



## Healthy Connecticut 2020 State Health Improvement Plan

### Chronic Disease ACTION Team Meeting AGENDA & NOTES

**Date:** Thursday, July 30, 2015

**Time:** 9:00 a.m. – 11:00 a.m.

**Location or Conference Call Number:** Connecticut Hospital Association- 110 Barnes Rd 1-888-640-7748

**Conference Call Access Code:** 6430258#

**Attendees (Please list all who participated):** Please see below

Agenda Items	Time	Discussion	ACTION Items and person responsible
1. Welcome and Introductions	5	<ul style="list-style-type: none"> <li>Members in the room and on the phone introduced themselves.</li> </ul>	•
2. Review of Agenda	1	<ul style="list-style-type: none"> <li></li> </ul>	•
3. Completion of Step 1 Identification of 2016 Action Agenda Objectives	15	<ul style="list-style-type: none"> <li>Data was presented for CD29 and CD30 from BRFSS</li> <li>The group had concerns that CD29- focused only on cigarette use for youths. There is an emerging trend for youths to use other tobacco products instead of cigarettes. Members voiced concern for the need to add another objective to address other tobacco products separately from cigarette use in youth.</li> <li>** If there is an emerging issue we want to discuss, then as a team it can be decided to expand focus on that</li> <li>An ad-hoc workgroup was formed to gather existing data specifically related to e-cigarettes and other tobacco products. This work group will make recommendations for a new objective to be shared with the ACTION team for feedback, then shared with the Advisory Council for possible inclusion.</li> </ul>	<ul style="list-style-type: none"> <li>Pat Checko and Carol Meredith will coordinate Ad-hoc meeting</li> </ul>

		<ul style="list-style-type: none"> <li>At the completion of the STEP 1 process, 12 objectives remain for consideration to be addressed by the 2016 ACTION Agenda. The goal of the group is to narrow that down further to three objectives.</li> <li></li> </ul>	
4. Discussion of Voting Process and Objective Prioritization	40	<ul style="list-style-type: none"> <li>In thinking about this first year, members were advised to identify where you can make the strongest impact - where are we most likely to take a bold step?</li> <li>Members were given three dots to vote on either three separate objectives, or to weight their vote by using more than one of their three dots on the same objectives.</li> <li>The chance was given for members to advocate to objectives of personal interest and significance</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>
5. Results of the voting	30	<ul style="list-style-type: none"> <li><b>CD16 9 votes</b></li> <li><b>CD22 8 votes</b></li> <li><b>CD27 17 votes</b></li> <li><b>CD30 13 votes</b></li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>
6. Preparation for Step 2 Work	15	<ul style="list-style-type: none"> <li>Breakout groups created to meet before the next meeting to look at strategies in the SHIP, fill out the tool in preparation for the August 20<sup>th</sup> meeting to discuss</li> <li>Only use evidence based strategies, or something that takes us towards evidence based strategies</li> <li><b>CD16 Decrease by 5% the rate of Emergency Department visits among all Connecticut residents for which among all Connecticut residents for which asthma was the primary diagnosis</b></li> <li><b>CD22 Reduce to 35% the proportion of children in third grade who have dental decay</b></li> <li><b>CD27 Reduce by 5% the prevalence of obesity in children 5-12 years of age and students in grades 9-12</b></li> </ul>	<ul style="list-style-type: none"> <li>Liz Beaudin, Nancy Jubinville, Mary Cooper, Charles Brown, Nancy Merkouriou, Delores Williams</li> <li>Mary Boudreau, Kristina Diamond</li> <li>Lynn Faria, Donna Heins, Mehul Dalal, Charles Brown, Anne Elwell</li> </ul>

		<ul style="list-style-type: none"> <li>• <b>CD30 Reduce by 25% the prevalence of smoking among students in grades 6-8 and 9-12</b></li> </ul>	<ul style="list-style-type: none"> <li>• Donna Heins, Mary Cooper, Augusta Mueller, Carol Meredith, Lynn Faria, Barbara Walsh (DPH) to consult</li> </ul>
7. Wrap up, next steps	15	<ul style="list-style-type: none"> <li>• Next Meeting Date/Time: Thursday, August 20, 2015 CHA 9:00 a.m. to 11:00 a.m.</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>

Attendance:

Attending	Name	Title	Organization
1.	Aye, Diane	Chairman, Human Investigations Com.	CT Department of Public Health
2.	Beaudin, PhD, Liz	Sr. Director, Nursing/Health/Workforce	Connecticut Hospital Association
3.	Boudreau, Mary	Executive Director	Connecticut Oral Health Initiative
4.	Brown, Charles	Director of Health	Central CT Health District
5.	Checko, DrPH, Patricia	Public Health Consultant	MATCH Coalition
6.	Cooper, MD, Mary	Vice President and Chief Quality officer	Connecticut Hospital Association
7.	Dalal, MD, Mehul	Chronic Disease Director	CT Department of Public Health
8.	Greene, Michael	Comp Cancer Control Health Program	CT Department of Public Health
9.	Heins, Donna	Education Consultant	CT Department of Education
10.	Jubenville, Nancy	Director Case Management	Hospital for Special Care
11.	Diamond, Kristina	Dir of Government Relations and Policy	Connecticut State Dental Association

12.	Elwell, Anne	Vice President for Community Relations	Qualidigm
13.	Meredith, Carol	Director of Prevention Services	Dept of Mental Health & Addiction
14.	Merkouriou, Nancy	HHC Manager, Respiratory Care Services	MidState Medical Center
15.	Faria, Lynn	Director, Community Relations	Hartford Healthcare Central Region
16.	Gill, Sandra	Project Consultant	CT Department of Public Health
17.	Williams, Delores	Executive Director	So CT Sickle Cell Disease Association
18.	Yedlin, Nancy	Vice President	Donaghue Medical Research Foundation
19.	Mueller, Augusta	Senior Community Benefits Administrator	Yale New Haven Hospital
20.	Rizvi, Fariha	Intern	Connecticut Department of Public Health

## STEP 2: Are We Employing Evidence-Based Strategies?

### Chronic Disease Prevention and Control

Objectives <span style="border: 1px solid black; padding: 2px;">Ph1</span>	Evidence-Based Sources							Other (write in source)
	<a href="#">US Preventive Services Task Force (USPSTF)</a>	<a href="#">CDC's Guide to Community Preventive Services</a>	<a href="#">CDC Community Health Improvement Navigator</a>	<a href="#">National Prevention Strategy (NPS)</a>	<a href="#">CDC Prevention Status Reports</a>	<a href="#">CDC Winnable Battles</a>	<a href="#">Healthy People 2020 (HP2020)</a>	
<b>Asthma and Chronic Respiratory Disease</b>								
<b>OBJECTIVE CD-16</b> Decrease by 5% the rate of Emergency Department visits among all Connecticut residents for which asthma was the primary diagnosis.								
<i>Advocacy and Policy</i>								
<ul style="list-style-type: none"> <li>Advocate for mandatory written asthma treatment plans for all children with asthma in schools and in licensed daycare centers.</li> </ul>								
<ul style="list-style-type: none"> <li>Advocate for legislation to prohibit smoking in cars with children.</li> </ul>								
<i>Communications, Education and Training</i>								
<ul style="list-style-type: none"> <li>Promote the use of evidence-based asthma guidelines (e.g., Easy Breathing and other programs) by primary care clinicians and dentists and other dental and medical professionals.</li> </ul>								
<ul style="list-style-type: none"> <li>Conduct a public education campaign, in partnership with local television news stations, on the effects of poor air quality days on health. (See ENV-5)</li> </ul>								

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<i>Planning &amp; Development</i>								
<ul style="list-style-type: none"> <li>Implement evidence-based, comprehensive asthma programs (patient self-management, environmental assessment, and remediation at home, at school, and in the workplace; e.g., Putting on Airm, Tools for Schools, Healthy Homes).</li> </ul>								
<ul style="list-style-type: none"> <li>Encourage pediatricians to discuss smoking cessation/prevention with parents.</li> </ul>								
<ul style="list-style-type: none"> <li>Implement evidence-based, comprehensive smoking prevention and cessation programs (e.g., counseling and Rx) in community and workplace settings, especially in urban areas.</li> </ul>								
<b>Oral Health</b>								
<b>OBJECTIVE CD-22</b> Reduce to 35% the proportion of children in third grade who have dental decay.								
<i>Advocacy and Policy</i>								
<ul style="list-style-type: none"> <li>Enhance the concept and utilization of a dental home through enrollment and utilization of HUSKY insurance coverage and the maintenance of an appropriate pool of providers accepting HUSKY</li> </ul>								

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<ul style="list-style-type: none"> <li>Maintain the fluoridation statute.</li> </ul>								
<ul style="list-style-type: none"> <li>Advocate for parity of oral health with physical and behavioral health (medical) in practice, policy, and reimbursement.</li> </ul>								
<i>Communications, Education and Training</i>								
<ul style="list-style-type: none"> <li>Enhance the acceptance and use of sealants through school-based programs; education and public awareness campaigns (include cultural and linguistic issues); and education of providers (dental and pediatric; include cultural and linguistic issues</li> </ul>								
<ul style="list-style-type: none"> <li>Expand existence of and participation in dental homes through education and public awareness on the benefits of annual dental preventive maintenance, including cultural and linguistic issues; education of providers on principles, models, and best practices including cultural and linguistic issues (see MICH-12).</li> </ul>								
<ul style="list-style-type: none"> <li>Educate public and policymakers on the safety and benefits of water fluoridation.</li> </ul>								

