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Review article

Effectiveness of workplace diabetes prevention programs: A systematic review of the evidence

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ABSTRACT

Purpose: The primary purpose is to review diabetes workplace interventions and the degree to which they improve diabetes-related outcomes in employees diagnosed with or at risk for T2DM.

Methods: Three electronic databases and ancestry searches were used to identify peer reviewed articles published in English from 2000 to June 2017.

Results: The number of participants represented by the 22 selected studies, excluding one large outlier, was 4243. On average, the samples were 57% female and ethnically diverse. Interventions—healthy eating behaviors, physical activity, and/or monitoring and self-managing diabetes and cardiovascular risk factors—were delivered in group sessions of fewer than 20 employees. Programs involved 1-h weekly sessions held during lunch hour or at other times during the workday for 12 to 24 weeks. Study outcomes, commonly measured at 6 and/or 12 months, were consistently positive.

Conclusion: The literature search uncovered beginning evidence that workplace interventions hold promise for preventing diabetes and/or its complications. More rigorous, creatively designed, workplace studies, are needed for employees at high-risk for developing diabetes.

Practice implications: Implications include the need for employer education about the benefits of employer support for such programs and attention to motivational strategies so employees will take full advantage of programs that are offered.

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1. Introduction

Type 2 diabetes mellitus (T2DM) is a growing epidemic, affecting ≥29.1 million people nationwide and costing the U.S. $245 billion annually [1], primarily due to the costs of complications and lost work productivity. The major precursor to T2DM is abdominal obesity, which is associated with the most dangerous risk factors for cardiovascular events and premature deaths, e.g., insulin resistance, high cholesterol, and hypertension (HTN) [2–7]. Small weight reductions (~7%) enhance insulin sensitivity and glycemic control and may reduce or delay diabetes-related comorbidities in those diagnosed with T2DM, as well as delay diabetes onset in those who are at high risk but not yet diagnosed [8–10].

Individuals from racial/ethnic minority backgrounds, particularly those who are African American, Hispanic American, or Native American, have higher rates of risk factors for T2DM, prevalence of diagnosed T2DM, and diabetes-related deaths [11]. Genetic factors have been linked to T2DM in some of these groups; [12–14] but other risk factors, many of which are modifiable, also have been implicated—low socioeconomic status (SES), barriers to health care access, underutilization of health care resources, lower rates of insurance coverage, and lack of health education [15,16]. Higher overweight/obesity rates and lower physical activity levels have been reported in minorities, compared to non-Hispanic Whites [17,18].

Recent estimates from the U.S. Bureau of Labor Statistics indicate that individuals from minority backgrounds hold many of the service positions in workplace settings, e.g., custodial services, landscaping, construction, and repairs/maintenance [19]. Because these individuals have high rates of T2DM or are at increased risk of developing it in the future, an effective workplace health program can be an efficient strategy for reducing escalating employer health care costs. However, few workplace studies focused on minority groups have been reported. Researchers recently made recommendations for "implement[ing] effective interventions targeting all workers with type 2 diabetes . . . [which] could be a good strategy for controlling productivity-related costs" [20].

Focus group interviews conducted by the authors with 36 local employees found that workplace diabetes prevention interventions, from the perspectives of both primary and secondary prevention, appealed to employees and have promise for effective implementation [21]. All employee informants in the focus groups were of Mexican-American origin and worked two jobs, arriving home every day after midnight. As the employee informants indicated, such work schedules pose major barriers to participating in health programs, as well as to making healthy lifestyle choices. Workplace health programs are more accessible than traditional programs because they eliminate many barriers to participation, e.g., the need for transportation and conflicting family responsibilities [22]. And a workplace program also provides a unique opportunity to involve men, a group that is often absent from behavioral interventions.

Few evidence-based, sustained health programs are found in employment settings, despite employee support, researcher recommendations, and evidence in the literature [23]. The CDC has developed a list of characteristics that should be incorporated in any workplace health programs in order for the programs to be effective, efficient, and sustainable. The CDC characteristics can be used as guidelines for developing and evaluating workplace health programs; they address the organizational culture and leadership of the employment setting, aspects of the program design (e.g., promoting employee participation, tailoring programs for the specific workplace), program implementation and resources, and program evaluation (See Table 1).

The purpose of this systematic review of the literature is to examine the: (1) effects of diabetes workplace interventions and the degree to which they improve diabetes-related outcomes (e.g., A1C, blood glucose levels, weight/weight loss, behavioral change, lipid levels, psychosocial effects, etc.) in both employees diagnosed with T2DM and in individuals with prediabetes or at risk for diabetes; and (2) variability in intervention outcomes based on race/ethnicity, gender, age, socioeconomic status (SES), and type of occupation individuals hold. A further objective is to explore the degree to which designers of reported workplace programs have

Table 1
CDC Essential Elements of a Workplace Health Programs.

Organizational Culture & Leadership	Program Design	Program Implementation & Resources	Program Evaluation
Develop a "Human Centered Culture"	Establish clear principles	Start small, scale up	Measure and analyze
Demonstrate leadership	Integrate relevant systems	Provide adequate resources	Learn from experience
Engage mid-level management	Eliminate recognized occupational hazards	Communicate strategically	
	Be consistent	Build accountability into program implementation	
	Promote employee participation		
	Tailor programs to the specific workplace & diverse needs of the workers		
	Consider incentives & rewards		
	Find & use right tools to track progress		
	Adjust program as needed		
	Make sure program lasts (sustainability)		
	Ensure confidentiality		

Source: Adapted from *Essential Elements of Effective Workplace Programs and Policies for Improving Worker Health and Wellbeing*. Retrieved 21 January 2017 from: https://www.cdc.gov/niosh/docs/2010-140/pdfs/2010-140.pdf.

incorporated the CDC's recommendations for workplace health programs (Table 1).

2. Methods

In conducting this systematic review, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) requirements, which were created to improve reporting in systematic reviews [24]. The PRISMA-based flow chart (Fig. 1) illustrates each step of the literature search, study selection, and study coding process.

2.1. Search strategy

We searched three electronic databases, Pubmed, Cumulative Index to Nursing and Allied Health Literature (CINHAL), and The Cochrane Database of Systematic Reviews, to identify relevant studies. We used the following search terms in differing combinations in order to locate a comprehensive group of studies: workplace, diabetes, and intervention. For workplace, we also used OR work-place OR work site. Along with the term diabetes, we also used OR diet OR exercise. Initial studies that were located were found with the electronic searches; three additional studies were found with ancestry searching of the reference lists of studies that met inclusion criteria. An additional study was located through a similar systematic review that was found in The Cochrane Database [25].

2.2. Study selection

Studies were included if they involved: (1) adult participants (aged 21+) diagnosed with type 2 diabetes or prediabetes; (2) an intervention provided at a workplace setting for employees; (3) an intervention that focused on lifestyle behaviors that would prevent diabetes or improve diabetes-related outcomes, such as exercise/physical activity, healthy dietary practices, glucose self-monitoring, accurate medication self-administration, and/or appointment keeping; and (4) were published in peer-reviewed journals since 2000. The year 2000 was selected as the literature "starting point," because in 2000 the diagnostic threshold for T2DM was lowered from 140 mg/dl to 126 mg/dl in recognition of the fact that "both micro- and macrovascular disease develop at lower fasting glucose levels than previously recognized" [26]. Studies were excluded if they involved case studies, systematic reviews/meta-analyses, or study protocols or instrument validation studies with no reported findings related to intervention outcomes.

