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Introduction to the dietary management of obesity in adults

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ABSTRACT

Obesity is a multifaceted and complex condition that requires holistic management. It currently affects nearly one in four adults in the UK, with the UK ranked 10th globally for the highest obesity rates. Obesity is projected to have an economic burden of ~£2 billion per year by 2030 in the UK.[1] Excess weight gain can coincide with myriad health concerns and multiple health conditions, which can be physical, metabolic or psychosocial. This includes type 2 diabetes mellitus (T2DM), hypertension, coronary heart disease, osteoarthritis, obstructive sleep apnoea, reproductive disorders, depression and cancer[2]; hence, there has been a significant emphasis on obesity prevention. Obesity is often associated with weight stigma, impacting psychological wellbeing and quality of life. This can influence an individual's likelihood of seeking support, delaying appropriate input from healthcare professionals, with a knock-on effect on pre-existing health conditions. This review explores the management of obesity from a nutritional perspective, because modifying dietary intake is essential to reduce the risk of non-communicable diseases, including those associated with obesity.

KEYWORDS: obesity, diet, nutrition

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Introduction

It is well documented how nutrition can impact our health and is important for all, regardless of body weight. However, eating patterns and macronutrient composition, as well as physical activity levels, have changed significantly. With globalisation and urbanisation, there has been a shift toward higher fat and sugar intake, larger portion sizes and the cost of fresh produce increasing, yet the cost of processed food decreasing.[3] This is a growing cause for concern, as discussed in the Marmot review, with widening disparities and health inequalities in the UK.[4] With increasing food insecurity and rising cost of living, many individuals question the affordability of nutritious meals.

Through the abundance of information readily accessed, individuals might resort to fad diets, which promise rapid weight loss results without the support of robust scientific grounding. This can often be unsustainable, leading to weight cycling and yo-yo weights, which are often more detrimental than beneficial. Weight cycling is often associated with feelings of failure or body dissatisfaction and body composition changes with reduction in muscle mass.[5]

Conventional guidance in several countries suggests a calorie deficit of 500–600 kcals per day from the current diet to achieve a weight loss of 0.5–1 kg/week.[6,7] However, weight loss is not a direct linear trajectory and fluctuations can occur. A 5–10% weight loss has been indicated to improve obesity-related conditions.[8–10]

Assessment

For any successful intervention, assessments should be patient centric. Clinicians should evaluate an individual's motivation and readiness for change, and whether there are any barriers to this, as well as previous weight loss attempts, in a non-judgemental manner. Tools such as food diaries, 24-h diet recalls or food frequency questionnaires can be helpful in establishing an individual's frequency of eating, eating patterns, meal timings, snacking or binge-eating tendencies. Of individuals living with obesity, 5–15% have a binge-eating disorder (BED) or night-eating syndrome (NES); therefore, psychological input is vital in this patient group.[11] It is important to gain an understanding of various motivations behind food choices and eating habits, and for clinicians to support individuals with evidence-based practice (Table 1). The food environment heavily impacts choice and influences the quality of meals. Individuals are additionally confronted with daily exposure of marketing of ultra-processed foods and beverages.

The effective application of psychological approaches, such as cognitive behavioural therapy (CBT) and motivational interviewing (MI), can empower individuals with autonomy and commitment to change, improving patient experience and enabling collaborative goal setting.

Dietary strategies

Fig 1 provides an overview of the nutritional management of obesity used in practice.

Stabilising eating behaviours

For sustainable dietary change for weight loss, dietary advice will need to be practical to implement, compatible with the individual's lifestyle, be satisfying to promote satiety and be lower in energy intake compared with the current diet, all while

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Table 1. Determinants of food choices[12]

Biological	Social determinants	Psychological determinants
Hunger	Culture	Mood
Appetite	Family and peers	Stress and guilt
	Attitudes and beliefs	Sensory characteristics of food
	Knowledge, including cooking skills	
	Accessibility	
	Economic	

remaining nutritionally adequate. Irregular, erratic, *ad libitum* eating behaviours can frequently increase grazing tendencies on high-energy foods. Therefore, as a priority, a structured meal pattern should be supported and developed, particularly in individuals who present with binge-eating tendencies.[13] This can form a foundation for further dietary changes. Implementation of having breakfast and its effects on weight loss have been inconclusive; however, it is suggested that individuals who habitually have breakfast tend to have increased amounts of fibre and protein, which might improve satiety and overall daily energy intake.[14-16]

Studies have suggested that reduced eating frequencies (ie fewer than three meals per day) can negatively impact appetite control, and long periods of fasting or skipping meals can lead to larger portion sizes secondary to compensatory eating.[17,18]

Meal planning

With time being a scarce commodity, convenient food options, such as fast-food, takeaways and ready meals, are often opted for, which tend to be higher in energy. However, meal planning, such as forward-planning intake for the next few days, can increase the likelihood of home-cooked meals as well as improving dietary quality and variety, with higher intakes of fruit and vegetables.[19,20]

Portion sizes

Over the years, the norm for portion sizes has become distorted. Dietary education on portion sizes should be incorporated in weight management advice because this can be a major contributor to excess energy intake and, thus, weight gain.[21] Strategies such as the use of simple hand measurements or household measurements can be effective, rather than the use of scales, which can be laborious.

