Maximizing lifestyle changes to manage type 2 diabetes

Four dietary plans can reduce A1C levels but may differ in long-term outcomes. Intensive lifestyle interventions may even make remission possible.

Type 2 diabetes has been increasing in incidence and prevalence over the past 20 years, with worldwide prevalence estimated at 6.28%. The estimated cost of diagnosed diabetes in the United States was $327 billion in 2017; this included direct medical costs and reduced productivity. Type 2 diabetes can be prevented in most patients, given that it is a metabolic derangement caused by a complicated interaction between a patient’s genetic predisposition and lifestyle. A consensus statement by the American Academy of Clinical Endocrinologists (AACE) and American College of Endocrinology indicates that the recommended lifestyle modifications for diabetes include medical nutrition therapy with healthy eating patterns, regular physical activity, adequate sleep, behavioral support/counseling, and smoking cessation. Evidence shows that adherence to these lifestyle changes alone yields a relative reduction in type 2 diabetes mortality of 57%.

In the discussion that follows, we review the current guideline recommendations for dietary modifications and physical activity and summarize their effectiveness in the treatment of type 2 diabetes. We also describe practical clinical strategies to promote change in patient behavior, and examine current literature supporting intensive lifestyle changes that, if achieved, may induce disease remission.

Dietary strategies

Low, or very low, carbohydrate diet

Carbohydrates can affect blood glucose levels in varying degrees depending on their intrinsic properties such as fiber content, sugars, and starches. According to the American Diabetes Association’s (ADA) 2019 consensus report, the carbohydrate quality that generally should be recommended is high in fiber, vitamins, and minerals, and low in added sugars, fats, and sodium (processed carbohydrates) (TABLE 1). A low-carbohydrate diet (LCD) typically has a
carbohydrate content < 130 g/d or < 26% of a 2000 kcal/d diet. A very low–carbohydrate diet (VLCD) is 20-50 g/d or < 10% of the 2000 kcal/day diet.

In a meta-analysis by Goldenberg et al, the LCD was shown to reduce A1C by 0.47% at 6 months (95% CI, –0.6 to –0.34) and by 0.23% at 12 months when compared with control diets. A review of multiple meta-analyses also showed a significant reduction in A1C especially with VLCD patterns; however, the results waned at the 12-month follow-up. In addition, confounding factors were seen when comparing adherence between LCD and VLCD, with patients in the latter group having larger problems with adherence, which decreased the benefit seen in the overall group comparison.

Very low–carbohydrate/high-fat (ketogenic) diet
Ketogenic diets generally follow a VLCD with the carbohydrate portion set at 5% to 10% of total caloric intake (generally < 30 g/d) and the rest of the calories taken up by protein (typically 1 g/kg/d) and fat (TABLE 1). The fat content recommended is primarily polyunsaturated fat such as olive oil, while saturated fats such as butter and lard (animal fat) should be limited.

A recent meta-analysis by Choi et al showed that in overweight or obese patients with type 2 diabetes, the average A1C reduction was 0.62% (95% CI, –0.89 to –0.35) in the ketogenic intervention group. Another meta-analysis showed an even more significant A1C reduction at 1.07% (95% CI, –1.37 to –0.78). Concerns have been raised about the ketogenic diet, particularly as it relates to lipid metabolism and cholesterol levels; however, in the 2 referenced meta-analyses, the total cholesterol and triglyceride levels actually declined in the ketogenic intervention groups with minimal effect on LDL-C. This may alleviate some of the concerns of lipid management with this diet.

Plant-based diet
Popularized by Dr. T. Colin Campbell, a plant-based diet refers to a low-fat, high-fiber, whole-foods diet (whole fruits, vegetables, and naturally occurring carbohydrates, as opposed to processed foods). Examples of this type of diet include the popular vegan diet, which restricts all animal-derived products, and the vegetarian diet, which is generally limited to foods in the plant category with some addition of animal products, such as milk and cheese. Other variations of these diets exist and include other sources of protein (eg, chicken, eggs, or fish). (TABLE 1).

