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Workplace Interventions to Prevent Type 2 Diabetes Mellitus: a Narrative Review

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Abstract

Purpose of review—This study aims to summarize the recent peer-reviewed literature on workplace interventions for prevention of type 2 diabetes mellitus (T2DM), including studies that translate the Diabetes Prevention Program (DPP) curriculum to workplace settings ($n = 10$) and those that use different intervention approaches to achieve the specific objective of T2DM prevention among employees ($n = 3$).

Recent findings—Weight reduction was achieved through workplace interventions to prevent T2DM, though such interventions varied substantially in their effectiveness. The greatest weight loss was reported among intensive lifestyle interventions (i.e., at least 4 months in duration) that implemented the structured DPP curriculum ($n = 3$). Weight reduction was minimal among less intensive interventions, including those that substantially modified the DPP curriculum ($n = 2$) and

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Compliance with Ethical Standards

Conflict of Interest

Dina Hafez, Allison Fedewa, Margaret Moran, Matthew O'Brien, and Ronald Ackermann declare that they have no conflict of interest. Jeffrey T. Kullgren has received consulting fees from SeeChange Health and HealthMine.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

those that used non-DPP intervention approaches to prevent T2DM ($n = 3$). Most studies ($n = 12$) reported increased levels of physical activity following the intervention.

Summary—Implementation of the DPP in workplaces may be an effective strategy to prevent T2DM among employees.

Keywords

Workplace; Prediabetes; Diabetes; Prevention

Introduction

Within the USA, type 2 diabetes mellitus (T2DM) costs an estimated \$176 billion annually in direct medical expenses and an additional \$69 billion in indirect costs due to absenteeism, lost productivity, and disability [1], and employers bear much of this financial burden [2, 3]. Increasingly, workplace prevention of T2DM through initiatives such as the Diabetes Prevention Program (DPP) is being promoted as a strategy to control costs and improve population health [4]. In 2002, the Diabetes Prevention Program Research Group demonstrated that 7% body weight loss and 150 min of physical activity per week could reduce the 3-year incidence of T2DM by 58% among individuals with prediabetes [5]. The DPP lifestyle intervention has since been adapted to a year-long, group-based curriculum, which can effectively promote weight loss among participants in numerous community [6–8] and clinical settings [9–11]. Because of the high costs of T2DM to employers and the growing availability of the DPP, a range of stakeholders including the American Diabetes Association [12], the American Medical Association [13], the Centers for Disease Control and Prevention (CDC) [14], and the National Business Coalition on Health [3] have urged employers to implement the DPP. Additionally, health plans across the USA have partnered with employers to offer diabetes prevention services to eligible employees [15, 16], and similar efforts have also been initiated by international employers [17–19].

Despite important reasons for employers to strive to prevent T2DM among their employees, little is known about whether the DPP can be effectively translated to this setting [20] or whether other intervention strategies that use an approach other than the DPP could be implemented by employers to prevent T2DM in the workplace. While the workplace provides a unique opportunity to facilitate healthy behaviors through group-based interactions and environmental modifications (e.g., increased healthy food options in the cafeteria or vending machines) [21], there are several factors that may encumber achievement of favorable outcomes in workplace initiatives to prevent T2DM. First, previous studies of community implementations of the DPP may not generalize well to workplace environments. Existing literature on translational (i.e., “real-world”) DPPs implemented in largely non-employer settings focused predominantly on reporting the program’s effectiveness, an assessment of its internal validity, which has been demonstrated in diverse settings. However, key considerations related to external validity, such as target population characteristics, representativeness of the enrolled participants, and adaptations of the intervention to local conditions and resources, are inconsistently reported in the literature [22, 23], thus making it difficult to conclude these approaches can be generalized to workplace translation and dissemination of the program. Further, there can be unique

barriers to participation in worksite wellness programs [24, 25], and tailored implementation approaches may be needed to achieve adequate program reach and effectiveness. Second, simply offering the DPP to employees may be an insufficient strategy to prevent T2DM in the absence of other social and environmental supports. Prior evaluations of workplace health promotion programs demonstrate that positive outcomes are achieved when the intervention is not only comprehensive (i.e., screening, education, and linkage to additional resources are all readily available) but also delivered within a culture that genuinely encourages employee wellness [26, 27]. Finally, although workplace health promotion programs can reduce expenditures related to health benefits as well as worker absenteeism [28], it may take years for these savings to be realized [28, 29]. Given this longer time horizon for maximum returns on investment, employers may opt to deliver a less intensive (and potentially less effective) intervention as a means to limit initial costs.

In this narrative review, we summarize recent peer-reviewed studies on workplace implementation of interventions to prevent T2DM among employees. We also aim to make two unique contributions to the literature. First, we provide a comprehensive summary of translations of the DPP in workplaces and offer insight into its effectiveness in this setting. Second, recognizing that workplaces may use diverse approaches to prevent T2DM among employees, we also review studies in which employers have aimed to prevent T2DM using an intervention not based on the DPP. We discuss our findings in the context of prior literature on translational DPPs [8, 20, 23, 30] and workplace wellness initiatives [31] and identify characteristics that make these programs more effective. Through this approach, we provide practical recommendations to employers and identify key opportunities for future research in this area.

