

Treatment of Obesity in Patients With Diabetes

Carolyn T. Bramante,¹ Clare J. Lee,² and Kimberly A. Gudzone^{1,3}

■ **IN BRIEF** More than 90% of patients with diabetes have overweight or obesity. Whereas weight gain and obesity worsen insulin resistance, weight loss slows the progression of diabetes complications. Given the elevated risk for diabetes complications in patients with obesity, clinicians must understand how to treat obesity in their patients with diabetes, including providing counseling and behavioral management, referral to weight loss programs, and medication management. This article summarizes guidelines for diagnosing and managing obesity in people with diabetes.

More than 90% of patients with type 2 diabetes have a BMI ≥ 25.0 kg/m² (1). In 2013, the American Medical Association designated obesity as a chronic disease (2), and there is growing appreciation of obesity as a complex chronic condition caused by multiple factors, including behaviors, genetics, and the environment. Adipose tissue is an endocrine organ, releasing and responding to hormones that contribute to metabolic disease, including diabetes (2). Obesity affects all organ systems, causing increased rates of cardiovascular and renal disease, certain cancers, arthritis, and sleep apnea (3–6). Given the high prevalence of concomitant disease, most clinicians will have patients with both diabetes and obesity.

Previous studies have shown that a lack of time and training limits clinicians' desire to engage patients in weight management discussions (7,8). However, research shows that clinicians can successfully provide behavioral counseling for obesity and also have important roles in referring to weight loss programs as needed, following up on patients' weight loss

goals, and providing ongoing support and encouragement (9–13). Thus, it is important for clinicians to understand obesity treatment in patients with diabetes because modest weight losses of 3–5% of initial body weight improve glucose intolerance and A1C, slow complications of diabetes, reduce the need for glucose-lowering agents, and prevent the progression of prediabetes to type 2 diabetes (3,14,15). This article will summarize guidelines for nonsurgical treatment of obesity in patients with diabetes.

Diagnosing Obesity

Obesity is traditionally diagnosed by BMI, which is an accurate approximation of adiposity for most individuals. Recent guidelines from the American Academy of Clinical Endocrinologists (AACE) and the American Heart Association/American College of Cardiology/The Obesity Society (AHA/ACC/TOS) recommend that clinicians evaluate metabolic health in addition to BMI (2,3). Patients should be screened for obesity with annual calculation of BMI after measuring both height and weight (2,3). For patients with a BMI ≥ 25 kg/m² (≥ 23 kg/m² in those

¹Division of General Internal Medicine, ²Division of Endocrinology, Diabetes, and Metabolism, and ³The Welch Center for Prevention, Epidemiology and Clinical Research, The Johns Hopkins University, Baltimore, MD

Corresponding author: Carolyn T. Bramante, cb@jhmi.edu

<https://doi.org/10.2337/ds17-0030>

©2017 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. See <http://creativecommons.org/licenses/by-nc-nd/3.0> for details.

TABLE 1. Weight-Related Complications Caused/Exacerbated by Excess Adiposity (2)

• Elevated blood pressure	• Reactive airway disease
• Hypertriglyceridemia	• Nonalcoholic fatty liver disease
• Hypercholesterolemia	• Gastroesophageal reflux disease
• Decreased HDL cholesterol	• Male hypogonadism
• Osteoarthritis	• Female infertility
• Depression	• Polycystic ovary disease
• Sleep apnea	• Stress urinary incontinence

TABLE 2. The 5 A's Model for Behavior Change and Its Use for Weight Management in Practice (22)

1. Assess	<ul style="list-style-type: none"> • Assess patients for obesity or overweight with metabolic risk factors • Assess for patients' readiness and ability to make change at this time
2. Advise	<ul style="list-style-type: none"> • Advise patients about the increased risks of cardiovascular disease with excess adiposity • Advise patients of the health benefits of weight loss and lifestyle change
3. Agree	<ul style="list-style-type: none"> • Agree with patients on a quantifiable and achievable weight loss goal that will lead to health benefits (i.e., a goal of losing 5% of initial body weight in 6 months)
4. Assist	<ul style="list-style-type: none"> • Assist patients in defining a weight management strategy (i.e., practice-based weight loss counseling vs. referral to a weight loss program)
5. Arrange	<ul style="list-style-type: none"> • Arrange follow-up to create a structure for accountability and feedback on progress