Reduction in sugar-sweetened beverages

Sugar-sweetened beverages (SSBs), including soft drinks and energy drinks, are a large source of added sugars in the UK diet; hence, there have been public health strategies, such as the UK soft drinks industry levy or 'sugar tax', to drive reformulation and reduction in portion sizes in the beverage industry. Several studies have discussed the significant association between the consumption of refined carbohydrates or simple sugars, particularly in SSBs and the likelihood of weight gain and obesity, as well as T2DM, cardiovascular disease, dental health and hyperactivity.[22–24]

A meta-analysis of six randomised controlled trials (RCTs) concluded a dose–response increase in body weight associated with higher intakes of SSBs.[25,26] A systematic review suggested a decreased intake of free sugars could lead to an average weight loss of 0.8 kg over 10 weeks to 8 months.[27]

This is particularly significant for young adolescents, by whom the consumption of SSBs is highly prevalent, comprising approximately one-third of their dietary intake. SSBs are poor in nutritional value and tend to have lower effects on satiety compared with isocaloric solid food intake.[28] There have been suggestions that this is the result of SSBs interrupting endocrine responses, such as insulin, GLP1 and ghrelin, as well as liquids having a rapid gastric-emptying rate.[29] Moreover, liquids do not provide the same sensory properties that solid food does, because they require very minimal processing orally, such as chewing, which might further impact satiety.[30,31]

Conversely, artificial or non-nutritive sweeteners provide a sweet taste with few if any calories, and do not appear to impact on glycaemic control in individuals living with diabetes; however, more research is required because of the heterogeneity between studies.[32]

Dietary balance and quality

Improving the overall balance and quality of a diet can lead to metabolic changes and associated health benefits, regardless of whether weight loss is observed.

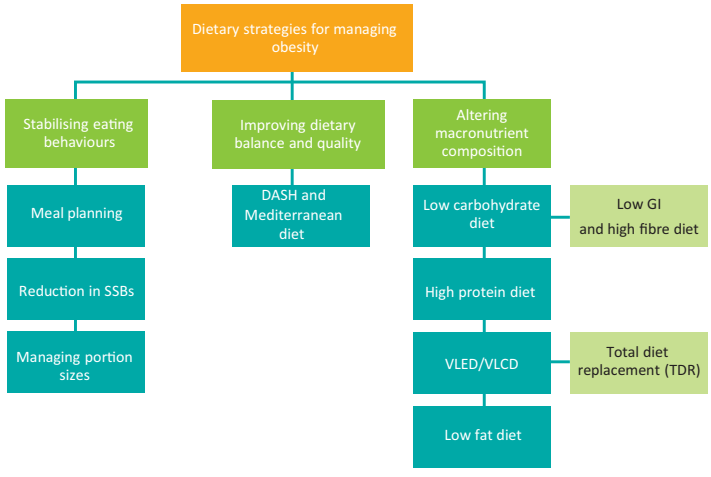

Fig 1. Overview of nutritional management of obesity used in practice. DASH = Dietary Approaches to Stop Hypertension; GI = glycaemic index; SSB = sugar-sweetened beverage; VLCD = very low-calorie diet; VLED = very low-energy diet.

Dietary Approaches to Stop Hypertension (DASH) and a Mediterranean diet

The Dietary Approaches to Stop Hypertension (DASH) diet comprises whole foods, such as fruits, vegetables, whole grains, nuts, legumes and low-fat dairy products, but limited sodium intake. Current evidence suggests that not only does DASH reduce the likelihood of hypertension, but there are also changes in metabolic health, such as improving cardiovascular disease risk, lipid levels and insulin resistance. A systematic review of 13 RCTs aimed to determine the efficacy of DASH on body weight. It was concluded that DASH moderately reduced body weight over 8 to 24 weeks compared with controls, with a small mean difference of 1.42 kg (95% confidence interval (CI): –2.03 to –0.82 kg).[33]

