modification (Knowler et al., 2002; Pan et al., 1997; Tuomilehto et al., 2001). Effective lifestyle interventions have been successfully implemented in community-based settings (Ackermann et al., 2008; Seidel et al., 2008; Katula et al., 2011) and primary care (Ma et al., 2013). Few randomized controlled trials, however, have evaluated the impact of translational DPP intervention studies delivered at worksites.

The workplace can be an effective setting for implementing health promotion programs (Goetzel and Ozminkowski, 2008). The worksite reaches a large segment of the population for most of their adult life and reaches them through preexisting organization-based communication channels. Employees spend most of their waking hours at the worksite, and the worksite offers a common culture and natural environment for social support. Moreover, the opportunity for long-term follow-up may be greater through worksites than through community-based programs. Psychosocial factors also have improved following worksite programs (Kristal et al., 2000; Glasgow et al., 1997). For example, a prior meta-analysis found that worksite physical activity (PA) interventions resulted in lower rates of absenteeism and job stress and higher rates of job satisfaction among intervention than control participants (Conn et al., 2009).

Despite the potential benefits of worksite prevention programs, little has been published about the impact of worksite interventions on modifiable psychological and behavioral variables to inform translational efforts, especially for diabetes prevention. The dimensions along

* Corresponding author.
E-mail addresses: miller.4453@osu.edu (C.K. Miller), weinhold.8@osu.edu (K.R. Weinhold), dgmarrer@iupui.edu (D.G. Marrero), nagaraja.1@osu.edu (H.N. Nagaraja), focht.10@osu.edu (B.C. Focht).

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which interventions may vary conceptually are high and the impact of worksite programs on modifiable variables is needed to identify potential mechanisms of behavioral change. Therefore, the objective of this study was to translate the DPP intervention to a university worksite and evaluate the impact on potentially modifiable and behavioral variables among employees with prediabetes to further inform diabetes prevention efforts.

Materials and methods

Research design

A pretest/posttest randomized control research design was employed at a university worksite. Participants were randomly assigned to treatment group, stratified by race in blocks of size four, following baseline data collection. Randomization assignment was generated by the statistician and allocations were concealed in sequentially numbered opaque envelopes. The project coordinator enrolled participants and revealed treatment allocation to them. Given the nature of the intervention, neither participants nor lifestyle coaches were blinded to treatment allocation; the statistician was blinded to treatment. Following randomization, the experimental group proceeded through the 16-week intervention based on the intervention curriculum used in the DPP. The control group received an information booklet regarding lifestyle changes for diabetes prevention (U.S. Department of Health and Human Services National Diabetes Education Program, 2006); they received no further contact from intervention staff and received medical care as they would normally do. All participants completed a second assessment following implementation of the intervention for the experimental group and a third assessment occurred 3-months after the second data collection period, 7 months from baseline.

Participants

To be eligible, participants had to be English-speaking employees of the University ages 18–65 years with documented prediabetes. A risk