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<ul style="list-style-type: none"> <li>Encourage the adoption of a non-cariogenic diet through non-sweetened beverage promotions; school-based programs; education and public awareness campaigns; education of providers (sugar meds; nutritional programs (e.g., WIC).</li> </ul>								
<i>Planning and Development</i>								
<ul style="list-style-type: none"> <li>Expand availability of sealants to high-risk populations.</li> </ul>								
<ul style="list-style-type: none"> <li>Identify and address barriers to access to dental services (transportation and locations; hours of services; cultural and linguistic barriers; non-ambulatory populations/institutional home-bound; other financial).</li> </ul>								
<i>(See also Objective MICH-12.)</i>								
<b>Obesity</b>								
<b>OBJECTIVE CD-27</b> Reduce by 5% the prevalence of obesity in children 5-12 years of age and students in grades 9-12.								
<i>Advocacy and Policy</i>								
<ul style="list-style-type: none"> <li>Review and revise local/school wellness policy by local Boards of Education annually as part of the Healthy Food Certification process including food as reward and/or for celebrations.</li> </ul>								



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<ul style="list-style-type: none"> <li>• Increase healthy food options in vending machines by reducing the price of healthy choices and increasing the number of healthy choices compared to unhealthy choices.</li> </ul>								
<ul style="list-style-type: none"> <li>• Increase availability of water (drinking fountains, water coolers, or bottled water in vending machines), and promote its consumption as a way to improve nutrition and overall health.</li> </ul>								
<ul style="list-style-type: none"> <li>• Implement age-appropriate policies that support increased physical activity such as decreased screen time, physically active classrooms, lunch after recess, and walking/biking to school.</li> </ul>								
<ul style="list-style-type: none"> <li>• Advocate for universal screening for overweight and obesity in schools.</li> </ul>								
<ul style="list-style-type: none"> <li>• Advocate for appropriate reimbursement for nutritional counseling, medical follow-up, and weight loss programs.</li> </ul>								
<i>Communications, Education and Training</i>								
<ul style="list-style-type: none"> <li>• Provide training and technical assistance to teachers on the implementation of early childhood programs' nutrition standards.</li> </ul>								

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<ul style="list-style-type: none"> <li>• Provide age-appropriate health education with pre- and post-testing on topics such as heart disease and healthy living.</li> </ul>								
<ul style="list-style-type: none"> <li>• Label menu items in cafeterias for nutrition content.</li> </ul>								
<ul style="list-style-type: none"> <li>• Educate providers concerning cognitive behavioral therapy and other proven strategies to promote healthy behavioral change.</li> </ul>								
<i>Planning &amp; Development</i>								
<ul style="list-style-type: none"> <li>• Develop and adapt Electronic Medical Records and disseminate decision support tools to providers.</li> </ul>								
<i>Surveillance</i>								
<ul style="list-style-type: none"> <li>• Identify or develop surveillance system with age-appropriate data collection methodology on consumption of fruits and vegetables, decreasing consumption of sugar sweetened beverages and increasing physical activity.</li> </ul>								
<ul style="list-style-type: none"> <li>• (See also strategies under objectives CD-1, CD-2, CD-5, CD-7, C-10, CD-18 and CD-19.)</li> </ul>								

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<b>Tobacco</b>								
<b>OBJECTIVE CD-30</b> <span style="border: 1px solid black; border-radius: 50%; padding: 2px;">Ph1</span> Reduce by 25% the prevalence of smoking among students in grades 6-8 and 9-12.								
<i>Advocacy and Policy</i>								
<ul style="list-style-type: none"> <li>Advocate for insurance coverage for smoking cessation and insurance incentives for nonsmokers.</li> </ul>								
<ul style="list-style-type: none"> <li>Advocate for higher taxes on all tobacco products.</li> </ul>								
<ul style="list-style-type: none"> <li>Advocate for a greater Tobacco Trust Fund allocation for education, prevention, and cessation on tobacco use.</li> </ul>								
<ul style="list-style-type: none"> <li>Advocate for legislation to prohibit smoking in cars with children.</li> </ul>								
<i>Education and Training</i>								
<ul style="list-style-type: none"> <li>Include smoking and tobacco use in the health education curriculum for all schools, K-12.</li> </ul>								
<i>Partnership and Collaboration</i>								
<ul style="list-style-type: none"> <li>Encourage pediatricians to discuss smoking cessation/prevention with parents and teens.</li> </ul>								

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<ul style="list-style-type: none"> <li>Enlist youth as consumers to develop, test, and evaluate smoking prevention/cessation strategies, campaigns, etc.</li> </ul>								
<i>Planning &amp; Development</i>								
<ul style="list-style-type: none"> <li>Increase smoke-free environments on campuses, school grounds, recreational areas and state parks.</li> </ul>								
<ul style="list-style-type: none"> <li>Implement evidence-based, comprehensive smoking prevention and cessation programs (e.g., counseling and Rx) in community and workplace settings, especially in urban areas.</li> </ul>								

# Combined Diet and Physical Activity Promotion Programs to Prevent Type 2 Diabetes Among Persons at Increased Risk: A Systematic Review for the Community Preventive Services Task Force

Ethan M. Balk, MD, MPH; Amy Earley, BS; Gowri Raman, MD, MS; Esther A. Avendano, BA; Anastassios G. Pittas, MD, MS; and Patrick L. Remington, MD, MPH

**Background:** Trials have shown efficacy of rigorous diet and physical activity promotion programs to reduce diabetes incidence and improve glycemic measures in adults at increased risk for type 2 diabetes.

**Purpose:** To evaluate diet and physical activity promotion programs for persons at increased risk for type 2 diabetes, primarily to reduce diabetes risk and decrease body weight and glycemia.

**Data Sources:** MEDLINE, the Cochrane Central Register of Controlled Trials, CAB Abstracts, Global Health, and Ovid HealthSTAR from 1991 through 27 February 2015, with no language restriction.

**Study Selection:** 8 researchers screened articles for single-group or comparative studies of combined diet and physical activity promotion programs with at least 2 sessions over at least 3 months in participants at increased risk for type 2 diabetes.

**Data Extraction:** 7 researchers extracted data on study design; participant, intervention, and outcome descriptions; and results and assessed study quality.

**Data Synthesis:** Fifty-three studies (30 of diet and physical activity promotion programs vs. usual care, 13 of more intensive vs. less intensive programs, and 13 of single programs) evaluated

66 programs. Compared with usual care, diet and physical activity promotion programs reduced type 2 diabetes incidence (risk ratio [RR], 0.59 [95% CI, 0.51 to 0.66]) (16 studies), decreased body weight (net change, -2.2% [CI, -2.9% to -1.4%]) (24 studies) and fasting blood glucose level (net change, -0.12 mmol/L [-2.2 mg/dL] [CI, -0.20 to -0.05 mmol/L {-3.6 to -0.9 mg/dL}]) (17 studies), and improved other cardiometabolic risk factors. Evidence for clinical events was limited. More intensive programs were more effective.

**Limitations:** Wide variation in diet and physical activity promotion programs limited identification of features most relevant to effectiveness. Evidence on clinical outcomes and in children was sparse.

**Conclusion:** Combined diet and physical activity promotion programs are effective at decreasing diabetes incidence and improving cardiometabolic risk factors in persons at increased risk. More intensive programs are more effective.

**Primary Funding Source:** Centers for Disease Control and Prevention Community Preventive Services Task Force.

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[www.annals.org](http://www.annals.org)

For author affiliations, see end of text.

This article was published online first at [www.annals.org](http://www.annals.org) on 14 July 2015.

Diabetes is a large and growing medical problem, and the costs to society are high and escalating. According to the latest figures from the Centers for Disease Control and Prevention (CDC), 29.1 million persons (9.3% of the U.S. population) have diabetes, and 1.7 million new cases are diagnosed annually (1). Worldwide, an estimated 387 million adults are living with diabetes, and this number is projected to increase to 592 million by 2035 (2). Prevalence of diabetes and related costs are expected to more than double in the next 25 years (3), given that more than 86 million Americans (37% of the adult population) are at risk for the disease (1). Effective prevention strategies are, therefore, critically important to slow the diabetes tide and its associated burden.

Nearly 9 out of 10 new diabetes cases are type 2 diabetes, which has a natural history characterized by a gradual increase in glycemia. Identification of persons at increased risk can enable the implementation of interventions to decrease the risk for progression to clinical diabetes. The American Diabetes Association has defined prediabetes as a high-risk category based on a glycemic level that does not meet criteria for diabetes but is too high to be considered normal (4). Persons with prediabetes progress to type 2 diabetes at a rate of about 5% to 10% per year without intervention (5).

Three large clinical trials from the United States (6), Finland (7), and China (8) have shown that the primary components of diabetes prevention in adults are weight loss and increased physical activity. In these trials, among persons at risk for type 2 diabetes, rigorous application of combined diet and physical activity promotion programs, with the goals of weight loss and increased physical activity, reduced risk for diabetes by 50% to 60% during the active intervention period (3 to 6 years). Although attenuated, the effect of the intervention can persist in the long term (9-11). The results of these trials are well-known; however, wide-scale implementation of combined diet and physical activity promotion programs in clinical and community-based settings has only recently begun and requires further expansion (12).

**See also:**

- Related article . . . . . 1
- Editorial comment . . . . . 2
- Web-Only Supplement

Combined diet and physical activity promotion programs aim to prevent type 2 diabetes among persons who are at increased risk for the disease. These programs actively encourage persons to improve their diet and increase their physical activity by using trained providers in various settings who work with clients for at least 3 months, providing some combination of counseling, coaching, and extended support in multiple sessions (delivered in person or by other methods) related to diet and physical activity. Programs may also include many other features, including specialized counselors; a range of number and frequency of sessions; different session types; and different diet, weight-loss, or exercise goals.