The Prevencion con Dieta Mediterranea (PREDIMED) trial has demonstrated the cardioprotective nature of a Mediterranean diet (MedDiet) (Fig 2), with improvements in blood pressure, metabolic syndrome, T2DM, insulin resistance and dyslipidaemia, particularly low-density lipoprotein (LDL), and overall mortality.[35,36]

Almost 40% of the total daily caloric intake in the MedDiet comes from fat and there have been concerns that this could lead to weight gain. However, there is an increasing body of data to indicate its sustainable efficacy on weight loss and encompassing nutritional quality. A meta-analysis of 3,436 participants concluded there was no significant weight gain. Furthermore, a mean weight loss of 1.75 kg with a MedDiet compared with control diets was observed, but the weight loss changes were amplified when the MedDiet was combined with energy restriction (–3.88 kg), or with increased physical activity levels (PALS) (–4.01 kg).[37,38]

The PREDIMED-Plus Study, which followed on from the initial study, combined PALS, behavioural changes and an energy-restricted MedDiet (erMedDiet) and compared this with a control group allowed an unrestricted MedDiet and in which PALS was not advised. The results showed that, at 6 months, there was a mean modest weight loss from baseline of –2.4 (–2.7%) and –0.4 kg (–0.5%) in the intervention and control group, respectively, benefits that extended further at 12 months, supporting the hypothesis that a combination of lifestyle changes and dietary modification supports greater weight loss.[37–39]

Fig 2. Summary of the Mediterranean diet.[34]

A systematic review in 2016 of trials in which participants with a mean body mass index (BMI) of 29–34 kg/m^2 were included, observed a slight efficacy in the reduction of body weight, ranging from –3.8 to 10.1 kg beyond 12 months. It was further concluded that the MedDiet resulted in higher reductions in weight and BMI compared with low-fat diets (LFDs), but that these changes were similar to the mean changes of other diets, including low carbohydrate approaches.[40]

A more recent large-scale umbrella review and meta-analysis involving 495 RCTs concluded there were statistically significant reductions in body weight with both DASH (median difference (MD) –1.42 kg; 95% CI: –2.03 to –0.82 kg) and MedDiet (MD –1.75 kg; 95% CI: –2.86 to –0.84 kg) compared with the control.[41] However, these dietary changes had very little impact on body weight post follow-up at 4.8 years.[42] Despite the amount of weight loss not being clinically significant, the MedDiet offers a varied dietary composition and is high in nutritional quality, and has a strong case for its associated metabolic and health benefits.

Altering macronutrient composition

Low-carbohydrate diet

Low-carbohydrate diets (LCDs), such as the Atkins diet, have been a popular weight loss intervention, followed more recently by ketogenic 'keto' diets, which were initially used as a treatment for epilepsy. There is no universal consensus over what is considered to be low carbohydrate; however, general recommendations are summarised in Table 2. Carbohydrates heighten the postprandial glycaemic response, and it is suggested that increased carbohydrate intake is associated with higher levels of insulin secretion, thus leading to weight gain because it is stored as adipose tissue.[43] LCDs have shown improvements in haemoglobin (Hb) A1c in individuals with T2DM in the immediate term (ie the first 12 months of intervention). A positive correlation between the greater carbohydrate restriction and HbA1c has been observed, with conclusions drawn of statistically and clinically significant importance.[44]

Systematic reviews have suggested that individuals on LCDs compared with controls, such as LFDs, have a statistically significant reduction in weight as well as triglycerides.[45,46] Another meta-analysis involving 7,286 individuals, concluded that both LCDs and LFDs resulted in statistically significant weight loss, but minimal differences were observed between the comparative diets. The LCD had a MD weight loss of 8.73 kg (95% CI: 7.27–10.20 kg) at 6-month follow-up and 7.25 kg (95% CI: 5.33–9.25 kg) at 12-month follow-up.[47]

Comparatively, with a keto diet, the body switches from using glucose as a main fuel source, to fatty acids and ketones via glycogen depletion. This can lead to initial rapid short-term weight loss, primarily because of water loss, as 1 g of glycogen holds ~3 g of water.[49]

There have been further suggestions that a very low carbohydrate ketogenic diet (VLCKD) can also improve appetite,[50,51] with meaningful short-term weight loss.[52-54] However, the safety and long-term effects of LCD and VLCKD remain unclear, with significant heterogeneity between studies.

Table 2. Carbohydrate content of named diets

Diet	Carbohydrate (g) per day	Percentage of total calories (%)
Very low-carbohydrate ketogenic diet (VLCKD)	20–50g	10
Low carbohydrate	<130	26
Moderate carbohydrate	130–230	26–45
High carbohydrate	>230	>45

[a]Adapted from Feinman *et al.*[48]

Furthermore, this dietary approach might not be suitable for all individuals (eg older and frail individuals) and, therefore, advice should be tailored.