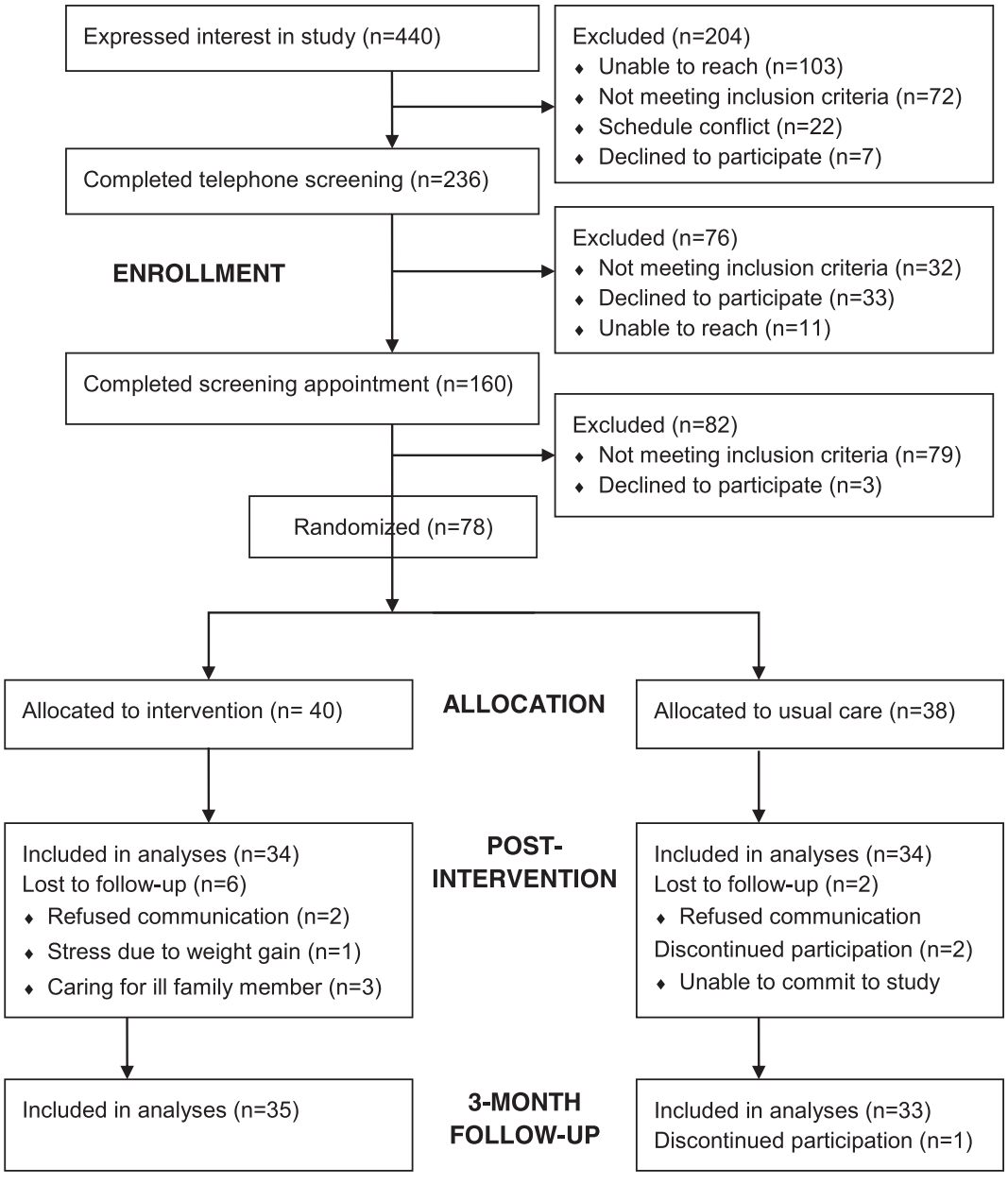

Fig. 1. CONSORT diagram of participant enrollment, allocation, and analyses.

questionnaire and point-of-care glucose testing to assess prediabetes (i.e., impaired fasting glucose) or undiagnosed diabetes were employed. Individuals completed the 7-item American Diabetes Association (ADA) diabetes risk assessment questionnaire (American Diabetes Association, 2014), height and weight measurement, and collection of a fingerstick blood sample to assess fasting capillary blood glucose for people with a BMI 25–50 kg/m^2 and an ADA risk score ≥5. People with a glucose ≥200 mg/dL were informed that they were at high risk for diabetes and were referred for formal testing and follow-up with their primary care provider. Individuals with an ADA risk score ≥5 and glucose of 100–125 mg/dL were potentially eligible and screened for any exclusionary criteria. People with a fasting glucose of 95–100 mg/dL or 126–140 mg/dL, on the margins of the prediabetes range, completed a second fingerstick to assess A1c. Those with an A1c value of 5.7–6.4% were identified as having prediabetes.

Potentially eligible people completed the Physical Activity Readiness Questionnaire and those who answered positively to ≥1 question(s) were excluded (Scott et al., 1992). Individuals diagnosed with diabetes, chronically using corticosteroids, participating in a structured weight loss program, preparing for bariatric surgery, planning to leave university employment or move from the community, or non-English speaking were ineligible. Women who were pregnant or lactating or planning to become pregnant also were ineligible. Employees >65 years old were excluded, since they were covered under a different health insurance plan and do not complete the health risk assessment used during recruitment.

Participants were recruited through electronic advertisements on the daily university newswire, campus flyers, a news story in the employee newspaper, and through direct mailings to employees with health insurance who completed the university health risk assessment and had a glucose value of 110–199 mg/dL. A telephone number and e-mail address were provided on recruitment material for interested individuals to contact to receive more information and, if interested, called to complete the ADA risk questionnaire. All procedures were followed in accordance with the ethical standards of the Institutional Review Board at the Ohio State University, and participants provided written, informed consent.

Worksite diabetes prevention intervention

The experimental group received the 16-week Group Lifestyle Balance intervention adapted from the individually administered DPP (DPP research group, 2002). Weekly 60-minute group sessions were held either at the noon hour or immediately following work to accommodate employee work schedules. A university dietitian/lifestyle coach facilitated each session using the program manual for lifestyle coaches. Two coaches were involved in the study and each completed the 2-day training program prior to study initiation. Participants received a written manual in English with session material, food and PA trackers for self-monitoring, a graph for tracking weekly weights, and a booklet with the nutrient content of commonly consumed foods (Stephenson and Bader, 2010). Participants were encouraged to record calories and fat grams consumed and minutes spent in PA daily during the intervention. Monitoring records were turned in at the beginning of group sessions and reviewed by the lifestyle coach weekly. Individualized feedback was provided to participants via returned records. Participants were weighed at the beginning of each group session. If participants missed a session, they were encouraged to attend a make-up session prior to the next regularly scheduled group meeting.

The lifestyle intervention was goal-based with a goal of losing 7% of initial body weight, progressively increasing PA to 150 min/week of at least moderate intensity PA, and consuming 25% of energy from fat to reduce energy intake. Brisk walking was encouraged to meet the activity goal but any activity of similar intensity could be performed. Incremental goals were established to facilitate improvement in self-efficacy for the target behaviors. The first 8 sessions presented the intervention goals, taught fundamental information about modifying energy and fat intake and increasing energy expenditure, and helped participants self-monitor. The latter 8 sessions focused on barrier identification to achieving lifestyle goals, problem solving, relapse prevention, and motivational factors for sustaining behavioral change. Participants did not receive contact from intervention staff following the 16-week intervention during the 3-month follow-up period. No monetary incentives were provided for data collection or study completion.