The purpose of this review was to assess the effectiveness of diet and physical activity promotion programs implemented in a wide range of clinical or community settings to reduce risk for new-onset diabetes among adults and children at risk for type 2 diabetes. The Community Preventive Services Task Force (Task Force) ([www.thecommunityguide.org](http://www.thecommunityguide.org)) used this review to update its guidance on diabetes prevention and to identify gaps in the evidence to inform future research. Potential effect modifiers, such as intensity and specificity of the programs, settings, and implementers, were evaluated. Furthermore, the potential benefit of the diabetes prevention programs extending to other cardiometabolic risk factors, such as overweight, high cholesterol level, and high blood pressure, was also assessed.

## METHODS

This review was conducted in accordance with the methods of the Task Force (13, 14) and the highest standards for conducting systematic reviews (15, 16). We convened a panel of domain experts and stakeholders (Coordination Team) that, together with our Community Guide Technical Monitor and Task Force members, provided input on the protocol, feedback on the findings, conclusions, and evidence gaps.

### Data Sources

We searched MEDLINE, the Cochrane Central Register of Controlled Trials, CAB Abstracts, Global Health, and Ovid HealthSTAR from 1991 through 27 February 2015 with no language restrictions. Table 1 of the Supplement (available at [www.annals.org](http://www.annals.org)) shows the search strategy. We also screened reference lists of related systematic and narrative reviews and suggestions from the expert panel.

### Study Selection

We included randomized, controlled trials and prospective nonrandomized comparative studies with at least 30 participants per group, as well as prospective single-group intervention studies with at least 100 participants. The population of interest was adults or children at increased risk for type 2 diabetes (that is, with prediabetes) as determined by glycemic measures or diabetes risk assessment tools. We included studies of participants with the metabolic syndrome (who are at

increased risk for *both* diabetes and cardiovascular disease) and studies with participants who were chosen because they were at risk for *either* type 2 diabetes or cardiovascular disease. However, we excluded studies of participants with established type 2 diabetes or whose only risk factor was obesity or increased risk for cardiovascular disease (without explicit inclusion of participants with prediabetes). The implied or explicit intent of the diet and physical activity promotion programs had to be to prevent diabetes, and the programs had to include at least 2 contact sessions (in-person or virtual) over at least 3 months. Programs had to include both dietary and increased physical activity components and could be conducted in any outpatient setting. We allowed any type of advice to improve diet and increase physical activity (except for single-food or supplement dietary changes, such as addition of fish oil). We excluded interventions that included antidiabetic medications. The comparative studies had to include a usual care group (no active diet and physical activity promotion program) or a lower-intensity diet and physical activity promotion program (for example, one with fewer contact sessions or a more liberal diet). We required at least 6 months of follow-up for any of the following outcomes: incident diabetes, reversion to normoglycemia, body weight, glycemic measures (fasting glucose level, 2-hour glucose level after a 75-g oral glucose tolerance test, or hemoglobin A<sub>1c</sub> [HbA<sub>1c</sub>] level), all-cause death, diabetes-related clinical outcomes (such as cardiovascular events, end-stage renal disease, nephropathy, amputation, retinopathy, neuropathy, skin ulcers, or periodontitis), blood pressure (BP), and lipid levels (total, low-density lipoprotein [LDL], and high-density lipoprotein [HDL] cholesterol and triglycerides).

### Data Extraction and Quality Assessment

We screened titles and abstracts using Abstrackr (17). Eight researchers double-screened the abstracts after iterative training of all reviewers on the same batches of abstracts. Discordant decisions and queries were resolved at group meetings. Full-text articles were retrieved for all potentially relevant abstracts and re-screened by the same researchers.

Data from each study were extracted by 1 of 7 experienced methodologists and confirmed by a senior methodologist; the same methodologists assessed study quality. Data extraction was conducted in the Systematic Review Data Repository (18) and included elements for study design, including eligibility criteria, population characteristics, detailed descriptions of the diet and physical activity promotion programs and comparison interventions, outcomes, and results. We assessed the quality of each study by using 12 Community Guide quality-of-execution questions (see the footnotes of Table 2 of the Supplement, available at [www.annals.org](http://www.annals.org)) (14, 19). Per Community Guide protocol, we excluded studies with "limited quality of execution," defined as those with at least 5 major limitations.

## Data Synthesis and Analysis

All extracted data were placed into summary evidence tables (available in the supporting materials at [www.thecommunityguide.org/diabetes/combineddietandpa.html](http://www.thecommunityguide.org/diabetes/combineddietandpa.html)). Two studies that were conducted in children were not included in the meta-analyses and are reported separately. For outcomes with data from at least 3 comparative studies of diet and physical activity promotion versus usual care, we performed meta-analysis of the risk ratio (RR) or net change (20) using a profile likelihood random-effects model. For nonrandomized studies, we preferentially used results of adjusted analyses. Meta-analyses were conducted with the metaan package in Stata 13.1 (StataCorp). For the overall meta-analyses of incident diabetes and reversion to normoglycemia, we used data from the longest reported follow-up. For continuous outcomes, we used data closest to 1 year of follow-up, data restricted to less than 2 years of follow-up, and data from the longest follow-up. We evaluated differences in effect (for incident diabetes and weight only) using direct comparisons of different diet and physical activity promotion programs within studies, reported within-study subgroup analyses, and across-study metaregression (based on predetermined study setting and program features and using a random-effects model) across all programs. Incident diabetes and weight change were chosen for metaregression because of their relative importance in determining the effectiveness of diet and physical activity promotion programs. Metaregressions were conducted with the metareg package in Stata and were considered potentially significant if the *P* value was less than 0.10. For each outcome with at least 10 studies, we examined the possibility of publication bias with funnel plots and the Harbord test (for diabetes incidence) or the Egger test (for continuous outcomes) using the metabias and metafunnel packages in Stata (21).

## Role of the Funding Source

One member of the Coordination Team and our Technical Monitor are employed by the CDC; none of the Task Force members are. The Coordination Team, the Technical Monitor, and members of the Task Force participated in the formulation of the study questions and the development of the protocol but did not participate in the literature search, the determination of study eligibility criteria, or data analysis or interpretation. The Coordination Team, the Technical Monitor, and CDC personnel were given an opportunity to provide feedback on the manuscript and the decision to submit the manuscript for publication, but the research team retained final determination of the content and the decision to publish the manuscript.

## RESULTS

Appendix Figure 1 (available at [www.annals.org](http://www.annals.org)) summarizes the search yield. Of 11 317 citations (plus articles from existing systematic reviews and suggestions from domain experts), 53 studies described 66

diet and physical activity promotion programs in 104 articles (6–11, 22–119). One additional study with 6 major limitations was excluded because of limited quality of execution (120). The included studies described 26 randomized and 4 nonrandomized comparisons of diet and physical activity promotion programs versus usual care, 12 randomized and 1 nonrandomized comparisons of 2 or more diet and physical activity promotion programs (3 of which also had usual care groups), and 13 single-group evaluations of diet and physical activity promotion programs. Thirty-three studies were of good quality (0 or 1 limitation), and 20 were of fair quality (2 to 4 limitations) (Table 2 of the Supplement). The most common limitations were poor descriptions of the study populations or intervention programs, problems with data measurement or interpretation, and high dropout rates. Although half of the studies (*n* = 27) analyzed all enrolled participants, 9 had rates of dropout or loss to follow-up greater than 20%.

The characteristics of the diet and physical activity promotion programs are summarized in Table 1, and details are provided in Tables 3 to 5 of the Supplement (available at [www.annals.org](http://www.annals.org)). All but 5 programs (in 4 studies) lasted at least 6 months. Programs offered a wide range of number of contact sessions (0 [virtual contacts only] to 72; median, 15), and most included both a core period (with frequent contact sessions) and a maintenance period (with less frequent contact). Except for 7 programs that were delivered entirely over the Internet or by video, telephone, or e-mail, programs used in-person individual or group sessions (or both) on diet or exercise (or both). Sessions were led by different combinations of trained diet counselors, including dietitians or nutritionists (among others); trained exercise counselors, including physical trainers (among others); nurses; physicians or psychologists; or trained laypersons. Many programs included specific weight-loss, diet, or physical activity goals (Table 1). Some included individually tailored plans for diet and physical activity.

Table 2 summarizes the participant characteristics, with details provided in Table 6 of the Supplement (available at [www.annals.org](http://www.annals.org)). Thirty (57%) studies were restricted to participants with prediabetes, of which 21 used standard diagnostic criteria; 12 (23%) studies included only participants at increased risk for diabetes on the basis of a risk score. More than three quarters of the studies included mostly overweight or obese participants, and most study participants were female and at least middle-aged. Two studies were conducted in adolescents at increased risk for type 2 diabetes; these studies were analyzed separately. None of the studies reported any long-term harms directly related to the diet and physical activity promotion programs.