Methods

Data Sources and Search Strategy

In August 2016, we conducted a comprehensive search of MEDLINE, CINAHL, and EMBASE for studies published after January 1, 2000 that aimed to prevent T2DM among employees through one of two strategies: (1) translation of the DPP to the workplace or (2) implementation of a non-DPP intervention that explicitly aimed to prevent T2DM. Studies using the Finnish DPP were classified as translational DPPs since that program has been proven to reduce the incidence of T2DM through approaches that closely resemble those used in the DPP [32]. The standard DPP curriculum consists of 16 one-hour sessions during the first 6 months (core phase) and monthly sessions during the next 6 months (maintenance phase) and includes topics related to diet, exercise, and behavioral modification. Program participants are encouraged to lose 5–7% of their baseline body weight through dietary change—specifically reduction in dietary fat intake—and to participate in 150 min of moderate-intensity physical activity per week [33].

Broad searches were conducted to identify relevant articles using controlled vocabulary and keywords related to T2DM (e.g., type 2 diabetes, prediabetes, blood glucose), T2DM prevention (e.g., risk reduction, weight loss, exercise), and the workplace (e.g., employer, company). The reference lists of articles meeting eligibility criteria were manually screened

and electronic citation tracking was performed using Scopus. Full search details are available in Appendix 1.

Study Eligibility and Selection Criteria

Eligible studies (1) were conducted in the workplace or sponsored by an employer in a non-workplace setting, (2) implemented an evidence-based DPP or implemented a non-DPP intervention that aimed to prevent T2DM, and (3) reported one or more of the following outcomes: change in weight or change in glycemic status as measured by hemoglobin A1c (HbA1c) or fasting blood glucose.

Many workplace interventions promote weight loss or cardiovascular risk reduction without the stated aim of prevention of T2DM. However, this large body of literature has been previously summarized [34–37] and is beyond the scope of this narrative review. We also excluded articles that described the design or development of workplace interventions for T2DM prevention without reporting outcomes and those that were not published in English.

Two authors (DH and AF) independently reviewed titles and abstracts for eligibility. In cases where the title and abstract contained insufficient information to determine study eligibility, the full article text was reviewed instead. All discrepancies were resolved through consensus discussion with a third author (JK). The full text of 27 articles meeting study eligibility criteria was reviewed in detail. Of these 27 articles, 14 publications representing 13 unique interventions met our eligibility criteria and were included in the final sample for our review (Fig. 1).

Data Abstraction

One reviewer (DH) abstracted the data of interest from the 13 articles using a template adapted from a prior review of translational DPPs [20]. A second reviewer (AF) independently reviewed each article to validate the abstracted data. Several studies included participants at risk for T2DM as well as participants with previously diagnosed T2DM. When possible, we abstracted data only for participants at risk for T2DM, as T2DM self-management is beyond the scope of this review. There was notable heterogeneity in the completeness of the reporting of intervention characteristics and study outcomes among our included studies. For six such studies, we attempted to contact the corresponding and/or first author(s) to solicit unpublished information that could facilitate comparison among studies.

Results

Fourteen publications describing 13 studies met our eligibility criteria. Of these, 11 papers describing 10 studies (i.e., one study provided a 2-year follow-up analysis, which was published separately) translated the DPP to the workplace [38–44, 45•, 46, 47•, 48], while 3 studies utilized alternative strategies to prevent T2DM among their employee population [49–51]. Most studies ($n = 11$) were offered by US employers; one was offered by a German employer [48] and one was offered by a Finnish employer [51]. Among these studies were two randomized controlled trials with individual-level randomization [40, 45•], one non-randomized controlled trial [41], one cluster randomized controlled trial [43], three single

group time series studies [38, 42, 49], two single-group pre-post studies [44, 47•], one multi-group pre-post study [46], and three longitudinal cohort studies [48, 50, 51].

Studies were categorized as translational DPP interventions if they used or intentionally modified an evidence-based diabetes prevention framework such as the DPP, a similar program such as the Finnish DPP. Studies were categorized as non-DPP interventions if they did not reference the DPP and if the intervention approaches did not resemble those included in the DPP (e.g., periodic consultation with a health counselor rather than intensive, weekly sessions).

Given the heterogeneity between DPP-based interventions (i.e., translational DPPs) and non-DPP based interventions to prevent T2DM among employees, we present and discuss the results for each of these categories separately. The characteristics for the translational DPP interventions are shown in Table 1 and the characteristics for non-DPP interventions are shown in Table 2.

Summary of Studies That Tested Workplace DPPs

Sample—Among the 10 translational workplace DPP-based interventions, the number of enrolled participants ranged from 37 to 300 individuals. Few studies reported information related to company size [38, 42, 45•, 48], which ranged from 167 employees at one site [42] to 3000 employees across five sites [48]. None of the studies reported information regarding the job classification program participants, although one study mentioned that most of the company's employees are paid hourly wages [38], another mentioned that company employees include both salaried and hourly workers [45•], and two studies mentioned that the employees perform shift work [42, 44].

