Research Brief

Diet Quality Outcomes of a Cooperative Extension Diabetes Prevention Program

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ABSTRACT

Objective: The effectiveness of the National Diabetes Prevention Program (DPP) in improving diet quality (DQ) in community settings is largely unknown. This study aimed to evaluate the DQ changes of Extension DPP participants.

Methods: A single-group, repeated-measures design was used to evaluate an Extension-implemented DPP using the PreventT2 curriculum. Participants were overweight adults with or at high risk for prediabetes (n = 88). Weight and DQ (Healthy Eating Index–2015, Dietary Screener Questionnaire) were evaluated using mixed-effects regression.

Results: There was no change in the Healthy Eating Index–2015 total score. Predicted fiber, fruit, and vegetable intake increased (P < 0.05) but remained below recommendations.

Conclusions and Implications: Clinically meaningful DQ changes of Extension DPP participants were limited. The effect of the DPP on DQ in Extension and other implementation settings should be evaluated through randomized controlled trials. Diabetes Prevention Program curriculum revisions that include more specific dietary goals and educational tools may promote greater DQ changes in DPP participants.

Key Words: prediabetes, diet quality, National Diabetes Prevention Program, Cooperative Extension, weight management

INTRODUCTION

With approximately one-third of the US population living with prediabetes, there is a need for increased dissemination of diabetes prevention interventions.1 Although weight loss is the primary driver for risk reduction observed in lifestyle interventions like the National Diabetes Prevention Program (DPP),2 diet quality (DQ) is related to type 2 diabetes mellitus (T2DM) risk, independent of weight.3 Ley et al4 observed that with > 10% improvement in DQ, T2DM risk decreased by 16%. This association between DQ and T2DM risk was only partly (32%) explained by changes in body weight.2

The Centers for Disease Control and Prevention (CDC) DPP is a public-private partnership to address diabetes through increased screening and interventions.4 A primary component of the DPP is the lifestyle change program that addresses weight status, DQ, and physical activity. The current 1-year DPP has been heavily informed by nearly 20 years of translational research on the basis of a clinical trial shown to reduce rates of T2DM by up to 58% in individuals with prediabetes.5 Although the original clinical trial involved individual counseling with registered dietitians (RDs), goal setting, and structured exercise,6 translational research has demonstrated that similar results can be achieved in group settings, as long as intervention duration (1 year) and intensity along with a standard curriculum aimed at dietary and physical activity behavior modification is facilitated by trained lifestyle coaches.7 In the current program overseen by the CDC, participants attend at least 22 group sessions throughout the year, with weekly sessions during the first half and monthly sessions during the second half of the year. A trained lifestyle coach uses the DPP curriculum to facilitate discussion and problem-solve nutrition and physical activity-related lifestyle behaviors.

The first DPP curriculum, released in 2012, focused on specific calorie and fat gram goals similar to the clinical trial’s methodology. In 2016, an updated DPP curriculum, the PreventT2 curriculum, was released.
Notably, the PreventT2 curriculum significantly deviates from the original curriculum and clinical trial intervention protocols for dietary goal setting, including calorie reduction. Although PreventT2 incorporates the Diabetes Plate Method, the curriculum includes no specific dietary goals for participants, such as energy intake or food groups. A review of the literature since the 2016 PreventT2 release yielded no studies of changes in DQ, warranting evaluation of DQ outcomes of PreventT2.

Cooperative Extension Services (Extension) have a history of delivering health education and interventions for chronic disease prevention and management and is increasingly adopting the DPP. With its presence in every county in almost every state and an infrastructure that includes state-level specialists with content and administrative expertise in nutrition and health programming, Extension is poised as an effective platform for disseminating and implementing the DPP. Many Extension organizations are becoming DPP providers, with 31 Extension organizations listed as CDC-recognized DPP providers, but there is limited published literature on the effectiveness of this program within Extension. Furthermore, there is no published evidence on DQ outcomes of the DPP when implemented as intended in community contexts such as Extension. Thus, this study aimed to evaluate the effectiveness of the DPP in improving participant DQ when delivered as intended by Georgia Extension.