Adherence to lifestyle changes alone yields a relative reduction in type 2 diabetes mortality of 57%.
A review by Salas-Salvadó et al.\textsuperscript{14} showed that a vegan diet yields an average A1C reduction of 0.41% (95% CI, –0.58 to –0.23). Several meta-analyses report similar effects on A1C with vegetarian and vegan eating patterns.\textsuperscript{6,15,16} The ADA review notes that weight loss was more significant in the vegan group and concluded that this diet should be studied further while controlling for weight loss.\textsuperscript{6}

**Mediterranean diet**

The Mediterranean diet emphasizes vegetables, whole grains, fruits, lean meats, nuts, and olive oil. The benefits of the Mediterranean diet are well known and, as a result, the diet is recommended by organizations including the American Heart Association as part of a strategy to reduce cardiovascular risk (TABLE 1\textsuperscript{7-10}).

Mediterranean diet interventions have generally shown mixed effects on A1C reduction, weight management, and lipid control in type 2 diabetes.\textsuperscript{6} The PREDIMED trial is the largest and longest randomized controlled trial to date comparing the Mediterranean diet to a low-fat diet.\textsuperscript{17} This trial has reliably shown a reduced risk for type 2 diabetes and a trend to reduced A1C.\textsuperscript{17} A reduction in the need for glucose-lowering medications was demonstrated in a subgroup analysis of the intervention group (adjusted hazard ratio = 0.78; 95% CI, 0.62–0.98).\textsuperscript{18} Also, the Mediterranean diet has shown a significant reduction in the incidence of cardiovascular disease in patients with type 2 diabetes.\textsuperscript{6}

**Physical activity and exercise**

What do current guidelines recommend?  
For most adults with type 2 diabetes, current guidelines by the ADA and by the National In-

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**TABLE 1**

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<th>Diet</th>
<th>Brief description</th>
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<td>Low carbohydrate</td>
<td>This diet limits carbohydrate intake, especially simple sugars, processed foods with high levels of fructose corn syrup, and large amounts of fruit. Complex carbohydrates such as high-fiber vegetables are usually acceptable in this diet. The extent of carbohydrate restriction can vary (&lt; 30 g/d to &lt; 130 g/d). The low-carbohydrate diet is encouraged by the American Diabetes Association.</td>
<td><a href="http://www.mayoclinic.org/healthy-lifestyle/weight-loss/in-depth/low-carb-diet/art-20045831">www.mayoclinic.org/healthy-lifestyle/weight-loss/in-depth/low-carb-diet/art-20045831</a></td>
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<td>Ketogenic (low carbohydrate, high fat)</td>
<td>This plan modifies diet to induce ketosis. Simple carbohydrates are limited to approximately &lt; 30 g/d with moderate intake of protein (1 g/kg/d) and an increased amount of vegetables and fats. The fat promoted in this diet is polyunsaturated (eg, extra virgin olive oil, vegetable oils).</td>
<td><a href="http://www.mayoclinic.org/is-the-keto-diet-for-you-a-mayo-expert-weighs-in/art-20457595">www.mayoclinic.org/is-the-keto-diet-for-you-a-mayo-expert-weighs-in/art-20457595</a></td>
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<tr>
<td>Plant based (eg, vegetarian, vegan, others)</td>
<td>This diet focuses on near-exclusive consumption of vegetables and fruit, with the inclusion of whole grains. Protein can come in the form of beans and other plant sources. Consumption of meat is allowed in small quantities (in contrast to vegetarian and vegan, which restricts protein in the form of meat). Individuals who consume a vegetarian diet tend to focus exclusively on plant products with some addition of animal products such as milk and cheese. Popular variations of vegetarian diets can also include eggs, chicken, and fish—depending on the strictness of the diet. Vegans do not eat any animal-derived products.</td>
<td><a href="http://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/vegetarian-diet/art-20046446">www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/vegetarian-diet/art-20046446</a></td>
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<tr>
<td>Mediterranean</td>
<td>This diet has a larger focus on complex carbohydrates, vegetables, nuts, and unprocessed meats with higher proportions of fish and chicken. Fats are encouraged to come from vegetable oils and nuts. Intake of simple carbohydrates, such as sugar and bread, is limited. The Mediterranean diet is supported by the American Heart Association for its proven cardiovascular benefits.</td>
<td><a href="https://www.heart.org/en/healthy-living/healthy-eating/eat-smart/nutrition-basics/mediterranean-diet">https://www.heart.org/en/healthy-living/healthy-eating/eat-smart/nutrition-basics/mediterranean-diet</a></td>
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stitute of Diabetes and Digestive and Kidney Diseases recommend at least 150 minutes of moderate-to-vigorous intensity exercise every week spread out over at least 3 days, with no more than 2 consecutive days without exercise; and resistance training at least 2 other days per week which should balance all major muscle groups (TABLE 2). The benefits of exercise for type 2 diabetes have been well reviewed: positive effects on glucose control, insulin sensitivity, cardiovascular disease, lipid profiles, skeletal muscle metabolism, and solid-organ functioning.