of Asian ethnicities), clinicians should assess for excess adiposity by taking into account muscularity, hydration status, edema, and sarcopenia (2). For patients with a BMI ≥ 25 kg/m² but < 35 kg/m², clinicians should assess waist circumference to further stratify patients by risk. In the United States, a waist circumference ≥ 88 cm (35 inches) in women and ≥ 102 cm (40 inches) in men indicates abdominal adiposity and increased risk for cardiometabolic disease (2). In Southeast Asian and East Asian populations, a waist circumference ≥ 80 cm (31 inches) for women and ≥ 85 cm (33 inches) for men indicate higher risk (2). Staging obesity via associated comorbid conditions and weight-related health and functional limitations has been recommended but is not yet codified in most published guidelines.

Patients who are diagnosed with overweight or obesity should also be

screened for, at minimum, the comorbidities listed in Table 1, which are associated with increased adiposity (2).

Approaching the Weight Loss Discussion

Clinicians should be sensitive when discussing the diagnosis of obesity with patients. Several studies have shown that patients with obesity are regarded with less respect than normal-weight patients (16); experiencing such biased interactions has been shown to negatively affect weight-related behaviors such as binge-eating, weight trajectory, and health outcomes (17). Approaching discussions about weight loss with the 5 A's model for behavior change has been shown to increase patients' motivation to lose weight and improve their success at weight loss (18–21). The 5 A's, described in Table 2 (22), are an important framework regardless of

whether clinicians will provide weight loss support in their practice or will be referring patients to a weight loss program.

Weight Loss Goals

Weight loss of 5–10% of baseline body weight is recommended as an initial goal of treatment, and this amount of weight loss is associated with a 0.6–1.0% reduction in A1C and numerous other health improvements (3). However, weight loss of as little as 2–5% produces a clinically meaningful reduction in fasting blood glucose (20 mg/dL) (3). The American Diabetes Association (ADA) recommends that patients with prediabetes lose 7% of baseline body weight to avoid developing diabetes (23).

In adult patients with type 2 diabetes, cohort studies have shown that individuals who lost 9–13 kg had a 25% reduction in all-cause mortality compared to weight-neutral patients (3). In the Look AHEAD (Action for Health in Diabetes) trial, adults with type 2 diabetes and overweight/obesity who were randomized to an intensive lifestyle intervention for weight loss had a 6.0% weight loss at 9 years compared to a 3.5% weight loss in the control group. Although the intervention group did not achieve a significant reduction in cardiovascular events compared to the control group, numerous other health improvements occurred, including reduced sleep apnea, lower A1C, reduced need for diabetes medications, improved mobility and quality of life, fewer hospitalizations, and reduced health care costs (24,25). Moreover, a secondary analysis of participants who lost and sustained $\geq 10\%$ of their body weight, which included $> 25\%$ of intervention subjects, did show significant improvements in cardiovascular morbidity and mortality (26–29). A sustained 7% weight loss improves many other outcomes in patients with diabetes and overweight/obesity, including fitness, waist cir-

TABLE 3. Common Commercial Weight Loss Programs' Weight Loss and Glycemic Outcomes In RCTs

	Time Point	Mean Weight Loss at Time Point (kg)	RCTs Conducted in Patients With Diabetes?	A1C Change at Time Point (%)	Patients Who Reduced Diabetes Medications at Time Point (%)
Weight Watchers	12 Months	-3.0 to -9.1	No	—	—
Jenny Craig	12 Months	-6.6 to -10.1	Yes	-0.3 to -0.7	30-39 (oral); 63-90 (insulin)
Nutrisystem	6 Months	-7.3 to -10.8	Yes	-0.7	28 (all medications)

cumference, blood pressure, sexual functioning, and reported peripheral neuropathy symptoms (15,26,27,30).

Clinician-Managed Weight Loss Support Versus Referral to a Weight Loss Program

When patients are ready to discuss weight loss strategies, clinicians should determine whether they are able to provide intensive counseling and follow-up for weight loss in their clinical practice or whether they should instead refer patients to an outside weight loss program. The 2016 ADA guidelines and the 2013 AHA/ACC/TOS guidelines recommend that clinicians refer patients with obesity and type 2 diabetes to high-intensity programs (3,23,31). Per these guidelines, high-intensity programs involve at least 14–16 visits over 6 months. In-person programs result in more weight loss than electronically delivered interventions, but both produce more weight loss than no program (3). Whether clinicians provide intensive support for weight loss or refer patients to a high-intensity program, they should see patients at least every 3 months to monitor their blood glucose control because patients may require decreased doses of glucose-lowering medications as they lose weight (23).