METHODS

Design

This study was part of a 12-month, multisite, hybrid type 2 effectiveness-implementation trial of the DPP in Georgia Extension. Detailed implementation evaluation and additional effectiveness outcomes are published elsewhere. This study uses a single-group, repeated-measures design to explore changes in DQ throughout the 1-year intervention. All methods and procedures were approved by the University’s Institutional Review Board of Human Subjects, and DPP participants provided written informed consent.

Setting

Lifestyle coaches administering the DPP were Family and Consumer Sciences Extension professionals in Georgia trained by the Diabetes Training and Technical Assistance Center (Emory University, Atlanta, GA) to deliver the DPP. Twelve Extension professionals delivered 13 DPPs across all 4 regions of Georgia, including 7 metropolitan and 6 nonmetropolitan counties.

Participants

According to CDC guidelines, participants were recruited for the DPP: body mass index $> 25 \text{kg/m}^2$ and a clinical prediabetes diagnosis or a score of $> 5$ on the CDC/American Diabetes Association prediabetes risk test. Adults, males and females, aged 18–75 years, were included in the study. Pregnant individuals or those with self-reported current diagnoses of T2DM, chronic kidney disease, liver disease, cancer, Alzheimer’s or other dementias, or severe physical or cognitive limitations were excluded from the analytical sample because of the unique dietary needs of those conditions.

Participants were recruited by Extension professionals in their respective counties through physician referrals, new or existing community collaborations, local employers, flyers, newspaper ads, radio announcements, social media advertisements, and in-person informational sessions. Potential participants who attended a DPP informational session or expressed interest in participating totaled 124. Of those, 119 were eligible for the DPP program, 89 were eligible for the research, and 88 were enrolled.

Intervention

The DPP was implemented according to the 2018 CDC Diabetes Prevention Recognition Program (DPRP) standards using the 2016 PreventT2 curriculum. Weekly sessions were held for the first 16 weeks, followed by 1 session every 2 weeks for approximately 2 months, with monthly sessions held after that for the last 6 months of the program. Program implementation began in person from January to March 2020 and continued through January-March 2021. At the onset of the coronavirus disease 2019 (COVID-19) pandemic, program implementation of all 13 DPPs was converted from in-person to synchronous distance learning formats following the CDC DPRP COVID-19 pandemic guidelines. Twelve groups used Zoom, and 1 group used FreeConferenceCall.com to conduct sessions. All groups remained in the distance learning format for the remainder of the program.

Main Outcome Measures

All outcome measures were assessed at baseline, midpoint (6 months), and postintervention (12 months). Baseline surveys were sent approximately 1 week before the first DPP session. Midpoint surveys were sent at month 6 of the program, and postintervention surveys were sent at the start of the final month of the DPP. Participants were given 2 weeks to complete all surveys at each time point.

Age, sex, race, ethnicity, education level, and number of sessions attended were collected according to CDC DPRP standards. Race was reduced to Black, White, and other because of the small sample size in the following categories: Asian ($n = 2$), multiracial ($n = 1$).

Weight change. Height was measured at baseline by Extension professionals with portable stadiometers (Seca model 213). Extension professionals measured weight at baseline and at each DPP session with research-grade digital scales (Seca model 876) per manufacturer guidelines. Following the onset of the COVID-19 pandemic, participants self-reported weight using a home scale. Weight change and percent weight change were calculated from baseline to 6 and 12 months, and the percentage of participants achieving 2%, 5%, and 7% weight loss was calculated to examine clinically meaningful weight change (2%) and meeting intervention goals (5% to 7%).
Body mass index was also calculated per conventional standards.22

Diet quality. Diet quality was assessed with the Healthy Eating Index—2015 (HEI—2015), calculated from at least 1 24-hour dietary recall, and the 26-item Dietary Screener Questionnaire (DSQ).23,24 Dietary recalls were collected online from participants using the Automated Self-Administered 24-hour recall (2018 version), and participants were instructed to complete 2 24-hour recalls, 1 weekday and 1 weekend day. The 26-item DSQ was used as an additional measure of DQ.23 The DSQ asks participants to report their usual intake of specific foods: fruits, vegetables, dairy/calcium, whole grains/fiber, and added sugars23 to predict their usual intake over 30 days. DSQs were administered online via Qualtrics survey software (Qualtrics).