Studies located through the electronic database search were downloaded and independently screened for inclusion by a minimum of two different individuals. The initial search yielded a total of 234 non-duplicate citations (Fig. 1). Following the screening of each title and abstract according to the pre-defined inclusion criteria, 77 articles remained; 22 studies remained after the exclusion criteria were applied during the full text screen and data extraction steps. Studies were excluded primarily because they did not involve individuals diagnosed with or at risk for type 2 diabetes or intervention findings were not reported. The 22 studies that met all of the inclusion criteria serve as the final sample for this systematic review. All decisions regarding the selection of studies were verified at group meetings of the research team members/authors.

2.3. Data extraction and analysis

Data from each individual study [27–48] were extracted into a synthesis table using Microsoft Word (Table 2), which provides a more parsimonious view of the studies and enables a review of patterns, trends over time, discrepancies, unique approaches, and unexpected findings. Data fields included study type, population/sample, setting, intervention/control, type of intervention (healthy diet, exercise/physical activity, glucose self-monitoring, mediation administration, and appointment keeping), instructors/interventionists, outcomes/dependent variables, level of program attendance, and results. We also coded important variables such as ethnic/racial breakdown of the sample in order to examine the

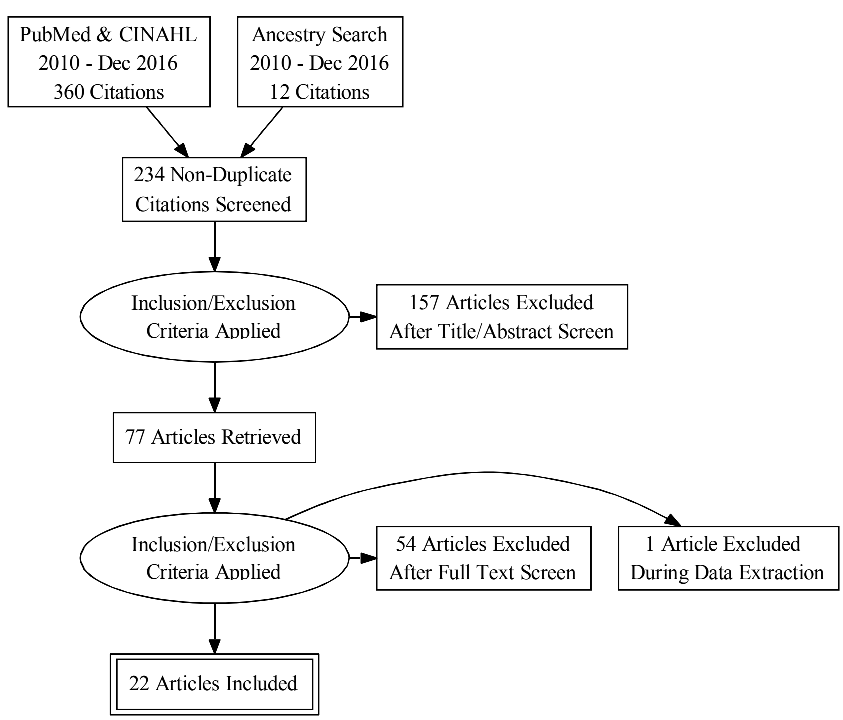

Fig. 1. PRISMA Flow Chart of Literature Search and Study Selection.

Table 2
Studies of Workplace Interventions for the Prevention and/or Treatment of Type 2 Diabetes ($N = 22$)

Author	Design & Purpose	Sample & Setting	Intervention	Measures	Results
Agarwal et al. [27]	Quasi-experimental design, 10 sites, 5 of the sites randomly assigned to control grp	Sample: $N = 292$	Intervention: 18 weekly 1-h lunchtime instruction sessions in low-fat vegan diet (<3 gms fat/serving) plus online support for dietary modifications	Physical & Emotional Well-being Question. (SF-36): depression, anxiety, physical wellbeing, emotional wellbeing	Sig. improvement in depression ($p = .02$), anxiety ($p = .04$), fatigue $p < 0.001$), emotional wellbeing ($p = .01$), daily functioning ($p = .01$), general health ($p = .02$)
	A plant-based nutrition program aimed at improving depression, anxiety, & productivity in employees w/ diabetes or at risk	Mean age: 44.6 ($SD = 11$)	Control: no instruction in dietary modification	Work Productivity & Activity Impairment Question. (WPAI-GH)	WPAI-GH: sig. improvements in impairment while working ($p = .01$), overall work impairment b/c of health ($p = .02$), non-work-related activity impairment b/c of health ($p = .001$), work time missed NS
	Data collection: baseline, 18 weeks	Women: 79.8%	Instructors: RD, MD, cooking instructor	Automated self-admin. 24-h recall program: adherence to dietary program	Sig. changes in fat, chol, fiber, phytonutrients
		White: 65%			Attendance: 33.8% failed to attend week 18 assessments, otherwise NR
		Black: 24% Asian: 5% Other: 6% Occupation: 62–71% professionals Setting: corporate sites of a major U.S. company			
Aldana et al. [28]	One group pre-test, post-test	Sample: $N = 37$	Intervention: lifestyle portion of DPP w/ diabetes risk assessment, PA, dietary education, social support, & behavior change education, goal setting, & activities for groups & individuals	Aerobic fitness, pedometer counts, self-reported PA exertion, & diet	Sig. improvements (<0.05) in weight, BMI, 2-h OGTT, A1C, VLDL, triglycerides, & aerobic fitness from baseline to 12 months
	Diabetes Prevention Program for employees diagnosed w/ impaired glucose tolerance & newly diagnosed diabetes	Mean age: NR	Program offered during regular work hours without losing pay or personal time	Biological markers: weight, BMI, waist circum., HR, BP, OGTT, fasting insulin, A1C, C-reactive protein, lipids	Attendance: 67% met attendance requirements for program classes & PA sessions (at least 16/24 of weekly sessions during first 24 weeks, then unspecified attendance at 6 monthly sessions for following 6 months); only 22 participants provided data for full 2 yrs
	Data collection: baseline, 6, 12, & 24 months	Women: 63.6%	Sessions offered weekly for 24 weeks then monthly for 6 months		
		White 50%	Participants given pedometers, free memberships to employee fitness center, & access to case management		
		Latino: 13.6% Asian: 31.8%	Control: NA Instructors: RNs & certified health educator		
		Pacific Islander: 4.6% Occupation: NR (mostly hourly-paid jobs) Setting: BD Medical in Utah			
Andres et al. [29]	Quasi-experimental design, 4 non-random group assignments based on participants' baseline measures	Sample: $N = 100$ (24 with diabetes/pre-diabetes)	Intervention: participants assigned to ≥ 1 of 4 treatment programs: hypertension, dyslipidemia, diabetes/ prediabetes, unhealthy lifestyle; monitoring visits included provider evaluations, lab tests, weight, BP, nutritional & exercise guidance; duration based on individual needs until goals met (or discharged from program), then optionally transitioned to annual monitoring phase	Medication regimen	Sig. improvement in A1C among women – 6.3% to 6.1% ($p = .01$) but not men

