RESEARCH
Review

The Effectiveness and Cost of Lifestyle Interventions Including Nutrition Education for Diabetes Prevention: A Systematic Review and Meta-Analysis

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ABSTRACT

Background Type 2 diabetes is a significant public health concern. With the completion of the Diabetes Prevention Program, there has been a proliferation of studies attempting to translate this evidence base into practice. However, the cost, effectiveness, and cost-effectiveness of these adapted interventions is unknown.

Objective The purpose of this systematic review was to conduct a comprehensive meta-analysis to synthesize the effectiveness, cost, and cost-effectiveness of lifestyle diabetes prevention interventions and compare effects by intervention delivery agent (dietitian vs non-dietitian) and channel (in-person vs technology-delivered).

Methods English and full-text research articles published up to July 2015 were identified using the Cochrane Library, PubMed, Education Resources Information Center, CAB Direct, Science Direct, and Google Scholar. Sixty-nine studies met inclusion criteria. Most employed both dietary and physical activity intervention components (four of 69 were diet-only interventions). Changes in weight, fasting and 2-hour blood glucose concentration, and hemoglobin A1c were extracted from each article. Heterogeneity was measured by the I^2 index, and study-specific effect sizes or mean differences were pooled using a random effects model when heterogeneity was confirmed.

Results Participants receiving intervention with nutrition education experienced a reduction of 2.07 kg (95% CI 1.52 to 2.62; $P<0.001$; $I^2=90.99\%$, 95% CI 88.61% to 92.87%) in weight at 12 months with effect sizes over time ranging from small (0.17, 95% CI 0.04 to 0.30; $P=0.012$; $I^2=86.83\%$, 95% CI 80.42% to 91.14%) to medium (0.65, 95% CI 0.49 to 0.82; $P<0.001$; $I^2=98.75\%$, 95% CI 98.52% to 98.94). Effect sizes for 2-hour blood glucose and hemoglobin A1c level changes ranged from small to medium. The meta-regression analysis revealed a larger relative weight loss in dietitian-delivered interventions than in those delivered by nondietitians (full sample: −1.0 kg; US subsample: −2.4 kg), and did not find statistical evidence that the delivery channel was an important predictor of weight loss. The average cost per kilogram weight loss ranged from $34.06 over 6 months to $1,005.36 over 12 months. The cost of intervention per participant delivered by dietitians was lower than interventions delivered by non-dietitians, although few studies reported costs.

Conclusions Lifestyle interventions are effective in reducing body weight and glucose-related outcomes. Dietitian-delivered interventions, compared with those delivered by other personnel, achieved greater weight reduction. No consistent trend was identified across different delivery channels.
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TYPE 2 DIABETES (T2D) HAS INCREASED SIGNIFICANTLY worldwide.[1] Among adults aged 20 to 79 years worldwide, 8.8% were estimated to have diabetes in 2015, and the prevalence of diabetes is estimated to increase to one in 10 adults by 2040.[1] Among adults in the United States, the estimated lifetime risk of developing T2D is 40%.[2] T2D is a challenging public health problem, with serious consequences on health and health care costs.[3,4] This condition greatly reduces life expectancy and leads to numerous medical complications, such as renal disease,

diabetic neuropathy, and macrovascular disease.[5] This condition has contributed to substantial increases in total economic costs in the United States—from $174 billion in 2007 to $245 billion in 2012—and shows no signs of slowing down.[6]

Since the completion of the Diabetes Prevention Program, there has been a proliferation of studies attempting to translate lifestyle interventions into clinical and community practice in an attempt to halt this growing public health epidemic.[7-9] Lifestyle interventions, specifically intensive diet and physical activity behavioral counseling programs, are recommended for the prevention of T2D.[10] Dietitians, who are trained to deliver medical nutrition therapy, play an important role in diabetes prevention counseling.[8,9,11] However, given limited access to dietitians and possibly higher program costs relative to other types of intervention delivery agents, nutrition education is sometimes provided by other types of delivery agents such as health care professionals, community health workers, or others (eg, average salary for a community health worker is $37,490 vs the average salary for an dietitian, which is $56,300).[12,13] Although understanding the appropriate personnel to deliver diabetes prevention intervention content has significant cost implications for clinical and community organizations, the relative effectiveness and cost-effectiveness of dietitian-delivered nutrition education compared with nutrition education delivered by other agents has yet to be examined.