Analysis

All statistical analyses were performed using SPSS (version 27, SPSS, 2020). The study sample includes all participants with data at baseline and who completed at least 1 session of the program. Following an intention-to-treat approach, missing data were not imputed, nor was the last value carried forward.

Descriptive statistics were used to characterize participant demographics, participation by site (county), session attendance, and primary outcomes. Regression models were used to explore changes in each outcome over time (repeated measures) and relationships of independent variables (demographics, attendance) with the primary outcomes of interest (DQ measures). Most were mixed-effects models to account for the random variation within an individual, over time, and by intervention site. For continuous, normally distributed outcomes (weight, HEI—2015 total score, most DSQ variables [except sugar-sweetened beverages]), linear mixed-effects models were used to evaluate changes over time and relationships with independent variables. Whole grains, fruits/vegetables/legumes, fruit, and sugar DSQ variables were natural log transformed to meet the distribution assumptions of the linear mixed-effects model.25 For sugar-sweetened beverages, ordinal logistic regression repeated-measures model with a cumulative logit link was used to evaluate changes over time and relationships with independent variables.

Forward selection and type III F tests were used, with the significance level for entry into and removal from the model set a priori at $P < 0.05$. Post-hoc analyses for significant independent variables included calculating estimated marginal means or proportions, $\beta$ coefficients, and pairwise comparisons using Bonferroni corrections when appropriate. For repeated measures, changes over time were included in the model first and remained even if not statistically significant, followed by demographics and attendance. All variables entered the model for forward selection purposes individually and in combination with their interaction with time. After adding additional variables, it was removed if a variable no longer met the significance threshold.

RESULTS

Participants (n = 88) were primarily middle-aged (mean age 56.4 years), White (70.5%), non-Hispanic (94.3%), females (85.2%), and college graduates (52.3%) (Table 1). Of the 88 participants that completed baseline measures, 68% (n = 60) met CDC DPRP attendance goals (>9 sessions during months 1–6, >3 sessions during months 6–12, and total attendance >9 months) and completed 6 and 12 month testing.18 However, not all participants provided complete data at each time point.

Descriptive statistics for the primary outcomes at each time point are reported in Table 2. Notably, participants lost an average of 4.90 ± 0.51 kg (median, 3.80 kg [range, −5.70 to 20.90 kg]) and 5.20% ± 5.00% of their initial body weight (median, 3.80% [range, −3.40% to 19.40%]) at 12 months. Clinically meaningful weight loss, defined as ≥2% body weight reduction,21 was achieved by 75% of participants. Furthermore, 46% of participants lost at least 5% of their initial weight, the CDC’s goal for participant weight loss following the intervention, and 31% exceeded the goal and lost at least 7% of their initial body weight.

Thirty-five participants provided complete Automated Self-Administered 24-hour recall data, and 42 participants provided complete DSQ data. Results are presented as $b$, SE, mean difference (MD; baseline minus midpoint or postintervention, as specified), estimated marginal means (EMM) or probabilities, odds ratio, and 95% confidence interval (CI).

Changes in Overall DQ (HEI—2015)

There was no change in HEI—2015 total score over time, and there were no interactions of independent variables with time. Age was a significant predictor of HEI—2015 total score, such that as age increased, HEI—2015 total increased ($b = 0.35$; SE, 0.12; $t (59.32) = −3.03; P = 0.004$). No other independent variables were significant predictors of HEI—2015 total.

Changes in Usual Food Group and Nutrient Intake

None of the individual food groups assessed by the HEI—2015 changed with time. Detailed descriptions of DSQ results are provided below.

Fiber. Mean fiber intake (g/d) at baseline was <50% of the recommended 28 g/d (Table 2).27 Predicted fiber intake significantly increased over time between baseline and midpoint ($P = 0.02$) and baseline and postintervention ($P = 0.01$), with no significant changes between midpoint and postintervention. Males had significantly higher predicted intakes than females at all time points (EMM males = 16.85 g [95% CI, 15.68−18.03], EMM females = 14.36 g [95% CI, 13.65−15.07]). College graduates had significantly higher predicted fiber intakes at the midpoint (MD = −1.66 [95% CI, −2.61 to −0.72]; $P < 0.001$) and postintervention (MD = −1.66 [95% CI, −2.52 to −0.56]; $P = 0.001$) compared with...
baseline, whereas there were no changes in fiber intake among those with high school or some college education ($P > 0.05$; Figure, A). When exploring predicted fiber intakes at different levels of attendance (5, 15, and 25 sessions), predicted fiber intake increased significantly from baseline to midpoint at the attendance of 5 ($MD = -4.76$ [95% CI, $-8.51$ to $-1.01$], $P = 0.008$) and 15 sessions ($MD = -2.60$ [95% CI: $-4.40$ to $-0.81$], $P = 0.002$), and intake increased significantly from baseline to postintervention at 25 sessions ($MD = -0.90$ [95% CI, $-1.75$ to $-0.04$]; $P = 0.04$; Figure, B).