Low glycaemic index and high-fibre diets

LCDs have been associated with lower intake of cereals and bread which are sources of dietary fibre; therefore, carbohydrate quality should be assessed.[55] Carbohydrate intake has become more refined in recent decades and UK guidance for the general population is 30 g per day of fibre for adults. However, National Diet and Nutrition Survey (NDNS) data indicated that mean intake was 19 g of fibre per day for 19–64-year olds.[56]

High-fibre foods, such as whole fruits and vegetables, beans, pulses and wholegrains, tend to be lower on the glycaemic index (GI). The GI is a system that ranks carbohydrate on how they impact blood glucose levels, 2 h post prandial, per 50 g of carbohydrate when compared with a reference food, such as white bread.[57] High GI foods might impact hunger and overall food intake. Conversely, low GI foods can improve satiety and satisfaction of meals by minimising secretion of insulin and, thus, postprandial glycaemia. Low GI meals have also been suggested to increase fat oxidation.[58]

A systematic review headed by the World Health Organization (WHO) showed a decrease in incidence of obesity-related non-communicable diseases, total cancer and mortality observed in diets with higher fibre intake.[59] Many countries, such as the UK, Canada and Australia, have recognised these benefits and have recommended low GI diets for individuals with diabetes in clinical guidance.

A Cochrane Review of low GI diets in 2007 reported reductions in body mass, BMI and total fat mass in individuals living with obesity, compared with those on control diets; however, the included RCTs only lasted from 5 weeks to 6 months and only two included overweight or obese individuals in their study.[60] A recent meta-analysis concluded similar results with individuals living with obesity on low GI diets, showing weight reductions of the equivalent of 1.8 kg.[61]

Studies have consistently indicated small but clinically significant improvements in glycaemic control and HbA1c of a low GI diet in those with prediabetes or T2DM.[61,62] However, low GI diets are discouraged by the National Institute for Health and Care Excellence (NICE) in individuals living with type 1 diabetes mellitus.[63] Low GI diets have been linked to improved fertility, insulin sensitivity, and reduced body fat and waist circumference in individuals with polycystic ovarian syndrome (PCOS).[64,65]

There is a lack of robust and well-controlled studies on the longitudinal efficacy of low GI diets for weight loss and for individuals without T2DM; therefore, such diets are unlikely to be recommended as a sole nutritional approach; however, low GI diets could be beneficial when used in conjunction with pharmacotherapy.[62]

High protein diet

Lower carbohydrate diets tend to be higher in protein (~30% of total daily energy), which are often associated with increasing satiety and satisfaction with dietary intake.[66,67] It has been proposed that the inclusion of a high-protein diet increased the advantage of dietary thermogenesis and suggestions of increased glucagon-like peptide 1 (GLP1) or cholecystokinin (CKK) release, compared with carbohydrates and fats.[68]

Individuals should be particularly encouraged to opt for leaner protein sources, with the inclusion of plant-based alternatives, because these tend to be lower in saturates and higher in fibre. This approach could be considered useful in maintaining weight loss.[69]

Very low-energy diet/very low-calorie diet and total diet replacement

There has been growing interest in the use of total diet replacement (TDR) as part of a very low-energy diet/very low-calorie diet (VLED/VLCD) in light of recent trials since the Diabetes Remission Clinical Trial (DiRECT) study in 2019, which showed that 46% of participants who used TDR products to replace all food intake were in remission from T2DM. The mean body weight reduced by 10 kg within the TDR group, compared with 1 kg in the control group.[70] Typically, a VLCD provides <800 kcal/day.

The efficacy and safety of TDR in the primary care setting was further assessed in the DROPLET study, with the control group receiving routine weight management support from practice nurses, which included moderate energy restriction. Results concluded that, at 12 months, the TDR group reported a mean weight change of 10.7 kg from baseline, compared with 3.1 kg in the control group, accompanied by greater improvements in patient quality of life (QoL).[71]

Low-calorie liquid diets (LCLD) as per NICE guidance should not be routinely prescribed as a treatment option.[72] However, there might be circumstances in which individuals are assessed as clinically requiring rapid weight loss, such as for an operation or for fertility purposes. LCLDs should only followed under clinical supervision, with regular monitoring and reviewing. However, they are not recommended to be continued for more than 12 weeks and should be followed by a stepped food reintroduction phase with meal replacement usage tapered down proportionately, followed by a weight maintenance phase.

Individuals undertaking LCLDs should be advised that some weight regain is very likely during food reintroduction and is not the fault of the individual. TDR should be accompanied by behavioural modification, assisted by a specialist dietitian within an obesity service. This provides support when regular foods are reincorporated into the diet, to minimise significant weight regain.