Outcome measures

Outcomes included measures that were consistent with the behavioral techniques employed during the intervention and the behavioral self-regulation and goal setting determinants targeted for change. Instruments to assess self-efficacy for eating a low fat (LF) diet and PA were adapted from previously validated instruments (Sallis et al.,

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

	Experimental Group (n = 35)	Control Group (n = 33)	p-Value
	Mean (±SD)	Mean (±SD)	
Age (years)	51.6 (±9.51)	50.8 (±8.14)	0.7282[a]
	n (%)	n (%)	p-Value
Race			
White	27 (77.14)	29 (87.88)	0.3435[b]
Non-White	8 (22.86)	4 (12.12)	
Ethnicity			
Non-Hispanic/Latino	35 (100.00)	32 (96.97)	0.4853[b]
Hispanic/Latino	0 (0.00)	1 (3.03)	
Gender			
Male	7 (20.00)	7 (21.21)	1.0000[b]
Female	28 (80.00)	26 (78.79)	
Education			
Less than bachelor's degree	15 (42.86)	9 (27.27)	0.3378[c]
Bachelor's degree	11 (31.43)	11 (33.33)	
Post-graduate degree	9 (25.71)	13 (39.39)	
Employment			
Full-time	32 (91.42)	32 (94.12)	0.6142[b]
Part-time	3 (8.57)	1 (3.03)	
Marital status			
Married	24 (68.57)	25 (75.76)	0.5938[b]
Not married	11 (31.43)	8 (24.24)	
Occupation [d]			
Professional	12 (35.29)	18 (54.55)	0.0128[c]
Clerical	10 (29.41)	13 (39.39)	
Other (i.e., clinical, technology, physical labor)	12 (35.29)	2 (6.06)	
Years at current job			
1–5 years	13 (37.14)	11 (33.33)	0.1959[c]
6–10 years	13 (37.14)	6 (18.18)	
11–15 years	3 (8.57)	6 (18.18)	
≥16 years	6 (17.14)	10 (30.30)	
Current student			
Non-student	30 (85.71)	31 (93.94)	0.2276[c]
Full-time student	3 (8.57)	0 (0.00)	
Part-time student	2 (5.71)	2 (6.06)	
Number of people in the household			
1	5 (14.29)	2 (6.06)	0.6290[c]
2	17 (48.57)	15 (45.45)	
3	6 (17.14)	5 (15.15)	
4	5 (14.29)	9 (27.27)	
≥5	2 (5.71)	2 (6.06)	
Annual household income [d]			
$20,000–39,999	8 (23.53)	3 (9.09)	0.2681[c]
$40,000–59,999	4 (11.76)	4 (12.12)	
$60,000–79,999	6 (17.65)	6 (18.18)	
$80,000–99,999	9 (26.47)	6 (18.18)	
≥$100,000	7 (20.59)	14 (42.42)	

[a] One-way ANOVA of between-group difference of mean.
[b] Fisher's exact test of between group differences.
[c] Pearson Chi-square test of between-group differences.
[d] One participant in experimental group did not provide this information.

1988) with 5-point response scales. The eating scale consisted of three subscales (5-items each), including "sticking to it," "reducing calories," and "reducing fat intake." The PA scale included two subscales entitled "sticking to it" (7 items) and "making time for exercise" (4 items). Test–retest reliabilities for the PA scale were 0.68 and for the eating scale ranged from 0.43 to 0.64 previously (Sallis et al., 1988).

Given the goal-based approach of the intervention, goal commitment to losing weight was assessed using a valid 7-item goal commitment questionnaire with 5-point response options. Two items were reverse scored so that a higher score indicates greater goal commitment (Seijts and Latham, 2000).

Goal difficulty was assessed with 1-item asking participants to indicate how easy or difficult it is to lose weight (0 = "very easy" to 8 = "very difficult") (Erez and Zidon, 1984). Similarly, goal satisfaction with losing weight was assessed with 1-item (0 = "a great deal of dissatisfaction" to 8 = "a great deal of satisfaction").

Satisfaction with the individual's level of physical fitness also was assessed using a modified 9-item instrument assessing the degree and frequency of one's satisfaction with physical function and appearance. Participants rated their satisfaction with physical function (e.g., muscle tone) and appearance (e.g., overall physical appearance) on a scale from −3 = "once in awhile" to +3 = "a lot." The instrument had high discriminant validity and was related to quality of life, affect and depression previously (Reboussin et al., 2000).

Since the intervention was delivered via a group setting, perceived social support was assessed. Support from family and friends was assessed for both eating and PA. The eating questionnaire included two subscales, entitled "encouragement" and "sabotage" (5 items each), and the PA questionnaire included two subscales, entitled "participation and involvement" (10 items) and "rewards and punishment" (3 items). Internal consistency based on coefficient α of the subscales ranged from 0.61 to 0.91 and test–retest coefficients ranged from 0.55 to 0.86 in previous research (Sallis et al., 1987).

Given the intervention focus on problem solving to minimize barriers to behavioral change, problem solving was assessed using the Social Problem-Solving Inventory-Revised, long form (SPSI-R:L) (D'Zurilla et al., 2002). The 52-item SPSI-R:L measures people's ability to resolve problems in everyday living with high reliability and validity. Two adaptive problem-solving dimensions (positive problem orientation and rational problem solving) and three dysfunctional dimensions (negative problem orientation, impulsivity/carelessness style, and avoidance style) are assessed. Raw scores were converted to standard scores (mean 100; standard deviation 15); higher total SPSI-R:L scores indicate better problem-solving ability than lower scores.

Presenteeism, defined as decreased workforce productivity and below-normal work quality (Koopman et al., 2002), was assessed for this worksite study. The instrument includes two subscales (3 items each) entitled "completing work" and "avoiding distraction" with 5-point response options. Previous research found acceptable internal consistency (coefficient α = 0.80) and scores were significantly related to worker disability (Koopman et al., 2002).