Table 2 (*Continued*)

Author	Design & Purpose	Sample & Setting	Intervention	Measures	Results
	Cardiovascular Risk Reduction Program to reduce modifiable CV risk factors in people w/ diabetes or at risk	Mean age: 51 (SD = 6.8)	Control: NA	Biological markers: fasting glucose, A1C, triglycerides, chol, HDL, LDL, TSH, liver enzyme tests, BMI, vital signs	Sig. reductions in total chol, HDL (males only), LDL, triglycerides
	Data collection: baseline, end (NR)	Women: 75%	Instructors: NR		Attendance: NR
		Race/ethnicity: NR Occupation: NR Setting: 3M worksite Medical Clinic			
Barham et al. [30]	RCT, w/ random assignment to intervention or wait-list control group	Sample: N = 45 (n = 22 w/ diabetes)	Intervention: 12 weekly lifestyle sessions, 45–60 minutes during lunch time to 4 groups of 12 participants; modified DPP curriculum & Conversation Maps; content on healthy diet, PA, stress reduction; followed by 9 monthly maintenance sessions w/ topics selected by participants	Short Form-12 (Shoul),	Sig. improvement in intervention group's weight at 3 mo: (−2.23 kg [−3.5 to 0.97]) vs +0.73 kg [+0.17 to +1.28], $p < 0.001$), BMI ($p < 0.001$) waist circum. ($p = 0.004$), PA ($p = 0.011$), dietary fat intake ($p = .018$), IWQLS ($p < 0.001$), 3-Factor Eating ($p < 0.001$, $p = .003$, $p = .001$), IPAQ ($p = .011$), Short Form-12 Physical Component Summary ($p = .048$)
	Modified DPP program to improve nutrition & PA, promote weight loss in people w/ diabetes or at risk	Mean age: 51 (SD = 6.4)		Perceived Stress Scale, Impact of Weight on Quality of Life Scale (IWQLS),	No differences in lipids, glucose, A1C, or BP
	Data collection: baseline, 3, 6, 12 months	Women: 84%	Control: 3-month wait list	Three-Factor Eating Question. -R18, NCI Dietary Fat Screener,	Attendance: 30–45 attended each session during core program; 7–30 attended monthly sessions
		White: 82%	Instructors: nurse educator, dietitian, psychologist, physical therapist	International Physical Activity Question. (IPAQ), Work Stress Inventory	
		Occupation: NR		Biological markers: BMI, waist circum., BP, FBG, lipids, A1C	
		Setting: Onondaga County, NY employees			
Bevis et al. [31]	One group pre-test, post-test	Sample: N = 224	Intervention: 4 2-h sessions, 8 telephone sessions on lifestyle & daily management	Workplace performance: Stanford Presenteeism Scale (SPS)	SPS sig. improved from baseline ($p < 0.0001$)
	Test an employer-endorsed diabetes wellness program	Mean age: 52.0 (SD = 9.3)	Control: NA	Health Risk Reporting questionnaire	Majority self-reported increase in exercise, stress management & a decrease in weight, fat consumption, & BP
	Data collection: baseline, 6, & 12 months	Men: 62%	Instructors: certified diabetes nurse educator	Biological markers: A1C, LDL, BMI	A1C sig. decreased ($p < 0.0001$)
		Race/ethnicity: NR Occupation: NR			Attendance: >90% participants w/ diabetes attended all 4 sessions; 151/175 attended at least 2 sessions & all blood draws; 73/99 prediabetes participants met attendance standards
		Setting: major employer in Orlando, FLA			
Burton et al. [32]	One group pre-test, post-test	Sample: N = 101	Intervention: one-on-one consultation w/ healthcare experts on lifestyle, disease & medication self-mgmt	Diabetes knowledge, diabetes self-mgmt	Risk for diabetes decreased from 96.4% to 85.7%
	Test Healthy Living w/ Diabetes program	Mean age: 49 (SD NR)	Group classes, webinars & bi-weekly educational emails	Biological markers: A1C, LDL, BMI, BP	Sig. increase in glucose monitoring ($p = 0.011$), foot exams ($p = 0.002$), meal planning ($p = 0.003$)
	Data collection: baseline, 6, & 12 months	Women: 69%	Control: NA		No change in biomarkers, diabetes control, or diabetes knowledge
		White: 51.5%	Instructors: certified diabetes health educator, dietitian, pharmacist, & employee assistance program counselors		Attendance: 12-month completion rate = 40%; 92 who completed preprogram question. but not post-program question. had

Table 2 (*Continued*)

Author	Design & Purpose	Sample & Setting	Intervention	Measures	Results
					poorer control of diabetes than those who completed all requirements; 40/65 w/ diabetes at baseline completed all biometric measures. 28/34 w/ prediabetes or at risk completed all biometric measures
		African American: 15.8% Asian: 12.9% Hispanic: 9.9% Other: 9.9% Occupation: NR Setting: Fortune 100 financial services corporation in US, multiple locations			
Dallam & Foust [33]	3-group quasi-experimental design	Sample: N = 264 (n = 151 completers)	3 approaches: 1) intensive 1-on-1 education: weekly meetings w/ lifestyle counselor (n = 49); 2) support group: weekly meetings w/ lifestyle educator (n = 45); & 3) control group, compared info via emails, flyers (n = 57), delivered over 26 weeks	Baecke Question. of Habitual Physical Activity	Sig. improvement in mean arterial pressure ($p < 0.002$) for all participants
	Implement diabetes risk factor reduction program, examine effectiveness of 3 approaches to Diabetes Prevention Program (DPP)	Age: NR	Instructors: see above	Diabetes risk score	Sig. greater improvement in BMI ($p < 0.002$), weight ($p < 0.014$), PA ($p < 0.039$), diabetes risk ($p < 0.006$) for intensive 1-on-1 approach compared to group & control groups
	Data collection: baseline, 26 weeks	Gender: NR		Biological markers: weight, mean arterial BP, BMI	Attendance: 57.2% completion rate (151 out of 264), otherwise NR
		Race/ethnicity: NR Occupation: NR Setting: 4 orgs in midsized urban area, western US (public hospital, county/city health dept, police dept)			
DeJoy et al. [34]	One group pre-test, post-test pilot study	Sample: N = 167	Intervention: 24-week diabetes prevention program: weekly individual sessions w/ lifestyle coach for weigh-ins, lesson presentation, problem solving, action plan; weekly reminders by foreman, posters, website, & casual interactions w/ PHC	Stage of readiness for behavioral change	Mean change in body weight at 12 mo = −1.43 kg ($p < 0.04$)
	Test diabetes prevention program translated to a worksite	Mean age: 45 (SD NR)	Control: NA	Self-efficacy for diet & physical activity	6 months: increase in healthy eating (67% $p < 0.001$) & exercise (51.7%); not maintained at 12 months (NS)
	Data collection: baseline, 6 & 12 months	Men: 97%	Instructors: dietitian, health educators, peer health coaches	Biological markers: BMI, weight	Attendance: 59/67 completed data collection at 6 months (88% 6-month retention rate)
		White: 85% African American: 7.5% Occupation: Locomotive engineers Setting: locomotive maintenance facilities			
Faghri & Li [35]	RCT w/ 4 worksites, 2 sites randomly assigned to experimental or control group	Sample: N = 73	Intervention: incentive group participants (2 worksites, n = 51) chose simple financial reward (up to $260 if weight loss exceeded 11–14 lbs) or simple financial reward + self-imposed penalty (up to $320 but a risk of losing up to $80)	Diabetes Risk Survey (PA & Health Eating subscales)	Intervention group (both types of incentives) sig. improved weight ($p = 0.027$), BMI ($p = 0.043$), & diabetes risk scores ($p = 0.011$) at 16 weeks; likelihood of healthy eating ($p = 0.013$) at 28 weeks
		Mean age: 47 (SD 11.3)			