By prescribing TDR, food choices are removed; therefore, this could benefit individuals who might eat secondary to alternative cues besides hunger. Furthermore, TDR provides a fixed amount of macronutrients and micronutrients. Given that TDR is often low in dietary fibre, the use of a high-fibre supplement or laxative might be required.

Lower calorie diets can be difficult to sustain, especially for individuals for whom this would be a significant change in their

habitual intake. TDR could be contraindicated in those who present with disordered eating, because of its restrictive nature; however, there is limited high-quality published literature available about the risks associated with such an approach.

Low-fat diet

LFDs typically provide <30% of the total energy intake. Each gram of fat provides ~9 kcals, and is the most energy-dense macronutrient; therefore, higher intake is often associated with weight gain.[73] There has been consistent evidence concluding a reduction in body weight with lower intakes of total dietary fat, although the differences are small but both statistically and clinically significant.[74,75]

The Look AHEAD trial was an RCT based on an intensive lifestyle programme (ILP) and compared changes from usual diabetes support and intervention (DSI). However, the trial was stopped at 9 years because of futility but met a target of 5% weight loss of initial body mass through the recommendations of LFD (<30% energy from fat and calorie intake of 1200–1500 kcals/day) at year 8 and inclusion of PALS.[38,76] LFDs can be effective in weight loss but have not demonstrated to be superior to other dietary approaches.

Conclusion

People living with obesity often feel scrutinised for their food choices, with frequent recommendations to eat less and do more; however, this notion negates the fact that there are many biological or physiological factors that can impact weight loss. Although this was not discussed in this review, such factors could be further explored in future articles.

There are many interventions that can bring about rapid weight loss, with significant interest into novel approaches, such as intermittent fasting (IF) and time-restricted feeding (TRF). Personalised nutrition has also gained popularity, which considers an individual's phenotype and genotype to optimise their metabolism. However, more research is required and there is no one diet that fits all or consensus on what diet is the gold standard for weight management. The most suitable approach is one that is tailored to the individual and can be undertaken safely and sustainably. Maintaining weight loss, with adherence to dietary changes made, remains the biggest challenge. Self-monitoring and physical activity should be encouraged in conjunction with dietary changes, to drive weight loss and support the maintenance phase.[37–39]

Even with emerging pharmacotherapy, such as GLP1 agonists (eg semaglutide and liraglutide), lifestyle changes, including alterations of dietary habits, should lie at the foundation of obesity management, to minimise lean body mass loss and enable optimal patient outcomes.[77–79] ■

Summary of key points

- Remove weight stigma in practice; appreciate the long-lasting effects of communication of clinicians with patients.
- Assessments should be patient centric and individuals living with obesity are best supported with holistic management with members of the MDT, including a specialist dietitian.
- There is no 'one-size-fits-all' diet for weight loss and the main aim is to sustain dietary changes. Personalisation of the diet to meet the needs of the individual is key.
- Both physical activity and dietary modification should be considered in combination for the weight maintenance phase as well as medicated pathways.