The valid 110-item Block 2005 Food Frequency Questionnaire was self-administered to assess usual dietary intake in the previous year (Mares-Perlman et al., 1993; Block et al., 1990). Participants received a food-portion visual to estimate portions; nine response options regarding frequency were included. Similar foods were grouped together and servings consumed were quantified for each food group based on U.S. dietary guidance (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010) per 1000 kcal to control for energy intake.

PA was assessed using the Lifecorder Plus Accelerometer (Suzuken-Kenz, Inc., Nagoya, Japan) to obtain step counts/day. Participants were instructed to wear the accelerometer on their hip at the waistline for all waking hours on seven consecutive days during each assessment period. Step counts were measured to assess how well employees met the public health goal of achieving 10,000 steps/day (Tudor-Locke et al., 2011).

Statistical analyses

Several of the variables had a skewed distribution, and an approximately normal distribution was achieved after logarithmic transformation. Hypothesis testing on these variables was performed on the transformed values. The Fisher exact test, Pearson chi-square test, or two-sample *t*-test compared between-group differences in participant characteristics at baseline. Repeated measures analysis of variance model with interaction compared the change in outcomes across time. The time-by-group interaction effect assessed group difference in outcome changes. Post-hoc *t*-tests were used to evaluate between- and within-group differences in outcome measures. Intent to treat analyses were performed with participants retained in the group to which they were randomized.

Power analysis for the primary outcome percent weight change (power = 0.90, 2-tailed α = 0.05) based on a previous DPP translational study (Ackermann et al., 2008) indicated that 25 in each treatment group were needed to detect a 4.04% difference between groups. All analyses were completed using the SAS statistical software package JMP version 10 (SAS Institute, Inc., Cary, NC).

Results

The flow of individuals from recruitment through analyses is provided in Fig. 1. Forty participants were randomized to the experimental group; 35 completed the final study visit. Thirty eight participants were randomized to the control group; 33 completed the final study visit. There was no significant difference in attrition between treatment groups ($p > 0.05$). There was no significant difference in baseline participant characteristics, glucose, or body mass index between those who did and did not complete the study (all $p > 0.05$). Also, there were no significant differences in demographic characteristics between treatment groups at baseline except for occupation (Table 1). More participants in professional positions were randomized to the control than experimental group ($p = 0.0128$). Similarly, more participants in the control than experimental group reported the ability to complete their work on the presenteeism scale at baseline ($p = 0.0323$) (Table 2).

Change in outcomes between treatment groups

The experimental group lost a greater percentage of their body weight than the control group (5.5% vs. 0.35%, respectively; $p < 0.0001$). The change in weight, the primary study outcome, and other clinical outcomes are reported in greater detail elsewhere (Weinhold et al., under review). In the present report, there was a significant difference in the change in total self-efficacy score associated with eating a LF diet and PA between groups post-intervention as well as for the "sticking to it" subscales (Table 2). The experimental group reported greater increase in their commitment to the weight loss goal, believed losing weight was less difficult, and felt greater satisfaction with losing weight, physical function, and physical appearance than the control group following the intervention. The change in encouragement from friends regarding healthy eating and their ability to generate alternatives to everyday problems was greater for the experimental than control group post-intervention (Table 3).

At the 3-month follow-up visit (i.e., study end), there was a significant difference between groups in the change in their efficacy for reducing calorie intake and in "sticking to it" for PA (Table 2). Participants' satisfaction with losing weight, physical function, and physical appearance remained greater for the experimental than control group. The change in participants' ability to complete work on the presenteeism scale also differed between groups at study end.

There was a significant difference between groups in the change in servings/1000 kcal for fruits, meat, fish, poultry, nuts, and seeds post-intervention (Table 4). The experimental group had a greater increase in fruit intake and a greater decrease in intake of meat, fish, poultry,

Table 2
Mean (±SE) value for self-efficacy, goal-related outcomes, and employee presenteeism and the change in outcomes by treatment group and time point at a U.S. university.