Program attrition ranged from 6 to 43% among the 10 workplace DPPs, which is consistent with previous literature on translational DPPs in other settings [8]. In the six studies that reported age, mean participant age ranged from 44 to 52 years. All studies reported mean baseline participant body mass index (BMI), which ranged from 27 to 39 kg/m². Of the nine studies that reported genders of participants, most studies ($n = 8$) included predominantly women (55–91%). The one study with a minority of female participants (8%) took place at a worksite with predominantly male employees [42].

Recruitment/Screening/Eligibility—Similar to a prior review of translational Diabetes Prevention Programs [20], these workplace DPPs showed heterogeneity in the eligibility criteria for participants, resulting in a varied level of T2DM risk among study samples. In two studies, all employees were eligible for participation, regardless of T2DM risk factors [40, 42]. Three studies used the American Diabetes Association (ADA) Risk Assessment Questionnaire [52] to identify individuals at high risk for T2DM [38, 43, 47•], and two used the risk assessment score to guide additional biomarker evaluation [38, 47•]. In two studies, all employees who were overweight or obese were eligible for participation [44, 46]. Self-measured waist circumference was used by one employer to identify individuals with central obesity (waist circumference was 80 cm for women or 94 cm for men) and eligibility for biomarker screening [48]. One study did not report eligibility criteria [41].

Intervention Characteristics—While the standard DPP curriculum consists of 16 weekly core sessions and 6 monthly maintenance sessions, the program is often modified or culturally adapted for diverse populations in varied settings [53]. Among the 10 studies that translated the DPP to the workplace, 6 delivered at least 16 core sessions [38, 41, 43, 44, 45•, 47•]. Two studies shortened the duration of the intervention's core phase from 16 to 12 weeks [40] and 4 weeks [46]. One workplace encouraged participants to complete a self-study manual adapted from the group-based curriculum within 24 weeks [42], and another used the Finnish DPP, which involved six sessions of dietary advice alternating with six sessions of physical activity and motivational advice; each session was 1.5 h in duration [48].

A maintenance phase was reported in six DPP studies [38, 40, 42, 45•, 46, 48] which ranged in duration from three brief “booster sessions” delivered during staff meetings [42] to nine monthly sessions [40]. Notably, only two studies offered both the 16-week core phase and the 6-month maintenance phase [38, 45•].

DPP Modifications and Workplace Adaptations—Worksites used various strategies to increase DPP engagement and attendance. For example, sessions were often offered during the lunch hour or immediately after work [38, 40, 46, 47•]. In two studies, participants were allowed to self-select the mode of program delivery, which included one-on-one lifestyle counseling [41] and a DVD-based curriculum [45•] in addition to a group-based option. Among the eight studies that reported race [38, 40, 42–44, 45•, 46, 47•], most had predominantly Caucasian participants (range 49 to 93%) [38, 40, 42, 43, 45•, 47•] and only one study specifically tailored the DPP curriculum for the target population [46]. Townsend et al. used a community-based participatory research (CBPR) approach to translate a culturally adapted DPP curriculum to worksites with a predominance of Native Hawaiian and Pacific Islander employees [46]. Most studies ($n = 6$) offered modest incentives such as a pedometer or \$10 gift card for initial enrollment and/or ongoing participation [38, 40–43, 45•] and one of these evaluated the effect of financial incentives on weight loss [43].

Outcomes—Of the 10 DPP studies, 8 reported short-term weight loss as an outcome, which ranged from 0.4 to 5.1 kg at 3 to 6 months. One study tested the effect of a financial incentive on participant weight loss and reported that recipients of the financial incentive lost 2.3 kg more at 12 weeks than those who did not receive a financial incentive ($p < 0.027$), but the investigators did not report absolute weight loss for either group [43]. Six studies reported weight loss after 6 months, which ranged from 1.43 to 4.9 kg at 7 to 12 months. One study included a 2-year follow-up analysis, which was reported separately from the first report of intervention effects and showed that intervention group participants maintained a 0.9-kg weight loss at 2 years [39]. One study reported the percent of participants who lost over 1 kg body weight at 1 year (26%), 2 years (58.1%), and 3 years (59.5%) [48].

Among the 10 DPP studies in our review, 7 reported average percent weight loss, which ranged from 0.5 to 5.5% between 12 weeks and 12 months. Percent weight loss was 5.5% at 12 months [38] and 5.0% at 6 months [45•] in the two studies that did not shorten the duration of the standard DPP curriculum. Only four studies reported the percent of

participants who achieved at least 5% weight loss, which ranged from 14 to 53% at 16 weeks [40, 44, 45•, 47•].

All of the workplace DPP studies assessed participant engagement in physical activity, but evaluation methods and reporting varied widely between studies, with only one study reported physical activity minutes [47•]. A second study collected self-reported physical activity minutes but did not analyze the data given concern that participant reporting was inaccurate [44].