**Table 1. Baseline Characteristics of Diabetes Prevention Program Cooperative Extension Service Participants**

<table>
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<th>Variable</th>
<th>n</th>
<th>Mean ± SD (Median [Range]) or %</th>
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<tr>
<td>Age (y)</td>
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<td>56.4 ± 13.2 (58 [18–75])</td>
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<td>94.3</td>
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<td>Weight (kg)</td>
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<td>96.7 ± 22.0 (89.6 [64.5–170.9])</td>
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<tr>
<td>Body mass index (kg/m²)</td>
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<tr>
<td>College graduate</td>
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<td>52.3</td>
</tr>
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</table>

GED indicates General Educational Development.

*aRace was reduced to Black, White, and Other because of the small sample size in the following categories: Asian (n = 2) and multiracial (n = 1).

Note: This study was part of a 12-month, multisite, hybrid type 2 effectiveness-implementation trial of the Diabetes Prevention Program in Georgia Cooperative Extension Service. Participants were overweight adults with or at high risk for prediabetes.

**Fruits and vegetables (including legumes and french fries).** The predicted intake of total fruits and vegetables, including legumes and french fries (cup equivalents/day), did not significantly change over time ($P > 0.05$). Males had significantly higher predicted intakes than females (EMM males = 2.76 cup Eq [95% CI, 2.51-3.02]; EMM females = 2.36 cup Eq [95% CI, 2.20–2.51]). College graduates had higher intakes than those with some college or technical school ($MD = -0.35$ [95% CI, $-0.61$ to $-0.10$]; $P = 0.003$).

**Fruits, vegetables, and legumes (excluding french fries).** The predicted intake of fruits, vegetables, and legumes (cup Eq/day) increased significantly over time. Again, males had significantly higher predicted intakes than females, and college graduates than those with some college or technical school ($MD = -0.156$ [95% CI, $-0.30$ to $-0.02$]; $P = 0.020$) or those with some high school or high school or GED ($MD = -0.17$ [95% CI, $-0.28$ to $-0.05$]; $P = 0.002$).

**Vegetables (including legumes and french fries).** The mean intake of total vegetables was approximately ≤ 65% of recommendations (Table 2). The predicted intake of vegetables, including legumes and french fries (cup Eq/d), did not significantly change over time in the unadjusted model; however, after controlling for sex, education, and race, time became significant. Again, males had significantly higher predicted intakes than females (EMM males = 1.84 cup Eq [95% CI, 1.67–2.02]; EMM females = 1.59 cup Eq [95% CI, 1.46–1.72]), and college graduates than those with some college or technical school ($MD = -0.16$ [95% CI, $-0.32$ to $-0.01$]; $P = 0.04$). In addition, participants in the other race category reported significant increases in vegetable intake between baseline and mid-point ($MD = -0.76$ [95% CI, $-1.28$ to $-0.24$]; $P = 0.002$) and baseline and postintervention ($MD = -0.65$ [95% CI, $-1.17$ to $-0.13$]; $P = 0.01$; Figure, C).

**Vegetables and legumes (excluding french fries).** The predicted intake of vegetables, including legumes but excluding french fries (cup Eq/d), did not significantly change over time in the unadjusted model; however, after controlling for sex, education, and race, time became significant. Males had significantly higher predicted intakes than females (EMM males = 1.71 cup Eq [95% CI, 1.52–1.91]; EMM females = 1.52 cup Eq [95% CI, 1.38–1.66]), and college graduates than those with some college or technical school ($MD = -0.18$ [95% CI, $-0.36$–$-0.03$]).
had significantly higher intakes than those with some college or technical school (MD = −0.85 [95% CI, −1.44 to −0.26]; P = 0.002) and baseline and postintervention (MD = −0.73 [95% CI, −1.32 to −0.15]; P = 0.01; Figure, D).