Outcome	Baseline			Post-intervention change from baseline			3-month follow-up change from baseline		
	Exper. group (n = 35)	Control group (n = 33)	p-Value[a]	Exper. group (n = 35)[b]	Control group (n = 33)	p-Value[c]	Exper. group (n = 35)	Control group (n = 33)	p-Value[c]
Self-efficacy: eating low fat diet [d]	4.11 (±0.09)	4.05 (±0.09)	0.6766	0.07 (±0.09)	−0.21 (±0.09)*	0.0336	0.0 (±0.09)	−0.23 (±0.09)*	0.0822
Sticking to it	3.87 (±0.13)	3.84 (±0.13)	0.8877	0.15 (±0.15)	−0.41 (±0.15)**[e]	0.0082	−0.05 (±0.15)	−0.33 (±0.15)*	0.1681
Reducing calorie intake	3.99 (±0.10)	4.02 (±0.11)	0.8286	0.11 (±0.11)	−0.20 (±0.11)	0.0596	0.09 (±0.11)	−0.27 (±0.11)*	0.0266
Reducing fat intake [f]	4.47 (±0.10)	4.30 (±0.12)	0.3169	−0.03 (±0.69)	−0.02 (±0.12)	0.7842	−0.05 (±0.09)	−0.08 (±0.10)	0.6137
Self-efficacy: physical activity [d]	3.76 (±0.14)	3.77 (±0.15)	0.9622	−0.15 (±0.12)	−0.54 (±0.12)***	0.0206	−0.27 (±0.12)	−0.57 (±0.12)***	0.0752
Sticking to it	3.70 (±0.14)	3.71 (±0.15)	0.9683	−0.03 (±0.13)	−0.47 (±0.13)***	0.0174	−0.17 (±0.13)	−0.57 (±0.13)***	0.0317
Making time for exercise	3.81 (±0.16)	3.82 (±0.16)	0.9603	−0.28 (±0.13)*	−0.62 (±0.13)***	0.0745	−0.38 (±0.13)**	−0.57 (±0.13)***	0.2929
Goal commitment, weight loss [d]	4.11 (±0.10)	4.04 (±0.10)	0.6310	0.15 (±0.11)	−0.32 (±0.11)**	0.0028	0.06 (±0.11)	0.33 (±0.11)**	0.0776
Goal difficulty, weight loss [d]	5.53 (±0.26)	5.42 (±0.27)	0.7858	−0.66 (±0.28)*	0.39 (±0.28)	0.0089	−0.36 (±0.28)	0.06 (±0.28)	0.2934
Goal satisfaction, weight loss [f,g]	–	–	–	5.91 (±0.41)	3.45 (±0.42)	0.0001	−0.68 (±0.41)	0.79 (±0.41)	0.0141
Satisfaction with physical fitness [d]									
Satisfaction with body function	0.23 (±0.17)	0.54 (±0.18)	0.2042	1.19 (±0.21)***	0.19 (±0.21)	0.0009	1.11 (±0.20)***	0.20 (±0.21)	0.0024
Satisfaction with appearance	−0.27 (±0.22)	−0.19 (±0.22)	0.8102	1.04 (±0.22)***	0.00 (±0.23)	0.0013	0.61 (±0.22)**	−0.08 (±0.23)	0.0303
Employee presenteeism [d,f]									
Completing work	4.23 (±0.11)	4.49 (±0.11)	0.0323	0.0 (±0.11)	−0.04 (±0.12)	0.6106	0.25 (±0.14)*	−0.14 (±0.14)	0.0329
Avoiding distraction	4.07 (±0.14)	4.20 (±0.15)	0.4228	−0.12 (±0.13)	0.07 (±0.13)	0.3361	0.18 (±0.17)	0.09 (±0.17)	0.8610

[a] Student *t*-test within an ANOVA for between-group comparison at baseline.
[b] One person in the experimental group did not complete the assessment post-intervention.
[c] Student *t*-test within an ANOVA to compare the between-group change from baseline to post-intervention and from baseline to 3-month follow-up.
[d] Response options for self-efficacy ranged from 1 = "I know I cannot" to 5 = "I know I can." Response options for goal commitment ranged from 1 = "strongly disagree" to 5 = "strongly agree." Response options for goal difficulty ranged from 0 = "very easy" to 8 = "very difficult." Response options for satisfaction with physical fitness ranged from -3 "once in awhile" to +3 = "a lot." Response options for employee presenteeism ranged from 1 = "strongly disagree" to 5 = "strongly agree." Higher scores indicate greater endorsement.
[e] Within-group change from baseline; *p-value < 0.05; **p-value < 0.01; ***p-value < 0.001.
[f] Comparisons based on Wilcoxon test due to violation of the normality assumption on the original or log scale.
[g] Mean scores for goal satisfaction for weight loss post-intervention and the change from post-intervention to 3-month follow-up are given, since goal satisfaction for weight loss was not assessed at baseline. Response options ranged from 0 = "a great deal of dissatisfaction" to 8 = "a great deal of satisfaction."

Table 3
Mean (±SE) value for social support and problem solving and the change in outcomes by treatment group and time point at a U.S. university.