Among workplace DPP studies, few ($n = 4$) evaluated glycemic change over the course of the intervention [38, 45•, 47•, 48]. Two studies showed improvement in HbA1c [38, 45•], one study showed improvement in fasting blood glucose [47•], and one showed improvement in fasting blood glucose among women, but worsening among men [48].

Six of the DPP studies reported session attendance [38, 40, 44, 45•, 46, 47•]. Three studies reported mean core session attendance which ranged from 9 out of 16 sessions [44] to 12 out of 16 sessions [45•, 47•]. One study reported a mean attendance of six out of eight total sessions, which included four core sessions and four maintenance sessions [46]. Two studies reported the mean percentage of enrolled participants that were in attendance at each session, which was 67% in one study [38] and ranged from 20 to 100% in another study [40].

Summary of Results for Non-DPP Interventions

Sample—Across the three non-DPP workplace interventions for T2DM prevention, the number of enrolled participants ranged from 34 individuals to 2312 individuals. Two of these studies reported attrition, which ranged from 18 to 26% [49, 50].

Recruitment/Screening/Eligibility—All three studies used on-site screening such as biomarker assessment, anthropometric measurement, and/or risk assessment questionnaires to identify eligible individuals [49–51]. In two studies, participants included individuals at risk for T2DM as well as those with diagnosed T2DM [49, 50]. One study targeted only those at risk for T2DM [51].

Intervention Characteristics—While the three non-DPP studies offered a variety of resources to support healthy behaviors such as educational sessions, health promotion websites, and one-on-one consultation services, the interventions were less intensive than translational DPP interventions. For example, participants in one study were only required to attend two in-person educational sessions followed by eight optional telephone sessions with a certified diabetes nurse educator [49] and in another participants were offered up to three individual lifestyle counseling sessions with a dietician and/or diabetes nurse over the 2.5-year study period [51].

Outcomes—Weight loss at 6 and 12 months was minimal among the two studies that reported this information [49, 50]. Viitasalo et al. reported weight loss at 2.5 years, stratified by gender and session attendance. Among men who attended more than one session, mean weight increased by 0.07 kg. However, 21% of men who attended more than one session

achieved 5% body weight loss over the study period compared to 8% of men who did not attend a session. Among women who attended more than one intervention session, weight decreased by 2.47 kg. While 7% of women who attended at least one session achieved 5% body weight loss, 10% of women who did not attend a session also achieved this outcome.

All non-DPP studies evaluated glycemic change over the course of the intervention. One study showed a 0.68% reduction in HbA1c at 12 months [49] and another showed a 0.1% reduction in HbA1c at 12 months [50]. The third study showed an increase in fasting blood glucose of 0.27 among men and 0.35 among women at 2.5 years [51]. Engagement in physical activity was not formally assessed in any of the non-DPP studies, although Viitasalo et al. commented that “sedentary lifestyle decreased significantly among men with an elevated risk of diabetes.”

Discussion

Our findings demonstrate that workplace interventions to prevent T2DM can reduce weight among at-risk employees, although the reviewed interventions varied substantially in their effectiveness. Weight loss, the main driver of T2DM prevention [54], was the primary outcome among all studies. In general, greater weight loss was achieved among studies that tested workplace translations of the DPP compared to studies that tested non-DPP interventions to prevent T2DM. Weight loss ranged from 1.43 to 4.9 kg at 7 to 12 months among the five DPP interventions that reported longer-term weight loss. Among the three non-DPP interventions, weight loss across the study periods (12 months to 2.5 years) was minimal, with a maximum achieved weight loss of 1.66 kg at 12 months. Methods used to assess physical activity varied across interventions, thus limiting our ability to describe between-study differences in physical activity outcomes. Only one study evaluated the number of participants who achieved 150 min of physical activity per week despite this being one of the primary lifestyle goals of the DPP.

Prior research on translational DPPs shows that programs are most effective when they include a minimum of 4 to 6 months of weekly sessions followed by periodic maintenance sessions for at least 1 year [30]. Session attendance among participants has been reported as a primary predictor of weight loss and glycemic improvements in these studies [8, 55]. Consistent with this literature, we found that the most favorable weight loss outcomes were reported by workplace interventions that offered at least 16 core sessions [38, 45•, 47•]. Participants attended a mean of 12 core sessions among the two studies that reported this information [45•, 47•], slightly higher than the mean attendance of 11 sessions reported in a recent meta-analysis of translational DPPs [55]. Two studies delivered at least 16 weekly core sessions and 6 monthly maintenance sessions [38, 45•]; in one study program, participants lost an average of 4.8 kg (5.5% body weight) at 12 months [38], and in the other, participants lost 4.7 kg (5.0% body weight) at 6 months [45•]. A third study, which consisted of 16-weekly sessions without a maintenance phase, reported an average weight loss of 4.9 kg (5.2% body weight) at 7 months [47•]. These weight loss outcomes are slightly higher than those reported in two recent meta-analyses, which showed an average weight loss of 3.77 kg across interventions of variable durations [56•] and 4% body weight loss at 12 months [8].