Table 2 (*Continued*)

Author	Design & Purpose	Sample & Setting	Intervention	Measures	Results
	Test effectiveness of financial incentives vs incentive plus penalty on reducing risks for diabetes, CVD, & weight in overweight & obese employees at risk for diabetes		Intervention participants received 16-week program consisting of weight loss consultation on PA, diet, social support, addressing barriers to weight loss, & goal setting plus Small Steps, Big Rewards educational program	Biological markers: weight, proportion achieving weight loss goal, BMI, waist-to-hip ratio, BP	Standard intervention plus penalty group had better outcomes than standard group: BMI, diabetes risk, and odds of achieving weight loss
	Data collection: baseline, 16 & 28 weeks	Women: 90.4%	Control: 2 worksites (n = 48) received same intervention w/o financial rewards		Attendance: 73/99 completed study, attendance NR
		White: 48% Latino: 4% African American: 44% Asian: 0 AI/AN: 1% No response: 1% Occupation: nursing assistant (36%), administrative/clerical (5%), LPN (15%), RN (12%), housekeeping (1.4%), dietary (7%), OT/PT (3%), recreation (4%), social work (1%), other (11%) Setting: long-term nursing home facilities owned by same corporation	Instructors: NR		
Ferdowsian et al. [36]	2-group prospective intervention study	Sample: N = 113	Intervention: 22–weekly group meetings on nutrition & cooking instructions, included low-fat vegan diet & vitamins; company cafeteria offered low-fat vegan options; interactive message board; grocery store tour	Unannounced 24-h dietary recall, 3-day diet record, analyzed w/ Nutrition Data System	Experimental group sig. decreased weight ($p < 0.001$), waist-hip ratio ($p = .0007$), HDL ($p = .002$)
	Test a multicomponent nutrition intervention program at a corporate site to reduce weight & improve cardiovascular risk factors	Age: 21–65	Control: alternative site w/ no intervention	Self-reported dietary adherence (vegan)	No differences between groups in macronutrients, LDL, BP, A1C
	Data collection: baseline & 22 weeks	Women: 82.3%	Instructors: physicians, dietitian, cooking instructor	Monthly missed hours of work due to health problems	Attendance: 71% met meeting attendance requirements (attended > 10 weekly sessions out of 22 total sessions)
		Race/ethnicity: NR		Biological markers: FBG, A1C, waist-hip ratio, lipids	
		Occupation: NR Setting: Government Employees Insurance Company (GEICO)			
Giese & Cook [37]	A pretest-posttest cohort design	Sample: N = 47	Intervention: 16-week diabetes prevention program on foundational skills, controlling external environment, psychological issues related to long-term change	Physical activity log	Stat. sig. changes in body weight ($p < 0.001$) & BMI ($p < 0.001$)
	Test if the Diabetes Prevention Program Lifestyle Core Curriculum would decrease weight in obese employees	Age: NR	Control: NA	Biological markers: weight	Attendance: mean number of sessions attended = 9 (SD 3.01), 35 completed at least 4 sessions
		Women: 65%	Instructors: nurse practitioner, diabetes educator		
	Data collection: weekly for 16 weeks	White: 18%			
		African American: 3% Hispanic: 52% Asian: 21% Native American: 6% Occupation: NR Setting: New Mexico manufacturing plant			

Table 2 (*Continued*)

Author	Design & Purpose	Sample & Setting	Intervention	Measures	Results
Haines et al. [38]	One group pretest-posttest cohort design	Sample: N = 120	Intervention: 12-week, 10-unit computer-based exercise program; weekly emails encouraged 10% step increase	Perceived improvement in wellbeing: fitness level, mood, health awareness, nutrition habits, health status, anxiety, happiness, weight loss, work productivity, work absenteeism	Greater than moderate effect of intervention on 5 areas of perceived improvement: fitness level, mood, health awareness, nutrition habits, & health status
	Test the Virtual Walking & Wellness exercise program in employees at risk for diabetes & CVD	Mean age: 44.4 (SD = 10)	Control: NA	Biological markers: BMI, blood glucose, total chol, BP, pedometer data	Biological markers: differences from baseline - BMI ($p = .024$), blood glucose ($p = .024$), & total chol ($p = .09$); increased steps by 27%
	Data collection: baseline & 12 weeks	Women: 92.5%	Instructors: computer-based program created by study authors		Attendance: 60/120 (50%) completed 12-week program (all follow-up and biometric tests)
		White: 85% Black: 15% Asian: 2% NR: 1% Occupation: 97.5% university staff Setting: Midwest college campus			
Hewitt et al. [39]	2 group RCT	Sample: N = 20	Intervention: individualized progressive exercise regimen, including brisk walking or light jogging 4× a week	Biological markers: exercise stress test (incl. peak oxygen consumption), inflammatory markers, vital signs, FBG, total chol	Biological markers: control group sig. improved oxygen consumption ($p < 0.05$) & C-reactive protein ($p < 0.05$)
	Test a 12-week exercise program	Mean age: 41.4 (SD = 8)	Control: wait list		No other group differences
	Data collection: baseline, 4, 8, & 12 weeks	Gender: NR	Instructors: NR		Attendance: of 16 prescribed exercise sessions, attendance was 81% at weeks 1–4, 84% weeks 4–8, & 70% weeks 8–12
		Race/ethnicity: NR Occupation: sedentary medical & non-medical lab staff Setting: Northern Ireland biological laboratory workers			
Kramer et al. [40]	Randomized 2 groups w/ 6-month delayed control group	Sample: N = 89	Intervention: group delivered version of DPP lifestyle intervention; 12 weekly 1-h sessions onsite during employee lunch hour followed by bi-weekly & then monthly meetings for 1 yr; choice given to attend face-to-face sessions or watch DVDs; intervention followed by brief weekly telephone calls to assess progress & understanding of program	Modified Activity Questionnaire: PA	Intervention group sig. greater mean weight loss (−10.4 lbs, $p = 0.0001$) & improvements in A1C ($p = 0.009$), systolic BP ($p = 0.005$), BMI ($p = 0.0003$), waist circum. ($p = 0.0006$); higher proportion achieved 5% weight loss goal (45% vs 7% for control [$p = 0.005$]) & fewer had weight gain (9% vs 46% for control [$p < 0.0001$]); increase in median MET-hours leisure activity at 6 months
	Test the year-long DPP intervention focused on weight loss & increasing PA	Mean age: 52.3 (SD = 7.2)	Control: 30% randomly assigned to receive DPP intervention 6 months later (from baseline)	Biological markers: weight, BMI, A1C, fasting glucose, serum insulin, lipids, BP, waist circum.	Across all groups, at 18 mos follow up, sig. weight loss maintained (−8.6 lbs, $p < 0.001$)
	Data collection: 6, 12, & 18 months	Women: 55%	Instructors: 2 trained lifestyle coaches		Intervention participants attended 12 of 16 sessions; women preferred face-to-face delivery vs DVD ($p = 0.009$)
		White: 93.3%			Attendance: attended 12/16 sessions; 91% attended ≥4 core sessions
		Occupation: professional & technical employees Setting: Bayer Corp., Pittsburgh			
Maruyama et al. [41]	RCT	Sample: N = 101	Intervention: in-person & remote monthly meetings w/	No. of steps	Intervention group sig. improved food choices