Clinicians can consider managing weight loss in their patients if they are able to provide the high frequency of visits, as well as the necessary behavioral and nutritional support. Individualized weight loss support is also contingent on

clinicians having enough time to take in-depth histories of patients' daily routines and eating behaviors (22). The AACE/ACE guidelines recommend that a weight loss intervention involve behavioral therapy focusing on goal-setting, education, self-monitoring, problem-solving strategies, stimulus control, behavioral contracting, stress reduction, psychological evaluation (with treatment if indicated), cognitive restructuring, motivational interviewing, and mobilization of social support structures (2,32). Medicare covers obesity screening and intensive counseling in the primary care setting, which may encourage clinicians to provide these services (33,34).

Given the intensity of follow-up required, many clinicians may prefer to refer patients to evidence-based weight loss programs in their community. However, these clinicians need to be aware that guideline-adherent community weight loss programs may be difficult to find (35). Popular commercial weight loss programs are available in many communities, and guidelines suggest that referral to an evidence-based commercial weight loss program that has documented efficacy via rigorous scientific studies is an acceptable strategy (3).

Table 3 summarizes outcomes with Weight Watchers, Jenny Craig, and Nutrisystem, which typically comprise the majority market share in the commercial weight loss industry (31,36–41). Both Weight Watchers and Jenny Craig have had randomized, controlled trials (RCTs)

documenting their long-term weight loss efficacy, and Jenny Craig has demonstrated long-term glycemic benefits among patients with diabetes (3,42–44).

Another community referral option is the Centers for Disease Control and Prevention (CDC) National Diabetes Prevention Program (DPP), which is based on the Diabetes Prevention Program RCT, in which an intensive behavioral program delayed the development of type 2 diabetes and showed a 58% reduced progression to diabetes compared to a control group (45,46). Patients with prediabetes can be referred to a clinical center or YMCA that has a certified National DPP program. Beginning in January 2018, National DPP interventions will be covered by Medicare, which is a significant benefit for Medicare patients with prediabetes (47).

Behavioral Components of Weight Loss and Weight Loss Maintenance

The goal of weight-related behavioral changes and programs should be to achieve a caloric deficit of 500–750 kcal/day (3,23). Dietary approaches that selectively restrict fat or carbohydrates or selectively increase protein or fiber are equally effective in producing weight loss if they meet the targeted reduction in calories (Table 4) (3,23). Each of these dietary approaches is considered safe for patients with diabetes, and each is effective if patients are able to adhere to the caloric restrictions (2,23). Patients may believe that they will have a higher likelihood of

TABLE 4. Eating Patterns With Equivalent Effects on Weight Loss (2)

• Low glycemic index/load	• Low carbohydrate
• High protein	• Moderate carbohydrate–moderate protein
• Low fat	• Mediterranean style

success if they use a meal-replacement option, and this option may be particularly helpful to patients who have limited time or ability to prepare food. As patients achieve caloric reduction, they may need to monitor their blood glucose more often depending on which glucose-lowering medication(s) they take.

It is important to understand that reducing caloric intake is more effective at achieving initial weight loss than only increasing exercise (48,49). Patients who made dietary changes alone lost 7 kg more at the 6-month follow-up than patients who added physical activity alone (49). Physical activity remains important for maintaining weight loss but should not be the primary focus of behavioral change for weight loss. Patients on insulin should increase glucose monitoring when starting a new exercise regimen to avoid hypoglycemia during or after exercise. The CDC does recommend that all adults, regardless of their weight or diabetes status, get 150 min/week of moderate aerobic activity and perform resistance exercise twice per week (32). Achieving this amount of physical activity, as well as avoiding long periods of inactivity, are good initial goals for patients who are not physically active (2).

Self-monitoring is another important tool in weight loss and weight maintenance efforts (50). Daily self-weighing has been shown to improve individuals' ability to refrain from excess caloric intake (51) and thus promotes weight loss (52). Breaks in daily weighing are associated with weight regain (52). Additionally, both the AHA/ACC/TOS and AACE/ACE guidelines rec-

ommend monitoring physical activity and food intake (3,53).

For maintaining weight loss, the ADA guidelines recommend that patients with diabetes be referred to a long-term (at least 1 year) weight maintenance program that involves at least monthly visits, at least weekly weight measurements, and at least 200–300 min/week of physical activity (23).