Notably, there were two studies in which participants achieved minimal short-term weight loss, despite delivery of the 16-week core intervention [41, 44]. Participants attended an average of 9 out of 16 sessions in the one study that reported that information [44]. Both studies also reported high attrition (25 and 43%), the reasons for which were examined in one study and included lack of motivation, lack of weight loss, competing personal issues, competing work issues, and health-related factors [44]. Reasons for this variation in achieved weight loss among the studies that delivered a 16-week core intervention are not clear, as none of the studies described barriers or facilitators to program implementation or delivery. However, important lessons have been learned through decades of research on workplace wellness programs, which show that certain workplace characteristics may influence the effectiveness of behavioral health interventions [57]. A culture of health, for example, is critical to the success of workplace wellness programs [57, 58], yet many employers do not establish the social and physical environments necessary to genuinely support employee well-being [27]. It is plausible that worksite cultural differences may explain, at least in part, the variation in weight loss outcomes among studies that adhered to the structured DPP curriculum. Future research on workplace diabetes prevention initiatives should characterize the social and physical workplace environments, which may influence the DPP's generalizability to certain settings. In addition, future studies may examine the impact of these contextual factors on the program's effectiveness.

The Diabetes Prevention Program is commonly modified—often by reducing the number or frequency of sessions—as a strategy to limit costs, increase feasibility, and reduce attrition in translational settings [59]. However, our review of the literature suggests some adaptations could compromise program effectiveness [53, 60]. Among the 10 workplace translations of the DPP, 2 studies substantially modified the DPP curriculum by decreasing the intensity of the intervention [42, 46] and the average participant weight loss was comparatively lower in these studies. One study offered only four core sessions [46] and the other adapted the DPP curriculum to a self-study manual [42]. Notably, both studies deliberately modified the curriculum to accommodate the specific needs of their respective employee populations. However, the lower weight loss observed in these studies was likely related to the shorter duration of these interventions relative to those that more closely followed the standard DPP curriculum structure [59].

This review has several important limitations. First, we only included interventions described in peer-reviewed literature and therefore may not have captured interventions sponsored by employers or health plans that have not been reported in journals. Second, cost is an important outcome for employers, yet none of the studies reported data related to program expense and only one study reported information suggestive of a potential reduction in healthcare spending [41]. Lastly, we used stringent eligibility criteria to identify non-DPP interventions that specifically aimed to prevent T2DM among employees. These criteria only identified three studies, which may underrepresent the various workplace wellness interventions which can reduce employees' risk for T2DM through the broader aims of obesity management or cardiovascular risk reduction.

Conclusions

Workplace interventions to prevent T2DM are most effective when they utilize the structured, evidence-based DPP curriculum with minimal modifications. Our findings suggest that it may be most efficient and effective for employers to do the following: (1) implement an evidence-based DPP; (2) assess objective weight loss and physical activity outcomes; (3) measure program-related costs; and (4) use these results—perhaps in conjunction with participant feedback and critical assessment of the workplace culture—to inform future iterations of the intervention. Additionally, future studies of workplace interventions for T2DM prevention should include extended follow-up to examine longer-term weight trajectory, T2DM incidence, and cost-effectiveness in order to inform employers' health promotion planning.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1.
Flowchart for excluding articles from review

Table 1

Workplace interventions to prevent type 2 diabetes mellitus based on the Diabetes Prevention Program