Table 2 (*Continued*)

Author	Design & Purpose	Sample & Setting	Intervention	Measures	Results
			dietitians & physical trainers for goal setting, & action plans, personal website page to record food intake, weight, healthy dietary habits, & PA, & steps from pedometer		(p = 0.00), weight (p = 0.01), BMI (p = 0.01), AST (p = 0.03), A1C (p = 0.05), fasting glucose (p = 0.02), insulin (p = 0.04), insulin resistance (p = 0.00)
		Mean age: 52 (SD 7.9)	Control: no treatment	Self-check for healthy foods choices	Attendance: NR
	Test the effects of the Life Style Modification Program for Physical Activity & Nutrition (LiSM10!®)	Men: 100%	Instructor: dietitians, physical trainer (both certified health counselors)	Biological markers: BMI, chol, HDL, LDL, TG, AST, ALT, γ-GTP, uric acid, plasma glucose, A1C, insulin, insulin resistance, waist circum., BP	
	Data collection: baseline & 5 months	Japanese: 100%			
		Occupation: white-collar workers Setting: Nichirei Corp., a producer of frozen foods in Tokyo, Japan			
McHugh & Suggs [42]	Quasi-experimental non-randomized 2-group longitudinal study	Sample: N = 238	Intervention: tailored online weight management program—question., tailored feedback, monthly tailored newsletters, PA & nutrition tracking	Biological markers (extracted from company's Health Risk Assessment): BMI, weight, BP, chol, blood glucose	Intervention overweight group sig. decreased blood glucose & systolic BP; obese group sig. decreased systolic BP
	Test a commercially available online tailored weight management program for overweight/ obese employees	Mean age: 41 (SD = 9.3)	Control: self-selected, did not choose to participate		Attendance: NR
	Data collection: 1 & 3 yrs	Male: 65%	Instructors: company staff, w/ master's & doctoral degrees in health sciences (public health, health education & promotion, health communication, & related areas)		
		Race/ethnicity: NR Occupation: NR Setting: Fortune 500 company in Switzerland			
Rouseff et al. [43]	One-group pre-test, post-test	Sample: N = 230	Intervention: 12-week intense group-based program, a multi-disciplinary wellness team; activities included personalized exercise regimen, nutrition consultation, diabetes education; follow-up continued for 12 months from study entry	Self-reported perceived energy & stress levels	12-week results: sig. reduction in all measures ($p < 0.001$, HDL p = .008), except hsCRP (p = .14); in persons w/ diabetes, mean A1C reduced from 7.6% to 6.7%
	Test intervention effectiveness of lifestyle intervention (My Unlimited Potential) in employees w/ cardio-metabolic risk factors	Mean age: 48.4 (SD = 9.6)	Control: NA	Biological markers: weight/ BMI, waist & hip circum., % body fat, chol, LDL, HDL, hsCRP, triglycerides, peak aerobic capacity, BP, A1C	3-month results: in persons w/ obesity (N = 113), 32% lost enough weight to be reclassified to lower BMI class
	Data collection: baseline, 3, 6, & 12 months	Female: 78%	Instructors: NR		12-month results: sustained reduction in BMI, weight, % body weight, not as large as at 3 & 6 months; 18% reduced or discontinued medications
		White: 20.9%			Attendance: 205 did not miss ≥3 sessions, completed blood work at 12 weeks (89% retention rate); 156 completed 6 months (68–80% retention); and 149 at 12 months (65–66% retention)
		Hispanic: 47.8% Black/AA: 23.5% Asian: 5.2% Setting: employees w/ high CVD risk at Baptist Health S. Florida (BHSF), large healthcare organization			
		Sample: N = 275			Sig. improvements in weight

Table 2 (*Continued*)

Author	Design & Purpose	Sample & Setting	Intervention	Measures	Results
Townsend et al. [44]	One group pre-test post-test (CBPR approach)		Intervention: adapted DPP intervention of 8 1-h interactive lessons delivered over 12 weeks in groups of 10–20; culturally-tailored activities included DPP lessons plus topics of economical healthy eating & doctor-patient communication	6-min walk test: physical functioning	
	Examine effectiveness of a DPP lifestyle intervention, translation to Native Hawaiian-serving worksites	Mean age: 46.2 (SD 11.3)	Control: NA	Exercise frequency, fat intake, locus of weight control, exercise self-efficacy, eating self-efficacy, family & community support	(−1.2 kg, $p < 0.001$), BP ($p < 0.001$), feet walked ($p < 0.001$), PA frequency ($p < 0.001$), perception of family support ($p = 0.004$), eating self-efficacy ($p = 0.03$), & decline in perception of community support ($p = 0.01$)
	Data collection: baseline & 3 months	Women: 87%	Instructors: trained worksite peer facilitators	Biological markers: body weight, height, BP	Sig. differences between worksite groups in weight, BMI, & perceived community support
		Native Hawaiian = 38.3% Other Pacific Islander = 21.2%			No sig. ethnic differences Attendance: completers received 6.2 lessons (SD 2.08) compared to dropouts (2.1 lessons, SD 2.09); mean number of lessons received by site ranged from 4.78–7.35
		Asian = 21.2% White = 23.8% Occupation: employees of social service orgs, health centers, health care systems, academic institutions Setting: 15 Native Hawaiian-serving organizations			
Viitasalo et al. [45]	One group pre-test post-test	Sample: N = 1347	Intervention: general health advice & information on health risks (heredity, lifestyle, work)	Questionnaire about work, working hours, sleep, diseases, medication, dietary intake, PA, & diabetes risk	Subjects at low risk for diabetes at baseline had sig. increased weight & lipids at follow-up
	Test if a lifestyle intervention was feasible & efficient to decrease risk factors for T2DM & CVD	Mean age: 45 (SD NR)	Those at higher risk of T2DM offered 1- to 3-h personalized lifestyle counseling (challenges re to shift work, PA, sleep, smoking, alcohol intake, diet, goal setting) in 2 visits 6 months apart	Biological markers: height, weight, waist circum., plasma glucose, serum lipids, high-sensitivity C-reactive protein; OGTT for subjects w/ high diabetes risk	Men at high risk for diabetes sig. decreased weight & lowered total & LDL, compared to men in low-risk group
	Data collection: baseline & follow-up (1.3–4 yrs later)	Men: 53.7%	Five 1.5-h group sessions offered plus access to diabetes prevention information website		Fasting glucose increased for men & women, of low & high-risk groups, regardless of participation
		Ethnicity: NR	Control: NA		Sedentary lifestyle decreased among men at elevated diabetes risk compared to men at low risk
		Occupation: included blue collar (e.g. cargo) & white collar (e.g., gate agents), & in-flight jobs (e.g., pilots, cabinet attendants); included individuals w/ regular day hours, shiftwork, & diverse working hours Setting: Finnish airline company	Instructors: occupational health physician, nurse &/or dietitian		Attendance: men who attended ≥1 sessions lost more weight ($p = 0.031$) than non-attenders; women at elevated risk who attended ≥1 sessions increased chol levels but at lower rate than non-attendees
Weinhold et al. [46]	RCT	Sample: N = 69	Intervention: 16-week DPP group lifestyle intervention met 1 h during lunch; focused on 7% weight loss, 150 min/week of mod. PA, ≤25% of total energy from fat	Block 2005 Food Frequency Question.: dietary intake	Intervention sig. decreased weight ($p < 0.001$); waist circum., FBG, BP (all $p < 0.025$); %-age energy from fat($p = .008$), total energy intake ($p < 0.001$), & intake of all fats
		Mean age: 51.3 (SD = 8.8)			