Medication Management

In addition to promoting patients' healthy lifestyle changes, managing medications is an important role for clinicians in treating patients with type 2 diabetes and obesity. Clinicians should consider altering the diabetes medication regimen and using weight loss medications for these patients.

First, clinicians should consider using the following glucose-lowering medications that are weight neutral or may promote weight loss: metformin, pramlintide, glucagon-like peptide 1 (GLP-1) receptor agonists, dipeptidyl peptidase 4 (DPP-4) inhibitors, and sodium–glucose cotransporter 2 (SGLT2) inhibitors. Metformin has been associated with a 3-kg weight loss (23,54–56). In addition to being associated with a 3.7-kg weight loss, pramlintide can also lower daily insulin requirements in patients with diabetes on insulin therapy (57). GLP-1 receptor agonists have been associated with a 5.3-kg weight loss (58). DPP-4 inhibitors are generally weight neutral (59,60). Finally, SGLT2 inhibitors can promote a 2.4-kg weight loss and lower insulin requirements (61). Of note, there is generally no benefit to using DPP-4 inhibitors and GLP-1 receptor agonists simultaneously because they work on the same pathway. Further

discussion on pharmacotherapy for obesity in patients with diabetes is covered elsewhere in this issue (p. 250).

In addition to avoiding diabetes medications that are associated with weight gain (e.g., sulfonylureas, thiazolidinediones, and insulin), clinicians should also assess for other medications that are associated with weight gain. When possible, clinicians should attempt to reduce or find alternatives to common medications that can increase appetite and promote weight gain, including sedating antihistamines, steroids, some selective serotonin reuptake inhibitors, beta-blockers, and most antipsychotic agents (62).

The AACE/ACE guidelines recommend that patients with diabetes and a BMI ≥ 27 kg/m² be prescribed weight loss medications (53). Treatment of obesity through pharmacotherapy, in conjunction with a healthy lifestyle, directly improves glycemic control (63,64). Five medications are now approved by the U.S. Food and Drug Administration (FDA) for long-term use for weight loss. Table 5 provides an overview of their weight loss and A1C outcomes and their side effects (62,65–69). Additionally, sympathomimetic appetite suppressant medications are approved for short-term use (up to 12 weeks). To avoid weight regain, the ADA recommends long-term use of weight loss medication for patients who successfully lose weight on the medication. Therefore, this article will focus only on medications approved for long-term use (70). For patients whose weight loss is $<5\%$ of initial body weight after the initial treatment period on a given medication (various medications have different initial treatment periods), the medication should be discontinued and an alternative medication or approach should be tried (23). The AACE/ACE guidelines recommend monitoring patients who are on insulin or sulfonylureas for hypoglycemia after starting any weight loss medication (2,53). When considering these

TABLE 5. Medications Approved by the FDA for Long-Term Use for Weight Management

Medication (Trade Names)	Mechanism of Action	Five Most Common Side Effects	Possible Safety Concerns*	Mean 1-Year Weight Loss Compared to Placebo (Dose)	A1C Change in Patients With Diabetes (%)
Decreases absorption					
Orlistat (Alli, Xenical)	Lipase inhibitor	Abdominal pain, flatulence, fecal urgency, back pain, and headache	Fat-soluble vitamin deficiencies, altered absorption of medications, cholelithiasis, nephrolithiasis	3.4 kg, 4.0% (120 mg TID)	-0.7
Suppresses appetite					
Lorcaserin (Belviq)	Serotonin receptor agonist	Headache, nausea, dizziness, fatigue, and nasopharyngitis	Serotonin syndrome, hypertension, edema, avoid in liver and renal failure	3.3 kg, 3.6% (10 mg BID)	-1.1†
Phentermine/Topiramate (Qsymia)	Norepinephrine release, GABA receptor modulation	Constipation, paresthesia, insomnia, nasopharyngitis, and xerostomia	Birth defects, cognitive impairment, acute angle-closure glaucoma, lactic acidosis with metformin, avoid in renal failure	6.7 kg, 6.6% (7.5/46 mg daily) 8.9 kg, 9.0% (15/92 mg daily)	-0.4
Naltrexone/Bupropion (Contrave)	Opiate antagonist, decreased re-uptake of norepinephrine	Constipation, nausea, headache, xerostomia, and insomnia	Depression, anxiety, acute angle-closure glaucoma, avoid in patients with uncontrolled hypertension and renal failure	4.1 kg, 5.2% (16/80 mg BID)	-0.6
Liraglutide (Saxenda)	GLP-1 receptor agonist	Hypoglycemia, constipation, nausea, headache, and indigestion	Gastroparesis, suicidal ideation, increased heart rate, caution in pancreatitis and cholelithiasis	4.5 kg, 5.6% (3 mg daily)	-0.6 to -1.8