## Incident Diabetes

Sixteen studies that compared diet and physical activity promotion programs versus usual care reported new-onset diabetes (6–9, 22–33); 2 studies each compared 2 programs with usual care. All but 3 were randomized trials (9, 22, 26). Incident diabetes was re-



**Table 1.** Characteristics of Combined Diet and Physical Activity Promotion Programs

Characteristic, by Category	Value
<b>Median sessions (66 programs) (IQR; range), n</b>	
Core	10 (6-16; 0*-72)
Maintenance†	6 (1.5-12; 0*-24)
Total	15 (6.5-24.5; 0*-72)
<b>Median program duration (66 programs) (IQR; range), mo</b>	
Core	6 (5-12; 1-60)
Maintenance†	12 (7-18; 4-68)
Total	12 (10-27; 3-72)
<b>Program design (66 programs), n (%)‡</b>	
Nominally based on DPP or DPS	27 (41)
<b>Weight-loss goal (66 programs), n (%)‡</b>	
	42 (64)
<b>Diet intervention (66 programs), n (%)‡</b>	
Individual sessions	40 (61)
Group sessions	41 (62)
Individual and group sessions	24 (36)
Individually tailored diet plan	16 (24)
Diet goal	19 (29)
Diet counselor	29 (44)
<b>Physical activity intervention (67 programs), n (%)‡</b>	
Individual sessions	41 (62)
Group sessions	39 (59)
Individual and group sessions	24 (36)
Individually tailored exercise plan	23 (35)
Exercise goal	32 (48)
Exercise counselor	18 (27)
<b>Counselors (51 programs), n (%)‡</b>	
Dietitian	37 (73)
Exercise therapist	26 (51)
Nurse	15 (29)
Layperson	13 (25)
Physician	8 (16)
Diabetes educator	3 (6)
<b>Country (53 studies), n (%)</b>	
United States/Canada	22 (42)
Western Europe/Australia	22 (42)
Japan	3 (6)
Middle-income§	6 (11)
<b>Setting (41 studies), n (%)</b>	
Community	12 (29)
Health care system	25 (61)
Worksite	0 (0)
Multiple	4 (10)
<b>Location (53 studies), n (%)</b>	
Urban	25 (47)
Regional	21 (40)
Suburban	2 (4)
Rural	1 (2)
Mixed	4 (8)

DPP = Diabetes Prevention Program; DPS = Diabetes Prevention Study; IQR = interquartile interval.

\* In some programs, the contacts were by telephone, e-mail, Internet, or video only.

† 28 programs.

‡ Likely underestimated because of inadequate or unclear reporting in articles.

§ India (n = 3), Brazil (n = 1), China (n = 1), and Pakistan (n = 1).

**Table 2.** Characteristics of Study Participants

Characteristic, by Category	Value
<b>Studies meeting eligibility criteria (53 studies), n (%)</b>	
Prediabetes, IGT, or IFG	30 (57)
By ADA/WHO criteria	21 (40)
At increased risk for diabetes (by risk score)	12 (23)
Prediabetes or at increased risk for diabetes	4 (8)
Prediabetes or at increased risk for cardiovascular disease	4 (8)
Metabolic syndrome, with or without prediabetes	3 (6)
<b>Body weight (47 studies)</b>	
Median of mean BMI (IQR; range), kg/m <sup>2</sup>	31.2 (28.1-33.6; 23.8-39.7)
<b>Hypertension (4 studies)</b>	
Median participants (range), %	34.5 (30.6-50)
<b>Female sex (39 studies)</b>	
Median participants (IQR; range), %	65.3 (50.3-73.9; 13.5-90.5)
<b>Age (39 studies)*</b>	
Median of mean age (IQR; range), y	53.6 (48-57; 43.1-65.0)
<b>Median ethnicity, %†</b>	
White (13 studies) (range)	74 (18-89)
Black/African American (10 studies) (range)	18 (12-39)
Hispanic/Latino (8 studies) (range)	13 (3-38)
East Asian (5 studies)	100
Southeast Asian (6 studies)	100
Asian/Pacific Islander (4 studies)	4, 5, 15, and 17‡
Native American (4 studies)	1, 3, 6, and 100‡
<b>Median education level, %</b>	
Less than high school or equivalent (9 studies) (IQR; range)	14 (11-33; 5-64)
High school or some college (20 studies) (IQR; range)	30 (21-48; 10-69)
Bachelor's degree or equivalent (11 studies) (IQR; range)	28 (20-37; 14-52)
Graduate degree or equivalent (4 studies)	13, 15, 16, and 35‡

ADA = American Diabetes Association; BMI = body mass index; IFG = impaired fasting glucose; IGT = impaired glucose tolerance; IQR = interquartile interval; WHO = World Health Organization.

\* Excludes 2 studies in adolescents.

† Excludes studies with 0% of an ethnicity.

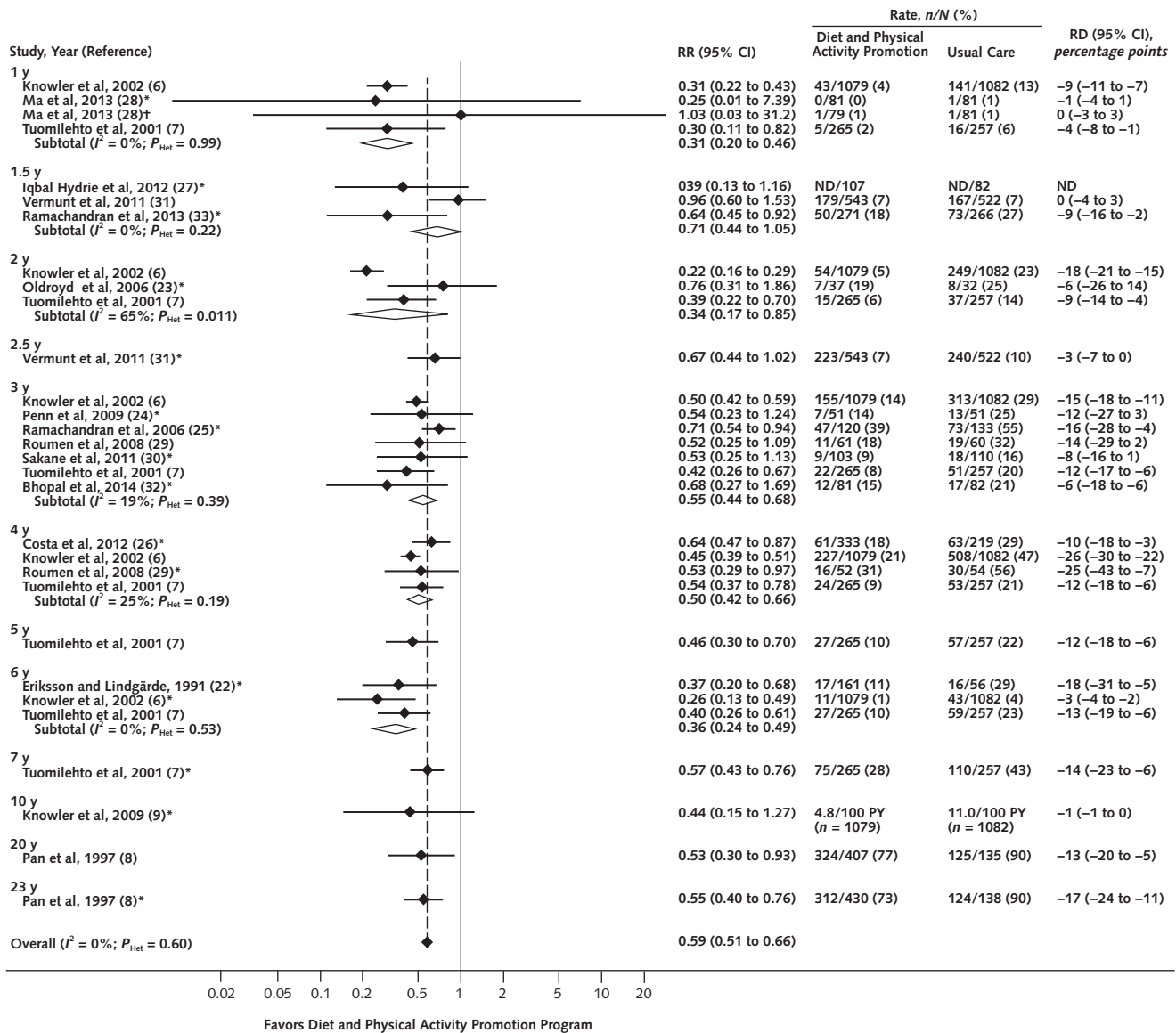
‡ Percentages among relevant studies.

ported between 1 and 23 years from the start of the programs (Figure 1). Across studies, 0% (at 1 year) to 73% (at 23 years) of program participants developed diabetes. At all time points, program participants were less likely to develop diabetes. Across all studies, the summary RR for incident diabetes was 0.59 (95% CI, 0.51 to 0.66), with no statistical heterogeneity. The median risk difference across studies was -11 percentage points (interquartile interval, -16 to -5 percentage points). Funnel plot analysis did not find different effects between larger and smaller studies (Harbord test  $P = 0.27$ ).

Both the U.S. DPP (Diabetes Prevention Program) study (6) and the Finnish DPS (Diabetes Prevention Study) (7) found statistically significantly larger effects in older participants, but although the latter found a non-



**Figure 1.** Random-effects model meta-analysis of RR of incident diabetes in at-risk participants in combined diet and physical activity promotion programs vs. usual care.



The meta-analysis of the overall RR (black diamond) used data from the longest follow-up from each study, as indicated by the asterisks. Subgroup meta-analyses by follow-up time (open diamonds) were conducted for time points with data from ≥3 studies. ND = no data; P<sub>Het</sub> = chi-square P value of heterogeneity; PY = person-year; RD = risk difference; RR = risk ratio.