Table 2 (*Continued*)

Author	Design & Purpose	Sample & Setting	Intervention	Measures	Results
	Test DPP lifestyle intervention in employees w/ verified prediabetes		Control: usual care from health care providers + DPP handouts	Lifecorder Plus Accelerometer: PA levels	Intervention sig. increased intake of carbohydrate & fiber ($p < 0.01$)
	Data collection: baseline, post intervention (4 months), 3-month follow-up (7 months)	Male: 20.3%	Instructors: dietitians	Biological markers: weight change, waist circum., glucose, blood lipids, BP	32.4% in intervention group met weight loss goal, compared to 2.9% in control group
		White: 82.6%			Change in body weight associated w/ self-monitoring, PA, session attendance
		Occupation: clerical & professional university employees, including students; 91.4% full time Setting: university worksite			Attendance: mean # sessions attended = 11.6 of 16 sessions
Widmer et al. [47]	Prospective observational cohort study	Sample: N = 30,974	Intervention: smart phone digital health intervention w/ personalized interface that tracks, logs, educates, & forms actionable tasks, e.g., exercise, medication adherence, diet, smoking cessation	Biological markers: weight, waist circum., BMI, BP, lipids, glucose, A1C	Users of the program more likely older, female, obese, worse lipid profiles, higher glucose levels
	Test effectiveness of a digital health intervention on CVD risk factors & adherence	Mean age: 48.1 (SD = 11.7)	Control: NA		Higher level of program participation associated w/ sig. improvements in weight (−5.24 lbs, $p < 0.001$) & HDL chol (+0.90 mg/dL), compared to those w/ either no or low participation
	Data collection: baseline, 3, 6, 9, 12 months	Male: 42.4%	(5 groups compared based on intervention use [no, low, monthly, weekly, >1× per week])		Attendance: NA
		White: 72.0% Occupation: 79.4% gov't workers Setting: employees in gov't & white & blue collar occupations across 42 states in US, employer sponsored insurance program	Instructor: NA		
Zyriax et al. [48]	One group pre-test, post-test	Sample: N = 291	Intervention: employees w/ elevated waist circum. & FPG≥100 followed for 3 yrs; offered voluntary group program of 1.5-h sessions on nutrition & PA; 6 sessions on diet, 6 sessions on PA, 6 sessions on follow-up advice & further education over a 1-year period; combined sessions of 1.5 h offered every 3 months for 2 yrs	Drug costs associated w/ increased screening	Decrease in weight, BMI, & body fat in people who lost ≥1 kg; 26% lost weight at 1 yr, 58% at 2 yrs, & 59.5% at 3 yrs
	Test feasibility of screening employees for diabetes risk factors & providing a voluntary diabetes prevention program	Mean age: 43.6 (SD 8.6)	Control: NA	Biological markers: waist circum., FPG, OGTT, chol, LDL, HDL, TG, BP, # w/ metabolic syndrome	None of those w/ prediabetes who lost ≥1 kg developed diabetes
	Data collection: baseline, 6 months, & 1,2, 3 yrs	Gender: NR	Instructor: dietitian or trainer		Prevalence of prediabetes decreased at 1,2, & 3 yrs
		Ethnicity: NR			Avg cost of drugs over 3 yrs slightly lower than yr before study began
		Occupation: NR Setting: employees of 5 companies (health insurance, wharf, camper, food industry, medical equip supplier)			Attendance: NR

LEGEND: NR = not reported; NA = not applicable; hsCRP = high sensitive C-reactive protein; circum.=circumference, CVD = cardiovascular disease; FBG = fasting blood glucose.

extent to which diabetes disparities have been addressed in the research literature. Further, variables such as who provided the intervention and the rates of intervention attendance were coded when reported by the authors of the primary studies. Risk of bias was assessed per Cochrane criteria and included an assessment of study design, sample size, attrition, and quality of the instruments used to measure outcomes [49]. Two independent coders extracted data from the sample of studies and all coding decisions were verified at group meetings of the research team members/authors.

3. Results

3.1. Study designs and methods

Only 6 of the 22 included studies involved randomized, experimental designs to test the effects of a workplace intervention [30,35,39–41,46]. The remaining 16 studies were designed as either quasi-experimental (n = 5) with no randomization to groups but with comparisons between a treatment and an existing control group [27,29,33,36,42], or as a one-group pre-test posttest study (n = 11) [28,31,32,34,37,38,43–45,47,48]. One large study involved the testing of a digital health intervention that was incorporated as part of an employer insurance company across 42 states in the U.S. [47]. The uniqueness and the large sample size involved in this study (N = 30,974) skewed some of the descriptive findings below, e.g., mean sample size. Therefore, we report data with and without this study included.