*A comprehensive list of safety concerns can be found in each medication's package insert, which is available from the manufacturing pharmaceutical company. †A1C change has only been assessed in patients with prediabetes (66). BID, twice daily; GABA, gamma-aminobutyric acid; TID, three times daily.

medications, clinicians should discuss typical weight loss results, side effects, and medication costs with their patients.

Obesity Treatment in Type 1 Diabetes

Obesity is increasingly common in patients with type 1 diabetes; in 1988, 25% of 40- to 49-year-olds with type 1 diabetes had overweight or obesity compared to 68% in 2007 (71). Patients with type 1 diabetes will need to continue to take their insulin and strive for a caloric reduction of 500–700 kcal/day to lose weight. The ADA recommends that adults with type 1 diabetes meet the CDC recommendations for physical activity for all adults—150 min/week of moderate aerobic activity and two sessions of resistance training per week (23). Patients with type 1 diabetes starting a new exercise regimen or caloric reduction will need to monitor closely for hypoglycemia. In addition, the weight loss medications described above can also be considered for patients with type 1 diabetes. Pramlintide may be considered in patients with type 1 diabetes as a means of reducing their insulin requirements and promoting weight loss.

Conclusion

Weight loss is particularly important for individuals who have both diabetes and obesity. Because of the high prevalence of their co-occurrence, clinicians should be aware of the guidelines for treating obesity in patients with type 2 diabetes. The ADA, AACE/ACE, and AHA/ACA/TOS guidelines all recommend referring patients to high-intensity weight loss programs. Caloric reduction is the mainstay of weight loss, and increased exercise is crucial for maintaining weight loss. Medication management is also important for these patients, whether that involves selecting diabetes medications that promote weight loss or are weight neutral, prescribing medications approved for weight loss, or both.

Funding

C.T.B. is funded by the National Heart, Lung, and Blood Institute (T32HL007180-41A1). C.J.L. is funded by a career development award from the National Institute of Diabetes and Digestive and Kidney Disease (K23DK107921). K.A.G. is funded by a career development award from the National Heart, Lung, and Blood Institute (K23HL116601).

Duality of Interest

No potential conflicts of interest relevant to this article were reported.