References

1 Wang YC, McPherson K, Marsh T *et al*. Health and economic burden of the projected obesity trends in the USA and the UK. *Lancet* 2011;378:815–25.
2 World Health Organisation. *Obesity: preventing and managing the global epidemic: report of a WHO consultation*. Geneva; WHO, 2000.
3 Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev* 2012;70:3–21.
4 Marmot M, Jessica A, Boyce T *et al*. *Health equity in England: the Marmot Review 10 years on*. Health Foundation, 2020.
5 Higgins M. Benefits and adverse effects of weight loss: observations from the Framingham Study. *Ann Internal Med* 1993;119:758–63.
6 National Heart, Lung, and Blood Institute. *Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults*. Bethesda; National Heart, Lung, and Blood Institute, 1998.
7 Hill JO, Thompson H, Wyatt H. Weight maintenance: what's missing? *J Am Dietetic Association* 2005;105:63–6.
8 Blackburn G. Effect of degree of weight loss on health benefits. *Obesity Res* 1995;3:211s–216s.
9 Goldstein DJ. Beneficial health effects of modest weight loss. *Int J Obes Relat Metab Disord* 1992;16:397–415.
10 Pi-Sunyer FX. Short-term medical benefits and adverse effects of weight loss. *Ann Internal Med* 1993;119:722–26.
11 McCuen-Wurst C, Ruggieri M, Allison KC. Disordered eating and obesity: associations between binge-eating disorder, night-eating syndrome, and weight-related comorbidities. *Ann N Y Acad Sci* 2017;1411:96–105.
12 Leng G, Adan RAH, Belot M *et al*. The determinants of food choice. *Proc Nutr Soc* 2016;76:316–27.
13 Haus G, Hoerr SL, Mavis B *et al*. Key modifiable factors in weight maintenance: fat intake, exercise, and weight cycling. *J Am Diet Assoc* 1994;94:409–13.
14 Sievert K, Hussain SM, Page MJ *et al*. Effect of breakfast on weight and energy intake: systematic review and meta-analysis of randomised controlled trials. *BMJ* 2019;364:l42.
15 Kant AK, Andon MB, Angelopoulos TJ *et al*. Association of breakfast energy density with diet quality and body mass index in American adults: National Health and Nutrition Examination Surveys, 1999–2004. *Am J Clin Nutr* 2008;88:1396–404.
16 Leidy HJ, Gwin JA, Roenfeldt CA *et al*. Evaluating the intervention-based evidence surrounding the causal role of breakfast on markers of weight management, with specific focus on breakfast composition and size. *Adv Nutr* 2016;7:563S–575S.
17 Leidy HJ, Campbell WW. The Effect of Eating Frequency on Appetite Control and Food Intake: Brief Synopsis of Controlled Feeding Studies. *J Nutr* 2011;141:154–7.
18 Garaulet M, Gómez-Abellán P. Timing of food intake and obesity: a novel association. *Physiol Behav* 2014;134:44–50.
19 Ducrot P, Méjean C, Aroumougame V *et al*. Meal planning is associated with food variety, diet quality and body weight status in a large sample of French adults. *Int J Behav Nutr Phys Act* 2017;14:12.
20 Crawford D, Ball K, Mishra G *et al*. Which food-related behaviours are associated with healthier intakes of fruits and vegetables among women? *Public Health Nutr* 2007;10:256–65.