Grace et al.24 showed in a meta-analysis that moderate aerobic exercise reduced A1C by 0.69% (95% CI, –1.09 to –0.3) at 13 weeks, and a Cochrane review showed an average A1C reduction of 0.6% with moderate-intensity exercise.25 Borror et al.26 demonstrated in a systematic review that postprandial moderate-intensity aerobic exercise starting 1 hour after meals results in a reduced 24-hour prevalence of hyperglycemia (33.5% reduction vs control). A meta-analysis in China showed an average A1C reduction of 0.68% for patients performing a Tai Chi physical activity intervention.27

**Consider high-intensity interval training** Multiple randomized controlled trials highlight the benefits of high-intensity interval training (HIIT) (TABLE 2) compared with moderate-intensity continuous training (MICT) on improving A1C. A meta-analysis showed a weighted mean difference in A1C of 0.23% (95% CI, –0.43 to –0.02%).28 Also, a patient could spend less time performing HIIT as opposed to MICT to achieve the same benefits. For example, a patient typically per-

<table>
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<th>Examples</th>
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<td>Moderate-intensity continuous training (ie, moderate-intensity exercise)</td>
<td>At least 150 minutes spread out over at least 3 days in a given week&lt;br&gt;Generally described as exercise during which one can talk but not sing&lt;br&gt;Consider a target of 60%-70% HRmax for a continuous interval</td>
<td>Walking briskly&lt;br&gt;Water aerobics&lt;br&gt;Cycling &lt; 10 mph&lt;br&gt;Ballroom dancing&lt;br&gt;Doubles tennis&lt;br&gt;Gardening</td>
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<td>High-intensity interval training</td>
<td>Intermittent intervals have rest periods generally the same length as the intense exercise intervals. For example, 1-4 minutes of high-intensity exercise and 1-4 minutes of relative rest&lt;br&gt;Individual shouldn’t be able to say more than a few words without taking a breath during a workout interval&lt;br&gt;Only need to exercise for half the total time of moderate-intensity exercise&lt;br&gt;Consider a target of 80%-90% HRmax during workout intervals and ~50% during recovery intervals</td>
<td>Running/jogging&lt;br&gt;Swimming laps&lt;br&gt;Aerobic dancing&lt;br&gt;Uphill hiking/rucking&lt;br&gt;Fast-paced sports such as basketball, singles tennis, exercise bike using all limbs, rowing</td>
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<td>Resistance training</td>
<td>Works major muscle groups on a rotating basis&lt;br&gt;Typically, 3 sets of 10-15 repetitions per set (muscle group worked) for 8-10 different exercises per session&lt;br&gt;Recommended at least 2 nonconsecutive days per week</td>
<td>Using resistance bands&lt;br&gt;Weightlifting&lt;br&gt;Using weight machines&lt;br&gt;Calisthenics with body weight (eg, pull-ups, push-ups, sit-ups)&lt;br&gt;Digging/hoeing</td>
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HRmax, maximum heart rate defined as 220 – age.
A meta-analysis showed that moderate aerobic exercise reduced A1C by 0.69% at 13 weeks.

**Interrupt sedentary behavior**
Risk for incident type 2 diabetes increases when someone is sedentary for more than 6 to 8 hours daily or watches TV for 3 to 4 hours (relative risk [RR] = 1.12). Recommendations for interrupting a sedentary lifestyle include standing from a seated position at least every 30 minutes and engaging in a light activity during the break interval for at least 3 minutes. Most studies have reliably shown that interrupting sedentary behavior reduces postprandial and 24-hour average blood glucose levels. Interrupted sitting/sedentary behavior has also been shown to reduce resting blood pressure in patients with type 2 diabetes.

**Other important lifestyle factors**

**Encourage 7 to 8 hours of sleep**
There is a U-shaped association between glycemic control and sleep quantity based on a meta-analysis by Lee et al that showed a 0.23% increase in A1C in patients with insufficient sleep (< 4.5-6 hours/night) and a 0.13% increase in patients with ≥ 8 hours of sleep per night. Patients should be encouraged to obtain 7 to 8 hours of sleep per night to help maximize their diabetes control.