References

- World Health Organization. Obesity and overweight fact sheet [Internet]. Available from http://www.who.int/dietphysicalactivity/media/en/gsf_s_obesity.pdf. Accessed April 2017
- Garvey WT, Mechanick JI, Brett EM, et al. American Association of Clinical Endocrinologists and American College of Endocrinology comprehensive guidelines for medical care of patients with obesity. *Endocr Pract* 2016;22(Suppl. 3):1–203
- Jensen MD, Ryan DH, Apovian CM, et al. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *J Am Coll Cardiol* 2014;63:2985–3023
- Macumber I, Schwartz S, Leca N. Maternal obesity is associated with congenital anomalies of the kidney and urinary tract in offspring. *Pediatr Nephrol* 2017;32:635–642
- Mitchell A, Fantasia HC. Understanding the effect of obesity on fertility among reproductive-age women. *Nurs Womens Health* 2016;20:368–376
- Simeone RM, Tinker SC, Gilboa SM, et al. Proportion of selected congenital heart defects attributable to recognized risk factors. *Ann Epidemiol* 2016;26:838–845
- Bleich SN, Bennett WL, Gudzone KA, Cooper LA. National survey of US primary care physicians' perspectives about causes of obesity and solutions to improve care. *BMJ Open* 2012;2:e001871
- Kushner RF. Barriers to providing nutrition counseling by physicians: a survey of primary care practitioners. *Prev Med* 1995;24:546–552
- Bennett WL, Gudzone KA, Appel LJ, Clark JM. Insights from the POWER practice-based weight loss trial: a focus group study on the PCP's role in weight management. *J Gen Intern Med* 2014;29:50–58
- Bennett WL, Wang NY, Gudzone KA, et al. Satisfaction with primary care provider involvement is associated with greater weight loss: results from the practice-based POWER trial. *Patient Educ Couns* 2015;98:1099–1105
- Gudzone KA, Bennett WL, Cooper LA, Bleich SN. Perceived judgment about weight can negatively influence weight loss: a cross-sectional study of overweight and obese patients. *Prev Med* 2014;62:103–107
- Moyer VA; U.S. Preventive Services Task Force. Screening for and management of obesity in adults: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med* 2012;157:373–378
- Leblanc ES, O'Connor E, Whitlock EP, Patnode CD, Kapka T. Effectiveness of primary care-relevant treatments for obesity in adults: a systematic evidence review for the U.S. Preventive Services Task Force. *Ann Intern Med* 2011;155:434–447
- Appel LJ, Champagne CM, Harsha DW, et al. Effects of comprehensive lifestyle modification on blood pressure control: main results of the PREMIER clinical trial. *JAMA* 2003;289:2083–2093
- Look AHEAD Research Group. Effects of a long-term lifestyle modification programme on peripheral neuropathy in overweight or obese adults with type 2 diabetes: the Look AHEAD study. *Diabetologia* 2017;60:980–988
- Huizinga MM, Cooper LA, Bleich SN, Clark JM, Beach MC. Physician respect for patients with obesity. *J Gen Intern Med* 2009;24:1236–1239
- Puhl RM, Moss-Racusin CA, Schwartz MB. Internalization of weight bias: implications for binge eating and emotional well-being. *Obesity (Silver Spring)* 2007;15:19–23
- Alexander SC, Cox ME, Boling Turer CL, et al. Do the five A's work when physicians counsel about weight loss? *Fam Med* 2011;43:179–184
- Jay M, Gillespie C, Schlair S, Sherman S, Kalet A. Physicians' use of the 5As in counseling obese patients: is the quality of counseling associated with patients' motivation and intention to lose weight? *BMC Health Serv Res* 2010;10:159
- Serdula MK, Khan LK, Dietz WH. Weight loss counseling revisited. *JAMA* 2003;289:1747–1750
- Whitlock EP, Orleans CT, Pender N, Allan J. Evaluating primary care behavioral counseling interventions: an evidence-based approach. *Am J Prev Med* 2002;22:267–284
- Gudzone K. Dietary and behavioral approaches in the management of obesity. *Gastroenterol Clin North Am* 2016;45:653–661
- American Diabetes Association. Standards of medical care in diabetes—2016: abridged for primary care providers. *Clin Diabetes* 2016;34:3–21
- Pi-Sunyer X. The Look AHEAD trial: a review and discussion of its outcomes. *Curr Nutr Rep* 2014;3:387–391
- Espeland MA, Glick HA, Bertoni A, et al.; Look AHEAD Research Group. Impact of an intensive lifestyle intervention on use and cost of medical services among overweight and obese adults with type 2 diabetes: the Action for Health in Diabetes. *Diabetes Care* 2014;37:2548–2556
- Look AHEAD Research Group; Wing RR, Bolin P, Brancati FL, et al. Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. *N Engl J Med* 2013;369:145–154
- Gibbs BB, Brancati FL, Chen H, et al., for the Look AHEAD Research Group. Effect of improved fitness beyond weight loss on cardiovascular risk factors in individuals with type 2 diabetes in the Look AHEAD study. *Eur J Prev Cardiol* 2014;21:608–617
- Rapp SR, Luchsinger JA, Baker LD, et al.; Look AHEAD Research Group. Effect of a long-term intensive lifestyle intervention on cognitive function: Action for Health in Diabetes study. *J Am Geriatr Soc* 2017;65:966–972
- Look AHEAD Research Group; Gregg EW, Jakicic JM, Blackburn G, et al. Association of the magnitude of weight loss and changes in physical fitness with long-term cardiovascular disease outcomes in overweight or obese people with type 2 diabetes: a post-hoc analysis of the Look AHEAD randomised clinical trial. *Lancet Diabetes Endocrinol* 2016;4:913–921
- Wing RR, Bond DS, Gendrano IN 3rd, et al.; Sexual Dysfunction Subgroup of the Look AHEAD Research Group. Effect of intensive lifestyle intervention on sexual dysfunction in women with type 2 diabetes: results from an ancillary Look AHEAD study. *Diabetes Care* 2013;36:2937–2944
- Jolly K, Lewis A, Beach J, et al. Comparison of range of commercial or primary care led weight reduction programmes with minimal intervention control for weight loss in obesity: Lighten Up randomised controlled trial. *BMJ* 2011;343:d6500
- Centers for Disease Control and Prevention. How much physical activity do adults need? [Internet]. Available from <https://www.cdc.gov/physicalactivity/basics/adults/index.htm>. Accessed 27 April 2017
- U.S. Preventive Services Task Force. Obesity in adults: screening and management [Internet]. Available from <http://www.uspreventiveservicestaskforce.org/uspstf/uspsobes.htm>. Accessed 30 April 2017
- Sebelius K. Report to Congress on preventive services and obesity-related services available to Medicaid enrollees [Internet]. Available from <https://www.medicaid.gov/medicaid/quality-of-care/downloads/rct-preventive-obesity-related-services2014.pdf>. Accessed 30 April 2017
- Bloom B, Mehta AK, Clark JM, Gudzone KA. Guideline-concordant weight-loss programs in an urban area are uncommon and difficult to identify