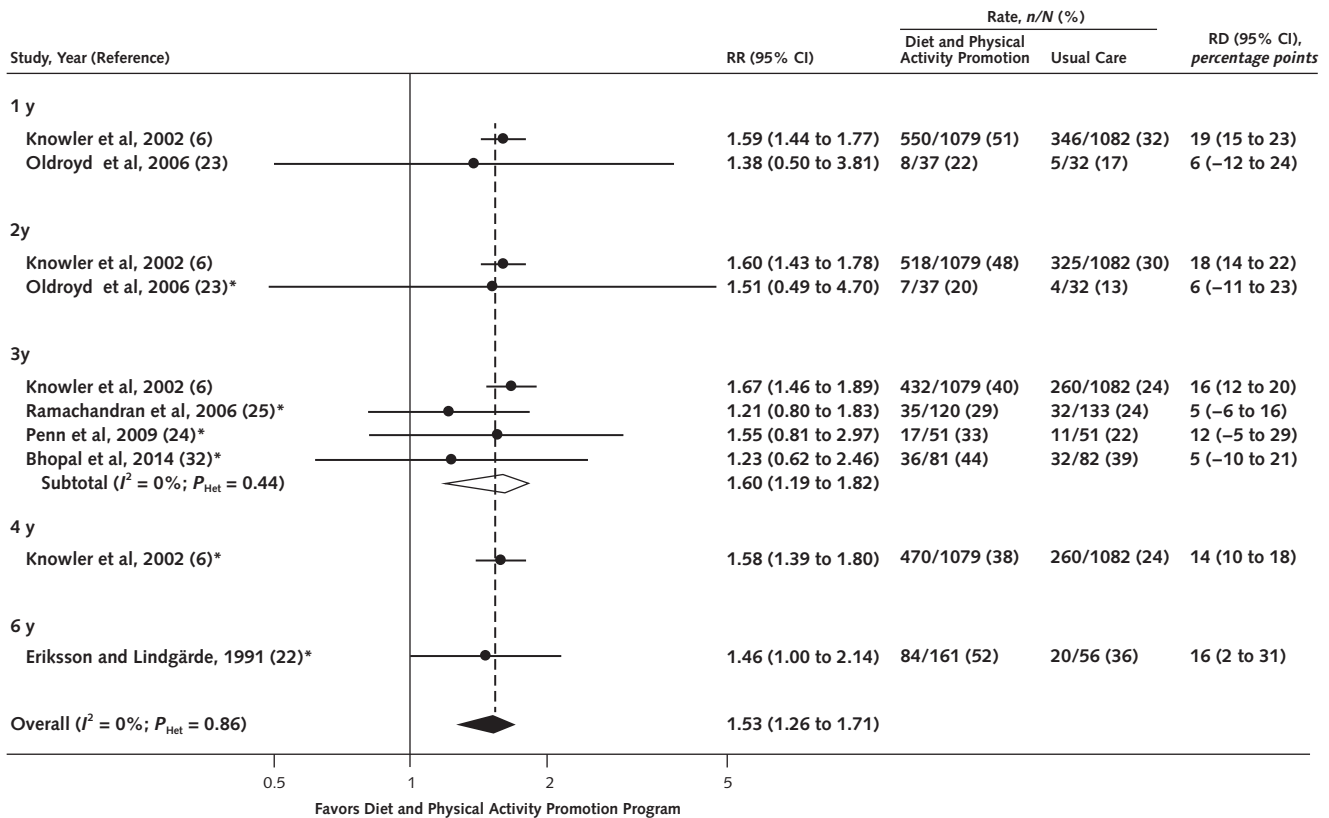
\* Included in overall meta-analysis.

† To avoid biased meta-analyses due to inclusion of correlated analyses, this comparison between the lower-intensity intervention and control was excluded.

significant effect in the youngest age group (<51 years), the former found statistically significant effects in all age groups. Neither study found differences by sex. The DPP found no difference by race or ethnicity, and the DPS found no difference by educational attainment. The JDPP (Japan Diabetes Prevention Program) study reported a significant effect of diet and physical activity promotion programs among participants with baseline HbA<sub>1c</sub> levels of at least 5.7% compared with those with lower levels, but it did not provide a statistical analysis of the difference between subgroups (34).

No significant differences across studies were found by setting; number of sessions; program duration; whether the program was based on the DPP or DPS approach; or inclusion of a weight-loss goal, individual or group diet or exercise sessions (analyzed separately), individually tailored diet plans, or diet or exercise counselors (analyzed separately). The 11 programs that included an individually tailored exercise plan (RR, 0.53 [CI, 0.45 to 0.63]) may have had a greater effect than the 5 that did not (RR, 0.67 [CI, 0.55 to 0.81]) (P = 0.070 for interaction).

**Figure 2.** Random-effects model meta-analysis of RR of reversion to normoglycemia in at-risk participants in combined diet and physical activity promotion programs vs. usual care.



The meta-analysis of the overall RR (black diamond) used data from the longest follow-up from each study, as indicated by the asterisks. Subgroup meta-analysis by follow-up time (open diamond) was conducted for the time point with data from >3 studies.  $P_{\text{Het}}$  = chi-square  $P$  value of heterogeneity; RD = risk difference; RR = risk ratio.

\* Included in overall meta-analysis.

Six studies directly compared more intensive versus less intensive diet and physical activity promotion programs (28, 45, 47, 48, 50, 56). Compared with less intensive programs, more intensive programs had more sessions (4 studies); weight-loss, diet, or exercise goals (3 studies); or a maintenance phase, more intensive diet and exercise plans, an exercise physiologist, individual contact sessions, or in-person (vs. DVD) sessions (1 study each). All 5 studies that reported at least 1 case of incident diabetes found lower incidence with a more intensive program (RR, 0.28 to 0.56), but this was statistically significant in only 1 study (50) (Appendix Figure 2, available at [www.annals.org](http://www.annals.org)).

### Reversion to Normoglycemia

Six studies (5 trials and 1 nonrandomized study) that compared diet and physical activity promotion programs versus usual care reported reversion to normoglycemia as early as 1 year from the start of the intervention (Figure 2) (6, 22-25, 32). Across studies, between 20% (at 2 years) and 52% (at 6 years) of program participants reverted to normoglycemia. At 3 years (4 studies) and across time points, the summary RRs for achievement of normoglycemia were statistically significant, with an overall summary RR of 1.53 (CI, 1.26 to

1.71) and no statistical heterogeneity. The median risk difference across studies was 12 percentage points (interquartile interval, 6 to 14 percentage points). No within-study subgroup differences were reported, and no between-study subgroup differences were found. Three studies that directly compared more intensive versus less intensive programs (45, 47, 48) found effects favoring more intensive programs (RR, 1.58 to 2.11), 2 of which were statistically significant (47, 48) (Appendix Figure 3, available at [www.annals.org](http://www.annals.org)).

### Clinical Events

Three long-term studies reported all-cause mortality, 2 of which also reported cardiovascular mortality with no consistent pattern of results. The Da Qing study reported lower risk for all-cause death (hazard ratio [HR], 0.71 [CI, 0.51 to 0.99]) with diet and physical activity promotion after 23 years (10), but this effect was restricted to women and was not significant at earlier time points (HRs, 1.33 at 6 years and 0.96 at 20 years) (8). Knowler and colleagues (DPP study) (6) found no effect at 3 years (risk difference, -0.6 per 1000 person-years), and Uusitupa and coworkers (DPS) found no effect at 10 years (HR, 0.57 [CI, 0.21 to 1.58]) (105). Similar results were found for cardiovascular death, with

significantly lower risk in the Da Qing study (HR, 0.59 [CI, 0.36 to 0.96]) at 23 years (10); this effect also was restricted to women and was not significant at earlier time points. The DPS found no significant effect on cardiovascular death at 3 years (RR, 0.50 [CI, 0.09 to 2.73]) (105). The Da Qing study reported a reduction in severe retinopathy at the 20-year follow-up (HR, 0.53 [CI, 0.29 to 0.99]) (71). Limited evidence suggested no significant effects on other clinical outcomes, including cardiovascular events (78, 95, 105), nephropathy (71), and neuropathy (71), often due to a lack of power.

### Body Weight and Glycemia

The 24 studies that compared diet and physical activity promotion programs versus usual care and reported weight change all found net weight loss with diet and physical activity promotion (6, 7, 9, 22-24, 27-33, 35-41, 52-55), ranging from  $-0.2\%$  to  $-10.5\%$  of initial body weight (summary net change,  $-2.2\%$  [CI,  $-2.9\%$  to  $-1.4\%$ ]); however, the studies had high statistical heterogeneity ( $I^2 = 89\%$ ;  $P < 0.001$ ) (Figure 3). Funnel plot analysis did not find different effects between larger and smaller studies (Egger test  $P = 0.51$ ). We used metaregression to test the same covariables examined for incident diabetes, and the only variable for which effects differed across studies was whether programs were based on the DPP or the DPS approach. The 12 programs based on either approach yielded a net change of  $-3.0\%$  (CI,  $-4.1\%$  to  $-1.9\%$ ) compared with  $-1.6\%$  (CI,  $-2.5\%$  to  $-0.6\%$ ) for the 13 other programs ( $P = 0.051$  for interaction). However, heterogeneity across studies remained high (residual  $I^2 = 95\%$ ). Across all 42 programs (not compared with usual care) (6, 7, 22, 23, 27-33, 35-51, 54-58), none of the factors explored by metaregression yielded statistically significant differences across studies. In contrast to the across-study analysis, 6 of the 10 studies that directly compared more intensive versus less intensive programs found statistically significantly greater weight loss with the more intensive programs (28, 35, 44, 45, 47-50, 56, 58) (Appendix Figure 4, available at [www.annals.org](http://www.annals.org)).