3.2. Characteristics of study samples

Sample sizes across the studies included in this review ranged from 20 to 30,974 in the large Widmer study [47]. The total number of participants represented by these studies, excluding the large Widmer study, was 4243. The weighted mean age of participants across the 18 studies in which age was reported was 48 years; 46 years across the 17 studies excluding the Widmer study. Standard deviations related to age were reported in 15 of the studies. Gender composition of the samples ranged from 0% female to 93% female. Overall, the total sample represented by these studies was 57% female across the 19 studies that reported data on gender, which included the Widmer study. Regarding race/ethnicity, authors of 14 of the 22 studies reported the race/ethnic backgrounds of their samples. The percentage of the samples that were White ranged from 0% to 85%; 9 of the 14 studies involved samples that were 50% White or greater. The 5 studies that involved more diverse samples with less than 50% White employees were conducted in nursing homes [35], a New Mexico manufacturing plant [37], a corporation located in Japan [41], a large healthcare organization [43], and Native-Hawaiian serving organizations [44]. Workplace settings were highly variable and involved sites such as corporate settings, healthcare facilities (clinics, hospitals, health departments), insurance companies, manufacturing plants, and college/university campuses.

3.3. Characteristics of study interventions

The authors of eight studies specifically stated their intent to test in a workplace setting a version of the lifestyle portion of the Diabetes Prevention Program (DPP) in a workplace setting [28,30,33,34,37,40,44,46]. When reported, these DPP-style interventions were primarily delivered in small group sessions of less than 20 employees and were offered, sometimes in the workplace cafeteria, during lunch hour or at times during the workday. Non-DPP interventions tended to focus on improving healthy eating behaviors, enhancing physical activity, and/or monitoring and self-managing diabetes and cardiovascular risk factors. Risk factors that were addressed in the interventions included stress reduction, medication adherence, weight monitoring, importance of logging health behaviors, smoking cessation, and reducing alcohol consumption. The length of the interventions tended to range from 12 to 24 weeks, usually involved 1-h weekly sessions, and were sometimes continued with less frequent follow-up meetings (e.g., bi-weekly, monthly). Among the 18 studies that contained information on intervention instructors, the most common group leaders were dietitians (n = 8), physicians (n = 3), and nurses (n = 5, including nurse educators and nurse practitioners). Other health professionals included in intervention teams were psychologists, physical therapists, and pharmacists. Lay group leaders included cooking instructors, employee assistance counselors, lifestyle counselors/coaches, peer health coaches, and trained company staff. A variety of technologies were used for the purposes of providing support, sending reminders, and/or tracking progress: online support/tracking [27,42,45], pedometers [28], webinars and email reminders [32], access to websites [34,41], interactive message board [36], computer-based exercise program [38], DVDs as an educational choice over face-to-face [40], and smartphones for tracking and support [47].

Few studies included information on whether employees could attend sessions during regular work hours without losing pay or using sick/vacation time. In a number of instances, employer support for these programs was implied but authors' statements were not sufficiently direct to draw any conclusions.

3.4. Intervention effects/outcomes

The intervention outcomes that were measured varied across studies but specific patterns in biological, cardiovascular, adherence, and psychosocial outcomes were seen. With regard to biological outcomes, typical diabetes-related variables were consistently measured, such as A1C, weight/BMI, blood glucose levels, insulin levels, blood pressure, and lipids. Some studies also included cardiovascular outcomes, such as blood pressure, other vital signs, and inflammatory markers. Self-reported adherence to dietary and physical activity recommendations were frequently reported. Common, valid psychosocial measures also were employed, including measures of depression, anxiety/stress, adherence to behavioral recommendations, self-efficacy, perceived support, and quality of life.

Across the 22 studies included in this review, a distinct pattern of intervention effects is apparent. Study results demonstrated consistent health improvements in biological measures, self-reported behavioral adherence measures, and psychosocial variables. Authors reported outcome data that showed significant improvements in most instances, either in comparing baseline-to-post intervention changes in one-group studies or in comparing at least two groups at post-intervention follow-up periods. Outcomes were measured most commonly at 6 and/or 12 months, while a few authors reported more longitudinal outcomes, e.g., 2 to 4 years post intervention [28,42,45,48]. Longitudinal effects in the few studies with extended outcome measurements demonstrated sustained, although ameliorated, intervention benefits.

As indicated above, the three main biological markers/outcomes consistently measured across these studies were A1C, BMI and/or weight loss, and blood pressure. The most frequently measured biological outcome was BMI/weight loss; 15 of the 20 studies that measured this variable found statistically significant intervention effects [28,30,33–38,40,41,43–47]. Six of the 14 studies that measured blood pressure reported statistically significant improvements [33,40,42–44,46]. And 6 of the 10 studies that measured A1C reported statistically significant reductions [28,29,31,40,41,43].

3.5. Effects of moderating factors

In addition to examining the types and effects of workplace diabetes health programs that have been studied, we also were interested in exploring variability in intervention outcomes based on race/ethnicity, gender, age, socioeconomic status, and types of occupations participants held. Data on these variables were not consistently reported by the authors of the primary studies. Thus, few conclusions can be drawn regarding the influence of these potential moderating factors. Fourteen of the 22 studies reported the racial/ethnic breakdown of their participants but data analyses based on racial/ethnic backgrounds were not provided. Therefore, these findings should be interpreted cautiously. Four of the studies [29,40,45,47] evaluated gender differences; males and females differed in intervention preferences (e.g., females preferred face-to-face intervention delivery compared to DVDs), intervention attendance rates (e.g., women were more likely to attend), and effects of intervention attendance on outcomes, as well as specific outcomes that were significantly improved. Mean ages or age ranges of study participants were provided by the authors of 18 studies but analyses based on age were not provided. Further, lack of information on socioeconomic status precluded any analyses regarding the effects of this key factor on health outcomes.

3.6. Risk-of-bias assessment

In terms of the quality of the studies, that is, considering the potential risk-of-bias of the findings of these studies, it is clear that this body of research is in the early stages of development. Only 6 of the 22 of the studies (27%) were conducted as randomized controlled trials. Fifty percent of the studies (n = 11) were designed as one-group pre-test posttest studies, a design that is considered to be the weakest test of intervention effects. Five studies employed quasi-experimental designs involving comparisons made to existing control groups, either with randomization of sites rather than people or without randomization. Regardless of the design used, outcomes were consistently favorable, except for the results from one experimental randomized controlled trial [30] in which researchers found no group differences in key diabetes-related outcomes of A1C, glucose, lipids, or blood pressure. The studies involved small samples, primarily because some of the studies were conducted as pilot/feasibility studies; 64% of the studies involved less than 200 participants, 36% involved less than 100 participants. In addition, across the 22 studies, attrition rates were inconsistently documented. The research designs employed and the small sample sizes involved in this body of literature preclude generalization. Conversely, a strength of this body of work is the relative consistency in the outcome measures employed, particularly the biological measures that are commonly used in studies of diabetes treatment and prevention. The psychosocial measures that were employed in these studies were fairly consistent as well.

3.7. Use of CDC recommendations for workplace health programs

Given the wide variation in the types of interventions provided and variable nature of the workplace settings, we were unable to determine the degree to which CDC recommendations for workplace health programs were followed (Table 1). Clearly, some of the recommendations are rather vague and not operationalized. However, several recommendations—promote employee participation, tailor programs to the specific workplace, and consider incentives and rewards—are important factors with relevance for the development of any workplace health program. One study included in this review [35] involved a randomized clinical trial of specific incentives, reporting significant weight loss and improved diabetes risk scores for incentive groups compared to a control group that received the same intervention but without incentives. The CDC recommendations, at least in part, have the potential to provide guidance for future studies of workplace health interventions.

