

BOX. Consensus Statements and Recommendations.

- Regular aerobic exercise training improves glycemic management in adults with type 2 diabetes, with less daily time in hyperglycemia and 0.5%–0.7% reductions in overall glycemia (as measured by A1C).
- High-intensity resistance exercise training has greater beneficial effects than low-to-moderate-intensity resistance training in terms of overall glucose management and attenuation of insulin levels.
- Greater energy expenditure postprandially reduces glucose levels regardless of exercise intensity or type, and durations ≥ 45 min provide the most consistent benefits.
- Small “doses” of PA throughout the day to break up sitting modestly attenuate postprandial glucose and insulin levels, particularly in individuals with insulin resistance and a higher body mass index.
- Weight loss (accomplished through lifestyle changes in diet and PA) of $>5\%$ seems to be necessary for beneficial effects on A1C, blood lipids, and blood pressure.
- For reductions in visceral fat in individuals with type 2 diabetes, a moderately high volume of exercise (~ 500 kcal) done 4–5 d $\cdot$ wk $^{-1}$ is needed.
- In youth with type 2 diabetes, intensive lifestyle interventions plus metformin have not been superior to metformin alone in managing glycemia.
- Despite the limited data, it is still recommended that youth and adolescents with type 2 diabetes meet the same PA goals set for youth in the general population.
- Pregnant women with and without diabetes should participate in at least 20–30 min of moderate-intensity exercise most days of the week.
- Individuals with type 2 diabetes using insulin or insulin secretagogues are advised to supplement with carbohydrate (or reduce insulin, if possible) as needed to prevent hypoglycemia during and after exercise.
- Participation in an exercise program before bariatric surgery may enhance surgical outcomes, and after surgery, participation confers additional benefits.

The writing group used a consensus approach to synthesize available evidence from clinical trials and case reports, narrative and systematic reviews, and meta-analyses, and the recommendations represent the consensus of the writing panel and ACSM and incorporate guidance from other professional organizations with expertise in this area, such as the ADA (1,2). Current science, new topics for discussion, and clinical experience in making recommendations for participation by people with T2D of all ages are highlighted. In addition, the title of the consensus statement and the text itself have been expanded to include physical activity (PA), a broader, more comprehensive definition of human movement of which structured or planned exercise is a subset.

INTRODUCTION

Currently diabetes affects over 463 million people worldwide (3), and its prevalence in the United States is 10.5% (4). T2D accounts for 90%–95% of all cases (5). The goal of treatment for T2D is to facilitate an individualized treatment plan, one that may include education, glycemic management, reduction of cardiovascular disease (CVD) risk, and ongoing screening for microvascular complications, in order to achieve and maintain optimal blood glucose, lipid, and blood pressure levels that prevent or delay chronic complications. Lifestyle interventions and/or medications are usually prescribed for treatment of T2D, and more recently, bariatric surgery has also become part of a possible treatment plan.

During any type of PA, glucose uptake into active skeletal muscles increases via insulin-independent pathways. Blood glucose levels are maintained by glucoregulatory hormone-derived increases in hepatic glucose production and mobilization of free fatty acids (6,7), which may be impaired by insulin resistance or diabetes (7). Improvements in systemic, and

possibly hepatic, insulin sensitivity after any PA can last from 2 to 72 h, with reductions in blood glucose closely associated with PA duration and intensity (8–10). In addition, regular PA enhances β -cell function (11), insulin sensitivity (12), vascular function (13,14), and gut microbiota (15), all of which may lead to better diabetes and health management as well as disease risk reduction.

IMPACT OF EXERCISE/PA ON DIABETES MANAGEMENT AND HEALTH RISKS

Multiple types of PA enhance health and glycemic management in people with T2D, although structured exercise training has been studied most frequently. Many of the proven benefits result from improved insulin sensitivity, postprandial hyperglycemia, and CVD risk.

Aerobic exercise. Short-term aerobic exercise training improves insulin sensitivity in adults with T2D, paralleling improved mitochondrial function (16). Vigorous aerobic exercise training for 7 d may improve glycemia without lowering body weight via increased insulin-stimulated glucose disposal and suppression of hepatic glucose production (12). Short-term aerobic exercise in individuals with obesity and T2D improves whole-body insulin action through gains in peripheral insulin sensitivity more so than hepatic insulin sensitivity (17). Meta-analyses and systematic reviews have confirmed that regular aerobic exercise training improves glycemia in adults with T2D, with fewer daily hyperglycemic excursions and 0.5%–0.7% reductions in hemoglobin A1C (A1C) (18–22). Regular training also improves insulin sensitivity, lipids, blood pressure, other metabolic parameters, and fitness levels, even without weight loss (23,24).

Resistance exercise. Resistance exercise training in adults with T2D typically results in 10%–15% improvements in strength, bone mineral density, blood pressure, lipid profiles, skeletal muscle mass, and insulin sensitivity (25). Combined with modest weight loss, resistance training may increase lean skeletal muscle mass and reduce A1C threefold more in older adults with T2D compared with a calorie-restricted, nonexercising group that lost skeletal muscle mass (26). A recent meta-analysis of resistance exercise suggests that high-intensity training is more beneficial than low-to-moderate-intensity training for overall glucose management and attenuation of insulin levels in adults with T2D (27).

Combined exercise. Interventions with combined aerobic and resistance exercise training may be superior to either mode alone. A greater reduction in A1C has been noted in adults with T2D undertaking a combined training program compared with either type alone (28); however, combined training group participants had a greater exercise volume. In another trial, combined training significantly improved A1C levels over nonexercising controls, although neither resistance nor aerobic training alone resulted in significant changes (29). Moreover, the combined group lost more weight and improved aerobic fitness more so than controls. A meta-analysis (21) showed that all three exercise modalities favorably impact glycemia and insulin