Outcome	Baseline			Post-intervention change from baseline			3-month follow-up change from baseline		
	Exper. group (n = 35)	Control group (n = 33)	p-Value[a]	Exper. group (n = 35)[b]	Control group (n = 33)	p-Value[c]	Exper. group (n = 35)	Control group (n = 33)	p-Value[c]
Social support: eating habits [d,e]									
Family encouragement	2.19 (±0.19)	2.37 (±0.19)	0.5839	0.34 (±0.19)*	−0.05 (±0.20)	0.1631	0.11 (±0.19)	−0.22 (±0.19)	0.2404
Family sabotage	2.50 (±0.15)	2.59 (±0.15)	0.9353	−0.20 (±0.13)	−0.30 (±0.14)*[f]	0.3526	−0.36 (±0.13)*	−0.33 (±0.14)	0.4294
Friend encouragement	1.83 (±0.15)	1.86 (±0.15)	0.8984	0.41 (±0.15)*	−0.19 (±0.16)	0.0113	0.28 (±0.15)	−0.26 (±0.15)	0.0072
Friend sabotage	2.38 (±0.16)	2.40 (±0.16)	0.9353	−0.13 (±0.18)	−0.38 (±0.18)*	0.3526	−0.39 (±0.17)*	−0.21 (±0.18)	0.4294
Social support: physical activity[d,e]									
Family participation	1.88 (±0.15)	2.05 (±0.15)	0.6392	0.13 (±0.14)	0.01 (±0.14)	0.5176	0.05 (±0.14)	−0.22 (±0.14)	0.3487
Family reward/punishment[g]	1.18 (±0.05)	1.29 (±0.14)	0.5683	0.06 (±0.11)	−0.16 (±0.11)	0.6961	0.06 (±0.10)	−0.15 (±0.10)	0.2445
Friend participation	1.93 (±0.13)	1.82 (±0.13)	0.5926	−0.22 (±0.14)	−0.16 (±0.14)	0.8305	−0.07 (±0.14)	−0.34 (±0.14)*	0.1420
Friend reward/punishment[g]	1.14 (±0.06)	1.06 (±0.03)	0.3041	−0.05 (±0.06)	0.0 (±0.06)	0.3207	−0.07 (±0.06)	−0.04 (±0.05)	0.5576
Total problem solving score[h]	100.09 (±2.14)	101.06 (±2.20)	0.7514	1.35 (1.24)	−1.27 (1.27)	0.1421	2.09 (1.23)	0.48 (1.27)	0.3669
Problem orientation									
Positive orientation	95.69 (±2.38)	96.15 (±2.45)	0.8917	1.32 (±1.81)	−2.12 (±1.85)	0.1861	4.51 (±1.80)*	0.45 (±1.85)	0.1177
Negative orientation	98.63 (±2.15)	97.67 (±2.21)	0.7558	−3.10 (±1.53)*	0.03 (±1.56)	0.1554	−1.63 (±1.52)	−1.48 (±1.56)	0.9475
Problem solving style									
Avoidance style	100.20 (±2.04)	98.82 (±2.10)	0.6382	−0.64 (±1.41)	−1.73 (±1.43)	0.5891	−0.26 (±1.39)	−0.73 (±1.43)	0.8143
Impulsive/careless style	93.89 (±2.00)	93.58 (±2.05)	0.9139	−1.09 (±1.63)	0.64 (±1.67)	0.4618	1.23 (±1.62)	1.06 (±1.67)	0.9424
Rational style	97.66 (±2.11)	97.15 (±2.18)	0.8679	1.72 (±1.71)	−2.94 (±1.74)	0.0588	2.63 (±1.69)	0.67 (±1.74)	0.4210
Problem definition	99.23 (±2.08)	97.73 (±2.15)	0.6169	0.40 (±1.83)	−1.97 (±1.86)	0.3648	1.26 (±1.81)	0.79 (±1.86)	0.8567
Generation of alternatives	98.40 (±2.06)	101.18 (±2.12)	0.3481	2.91 (±1.87)	−5.33 (±1.91)**	0.0025	4.29 (±1.85)*	−2.82 (±1.91)	0.0085
Decision making	98.80 (±2.30)	98.97 (±2.37)	0.9592	1.43 (±2.02)	−2.55 (±2.05)	0.1697	2.80 (±2.00)	0.24 (±2.05)	0.3735
Solution implementation	95.71 (±2.13)	93.70 (±2.19)	0.5109	1.21 (±1.89)	−1.45 (±1.93)	0.3257	1.06 (±1.87)	3.09 (±1.93)	0.4499

[a] Student *t*-test within an ANOVA for between-group comparison at baseline.
[b] One person in the experimental group did not complete the assessment post-intervention.
[c] Student *t*-test within an ANOVA to compare the between-group change from baseline to post-intervention and from baseline to 3-month follow-up.
[d] Response options for social support ranged from 1 = "none" to 5 = "very often." Higher scores indicate greater endorsement.
[e] Social support responses were not normally distributed and were log-transformed; the p-values were based on the comparison of means of the log-transformed data using the transform log(x).
[f] Within-group change from baseline; *p-value < 0.05; **p-value < 0.01; ***p-value < 0.001.
[g] Comparisons based on Wilcoxon test due to violation of the normality assumption on the original or log scale.
[h] Response options ranged from 0 = "not at all true of me" to 4 "extremely true of me." Values were converted to standard scores with a mean of 100 and a standard deviation of 15.

Table 4
Mean (±SE) intake for energy, servings/1000 kcal from food groups, and step counts and change in outcomes by treatment group and time point at a U.S. university.