Eighteen studies that compared diet and physical activity promotion programs versus usual care reported glycemic outcomes (6-9, 23, 28-32, 35-40, 52, 53). Overall, such programs improved measures of glycemia. Across studies, at follow-up durations closest to 1 year, fasting glucose level had a summary net change of  $-0.12$  mmol/L ( $-2.2$  mg/dL) (CI,  $-0.20$  to  $-0.05$  mmol/L [ $-3.6$  to  $-0.9$  mg/dL]) (17 studies;  $I^2 = 77\%$ ), 2-hour glucose level improved by  $-0.48$  mmol/L ( $-8.6$  mg/dL) (CI,  $-0.86$  to  $-0.17$  mmol/L [ $-15.5$  to  $-3.1$  mg/dL]) (11 studies;  $I^2 = 87\%$ ), and HbA<sub>1c</sub> level improved by  $-0.08\%$  (CI,  $-0.12\%$  to  $-0.04\%$ ) (8 studies;  $I^2 = 0\%$ ) (Table 7 of the Supplement, available at [www.annals.org](http://www.annals.org)). Funnel plot analysis found no significant small-study effect for fasting glucose level (Egger test  $P = 0.54$ ), but smaller studies were more likely to have large net reductions in 2-hour glucose level ( $P = 0.003$ ). However, studies reporting significant effects on fasting glucose level were no more likely to report 2-hour glu-

cose results than those with nonsignificant effects ( $P = 0.21$ ). Across 8 studies that compared more intensive versus less intensive programs (28, 43-45, 48-50, 56) (Table 8 of the Supplement, available at [www.annals.org](http://www.annals.org)), the median net change in fasting glucose level was  $-0.11$  mmol/L ( $-2.0$  mg/dL) (range,  $-0.20$  to  $0.17$  mmol/L [ $-3.6$  to  $3.0$  mg/dL]), favoring more intensive programs; however, the difference was statistically significant in only 1 study (56). Among 4 studies (44, 45, 48, 50), the median net change in 2-hour glucose level was  $-0.37$  mmol/L ( $-6.7$  mg/dL) (range,  $-0.6$  to  $-0.2$  mmol/L [ $-11$  to  $-3.6$  mg/dL]), favoring more intensive programs; the difference was significant in 2 studies (48, 50). None of these studies reported on HbA<sub>1c</sub> level.

Across the 31 diet and physical activity promotion programs (not compared with usual care) in 24 studies that reported on fasting glucose level (6-9, 23, 28-32, 36-39, 43-46, 48-50, 52, 53, 56), results differed on the basis of whether individual diet sessions and diet counselors were included. After adjustment for follow-up duration, programs with individual diet sessions ( $n = 25$  of 31) or diet counselors ( $n = 22$  of 31) yielded larger decrements in fasting glucose level (individual sessions:  $-0.24$  vs.  $-0.02$  mmol/L [ $-4.3$  vs.  $-0.4$  mg/dL] [ $P = 0.020$ ]; counselors:  $-0.25$  vs.  $-0.07$  mmol/L [ $-4.5$  vs.  $-1.3$  mg/dL] [ $P = 0.034$ ]).

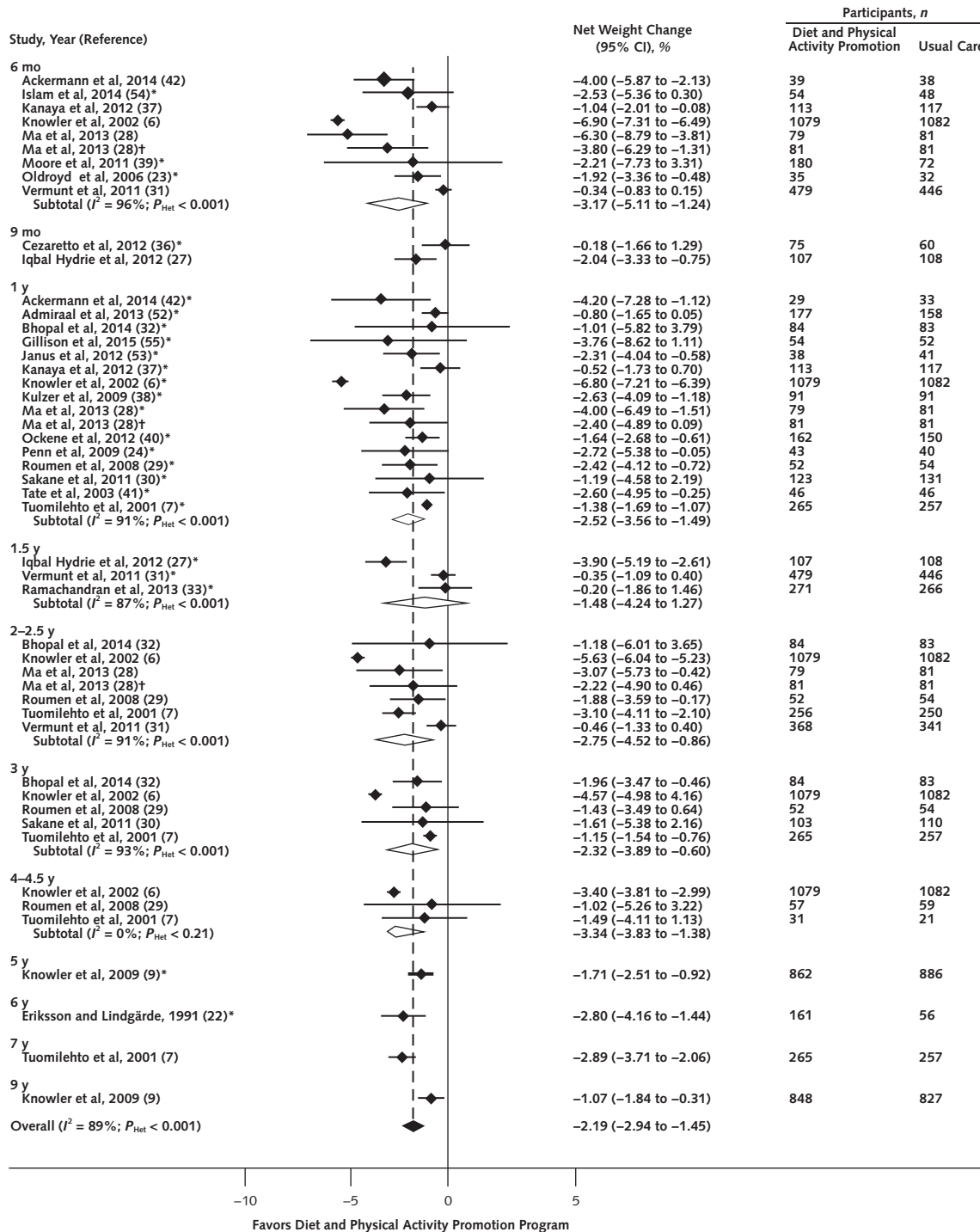
### Blood Pressure and Lipid Levels

Across 17 studies comparing diet and physical activity promotion programs versus usual care (6, 7, 9, 22, 23, 28, 29, 32, 33, 35-39, 52-54), at follow-up durations closest to 1 year, the programs improved systolic BP (net change,  $-1.6$  mm Hg [CI,  $-2.7$  to  $-0.5$  mm Hg];  $I^2 = 45\%$ ) and diastolic BP (net change,  $-1.6$  mm Hg [CI,  $-2.5$  to  $-0.8$  mm Hg];  $I^2 = 73\%$ ) (Table 9 of the Supplement, available at [www.annals.org](http://www.annals.org)). We found no evidence of small-study effects (Egger test  $P = 0.51$  for systolic BP and  $0.83$  for diastolic BP). Across 14 studies (7, 9, 22, 23, 28, 29, 33, 35-39, 52, 53), the programs also statistically significantly improved total cholesterol levels (net change,  $-0.05$  mmol/L [ $-1.8$  mg/dL] [CI,  $-0.12$  to  $-0.002$  mmol/L [ $-4.6$  to  $-0.1$  mg/dL]]) (12 studies;  $I^2 = 0\%$ ), LDL cholesterol levels (net change,  $-0.09$  mmol/L [ $-3.3$  mg/dL] [CI,  $-0.17$  to  $-0.01$  mmol/L [ $-6.4$  to  $-0.3$  mg/dL]]) (8 studies;  $I^2 = 0\%$ ), HDL cholesterol levels (net change,  $0.03$  mmol/L [ $1.2$  mg/dL] [CI,  $0.02$  to  $0.05$  mmol/L [ $0.7$  to  $1.7$  mg/dL]]) (12 studies;  $I^2 = 0\%$ ), and triglyceride levels (net change,  $-0.07$  mmol/L [ $-6.5$  mg/dL] [CI,  $-0.14$  to  $-0.02$  mmol/L [ $-12.7$  to  $-1.8$  mg/dL]]) (13 studies;  $I^2 = 38\%$ ) (Table 10 of the Supplement, available at [www.annals.org](http://www.annals.org)). No evidence of small-study effects was found (Egger test  $P = 0.17$  for total cholesterol level,  $0.75$  for HDL cholesterol level, and  $0.12$  for triglyceride level).

### Virtual Programs

Five studies evaluated programs that were conducted via Web tools, social networking, e-mail, text messaging, video, or a combination of these, with no

**Figure 3.** Random-effects model meta-analysis of net percentage of change in weight (from baseline) in at-risk participants in combined diet and physical activity promotion programs vs. usual care.



The meta-analysis of the overall net percentage of change in weight (black diamond) used data from follow-up durations closest to 1 y, as indicated by the asterisks. Subgroup meta-analyses by follow-up time (open diamonds) were conducted for time points with data from  $\geq 3$  studies.  $P_{\text{Het}}$  = chi-square  $P$  value of heterogeneity; RR = risk ratio.