	Aldana et al. [38, 39], USA	Barham et al. [40], USA	Dallam and Foust [41], USA	DeJoy et al. [42], USA	Faghri and Li [43], USA	Giese and Cook [44], USA	Kramer et al. [45], USA	Townsend et al. [46], USA	Weinhold et al. [47], USA	Zyriax et al. [48], Germany
Reach										
Enrolled	<i>N</i> = 37	<i>N</i> = 45	<i>N</i> = 264	67	<i>N</i> = 99	<i>N</i> = 47	<i>N</i> = 89	<i>N</i> = 275	<i>N</i> = 78	<i>N</i> = 300
Analyzed	<i>N</i> = 35 at 12 months; <i>N</i> = 22 at 24 months	<i>N</i> = 41	<i>N</i> = 151	59	<i>N</i> = 73 ("non-incentive group-NIG"; <i>n</i> = 38; "incentive group-IG" <i>n</i> = 35)	<i>N</i> = 35	<i>N</i> = 82	<i>N</i> = 217	<i>N</i> = 66 (results below are for intervention group, <i>n</i> = 35)	<i>N</i> = 55 (women <i>n</i> = 34; men <i>n</i> = 21)
Worksite/population	BD Medical; Sandy, UT	County employees	1 newspaper publisher; 2 departments of public hospital; city/county health department; 1 city/county police	Union Pacific Railroad, maintenance facility	Long-term nursing home facility employees	Manufacturing plant, New Mexico	Bayser Corporation; Pittsburgh, PA	15 organizations with a mission to serve Native Hawaiian communities; predominance of Native Hawaiian (38%) and Pacific Islander (21%) employees	Major midwestern university	5 companies (health insurance, wharf, camper, food industry, medical equipment supplier)
Study design	Single group time series	Randomized delayed controlled trial	3-group quasi-experimental study	Single group time series	Cluster randomized controlled trial	Single group pre/post design	Randomized delayed controlled trial	Pre/post study	Randomized pre/post controlled trial	Longitudinal cohort
Recruitment	Email, flyers, word of mouth	ADA risk assessment questionnaire	NR	Posted signs; announcements at staff meetings; word of mouth	Workplace announcements; newsletters; posters; flyers	Presentation about DPP at quarterly plant meetings; digital flat screen monitor announcements	Mailing, email blasts, "lunch and learn" meetings	NR	Direct mailing to employees with blood glucose 110–199 mg/dL; advertisements; flyers, story in employee newspaper	Flyers, intranet, work meetings
Screening	Biomarker, anthropometric, and T2DM risk factor assessment followed by OGTT if prediabetes suspected	ADA risk assessment questionnaire	Group health screenings	None	NR	BMI screening	Phone screening to identify non-diabetic employees with BMI > 25 kg/m ² followed by worksite biomarker screening	NR	Employees with ADA risk assessment score > 5 were screened with fasting blood glucose and/or HbA1c	Employees self-measured their waist circumference; eligible for checkup if WC was > 80 cm for women or > 94 cm for men
Eligibility	Abnormal OGTT	All employees, although goal was to enroll those at highest risk	NR	All employees	Non-diabetic; BMI > 25 kg/m ² ; ADA Diabetes risk score ≥ 8	BMI > 25 kg/m ²	Non-diabetic; BMI > 25 kg/m ² ; prediabetes; metabolic syndrome, and/or hyperlipidemia	Age > 18 years; BMI > 25 kg/m ² for Caucasians or > 23 for Asians; able to engage in 150 min of brisk walking/week	Age 18–65 years; BMI > 25 kg/m ² ; prediabetes	Elevated WC and fasting plasma glucose of > 100 mg/dL and/or plasma glucose of > 140 mg/dL 2 h after OGTT
Participant characteristics										
Mean age in years (SD)	NR 32 (8.4)	51 (9.6) 39.4 (6.9)	NR	NR 32.1 (5.32)	IG: 45 (11) NIG: 49 (11) IG: 36.7 (7.7)	NR 34.8 (7.5) ^a	52 (7.2) 33.0 (5.8)	46 (11.3) 33 (6.9)	52 (9.5) 35 (1.0)	Men: 44 (8.5) Women: 45 (8.5) Men: 29.6 (3.3)
Mean baseline BMI (kg/m ² (SD))			1-on-1 counseling: 31.4 Group-based: 27.8 Passive education: 27.2		NIG: 33.9 (5.8)					Women: 29.9 (5.4)

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	Aldana et al. [38, 39], USA	Barham et al. [40], USA	Dallam and Foust [41], USA	Dejoy et al. [42], USA	Faghri and Li [43], USA	Giese and Cook [44], USA	Kramer et al. [45], USA	Townsend et al. [46], USA	Weinhold et al. [47], USA	Zyriax et al. [48], Germany
Gender (% female)	66%	81%	NR	8%	IG: 91% NIC: 89%	65%	55%	87%	80%	82%
Race (% Caucasian)	49%	81%	NR	79%	IG: 40% NIC: 55%	18%	93%	14%	77%	NR
Ethnicity (% Hispanic)	14%	NR	NR	NR	IG: 2.9% NIC: 6.3%	52%	NR	13%	0%	NR
Intervention characteristics										
No. of core sessions	24 weekly group sessions + 4 individual sessions; additional sessions available by request	12 weekly group sessions	26 weekly sessions	Expected to complete self-study program within 24 weeks	16 weekly sessions	16 weekly sessions	Face-to-face: 12 weekly sessions followed by 4 bi weekly sessions; DVD: 12 weekly DVD sessions; brief weekly telephone call from lifestyle coach	4 weekly sessions	16 weekly sessions	Based on Finnish DPP: 6 sessions
Maintenance sessions	6 monthly group sessions	9 monthly group sessions	None	3 "booster sessions" delivered by occupational health nurse during staff meeting	None	No maintenance phase completed due to high attrition rate	6 monthly sessions for both intervention groups	4 biweekly sessions	None	6 monthly sessions followed by 6 biweekly sessions, then sessions offered every 3 months for 2 years
DPP modifications	Increased number of group sessions; offered individual sessions	Added components of National Diabetes Education Program and Healthy Interactions Inc. conversation maps	(1) 1-on-1: weekly meeting with lifestyle coach (2) Group-based: weekly group meeting with health educator (3) Passive education: no meetings; education via e-mails, flyers, and brief presentations	Self-study manual adapted from the DPP curriculum; 1-on-1 session with dietitian or health educator at start of intervention	None	None	None	Culturally adapted to Native Hawaiian and Pacific Islander population through community-based participatory research	None	1.5-h sessions on nutrition or physical activity supervised by a dietitian or trainer
Workplace adaptations	Sessions offered during work hours without loss of pay or personal time	Sessions offered during lunch hour; 30 minutes administrative leave per session	None	Intervention informed by evaluation of work environment and employee needs; presentations at staff meetings; program available to family members; posters in high-traffic areas; educational website	None	Used existing professional expertise within the health service and company (e.g., company dietitian, on-site fitness staff)	None	Delivered during lunch period or immediately after work; most group facilitators were employees of the organization	Sessions offered during lunch hour	None
Personnel	Nurse, certified health educator	Nurse educator, dietitian, psychologist, physical therapist	Grant employees trained in health promotion; community professionals	Grant employees trained in health promotion; some presentations delivered by community professionals	Occupational health nurses gave 6 brief presentations and provided foreman with pre-shift announcements; peer health coaches offered informal support	NR	NR	Nurse practitioner and diabetes educator; on-site fitness staff delivered physical activity sessions; licensed counselors delivered behavioral and mental health content	Lifestyle coaches provided by study team	Trained worksite employees (<i>n</i> =15) or external hires (<i>n</i> =7)
									University dietitians	Dietician or trainer