- through the Internet. *Obesity* (Silver Spring) 2016;24:583–588
36. Foster GD, Wadden TA, Lagrotte CA, et al. A randomized comparison of a commercially available portion-controlled weight-loss intervention with a diabetes self-management education program. *Nutr Diabetes* 2013;3:e63
37. Rock CL, Flatt SW, Pakiz B, et al. Weight loss, glycemic control, and cardiovascular disease risk factors in response to differential diet composition in a weight loss program in type 2 diabetes: a randomized controlled trial. *Diabetes Care* 2014;37:1573–1580
38. Pinto AM, Fava JL, Hoffmann DA, Wing RR. Combining behavioral weight loss treatment and a commercial program: a randomized clinical trial. *Obesity* (Silver Spring) 2013;21:673–680
39. Foster GD, Borradaile KE, Vander Veur SS, et al. The effects of a commercially available weight loss program among obese patients with type 2 diabetes: a randomized study. *Postgrad Med* 2009;121:113–118
40. Rock CL, Pakiz B, Flatt SW, Quintana EL. Randomized trial of a multifaceted commercial weight loss program. *Obesity* (Silver Spring) 2007;15:939–949
41. Jolly K, Daley A, Adab P, et al. A randomised controlled trial to compare a range of commercial or primary care led weight reduction programmes with a minimal intervention control for weight loss in obesity: the Lighten Up trial. *BMC Public Health* 2010;10:439
42. Gudzone KA, Doshi RS, Mehta AK, et al. Efficacy of commercial weight-loss programs: an updated systematic review. *Ann Intern Med* 2015;162:501–512
43. Johnston BC, Kanters S, Bandayrel K, et al. Comparison of weight loss among named diet programs in overweight and obese adults: a meta-analysis. *JAMA* 2014;312:923–933
44. Chaudhry ZW, Doshi RS, Mehta AK, et al. A systematic review of commercial weight loss programmes' effect on glycemic outcomes among overweight and obese adults with and without type 2 diabetes mellitus. *Obes Rev* 2016;17:758–769
45. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002;346:393–403
46. Knowler WC, Fowler SE, Hamman RF, et al. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet* 2009;374:1677–1686
47. U.S. Department of Health and Human Services. Certification of Medicare Diabetes Prevention Program [Internet]. Available from <https://www.cms.gov/Research-Statistics-Data-and-Systems/Research/ActuarialStudies/Downloads/Diabetes-Prevention-Certification-2016-03-14.pdf>. Accessed 8 April 2017
48. Dansinger ML, Gleason JA, Griffith JL, Selker HP, Schaefer EJ. Comparison of the Atkins, Ornish, Weight Watchers, and Zone diets for weight loss and heart disease risk reduction: a randomized trial. *JAMA* 2005;293:43–53
49. Wing RR, Venditti E, Jakicic JM, Polley BA, Lang W. Lifestyle intervention in overweight individuals with a family history of diabetes. *Diabetes Care* 1998;21:350–359
50. Voils CI, Olsen MK, Gierisch JM, et al. Maintenance of weight loss after initiation of nutrition training: a randomized trial. *Ann Intern Med* 2017;166:463–471
51. Butryn ML, Phelan S, Hill JO, Wing RR. Consistent self-monitoring of weight: a key component of successful weight loss maintenance. *Obesity* (Silver Spring) 2007;15:3091–3096
52. Helander EE, Vuorinen AL, Wansink B, Korhonen IK. Are breaks in daily self-weighing associated with weight gain? *PLoS One* 2014;9:e113164
53. Garber AJ, Abrahamson MJ, Barzilay JI, et al. Consensus statement by the American Association of Clinical Endocrinologists and American College of Endocrinology on the comprehensive type 2 diabetes management algorithm—2017: executive summary. *Endocr Pract* 2017;23:207–238