21 Livingstone MBE, Pourshahidi LK. Portion size and obesity. *Adv Nutr* 2014;5:829–34.
22 Malik VS, Hu FB. Fructose and cardiometabolic health. *J Am Coll Cardiol* 2015;66:1615–24.
23 Valenzuela MJ, Waterhouse B, Aggarwal VR *et al*. Effect of sugar-sweetened beverages on oral health: a systematic review and meta-analysis. *Eur J Public Health*. 2020;31:122–9.
24 Milich R. Sugar and hyperactivity: a critical review of empirical findings. *Clin Psychol Rev* 1986;6:493–513.
25 Mattes RD, Shikany JM, Kaiser KA *et al*. Nutritively sweetened beverage consumption and body weight: a systematic review and meta-analysis of randomized experiments. *Obesity Rev* 2010;12:346–65.
26 Hu FB. Resolved: there is sufficient scientific evidence that decreasing sugar-sweetened beverage consumption will reduce the prevalence of obesity and obesity-related diseases. *Obesity Rev* 2013;14:606–19.
27 Te Morenga L, Mallard S, Mann J. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ* 2012;346:e7492.
28 De Castro JM. The effects of the spontaneous ingestion of particular foods or beverages on the meal pattern and overall nutrient intake of humans. *Physiol Behav* 1993;53:1133–44.
29 Cassady BA, Considine RV, Mattes RD. Beverage consumption, appetite, and energy intake: what did you expect? *Am J Clin Nutr* 2012;95:587–93.
30 McCrickerd K, Forde CG. Sensory influences on food intake control: moving beyond palatability. *Obesity Rev* 2015;17:18–29.
31 Wijlens AGM, Erkner A, Alexander E *et al*. Effects of oral and gastric stimulation on appetite and energy intake. *Obesity* 2012;20: 2226–32.
32 Martínez-González MA, Salas-Salvadó J, Estruch R *et al*. Benefits of the Mediterranean diet: insights from the PREDIMED study. *Prog Cardiovasc Dis* 2015;58:50–60.
33 Lohner S, Kuellenberg de Gaudry D, Toews I *et al*. Non-nutritive sweeteners for diabetes mellitus. *Cochrane Database System Rev* 2020;5:CD012885.
34 Soltani S, Shirani F, Chitsazi MJ *et al*. The effect of dietary approaches to stop hypertension (DASH) diet on weight and body composition in adults: a systematic review and meta-analysis of randomized controlled clinical trials. *Obesity Rev* 2016;17: 442–54.
35 Martínez-González M, Hershey M, Zazpe I *et al*. Transferability of the Mediterranean diet to non-Mediterranean countries. What is and what is not the Mediterranean diet. *Nutrients* 2017;9:1226.
36 Sofi F, Macchi C, Abbate R *et al*. Mediterranean diet and health status: an updated meta-analysis and a proposal for a literature-based adherence score. *Public Health Nutr* 2013;17:2769–82.
37 Esposito K, Kastorini CM, Panagiotakos DB *et al*. Mediterranean diet and weight loss: meta-analysis of randomized controlled trials. *Metab Syndr Relat Disord* 2011;9:1–12.
38 Look AHEAD Research Group. Eight-year weight losses with an intensive lifestyle intervention: the Look AHEAD Study. *Obesity* 2014;22:5–13.
39 Salas-Salvadó J, Díaz-López A, Ruiz-Canela M *et al*. Effect of a lifestyle intervention program with energy-restricted mediterranean diet and exercise on weight loss and cardiovascular risk factors: one-year results of the PREDIMED-Plus trial. *Diabetes Care* 2019;42:777–88.
40 Mancini JG, Filion KB, Atallah R *et al*. Systematic review of the Mediterranean diet for long-term weight loss. *Am J Med* 2016;129:407–15.
41 Dinu M, Pagliai G, Angelino D *et al*. Effects of popular diets on anthropometric and cardiometabolic parameters: an umbrella review of meta-analyses of randomized controlled trials. *Adv Nutr* 2020;11:815–33.
42 Estruch R, Martínez-González MA, Corella D *et al*. Effect of a high-fat Mediterranean diet on bodyweight and waist circumference: a prespecified secondary outcomes analysis of the PREDIMED randomised controlled trial. *Lancet Diabetes Endocrinol* 2019;7:e6–e17.
43 Willems AEM, Sura-de Jong M, van Beek AP *et al*. Effects of macronutrient intake in obesity: a meta-analysis of low-carbohydrate and low-fat diets on markers of the metabolic syndrome. *Nutr Rev* 2020;79:429–44.
44 Snorgaard O, Poulsen GM, Andersen HK *et al*. Systematic review and meta-analysis of dietary carbohydrate restriction in patients with type 2 diabetes. *BMJ Open Diabetes Res Care* 2017;5:e000354.
45 Noto H, Goto A, Tsujimoto T *et al*. Low-carbohydrate diets and all-cause mortality: a systematic review and meta-analysis of observational studies. *PLoS ONE* 2013;8:e55030.
46 Sackner-Bernstein J, Kanter D, Kaul S. Dietary Intervention for overweight and obese adults: comparison of low-carbohydrate and low-fat diets. A Meta-analysis. *PLoS ONE*. 2015;10:e0139817.
47 Johnston BC, Kanters S, Bandayrel K *et al*. Comparison of weight loss among named diet programs in overweight and obese adults. *JAMA* 2014;312:923–33.
48 Feinman RD, Pogozelski WK, Astrup A *et al*. Dietary carbohydrate restriction as the first approach in diabetes management: critical review and evidence base. *Nutrition* 2015;31:1–13.
49 Westman EC, Feinman RD, Mavropoulos JC *et al*. Low-carbohydrate nutrition and metabolism. *Am J Clin Nutr* 2007;86:276–84.
50 Martin CK, Rosenbaum D, Han H *et al*. Change in food cravings, food preferences, and appetite during a low-carbohydrate and low-fat diet. *Obesity* 2011;19:1963–70.
51 Gibson AA, Seimon RV, Lee CMY *et al*. Do ketogenic diets really suppress appetite? A systematic review and meta-analysis. *Obesity Rev* 2014;16:64–76.
52 Anton S, Hida A, Heekin K *et al*. Effects of popular diets without specific calorie targets on weight loss outcomes: systematic review of findings from clinical trials. *Nutrients* 2017;9:822.
53 Harvey CJDC, Schofield GM, Zinn C *et al*. Low-carbohydrate diets differing in carbohydrate restriction improve cardiometabolic and anthropometric markers in healthy adults: a randomised clinical trial. *PeerJ* 2019;7:e6273.
54 Bueno NB, de Melo ISV, de Oliveira SL *et al*. Very-low-carbohydrate ketogenic diet v. low-fat diet for long-term weight loss: a meta-analysis of randomised controlled trials. *Br J Nutr* 2013;110:1178–87.
55 Elidottir AS, Halldorsson TI, Gunnarsdottir I *et al*. Dietary Intake and Cardiovascular Risk Factors in Icelanders Following Voluntarily a Low Carbohydrate Diet. *PLoS ONE* 2016;11:e0156655.
56 Public Health England, Food Standards Agency. *National Diet and Nutrition Survey (NDNS) results from years 7 and 8 (combined) of the Rolling Programme (2014/2015 to 2015/2016)*. London; Public Health England Publications, 2018.
57 Jenkins DJ, Wolever TM, Taylor RH *et al*. Glycemic index of foods: a physiological basis for carbohydrate exchange. *Am J Clin Nutr* 1981;34:362–6.
58 McMillan-Price J, Brand-Miller J. Low-glycaemic index diets and body weight regulation. *Int J Obesity* 2006;30:S40–6.
59 Reynolds A, Mann J, Cummings J *et al*. Carbohydrate quality and human health: a series of systematic reviews and meta-analyses. *Lancet* 2019;393:434–45.
60 Thomas D, Elliott EJ, Baur L. Low glycaemic index or low glycaemic load diets for overweight and obesity. *Cochrane Database Syst Rev* 2007;2007:CD005105.
61 Zafar MI, Mills KE, Zheng J *et al*. Low-glycemic index diets as an intervention for diabetes: a systematic review and meta-analysis. *Am J Clin Nutr* 2019;110:891–902.
62 Chiavaroli L, Lee D, Ahmed A *et al*. Effect of low glycaemic index or load dietary patterns on glycaemic control and cardiometabolic risk factors in diabetes: systematic review and meta-analysis of randomised controlled trials. *BMJ* 2021;374:n1651.