	Aldana et al. [38, 39], USA	Barham et al. [40], USA	Dallam and Foust [41], USA	DeJoy et al. [42], USA	Faghri and Li [43], USA	Giese and Cook [44], USA	Kramer et al. [45], USA	Townsend et al. [46], USA	Weinhold et al. [47], USA	Zyriax et al. [48], Germany	
Average attendance	67%	Weekly sessions: 67–100%; Monthly sessions: 19.5–56%	NR			NA	NR	74% attended 4+ sessions (mean 9, SD 3)	Mean 12/16; 91% attended 4+ core sessions	Mean 6.2 (SD 2); 77.5% attended 4+ sessions	NR
Attrition	12 months: 6%; 24 months: 41%	3 months: 9%	26 weeks: 43%			6 months: 12%	12 weeks: IG 31%; NIG 21%	16 weeks: 25%	16 weeks: 7%	3 months: 21%	NR
Incentive	\$10 gift certificate; pedometer; educational tools; membership to employee fitness center	Pedometer; portion plate; measuring utensils and educational tools	Gift certificate to retail vendor; lottery approach to minimize costs			\$10 gift card for completing questionnaire and biometric screening	Weight loss-based incentives (\$10 per 1 lb/week lost if BMI < 25 or 1.5 lbs/week lost if BMI > 30) +/- self-imposed deposit	None	Gift certificates (\$5 to \$25); Fat and calorie counter; pedometer, exercise bands	None	NR
Short-term weight loss in kg (SD)	6 months: 2.9 kg	3 months: 2.3 kg [−3.5 to −0.97]	26 weeks: 1-on-1: 2.4 kg; group-based: 0.7 kg ; passive education: 0.4 kg			6 months: 0.94 kg (3.68)	16 weeks: IG lost 2.3 kg more than NIG	Weight loss only reported as Z-score of 3.89 BMI at conclusion was reduced by 0.57 ¹	6 months: 5.1 kg (4.9)	3 months: 1.2 kg (2.6)	4 months: 5.1 kg (SE 0.6) Men with 1 kg weight loss: 4.3 (3.6) kg Women with 1 kg weight loss: 3.6 (2.4) kg
Long-term weight loss in kg	12 months: 4.8 kg 24 months: 0.9 kg	NR	NR			12 months: 1.43 kg (4.38)	28 weeks: IG lost 2.4 kg more than NIG	NA	12 months: 4.7 kg (6.2)	NR	1 year: 26.1% of participants had lost 1 kg 2 years: 58.1% of participants had lost 1 kg 3 years: 59.5% of participants had lost 1 kg
% weight loss	6 months: 3.3%; 12 months: 5.5%; 24 months: 1.1%	3 months: 2.1%	26 weeks: 1-on-1: 2.8%; group-based: 0.9% ; passive education: 0.5%			12 months: 2.8%	NR	Range from gain of 3% to loss of 9.7%; Median: loss of 2.5% (IQR 0.2 to 3.6% loss)	6 months: 5.0%	NR	4 months: 5.5% (SE 0.6) 7 months: 5.2% (SE 1.0)
% participants who met 5% weight loss	NR	3 months: 22.50%	NR			NR	NR	14% of participants had 4–7% weight loss	6 months: 45% (<i>n</i> = 56)	NR	4 months: 52.9% 7 months: 48.6%
% participants who met 7% weight loss	NR	3 months: 12.50%	NR			NR	NR	5.70%	6 months: 29% (<i>n</i> = 56)	NR	4 months: 32.4%
Physical activity	Statistically significant improvement in aerobic fitness (ml/kg/min) at 6, 12, and 24 months	3 months: physical activity levels increased significantly as measured by the International Physical Activity Questionnaire	26 weeks: physical activity increased for all 3 intervention groups as measured by the Baecke Questionnaire of Habitual Physical Activity			6 months: physical activity increased significantly as measured by the stage of behavioral change questionnaire	16 weeks: activity increased slightly as measured by self-reported probability of being active 30 min in a day	Self-reported physical activity minutes collected, but not analyzed, as investigators believed they were self-inflated	6 and 12 months: statistically significant increase in physical activity as measured by MET-hours	3 months: increase in feet walked during 6-minute walk test and physical activity frequency	4 months: physical activity increased as measured by the number of participants exercising for 150 min/week 7 months: returned to baseline
Glycemic change (SD)	HbA1c at 12 months: −0.18; HbA1c 24 months: 0.11	NR	NR			NR	NR	NR	HbA1c at 6 months: −0.07 (0.16) HbA1c at 12 months: −0.06 (0.17) (<i>n</i> = 71)	NR	Fasting blood glucose at 1–3 years: men with 1 kg weight loss: +3.4 (7.4); women with 1 kg weight loss: −2.7 (4.6)