4. Discussion and conclusion

4.1. Discussion

The literature review reported here involved 22 primary studies that were designed to evaluate workplace health programs specifically targeting employees diagnosed with diabetes and/or preventing or delaying diabetes onset in individuals with prediabetes. Despite advances in technology and pharmacological treatments, obesity and subsequent diabetes rates continue to rise, not only in the U.S. but globally as well. These facts suggest that more effective, practical, and sustainable diabetes treatment and prevention strategies need to be employed.

The authors of this review have more than 60 combined years of research experience in diabetes self-management interventions and have contributed to the literature supporting the effectiveness of self-management interventions, particularly among minority groups who bear a disproportionate diabetes burden. The findings of our research, as well as the research of other investigators, have supported the importance of participants' intervention attendance as a major factor in promoting significant health improvements [50]. However, significant challenges among all populations pose barriers for people wishing to access such programs. In fact, less than 10% of persons newly diagnosed with diabetes attend a diabetes self-management program within the first year of the diagnosis [51]. For a variety of reasons—lack of time, inconvenient location, lack of personal commitment to improving health, lack of awareness of available programs—many individuals who could benefit from health guidance fail to receive these services, which have been demonstrated to be important to diabetes prevention and disease outcomes. Thus, offering such programs in the workplace where people are located is a particularly appealing strategy, because this approach circumvents many of the known barriers to accessing such programs.

In the review reported here, findings across the 22 studies were consistently favorable for persons diagnosed with diabetes as well as in employees at high risk for developing diabetes in the future. The studies were highly variable in terms of research designs; few clinical trials have been conducted and many of the studies were pilot or feasibility studies. Most of the studies evaluated short-term outcomes within 6 to 12 months post intervention. Authors of the primary studies provided inconsistent information on the degree to which there was employer support for employee attendance. Further, the interventions employed were highly variable and lacked standardization, including those that were designed to test DPP-style programs in workplace settings. Thus, although a meta-analysis of this body of literature would allow more direct comparisons of interventions, outcomes, and potential validity threats through moderator analyses, the fact that this research is in the early stages of development precluded such an approach.

The challenges to conducting studies in the workplace are significant and potentially influence the nature of the study designs used. Studies involving mixed research designs, e.g., including focus groups or community-based participatory research, may be needed to identify important cultural values that are critical to the success of any diabetes prevention program. However, the workplace setting poses research challenges such as whether randomization is employed; the specific type of employee targeted for the program, for example, whether the program will be culturally tailored for specific minority groups; recruitment strategies and difficulties since employees may be concerned about the confidentiality of their health information; characteristics of the intervention, such as whether the program will be offered for only one-hour sessions, how often, and for how long; and whether the employer allows employees to attend the program during work hours without loss of pay. Given the practical worksite considerations, the use of randomized control designs may be contraindicated. Wait-listed control groups may be the only design option but such designs preclude the conduct of more longitudinal studies. Obtaining employer support for such studies may be difficult because employers prefer to provide programs for all their employees and will not permit singling out any specific employee group. However, the findings of the literature review reported here provide optimism for the potential utility and effectiveness of workplace health programs, despite the design flaws and variability in interventions reflected in these studies.

Findings of this systematic review are consistent with the narrative review conducted by Hafez et al. [25] in which the authors synthesized the findings of studies that evaluated the DPP offered in workplace settings (n = 10), as well as other diabetes prevention intervention studies (n = 3). The Hafez review was focused primarily on weight reduction and enhancing physical activity, finding that positive outcomes were fairly consistent across studies, particularly as a result of those interventions that most closely resembled the DPP lifestyle program. The review reported here involved some of the same diabetes prevention studies as the Hafez review but also included studies that focused on persons with diabetes as well. The decision to include in this review both diabetes prevention interventions in persons with prediabetes as well as diabetes self-management interventions in persons already diagnosed with diabetes stemmed from the authors' personal knowledge of employers' preferences. Employers tend to require that investigators target broader, more inclusive groups of employee participants in workplace health programs.

While some of these studies included racially/ethnically and gender diverse samples, reflecting the diversity of many employment settings, the literature search did not locate any studies that specifically tested culturally tailored workplace interventions. Given that many employees hired for service positions come from minority backgrounds [20], evidence-based, culturally tailored workplace health interventions seem imperative. And finally, more information is needed on the culture of individual workplace settings, which may differ significantly depending on the nature of the work and the growing gender and ethnic diversity of the employee base.

The approach used and results derived from the review reported here were constrained by a number of factors, some of which have been delineated above. Our initial intent was to focus on culturally-tailored interventions designed specifically for ethnic/racial groups; however, few such studies were found in the extant literature. Further, we were unable to examine in depth the use of the CDC's recommendations for workplace health programs. The variety of outcome measures contributed another barrier to further evaluation of workplace intervention effectiveness. However, we were able to delineate gaps in the literature and make recommendations for future research and practice.

4.2. Conclusion

The literature search uncovered beginning evidence that workplace interventions hold promise for preventing diabetes and/or its complications. More rigorous, perhaps more creatively designed studies conducted in the workplace on DPP-style diabetes prevention and treatment are needed, particularly for employees at high-risk for developing diabetes (e.g., minority groups, obese employees, and/or individuals with a family history of diabetes). The growing obesity and diabetes epidemic require effective and creative solutions for preventing and treating diabetes. Offering evidence-based health programs in the workplace setting is an excellent strategy for providing greater access to programs. Previous research, such as the national DPP study as well as the studies included in this and other literature reviews, has consistently demonstrated favorable results. Such programs may prevent or delay diabetes onset in individuals at high-risk for the disease or improve diabetes self-management in individuals who have already been diagnosed. The most effective, yet practical and sustainable, approaches must be identified so that employees obtain the greatest health benefits in a cost-effective manner. Researchers must develop creative strategies in order to reach populations with the greatest need for such programs and to overcome the numerous barriers to program participation and lifestyle changes. For example, research needs to be conducted on how to incorporate family support for workplace programs, because such support has been found to be a critical factor in achieving sustainable healthier lifestyles. Additional research is also needed in the area of enhancing physical activity. How can individuals with busy work schedules integrate physical activity recommendations at the worksite?

4.3. Practice implications

The main implications derived from this review are the need for employer education regarding the benefits of employer support for their employees participating in such programs and providing accessibility and attention to motivational strategies in order for employees to take full advantage of programs that are offered. Only one study in this review addressed employer support [28], noting that the program was made available during employee work hours with no loss of pay or personal time. Any incentive(s) that will stimulate interest and attendance in the intervention will have benefits for both the employee and the employer [23].

Author contributions

Design concept of the overall literature review: SA Brown

Acquisition (sample selection and coding of the review data): SA Brown, AA García, JA Zuñiga, KA Lewis

Manuscript drafts: SA Brown, AA García, JA Zuñiga, KA Lewis

Conflicts of interest

All authors declare that they do not have any actual or potential conflicts of interest.

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