As reported by Sherwood and colleagues,[14] consumers desire interventions with less person-to-person contact. Technology-based programs represent an alternative approach to minimize in-person interactions. Technology-based lifestyle interventions have been broadly defined as those that utilize web-based platforms, mobile applications, telecommunication technology, telephone counseling sessions such as interactive voice response calls, or text messaging. These technologies may be used alone or in combination with in-person intervention contacts. Technology-based approaches also have the potential advantage of reducing personnel resource demands, and can overcome transportation barriers to reach geographically disparate population groups.[15] Therefore, there is a need to investigate the relative effectiveness of technology-based interventions compared with traditional in-person interventions. Having these data available could inform decision making related to organizational selection, adaptation, and implementation of diabetes prevention programs.[2,3]

Seven meta-analyses that evaluated nutrition education in diabetes prevention programs were identified. They reported nonstandardized mean differences in weight and glucose tolerance or economic evaluation ratio,[13,16-21] and four analyses focused on changes in health outcomes at 12 months.[13,16-18] Two meta-analyses reported the effectiveness of prevention programs at multiple time points.[19,21] Those that limited the review to only randomized controlled trials (RCTs) reported a reduction in 2-hour blood glucose (2-h BG).[17] Those focused on clinical care settings reported change in weight,[18] and those conducted in real-world settings reported the percentage of body weight change.[16] Meta-analyses focused on routine clinical settings examined the effectiveness of adherence to guidelines,[13] and others did not describe the study setting in their inclusion criteria. Only two meta-analyses included a summary of costs. The reported median program cost per participant was $653 (2013 dollars)[20] and it was suggested that nonmedical personnel may reduce program costs without sacrificing effectiveness.[16] Overall, these meta-analyses have demonstrated that lifestyle-based diabetes intervention programs are effective in reducing risk for developing T2D in adults.

Although the findings across these meta-analyses are promising, there still is an absence in evidence synthesis that examines the effectiveness, costs, and cost-effectiveness of diabetes prevention interventions across delivery personnel, delivery channel, setting, and populations. The paucity of these data make it difficult for typical clinical or community organizations to determine whether intervention delivery is affordable, program delivery personnel are available, or the intervention content is adaptable to fit the context.[22] The purpose of this systematic review was to conduct a comprehensive meta-analysis to synthesize the effectiveness, cost, and cost-effectiveness reported across studies testing diabetes prevention interventions. We also examined, with subgroup analyses, whether differences in these outcomes existed between interventions that were delivered by dietitians compared with non-dietitians, or whether differences existed based on technology vs in-person intervention delivery. Nondietitians included intervention delivery agents such as wellness instructors, lay leaders, community health workers, health department counselors, lifestyle coaches, health care professionals, group leaders, diabetes educators, health educators, community residents, research staff, nutrition scientists, physiotherapists, general practitioners, study physician, nurses, facilitators, and pharmacists. Subgroup analyses were performed to explore the average effect size differences in intervention effects across those subgroup dimensions including US vs non-US study locations, RCTs vs studies using a quasiexperimental design (QED), and length of study follow-up (eg, 3, 6, and 12 months, and up to 60 months).

MATERIALS AND METHODS

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines[23] and was registered with the PROSPERO International register of systematic reviews (registration no. CRD42014013817).

Eligibility Criteria

Studies that focused on diabetes prevention for high-risk adults through lifestyle interventions, used RCTs or QEDs (with and without control groups), and reported relevant clinical outcomes within 5 years (eg, body weight, fasting blood glucose [FBG], or glucose tolerance) were included. Risk criteria for T2D included overweight or obesity status (body mass index [BMI] $\geq$24 or $\geq$23 for Asian adults), prediabetes (FBG ranging from 95 to 125 mg/dL [5.27 to 6.94 mmol/L]), impaired fasting glucose (FBG measurement of 101 to 108 mg/dL [5.61 to 6.00 mmol/L] or fasting venous plasma glucose measurement of 110 to 124 mg/dL [6.11 to 6.88 mmol/L] or fasting glucose measurements of 100 to 125 mg/dL [5.55 to 6.94 mmol/L]), impaired glucose tolerance and Diabetes Risk Score reflecting increased risk for T2D (American Diabetes Association score $\geq$10, Finnish Diabetes Risk Score$\geq$9, or Australian Diabetes Risk Score $\geq$12). Only