Outcome	Baseline (servings/1000 kcal)			Post-intervention change from baseline (servings/1000 kcal)			3-month follow-up change from baseline (servings/1000 kcal)		
	Exper. group (n = 35)	Control group (n = 33)	p-Value[a]	Exper. group (n = 35)[b]	Control group (n = 33)	P-Value[c]	Exper. group (n = 35)	Control group (n = 33)	p-Value[c]
Energy (total kcal)	1797 (±117)	1903 (±120)	0.2594	−424 (±99)	−183 (±101)	0.1199	−318 (±97)	−309 (±100)	0.7247
Total vegetables (cups)	1.27 (±0.12)	1.14 (±0.13)	0.5806	0.17 (±0.09)* [d]	0.13 (±0.09)	0.2617	0.13 (±0.09)	0.28 (±0.09)*	0.4989
Vegs., yellow/orange	0.10 (±0.01)	0.08 (±0.01)	0.7047	0.02 (±0.02)**	0.01 (±0.02)	0.2498	−0.001 (±0.02)*	0.005 (±0.02)	0.3096
Vegs., green leafy	0.36 (±0.06)	0.33 (±0.06)	0.8555	0.06 (±0.04)	0.07 (±0.04)	0.5230	0.01 (±0.04)	0.12 (±0.04)*	0.3376
Vegs., potatoes	0.15 (±0.01)	0.14 (±0.01)	0.3841	−0.04 (±0.02)*	−0.02 (±0.02)	0.2778	−0.04 (±0.02)*	0.001 (±0.02)	0.0907
Vegs., starchy	0.07 (±0.01)	0.05 (±0.01)	0.2042	0.01 (±0.01)**	0.01 (±0.01)	0.1594	0.01 (±0.01)*	0.02 (±0.01)	0.9195
Total fruits (cups)	0.60 (±0.09)	0.79 (±0.09)	0.1145	0.38 (±0.07)***	0.11 (±0.07)	0.0023	0.17 (±0.07)***	0.09 (±0.07)	0.1047
Fruits, not juice	0.52 (±0.08)	0.63 (±0.09)	0.1967	0.32 (±0.06)***	0.13 (±0.07)*	0.0093	0.14 (±0.06)***	0.10 (±0.07)	0.1435
Total grains (ounce equivalents)	2.78 (±0.15)	2.77 (±0.15)	0.9594	−0.09 (±0.12)	−0.09 (±0.12)	0.9758	−0.31 (±0.11)**	−0.19 (±0.12)	0.4724
Whole grains	0.70 (±0.07)	0.62 (±0.07)	0.4211	0.07 (±0.07)	0.02 (±0.06)	0.2980	−0.10 (±0.06)	0.03 (±0.06)	0.4698
Meat, fish, poultry (oz.)	2.03 (±0.13)	1.81 (±0.14)	0.2354	−0.17 (±0.13)	0.24 (±0.13)	0.0309	−0.12 (±0.13)	0.06 (±0.13)	0.3431
Eggs (oz. equivalents)	0.20 (±0.04)	0.21 (±0.04)	0.4803	0.06 (±0.03)	0.05 (±0.03)	0.6948	0.08 (±0.03)*	−0.03 (±0.03)	0.0439
Nuts, seeds (ounce equivalents)	0.44 (±0.06)	0.48 (±0.06)	0.7730	−0.09 (±0.06)*	0.05 (±0.06)	0.0086	−0.03 (±0.06)	−0.01 (±0.01)	0.6770
Total dairy (milk equivalents)	0.77 (±0.06)	0.73 (±0.07)	0.8852	−0.12 (±0.06)*	0.03 (±0.06)	0.3676	−0.05 (±0.06)	0.05 (±0.06)	0.1631
Cheese	0.31 (±0.03)	0.36 (±0.03)	0.1444	−0.08 (±0.03)**	0.04 (±0.03)	0.3152	0.05 (±0.03)	0.03 (±0.03)	0.6104
Milk	0.40 (±0.06)	0.29 (±0.06)	0.2535	−0.06 (±0.04)	0.02 (±0.05)	0.4922	0.0 (±0.04)	0.08 (±0.04)	0.1938
Fats, oils (g)	11.63 (±0.73)	12.00 (±0.75)	0.6576	−0.01 (±0.74)	0.76 (±0.76)	0.4844	0.24 (±0.73)	0.73 (±0.75)	0.5176
Fats, solid (g)	20.68 (±0.87)	21.69 (±0.90)	0.4219	−2.49 (±0.79)**	−0.64 (±0.81)	0.1029	−0.36 (±0.77)	−0.12 (±0.80)	0.4476
Added sugars (tsp. equivalent)	6.73 (±0.50)	6.14 (±0.51)	0.2639	−0.07 (±0.47)	−0.72 (±0.48)	0.5023	−0.09 (±0.46)	−0.25 (±0.47)	0.8283
Physical activity (mean steps/day)	6538.37 (±439.00)	6681.65 (±452.10)	0.7432	965.02 (±370.28)*	145.19 (±381.58)	0.1200	504.71 (±366.52)	192.06 (±377.46)	0.3427

[a] Student *t*-test within an ANOVA for between-group comparison at baseline.
[b] One person in the experimental group did not complete the assessment post-intervention.
[c] Student *t*-test within an ANOVA to compare the between-group change from baseline to post-intervention and from baseline to 3-month follow-up.
[d] Within-group change from baseline *p-value < 0.05; **p-value < 0.01; ***p-value < 0.001.

nuts, and seeds. At study end, the only significant difference between groups in the change in food group intake was for eggs. There was no significant difference between groups for the change in step counts for PA.

Change in outcomes within each treatment group

The experimental group reported a significant decrease in their self-efficacy for making time for exercise both following the intervention and at study end (Table 2). Encouragement from family and friends significantly improved for the experimental group post-intervention and sabotage from family and friends significantly decreased at study end. Following the intervention, the experimental group reported a significant decrease in negative orientation on the SPSI-R:L and significant increase in positive orientation and generation of alternatives to problems at study end (Table 3). The experimental group reported a significant increase in intake of vegetables and fruits and a significant decrease in intake of nuts, seeds, dairy foods, and solid fats following the intervention (Table 4). Egg intake significantly increased and total grain intake significantly decreased for the experimental group at study end. This group also experienced a significant increase in their step count for PA following the intervention.

The control group reported a significant decrease in their overall self-efficacy associated with eating a LF diet and PA, including "sticking to it" and "making time for exercise," following the intervention and at study end. They reported a significant decrease in their commitment to losing weight, in sabotage from family and friends, and in generation of alternatives to everyday problems post-intervention. At study end, the control group reported a significant decrease in their self-efficacy for reducing calorie intake and in peer social support for PA. There was little change in dietary intake for the control group except for a significant increase in fruit intake post-intervention and a significant increase in green leafy and total vegetable intake at study end. There was no significant change in step counts for the control group.

There were no adverse events directly related to the study for either treatment group.

Discussion

The findings demonstrate the efficacy of a group-based lifestyle intervention at a university worksite setting to prevent type 2 diabetes. Participants lost weight, improved efficacious beliefs and social support for consuming a LF diet, reported greater commitment to the goal of losing weight, expressed ability to generate alternatives to solving everyday problems, and were more satisfied with their appearance and physical functioning, while increasing their PA. Intake of fruits and vegetables increased while intake of high-fat foods, such as cheeses, nuts, seeds, and solid fats decreased. These findings demonstrate that the psychological and behavioral measures selected can be modified following implementation of the worksite intervention.