Fruit. The mean intake of total fruit was approximately ≤50% of recommendations (Table 2). Predicted fruit intake (cup Eq/d) did not significantly change over time. College graduates at 25 sessions (Figure, E). Similarly, predicted fruit intakes were assessed at different age levels. At 65 years old, predicted mean fruit intake was significantly greater at the midpoint (MD = −0.16 [95% CI, −0.31 to −0.01]; P = 0.027) and at postintervention (MD = −0.18 [95% CI, −0.34 to −0.03]; P = 0.018) compared with baseline (Figure, F). At 80 years old, predicted fruit intake increased significantly from baseline to postintervention (MD = −0.33 [95% CI, −0.58 to −0.08]; P = 0.005; Figure, F).
Dairy and calcium. Predicted dairy intake (cup Eq/d) and calcium intake (mg/d) did not significantly change over time, though males had higher predicted dairy and calcium intakes than females.

Whole grains and added sugars (total and from sugar-sweetened beverages). Predicted whole grain and added sugar intake did not change significantly, and no significant independent variables or interactions with time existed.

DISCUSSION

This study provides insight into the weight and DQ outcomes of the DPP when implemented in the community setting of state Extension.
Statistically significant and clinically meaningful weight loss occurred throughout the program. Although the average weight loss achieved by participants in this study (mean = 4.9 kg; 5.2% initial body weight) did not reach the level observed in the DPP clinical trial (6.5 kg; 6.9% initial body weight), average percent weight loss of participants in this study (5.2%) exceeded average weight loss reported in a recent analysis of 14,747 participants in the DPP effort (4.2%; median = 3.1%).

Percentage of participants in this study meeting the minimum 5% weight loss goal of the DPP (46.7%) also exceeded that found previously (35.5%). Notably, the evaluation by Ely et al included DPP implemented in a variety of settings, including clinical and community settings.

It was expected that, even though this study involved delivering the DPP as intended, the weight loss outcomes would be less than those of the DPP clinical trial. The lifestyle change intervention in the DPP clinical trial was delivered mostly by RDs in one-on-one settings with participants, whereas the DPP effort allows individuals who are not RDs and come from various educational and experience backgrounds to deliver the DPP in group settings. Furthermore, the revised DPP curriculum used in this study, the PreventT2 curriculum, focuses less on specific energy intake goals and more on encouraging self-monitoring and goal setting for a lifestyle change to allow for greater dissemination by a variety of individuals. In light of these changes, the weight loss outcomes of this translational study compared with the clinical trial are not surprising but are noteworthy in the context of current clinical and community DPP translational studies. The only other comparable literature at this time observed similar results in the Extension-facilitated DPP lifestyle program group at 6 months (∼5.4%; 44% achieved 5% weight loss goal). Because the intervention ceased at 6 months, it is unknown if the 1-year weight loss is similar when implemented by other Extension organizations.

Few studies of the DPP have explored the impact of the intervention on DQ. Participants in this study did not significantly increase their reported adherence to the Dietary Guidelines for Americans, as measured by the HEI–2015 total score throughout the study. Older participants had higher DQ (as measured by HEI–2015 total score), a finding consistent with previous research and national data on average HEI across the lifespan.

Although changes in several DQ outcomes as measured by the DSQ occurred in this study (fiber, fruit, and some vegetable groups), these changes were often limited to individuals with certain characteristics in the sample. For example, although predicted fiber intake increased significantly throughout the intervention, further exploration revealed that only college graduates significantly increased their predicted intake. Multiple factors could have contributed to this finding, including greater resources among the college graduate population to purchase fiber-rich foods like whole grains, vegetables, and fruits.

This finding could also be due to the curriculum potentially being more appropriate for individuals with higher levels of education. Vegetable and legume intake, including and excluding french fries, significantly increased over time, but these increases were limited to individuals in the other race category. Little can be concluded about these relationships, given the small sample size. When participants in the other race category were removed from the sample, the change in vegetable and legume intake, including and excluding french fries, was no longer significant.