NR not reported, NA not applicable

Unpublished data, obtained through communication with study author

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Table 2

Workplace interventions to prevent type 2 diabetes mellitus not based on the Diabetes Prevention Program

	Bevis et al. [49], USA	Burton et al. [50], USA	Viitasalo et al. [51], Finland
Reach			
Enrolled	<i>N</i> = 99	<i>N</i> = 34	<i>N</i> = 2312 (men = 1199, women = 1113)
Analyzed	<i>N</i> = 73	<i>N</i> = 28	<i>N</i> = 402 (men = 238, women = 165)
Worksite/population	Major employer in Orlando, FL	US-based, multinational Fortune 100 financial services corporation	Airline company
Study design	Single group time series	Longitudinal cohort study	Longitudinal cohort study
Recruitment	Publicized screening events	Wellness center flyers, posters and internal advertising	Each year, 1/5th of the airline's employees are invited to participate in a "health check-up"
Screening	Anthropometric and biomarker assessment at employer-based screenings	Employer-based health screenings	Anthropometric and biometric assessment; T2DM risk assessment (FINDRISC questionnaire)
Eligibility	12 months continuous employment; age ≥ 18 years, fasting glucose ≥ 100 mg/dL; ADA risk assessment score ≥ 10	Self-selected members of employee wellness center with T1DM, T2DM, prediabetes, and risk for T2DM	Non-diabetic; FINDRISC score ≥ 10 and laboratory evidence of prediabetes
Participant characteristics			
Mean age in years (SD)	50 (10)	48.8	Men (<i>n</i> = 195): 50(7) Women (<i>n</i> = 131): 47(8)
Mean baseline BMI (kg/m ²) (SD)	38.2 (6.4)	32.1	Men (<i>n</i> = 195): 30(4) Women (<i>n</i> = 131): 29(5)
Gender (% female)	27%	68.1%	41%
Race (% Caucasian)	NR	50.7%	Not reported for study population, although employee population is 95% Caucasian
Ethnicity (% Hispanic)	NR	8.7%	Not reported
Intervention characteristics			
Program description	2 educational sessions (2 h); 8 voluntary telephone sessions focused on healthy eating, physical activity and diabetes-related education (e.g., foot screening)	1-year multifaceted program consisting of 1-on-1 consultation, group classes, health webinars, educational e-mails sent every 2 weeks to maintain contact	Individualized written health promotion plan provided at check-up; educational printed material and website on healthy behaviors to prevent T2DM; individual lifestyle counseling sessions offered to participants with FINDRISC ≥ 10; small group counseling sessions offered
Personnel	Certified diabetes nurse educators	Nurse practitioner, health coach, dietitian, pharmacist, employee assistance program counselor; certified diabetes health educator available for group classes	Dietitians and/or diabetes nurse delivered individual lifestyle counseling sessions
Average attendance	100% of analysis sample	NR	60% (<i>n</i> = 245) attended at least one individual counseling session; 4.5% (<i>n</i> = 18) participated in group sessions
Attrition	26.3% did not attend 2 sessions or did not participate in telephone program	17.6%	Not reported
Incentive	Cash cards at enrollment and completion	Raffle prizes for participation in group classes or webinar presentations	None

	Bevis et al. [49], USA	Burton et al. [50], USA	Viitasalo et al. [51], Finland
Short-term weight loss in kg (SD)	6 months: BMI decreased by 0.62 (4.70)	6 months: 0.05 kg	Not reported
Long-term weight loss in kg	12 months: BMI decreased by 0.62 (2.44)	12 months: 0.6 kg	2.5 years, >1 intervention session attended: men + .07 kg; Women: 2.47 kg
% weight loss	NR	12 months: 0.65%	2.5 years, >1 intervention session attended: Men + .09%; Women: +3.8%
% participants who met 5% weight loss	NR	NR	2.5 years, >1 intervention session attended: men 20.8%; women 7.0%
% participants who met 7% weight loss	NR	NR	Not reported
Physical activity	NR	NR	2.5 years: "sedentary lifestyle decreased significantly among men with an elevated risk of diabetes"
Glycemic change (SD)	HbA1c at 6 months: -0.67 (0.74) HbA1c at 12 months: -0.68 (0.08)	HbA1c at 6 months: -0.1 HbA1c at 12 months: -0.1	Fasting blood glucose at 2.5 years among those who attended >1 intervention session: men +0.27; women +0.35

NR not reported