\* Included in overall meta-analysis.

† To avoid biased meta-analyses due to inclusion of correlated analyses, this comparison between the lower-intensity intervention and control was excluded.



in-person sessions (28, 33, 41, 42, 88). One study (28) found smaller but still significant improvements from baseline in weight (−5% vs. −7%) and fasting glucose level (−0.15 vs. −0.23 mmol/L [−2.7 vs. −4.2 mg/dL]) with a DVD compared with an in-person program. Two studies (41, 42) found effects on weight loss similar to those in studies with in-person sessions (−3% to −5% from baseline). One study in India (33) found that an intervention relying on text messages was effective compared with usual care, with lower diabetes incidence over 2 years (18% vs. 27%; HR, 0.64 [CI, 0.45 to 0.92]) and statistically significant net differences in HDL cholesterol and triglyceride levels but not weight, BP, or total cholesterol level. However, the fifth study (88), which was done in adolescents, found no effect on weight, although this was also true for a similar program with group sessions.

### Programs in Adolescents

Two studies were conducted in adolescents. In the study by Savoye and associates (102), adolescents who participated in twice-weekly group sessions were significantly more likely to revert to normoglycemia, lose weight, and have lower fasting glucose levels and BP compared with a control group, but there was no change in lipid profile, except triglyceride levels. None developed diabetes during the 6-month follow-up. The study by Patrick and colleagues (88) evaluated 3 programs (Web, Web and text message, and Web and group session programs) and reported no difference in weight loss compared with a control group or between the more intensive and less intensive interventions after 6 and 12 months. The study did not report incident diabetes or fasting glucose outcomes.

## DISCUSSION

Across a wide spectrum of diet and physical activity promotion programs, there is strong evidence of effectiveness in reducing new-onset diabetes. Among 16 studies, participants in these programs were consistently about 40% less likely to develop diabetes, but this outcome was evaluated in a minority (30%) of studies. Such programs also increase the likelihood of reversion to normoglycemia and improve diabetes and cardiometabolic risk factors, including overweight, high blood glucose level, high BP, and abnormal lipid profile. The effectiveness of these programs in reducing cardiovascular disease, diabetes-related complications, and death is yet to be determined because few studies reported these outcomes.

During protocol development, we searched MEDLINE and the Cochrane Database of Systematic Reviews for pertinent systematic reviews; none was found that was sufficiently up-to-date and that evaluated the breadth of outcomes and range of analyses evaluated in the current review. The most comprehensive review was a health technology assessment by Gillett and coworkers (121), whose search was conducted in 2011 but also included diet or exercise interventions (not in combination); 9 randomized trials were in-

cluded. An updated search found 3 similar but more restrictive reviews published since 2013, which focused on narrower subsets of studies in adults. Schellenberg and associates (122) included 9 randomized trials of diet and physical activity promotion programs that had at least 1 other component. Dunkley and colleagues (123) included 25 studies (11 randomized trials) of programs that explicitly translated previous efficacy trials into community settings, but they also included studies of a broader population (such as obese or sedentary persons). Aguiar and coworkers (124) included only 8 studies (5 randomized trials) of diet and physical activity promotion interventions that included both aerobic and resistance training. The latter 2 reviews found effects on weight loss similar to those in our review (123, 124), and Aguiar and coworkers also found effects on fasting glucose levels similar to those in our review. In metaregression, Dunkley and colleagues found larger changes in weight with better alignment with lifestyle intervention attributes (123).

Evidence suggests that higher-intensity programs lead to greater weight loss and reduction in new-onset diabetes. Although the evaluated programs differed from each other too much to draw firm conclusions about the unique contributions of specific components, results from 12 studies that directly compared programs showed that persons who participated in more intensive programs (based on such features as number of sessions, individual sessions, and additional personnel) lost more weight and were less likely to develop diabetes. Effects on diabetes risk were similar across studies that compared programs with control groups; therefore, no differences based on differences in their programs could be ascertained. However, across all studies, programs that provided individual (vs. group) diet sessions resulted in greater reductions in fasting glucose levels, as did programs that used diet counselors (vs. no diet counselors). Programs based on the DPP study or the DPS (which were more intensive than many other programs) resulted in greater weight loss. More information on virtual delivery will be useful to increase the reach of effective programs.

On the basis of evidence from 2 of the larger studies (the U.S. DPP study and the Finnish DPS), findings seem to be applicable to wide populations (in Western countries) across race and ethnicity, socioeconomic status, risk factor status, and other demographic features. Except in 2 studies, all programs were conducted in adults; therefore, our results may not apply to children and adolescents. However, the benefit of diet and physical activity promotion programs is probably applicable to younger persons at risk for type 2 diabetes because adults and children share the mechanisms of the disease. Although most diabetes cases in children are type 1 diabetes, nearly all cases that develop from prediabetes are type 2 diabetes. Key aspects of the pathophysiology of type 2 diabetes are similar in persons of all ages; thus, the programs are likely to be effective regardless of age, assuming that they are effective at changing children's diet and physical activity. The one in-person program conducted in adolescents

had effectiveness similar to that in programs conducted in adults; however, the other study of various virtual programs in adolescents found no effect on weight.

Additional studies comparing diet and physical activity promotion programs versus usual care (no program) will probably not change the overall conclusion about the effectiveness of such programs, except those in children and adolescents and, possibly, in specific populations or settings with gaps in data. However, several areas would benefit from future research. Because the available programs were highly heterogeneous and included many features, all of which likely interacted with each other, we were unable to explain the observed heterogeneity by whether programs included specific features. Furthermore, despite often protracted descriptions of the interventions, articles often did not clearly identify who led them or what the goals were or provide other details so that the intervention could be reproduced. Future studies that compare specific program features are needed to clarify which features (for example, individual vs. group sessions, few vs. many sessions, or differently trained counselors) optimize the effectiveness of the programs and which are less critical. The most effective way to structure the maintenance phase to help program participants maintain their improvements is also unclear. In addition, with the proliferation of mobile devices and applications, the effectiveness of virtual programs needs to be investigated further. Of note, long-term follow-up of existing community-based programs is needed to evaluate the durability of the programs' effects and their effects on clinical outcomes. Although this review did not specifically address participant attrition, a better understanding of typical attrition rates is needed to understand the reasons program participants drop out and to develop methods to retain them.

In conclusion, combined diet and physical activity promotion programs are effective in reducing new-onset diabetes, increasing reversion to normoglycemia, and improving diabetes and cardiometabolic risk factors in persons at increased risk for type 2 diabetes. Programs are effective across a wide range of features, but more intensive interventions seem to be more effective. Further research is needed to discern which specific program features are most important.

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**Reproducible Research Statement:** *Study protocol:* No protocol document is available, but interested readers may contact Dr. Balk to receive copies of working documents (e-mail, [ethan\\_balk@brown.edu](mailto:ethan_balk@brown.edu)). *Statistical code and data set:* Available from Dr. Balk (e-mail, [ethan\\_balk@brown.edu](mailto:ethan_balk@brown.edu)).

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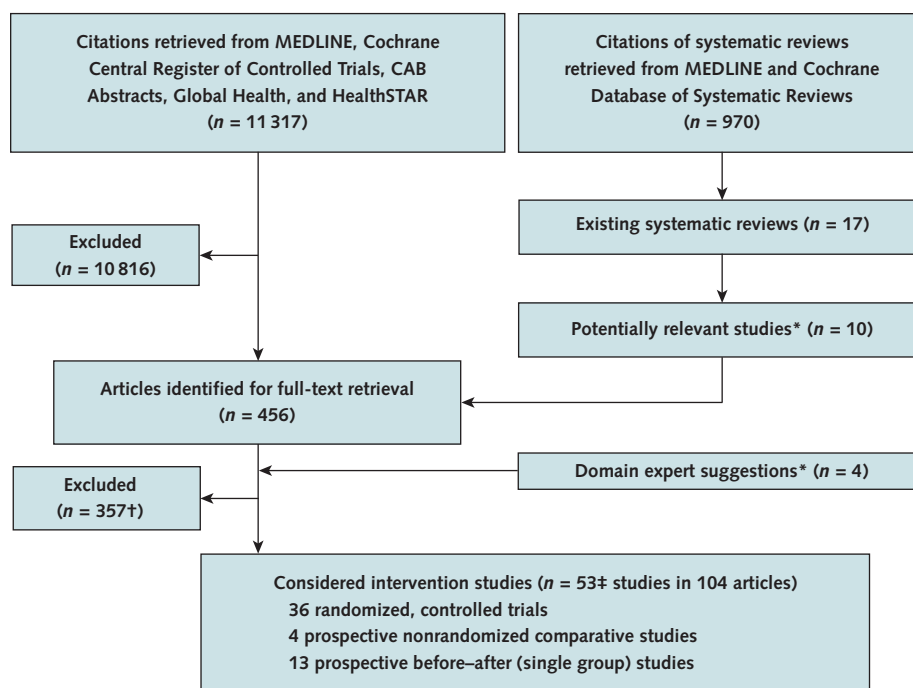
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**Appendix Figure 1.** Summary of evidence search and selection.