54. Diabetes Prevention Program Research Group. Long-term safety, tolerability, and weight loss associated with metformin in the Diabetes Prevention Program Outcomes Study. *Diabetes Care* 2012;35:731–737
55. Fontbonne A, Diouf I, Baccara-Dinet M, Eschwege E, Charles MA. Effects of 1-year treatment with metformin on metabolic and cardiovascular risk factors in non-diabetic upper-body obese subjects with mild glucose anomalies: a post-hoc analysis of the BIGPRO1 trial. *Diabetes Metab* 2009;35:385–391
56. Seifarth C, Schehler B, Schneider HJ. Effectiveness of metformin on weight loss in non-diabetic individuals with obesity. *Exp Clin Endocrinol Diabetes* 2013;121:27–31
57. Aronne L, Fujioka K, Aroda V, et al. Progressive reduction in body weight after treatment with the amylin analog pramlintide in obese subjects: a phase 2, randomized, placebo-controlled, dose-escalation study. *J Clin Endocrinol Metab* 2007;92:2977–2983
58. Klonoff DC, Buse JB, Nielsen LL, et al. Exenatide effects on diabetes, obesity, cardiovascular risk factors and hepatic biomarkers in patients with type 2 diabetes treated for at least 3 years. *Curr Med Res Opin* 2008;24:275–286
59. Pratley RE, Kipnes MS, Fleck PR, Wilson C, Mekki Q, Alogliptin Study Group. Efficacy and safety of the dipeptidyl peptidase-4 inhibitor alogliptin in patients with type 2 diabetes inadequately controlled by glyburide monotherapy. *Diabetes Obes Metab* 2009;11:167–176
60. Raz I, Chen Y, Wu M, et al. Efficacy and safety of sitagliptin added to ongoing metformin therapy in patients with type 2 diabetes. *Curr Med Res Opin* 2008;24:537–550
61. Rosenstock J, Jelaska A, Frappin G, et al. Improved glucose control with weight loss, lower insulin doses, and no increased hypoglycemia with empagliflozin added to titrated multiple daily injections of insulin in obese inadequately controlled type 2 diabetes. *Diabetes Care* 2014;37:1815–1823
62. Apovian CM, Aronne LJ, Bessesen DH, et al. Pharmacological management of obesity: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2015;100:342–362
63. Goldstein DJ. Beneficial health effects of modest weight loss. *Int J Obes Relat Metab Disord* 1992;16:397–415
64. U.K. Prospective Diabetes Study Group: UKPDS 7: response of fasting plasma glucose to diet therapy in newly presenting type II diabetic patients. *Metabolism* 1990;39:905–912
65. Jacob S, Rabbia M, Meier MK, Hauptman J. Orlistat 120 mg improves glycaemic control in type 2 diabetic patients with or without concurrent weight loss. *Diabetes Obes Metab* 2009;11:361–371
66. Mahgerefteh B, Vigue M, Freestone Z, Silver S, Nguyen Q. New drug therapies for the treatment of overweight and obese patients. *Am Health Drug Benefits* 2013;6:423–430
67. Garvey WT, Ryan DH, Look M, et al. Two-year sustained weight loss and metabolic benefits with controlled-release phentermine/topiramate in obese and overweight adults (SEQUEL): a randomized, placebo-controlled, phase 3 extension study. *Am J Clin Nutr* 2012;95:297–308
68. Makowski CT, Gwinn KM, Hurren KM. Naltrexone/bupropion: an investigational combination for weight loss and maintenance. *Obes Facts* 2011;4:489–494
69. Bays H, Pi-Sunyer X, Hemmingson JU, Claudius B, Jensen CB, Van Gaal L. Liraglutide 3.0 mg for weight management: weight-loss dependent and independent effects. *Curr Med Res Opin* 2017;33:225–229
70. Heymsfield SB, Wadden TA. Mechanisms, pathophysiology, and management of obesity. *N Engl J Med* 2017;376:254–266
71. Conway B, Miller RG, Costacou T, et al. Temporal patterns in overweight and obesity in type 1 diabetes. *Diabet Med* 2010;27:398–404