**Address stress reduction**
Although evidence for stress reduction interventions on glycemic control is mixed, there does seem to be a benefit in diminishing emotional distress in patients with diabetes. A systematic review by Noordali et al demonstrated that patients who received mindfulness-based interventions had improvements in stress, anxiety, and depression symptoms which resulted in improved quality of life. These psychological benefits may subsequently lead to positive behavioral changes.

**Assist patients with smoking cessation**
A large meta-analysis showed that active smoking increases the risk of cardiovascular events in patients with type 2 diabetes (RR = 1.44; 95% CI, 1.34–1.54). Former smokers still have an increased risk (RR = 1.09; 95% CI, 1.05–1.13), but it is lower than that of current smokers, so patients should be encouraged to quit smoking.

**How can I get my patient to change?**
The AACE recommends using motivational interviewing, behavioral therapy consultation, and wearable feedback devices (eg, accelerometers/pedometers) to stimulate behavioral change in patients. Motivational interviewing is the principal counseling strategy and is supported by multiple studies showing the benefits of using this technique in a clinical encounter to induce behavioral changes. In general, offer receptive patients intensive behavioral interventions and provide them with resources to accomplish their goals. For example, a 7-step yearly intensive behavioral counseling intervention over 3 years showed significant improvements in activity of any intensity, reduced sedentary time, and led to favorable metabolic outcomes. Wearable devices result in up to a 1 hour increase in physical activity per week for the wearers vs control, although there was no appreciable effect on A1C.

One systematic review showed a 0.5% reduction in A1C (95% CI, −0.65 to −0.34) by focusing on environmental changes related to the diet, with the most effective intervention being full meal replacement for calorie control (ie, each meal was pre-made and provided to the patients based on macro-nutrient and caloric goals). Additionally, diabetes self-management education includes coping strategies, problem solving, self-advocacy, and health care system navigation, which have been shown to reduce A1C by an average of 0.6%. Patient resources are available for further assistance with lifestyle modifications (TABLE 3).

**Can your patient achieve remission?**
Emerging evidence suggests that patients may achieve remission from type 2 diabetes with intensive lifestyle interventions. This is supported by the American College of Lifestyle Medicine. Although there is no consensus definition for remission, in
general it is reasonable to presume remission if a patient achieves normo-glycemia (A1C < 5.7%) for at least 1 year without any medication therapy.\(^5\) These intensive lifestyle interventions would include a mostly plant-based diet with moderate calorie restriction, appropriate and sustained physical activity, adequate sleep, and stress-reduction techniques.\(^5\) One study found that 46% of patients in a weight-management program across multiple primary care clinics achieved remission at 12 months.\(^40\) A meta-analysis showed that a low-carbohydrate diet induced remission at 6 months in 32% of patients (although the result was not controlled for weight loss as a possible confounding factor and an A1C cutoff of 6.5% was used).\(^13\) Thus far, most studies have focused on short-term follow-up intervals, but evidence is emerging that with intensive lifestyle interventions the effects are sustained at the 2-year mark.\(^41\)

This evidence could reframe our understanding of type 2 diabetes therapy and could change the conversations we have with patients regarding their treatment. Instead of focusing on an A1C goal that is adequate for control of type 2 diabetes, we would instead focus on achieving remission.

**Patient resources for lifestyle recommendations in type 2 diabetes**

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<thead>
<tr>
<th>Organization</th>
<th>Resource description</th>
<th>Link</th>
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<tr>
<td>American Diabetes Association</td>
<td>Offers education and resources pertaining to nutrition, physical activity, mental health, and weight loss</td>
<td><a href="http://www.diabetes.org/healthy-living">www.diabetes.org/healthy-living</a></td>
</tr>
<tr>
<td>Centers for Disease Control and Prevention</td>
<td>“Living with Diabetes” page features multiple education links, including patient tools (eg, meal planning, grocery shopping tips, activity recommendations)</td>
<td><a href="http://www.cdc.gov/diabetes/managing/index.html">www.cdc.gov/diabetes/managing/index.html</a></td>
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**REFERENCES**

5. Kelly J, Karlsen M, Steinke G. Type 2 Diabetes Remission and

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