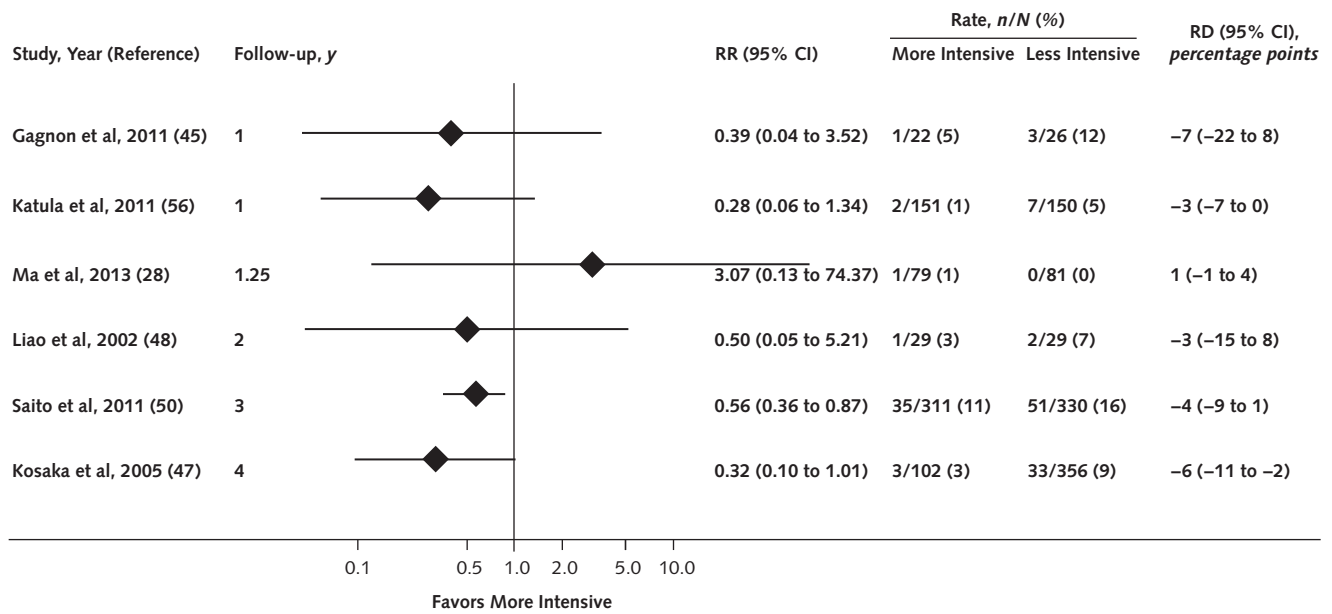


\* Not already screened.

† Not a population of interest ( $n = 70$ ), diet or physical activity alone ( $n = 47$ ), no outcome of interest reported ( $n = 36$ ), not intervention of interest ( $n = 31$ ), single-group study with  $<100$  participants ( $n = 25$ ), protocol or baseline data only ( $n = 21$ ), not a primary study ( $n = 18$ ), no additional data compared with included article ( $n = 18$ ), cost-effectiveness analysis only ( $n = 15$ ),  $<30$  participants per group ( $n = 15$ ),  $>10\%$  of participants did not meet eligibility criteria ( $n = 15$ ), intervention lasted  $<3$  mo or involved only 1 session ( $n = 13$ ),  $<6$  mo of follow-up ( $n = 13$ ), no analyses of interest ( $n = 10$ ), abstract only ( $n = 6$ ), retrospective study or retracted or unavailable article ( $n = 4$ ).

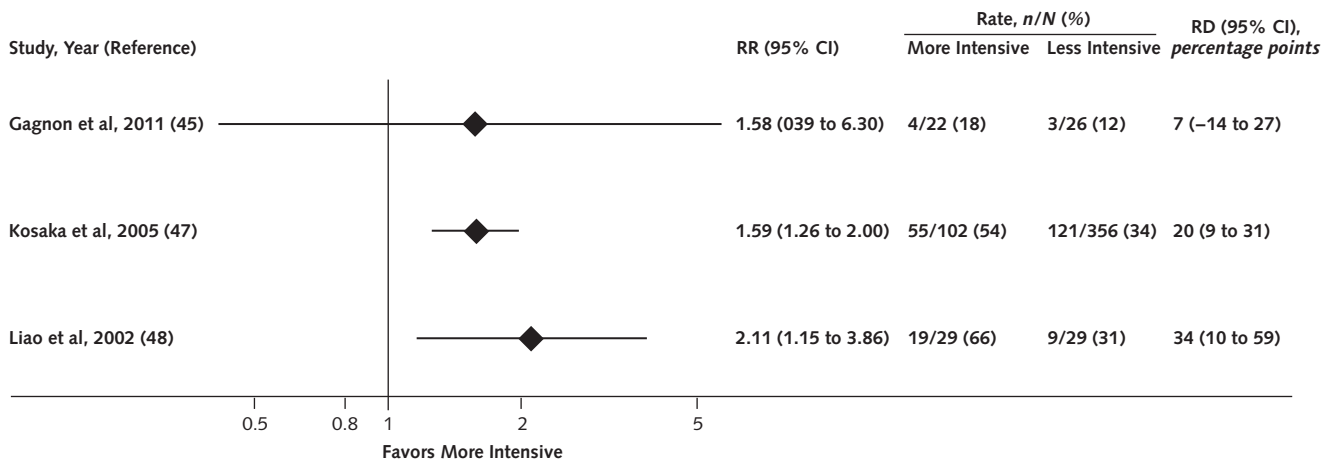
‡ Excludes 1 prospective nonrandomized comparative study not analyzed because of limited quality of execution.

**Appendix Figure 2.** Forest plot of RR of incident diabetes in at-risk participants in more intensive vs. less intensive combined diet and physical activity promotion programs.



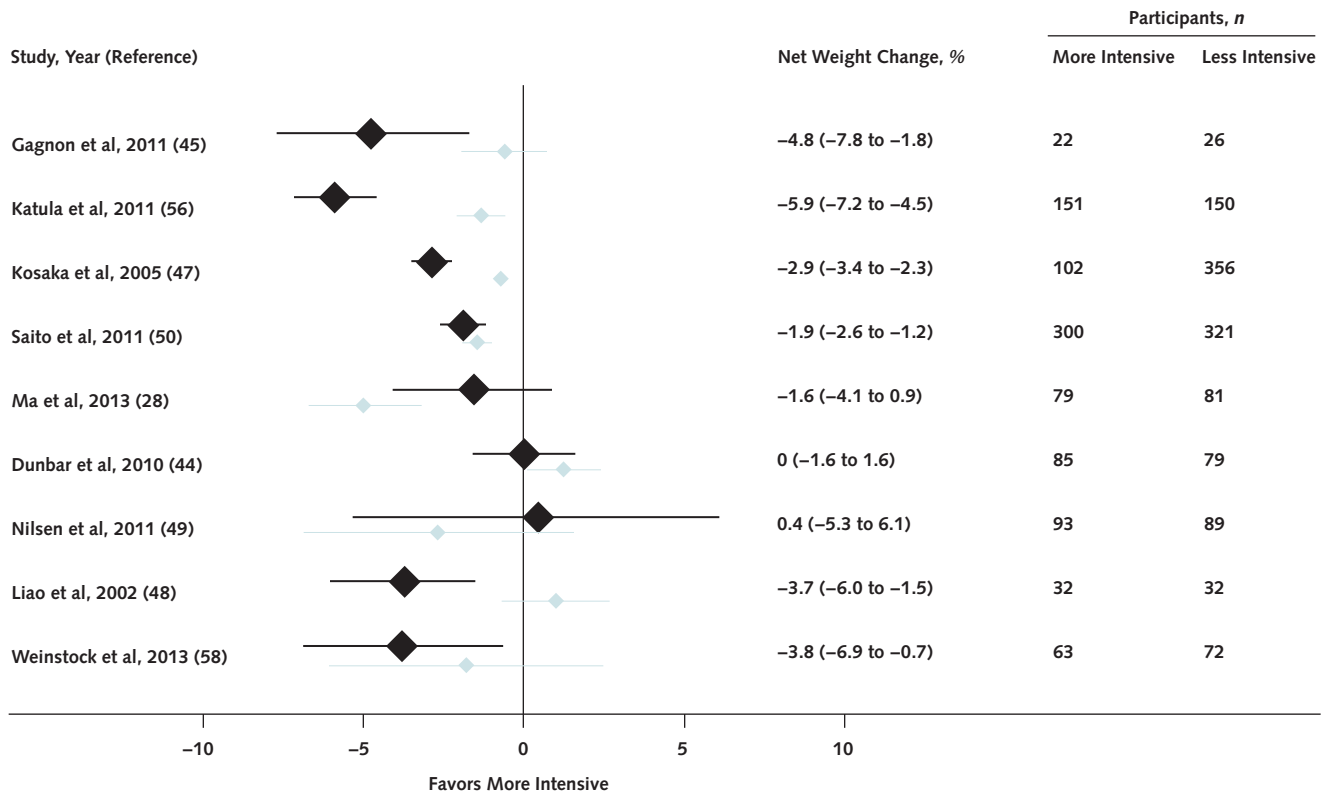
RD = risk difference; RR = risk ratio.

**Appendix Figure 3.** Forest plot of RR of reversion to normoglycemia in at-risk participants in more intensive vs. less intensive combined diet and physical activity promotion programs.



RD = risk difference; RR = risk ratio.

**Appendix Figure 4.** Forest plot of net percentage of change in weight (from baseline) in at-risk participants in more intensive vs. less intensive combined diet and physical activity promotion programs.



Green lines show percentage of weight change in less intensive groups. The study by Ackermann and colleagues (35) was not included because it reported only that there was no significant difference between the more intensive and less intensive interventions at 12 mo (overall mean weight loss, 3.3% [CI, 2.7% to 3.9%];  $P = 0.26$  between interventions).