63 NICE. *Recommendations: Type 1 diabetes in adults: diagnosis and management*. London; National Institute for Health and Care Excellence, 2015.
64 Saadati N, Haidari F, Barati M *et al*. The effect of low glycemic index diet on the reproductive and clinical profile in women with polycystic ovarian syndrome: a systematic review and meta-analysis. *Heliyon* 2021;7:e08338.
65 Shishehgar F, Mirmiran P, Rahmati M *et al*. Does a restricted energy low glycemic index diet have a different effect on overweight women with or without polycystic ovary syndrome? *BMC Endocrine Disorders* 2019;19:93.
66 Porrini M. Weight, protein, fat, and timing of preloads affect food intake. *Physiol Behav* 1997;62:563–70.
67 Westerterp-Plantenga M, Rolland V, Wilson S *et al*. Satiety related to 24 h diet-induced thermogenesis during high protein/carbohydrate vs high fat diets measured in a respiration chamber. *Eur J Clin Nutr* 1999;53:495–502.
68 Lejeune MP, Westerterp KR, Adam TC *et al*. Ghrelin and glucagon-like peptide 1 concentrations, 24-h satiety, and energy and substrate metabolism during a high-protein diet and measured in a respiration chamber. *Am J Clin Nutr* 2006;83:89–94.
69 van Baak MA, Mariman ECM. Dietary strategies for weight loss maintenance. *Nutrients* 2019;11:1916.
70 Lean ME, Leslie WS, Barnes AC *et al*. Primary care-led Weight Management for Remission of Type 2 Diabetes (DiRECT): an open-label, cluster-randomised Trial. *Lancet* 2018;391:541–51.
71 Jebb SA, Astbury NM, Tearne S *et al*. Doctor Referral of Overweight People to a Low-Energy Treatment (DROPLET) in primary care using total diet replacement products: a protocol for a randomised controlled trial. *BMJ* 2017;7:e016709.
72 National Institute for Health and Care Excellence. *Obesity: identification, assessment and management*. NICE, 2014.
73 Tobias DK, Chen M, Manson JE *et al*. Effect of low-fat diet interventions versus other diet interventions on long-term weight change in adults: a systematic review and meta-analysis. *Lancet Diabetes Endocrinol* 2015;3:968–79.
74 Hooper L, Abdelhamid A, Moore HJ *et al*. Effect of reducing total fat intake on body weight: systematic review and meta-analysis of randomised controlled trials and cohort studies. *BMJ* 2012;345:e7666.
75 Ma C, Avenell A, Bolland M *et al*. Effects of weight loss interventions for adults who are obese on mortality, cardiovascular disease, and cancer: systematic review and meta-analysis. *BMJ* 2017;359:j4849.
76 Pi-Sunyer X. The Look AHEAD Trial: a review and discussion of its outcomes. *Curr Nutr Rep* 2014;3:387–91.
77 Wilding JPH, Batterham RL, Calanna S *et al*. Once-weekly semaglutide in adults with overweight or obesity. *N Engl J Med* 2021;384:989–1002.
78 Wharton S, Batterham RL, Bhatta M *et al*. Two-year effect of semaglutide 2.4 mg on control of eating in adults with overweight/obesity: STEP 5. *Obesity (Silver Spring)* 2023;31:703–15.
79 Sargeant JA, Henson J, King JA *et al*. A review of the effects of glucagon-like peptide-1 receptor agonists and sodium-glucose cotransporter 2 inhibitors on lean body mass in humans. *Endocrinol Metab (Seoul)* 2019;34:247–62.

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