Similarly, fruit intake significantly increased over time; but further exploration revealed that these significant changes were related to attendance and age. Interestingly, predicted fruit intake increased among those with lower attendance and did not change among those with higher attendance. Again, various factors could have contributed to this observation; but those with lower attendance might have overestimated their fruit intakes compared with those participants who attended more sessions and had greater exposure to food tracking and accurate portion size estimations. Older individuals (aged 65–80 years) were also the only age categories with significant fruit intake increases. As discussed above, older individuals have higher DQ on average than younger individuals. Older individuals may have been more receptive to adjusting their dietary intake, perhaps because of higher risk susceptibilities, or they had more time and/or resources to improve their dietary intake.

Importantly, fruit/vegetable/legume intake significantly increased throughout the intervention, and this increase was not limited to certain subgroups of the study sample. However, intakes at the end of the intervention were still below recommendations, and the predicted intake of whole grains, total added sugars, and added sugars from sugar-sweetened beverages did not change throughout the intervention. One would expect that predicted intake of carbohydrate sources like these would change throughout the program, as the curriculum teaches the Diabetes Plate Method with half of the plate for nonstarchy vegetables and one-quarter of the plate for grains/starches, as new research has supported the effectiveness of the Diabetes Plate Method for blood sugar control.

Neither the DPP clinical trial nor the DPP outcomes study reports DQ changes in participants. However, a recent secondary analysis was published evaluating the DQ of DPP clinical trial participants. This study used the Alternative Healthy Eating Index, which measures DQ on a 0–110 (compared with the HEI scale of 0–100). This secondary analysis found a significant increase in Alternative Healthy Eating Index scores of DPP participants, from an average score of 44.4 at baseline to 48.6 at postintervention. A few translational studies of the DPP have also explored dietary changes, focusing on vegetable and fruit intake and total fat intake, as that was a major component of the original 2012 DPP curriculum. Two studies reported significant increases in vegetable and fruit intake and significant decreases in total fat intake, whereas the others observed no significant changes in these indicators of DQ. However, none of
these used the PreventT2 curriculum, a relevant distinction in light of the different nutrition education methods and quantity of nutrition information in the PreventT2 curriculum vs the original 2012 curriculum, as discussed previously.37

The COVID-19 pandemic undoubtedly influenced participants’ nutrition and physical activity behaviors, thus, weight loss and DQ. As reported elsewhere, participants noted both positive and negative influences of the COVID-19 pandemic on participants’ health behaviors, including nutrition behaviors.42 Although it is important to remember the context of this study and take caution when interpreting and applying its outcomes to future iterations of the DPP in Extension, it is also notable that weight loss was nevertheless comparable to prepandemic DPP translational studies.

Another limitation of this study is the lack of a control group. Although advanced statistical methods were used to account for as much variability as possible, it is still possible that the outcomes observed could be due to factors outside the DPP intervention. Thus, no causal relationships can be inferred from this study; and the results should be interpreted with this limitation in mind. Finally, weight was self-reported at the midpoint and postintervention because of the pandemic and social distancing requirements. However, self-reported weights are consistent with outcome measurement methods of many community-based studies because of the resource limitations in community settings and align with methods acceptable for weight reporting in the CDC DPRP.18

IMPLICATIONS FOR RESEARCH AND PRACTICE

This study provides valuable insight into the weight and DQ outcomes of the DPP when implemented as intended in the community setting of Extension. Participants experienced significant reductions in weight and improvements in some measures of DQ. However, the lack of dietary changes observed in the present and comparable studies highlights the need for potential revisions to the DPP lifestyle change program to have meaningful effects on DQ for disease prevention.

Practitioners and nutrition educators are encouraged to consider that the 2016 PreventT2 curriculum may not lead to significant DQ changes and be prepared to support participants with additional evidence-based information, such as from MyPlate, or refer participants who desire more information to qualified professionals, such as registered dietitian nutritionists. Although the PreventT2 curriculum was revised in 2021 to incorporate additional nutrition information on processed foods and portion sizes, the new curriculum still lacks specific energy and nutrient intake goals.43 Future research is warranted to evaluate DQ changes using controlled trials and consistent measures in the postpandemic era and explore potential nutrition education enhancements to the DPP curriculum to inform future curriculum revisions and maximize weight and DQ outcomes for DPP participants.

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REFERENCES


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