Self-efficacy associated with consuming a LF diet and PA were significantly different between groups post-intervention. Prior research found DPP participants who reported improvement in LF diet self-efficacy at 6-months was a significant predictor of achieving the 7% weight loss goal at end of study (Delahanty et al., 2013). Similarly self-efficacy for engaging in PA at baseline in the DPP was an independent predictor of leisure PA at 1-year, 2-year, and end of study follow-up (Delahanty et al., 2006). While there was a significant difference between groups for self-efficacy in this study, the between-group differences were due primarily to a significant decline in self-efficacy for the control group both post-intervention and at study end. The lack of education and support received by the control group likely contributed to the decline in participants' beliefs to achieve the target behaviors. In addition, a significant decline in intervention participants' beliefs in their ability to make time for exercise was observed, which illustrates the barriers people often encounter when initiating and maintaining PA. In addition, participants may have over-estimated their confidence for engaging in PA at baseline and the exercise demands during the intervention period may have led participants to form more realistic PA-related efficacy beliefs post-intervention. While the lifestyle intervention devoted three sessions specifically to PA, more time during each session may need to be devoted to identifying strategies for incorporating activity into one's daily routine. Greater emphasis on consistent incremental goals may be needed overall during the intervention to strengthen PA-related self-efficacy.

Group-based interventions offer promise as a means of providing social support to participants, especially at worksites where employees share a common culture and communication systems. The experimental group reported significant increase in the encouragement received from family and friends post-intervention and significant decrease in sabotage from family and friends at study end for their new eating habits. It is not known if participants in the experimental group considered other group members as "friends." No significant change in social support for PA was reported by participants except the control group at study end reported less peer support for engaging in exercise. Whether worksites could be a more influential source of support for a healthy lifestyle requires further study. Employees spend a significant portion of their day together at work, and the creation of supportive organizational structures, through formal or informal channels or "buddy systems," could be influential in promoting and sustaining a healthy lifestyle.

The SPSI-R:L assesses people's ability to resolve problems in everyday living (D'Zurilla et al., 2002); it does not assess problems specific to eating, PA, or diabetes prevention. Nevertheless, social problem solving is the process by which people attempt to identify effective solutions to life's problems (e.g., thoughts, relationships) and is a widely used measure. Effective problem solvers are more likely to have a positive orientation to problems (e.g., "Whenever I have a problem, I believe that it can be solved.") and implement a rational 5-step process of problem definition, alternative generation, decision-making, solution implementation, and solution revision, as necessary. Following completion of the intervention in this study, the experimental group reported a significant decline in negative problem orientation (e.g., "When my first efforts to solve a problem fail, I get very frustrated.") and significant increase in positive problem orientation at study end with a greater ability to generate alternatives to problems. One session in the intervention was devoted to the 5-step problem solving process. Furthermore at the beginning of each group session, participants shared their experiences in goal striving during the preceding week and discussed strategies for minimizing problems as they occurred. Despite these efforts, training in problem solving therapy per se was not a component of the intervention. While the improvements in problem solving orientation and generation of alternative solutions in this study are promising, a more specific focus on problem-solving therapy during the intervention is likely needed to achieve further change in these dimensions (D'Zurilla and Nezu, 2007). Prior research found that problem-solving was the most widely used strategy for addressing barriers to goal attainment by DPP lifestyle coaches (Venditti et al., 2014). Thus, problem solving is a key skill for participants to develop and should be retained as a critical intervention tool.

Few translational diabetes prevention trials have assessed changes in dietary intake. The dietary changes achieved in this study were consistent with the behavioral goals of the intervention. Intake of high-fat foods, such as full-fat dairy products, nuts, seeds, and solid fats (e.g., meat fat) decreased, while intake of fruits and vegetables increased in the experimental group. Findings from the DPP revealed participants in the lifestyle arm maintained higher intake of fruits and vegetables and lower intake of sweets compared with those in the metformin and placebo arms up to 9 years post-randomization (Jaacks et al., 2014). Prospective observational studies reported that certain dietary patterns (e.g., higher intake of fried foods and refined carbohydrates or lower intake of fruits and vegetables) raised the risk for type 2

diabetes (McEvoy et al., 2014). Thus, the adoption of a more healthful dietary pattern poses a benefit in risk reduction and is a critical outcome following diabetes prevention studies.

Although the present findings are promising, some study limitations should be noted. The study was implemented at a major U.S. university and results may differ at alternate worksite settings. The group-based curriculum adapted from the original DPP intervention has not been implemented outside the U.S.; thus, the group-based intervention would need to be tailored to meet the needs of other cultural groups prior to implementation. The sample consisted primarily of women, which is common for weight loss studies (Gardner et al., 2007; Rock et al., 2010). Strategies for improving the recruitment of men for diabetes prevention are sorely needed. One effective strategy may be to conduct "men only" intervention groups facilitated by male lifestyle coaches, which was successful in previous weight loss research (Morgan et al., 2013). One man in this study dropped out after the first group session because he did not want to discuss his health in a mixed gender group. Whether recruitment efforts and group sessions for men only would attract more men to the study requires further research. Formal mediation analyses were not conducted given the sample size. The role of the psychosocial outcomes assessed in mediating behavioral change requires further research with a sample of sufficient size. Finally, the impact of the intervention beyond the 3-month follow-up is not known.

Conclusion

It is feasible to implement intensive group-based interventions at a university worksite. The diabetes prevention trial effectively improved dietary patterns, step counts for PA, and psychosocial outcomes. Worksites offer promise for following employees long-term, and the impact of diabetes prevention efforts on disease occurrence and health care costs warrant further investigation.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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