Canadian Adult Obesity Clinical Practice GUIDELINES

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L'ASSOCIATION CANADIENNE des MEDECINS et CHIRURGIENS BARIATRIQUE
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Medical Nutrition Therapy in Obesity Management

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Version 1, August 4, 2020. Adult Obesity Clinical Practice Guidelines are a living document, with only the latest chapters posted at obesitycanada.ca/guidelines.

KEY MESSAGES FOR HEALTHCARE PROVIDERS

- Healthy eating is important for all Canadians, regardless of body size, weight or health status. Key messages from *Canada's Food Guide for Healthy Eating* can be used as a foundation for nutrition and food-related education. Use evidence-based nutrition resources to give your patients nutrition and behaviour-change advice that aligns with their values, preferences and social determinants of health (Figure 1).
- There is no one-size-fits-all eating pattern for obesity management. Adults living with obesity may consider various nutrition intervention options that are client-centred and flexible. Evidence suggests this approach will better facilitate long-term adherence (Table 1, Figure 2).
- Nutrition interventions for obesity management should focus on achieving health outcomes for chronic disease risk reduction and quality of life improvements, not just weight changes. Table 2 outlines health-related outcomes to support patients/clients in obesity management.
- Nutrition interventions for obesity management should emphasize individualized eating patterns, food quality and a healthy relationship with food. Including mindfulness-based eating practices that may help lower food cravings, reduce reward-driven eating, improve body satisfaction and improve awareness of hunger and satiety.
- Caloric restriction can achieve short-term reductions in weight (i.e.,< 12 months) but has not shown to be sustainable long-term (i.e., > 12 months). Caloric restriction may affect neurobiological pathways that control appetite, hunger, cravings and body weight regulation that may result in increased food intake and weight gain.
- People living with obesity are at increased risk for micronutrient deficiencies including but not limited to vitamin D, vitamin B12 and iron deficiencies. Restrictive eating patterns and obesity treatments (e.g. medications, bariatric surgery) may also result in micronutrient deficiencies and malnutrition. Assessment including biochemical values can help inform recommendations for food intake, vitamin/mineral supplements and possible drug-nutrient interactions.
- Collaborate care with a registered dietitian who has experience in obesity management and medical nutrition therapy. Dietitians can support people living with obesity who also have other chronic diseases, malnutrition, food insecurity or disordered patterns of eating.
- Future research should use nutrition-related outcomes and health behaviours in addition to weight and body composition outcomes. Characterization of population sample collections should use the updated definition of obesity as "a complex chronic disease in which abnormal or excess body fat (adiposity) impairs health, increases the risk of long-term medical complications and reduces lifespan" rather than BMI exclusively. Qualitative data is needed to understand the lived experience of people with obesity.

RECOMMENDATIONS

1. We suggest that nutrition recommendations for adults of all body sizes should be personalized to meet individual values, preferences and treatment goals to support a dietary approach that is safe, effective, nutritionally adequate, culturally acceptable and affordable for long-term adherence (Level 4, Grade D).[5]

2. Adults living with obesity should receive individualized medical nutrition therapy provided by a registered dietitian (when available) to improve weight outcomes (body weight, BMI), waist circumference, glycemic control, established lipid, and blood pressure targets (Level 1a, Grade A).[6]

3. Adults living with obesity and impaired glucose tolerance (prediabetes) or type 2 diabetes may receive medical nutrition therapy provided by a registered dietitian (when available) to reduce body weight and waist circumference and improve glycemic control and blood pressure. (Level 2a, Grade B.)[7,8]

4. Adults living with obesity can consider any of the multiple medical nutrition therapies to improve health-related outcomes, choosing the dietary patterns and food-based approaches that support their best long-term adherence:

    a. Calorie-restricted dietary patterns emphasizing variable macronutrient distribution ranges (lower, moderate, or higher carbohydrate with variable proportions of protein and fat) to achieve similar body weight reduction over 6–12 months (Level 2a, Grade B).[9]

    b. Mediterranean dietary pattern to improve glycemic control, HDL-cholesterol and triglycerides (Level 2b, Grade C),[10] reduce cardiovascular events (Level 2b, Grade C),[11] reduce risk of type 2 diabetes; (Level 2b, Grade C),[12,13] and increase reversion of metabolic syndrome (Level 2b, Grade C)[14] with little effect on body weight and waist circumference (Level 2b, Grade C).[15]

    c. Vegetarian dietary pattern to improve glycemic control, established blood lipid targets, including LDL-C, and reduce body weight, (Level 2a, Grade B),[16] risk of type 2 diabetes (Level 3, Grade C)[17] and coronary heart disease incidence and mortality (Level 3, Grade C).[18]

    d. Portfolio dietary pattern to improve established blood lipid targets, including LDL-C, apo B, and non-HDL-C (Level 1a, Grade B),[19] CRP, blood pressure, and estimated 10-year coronary heart disease risk (Level 2a, Grade B).[19]

    e. Low-glycemic index dietary pattern to reduce body weight (Level 2a, Grade B)[20] glycemic control, (Level 2a, Grade B),[21] established blood lipid targets, including LDL-C (Level 2a, Grade B),[22] and blood pressure (Level 2a, Grade B)[23] and the risk of type 2 diabetes (Level 3, Grade C)[24] and coronary heart disease (Level 3, Grade C).[25]

    f. Dietary Approaches to Stop Hypertension (DASH) dietary pattern to reduce body weight and waist circumference; (Level 1a, Grade B),[26] improve blood pressure (Level 2a, Grade B),[27] established lipid targets, including LDL-C (Level 2a, Grade B),[27] CRP (Level 2b, Grade B),[28] glycemic control; (Level 2a, Grade B),[27] and reduce the risk of diabetes, cardiovascular disease, coronary heart disease, and stroke (Level 3, Grade C).[27]

    g. Nordic dietary pattern to reduce body weight (Level 2a, Grade B)[29] and body weight regain (Level 2b, Grade B)[30] improve blood pressure (Level 2b, Grade B)[30] and established blood lipid targets, including LDL-C, apo B, (Level 2a, Grade B),[31] non-HDL-C (Level 2a, Grade B)[32] and reduce the risk of cardiovascular and all-cause mortality (Level 3, Grade C).[33]

    h. Partial meal replacements (replacing one to two meals/day as part of a calorie-restricted intervention) to reduce body weight, waist circumference, blood pressure and improve glycemic control (Level 1a, Grade B).[34]

    i. Intermittent or continuous calorie restriction achieved similar short-term body weight reduction (Level 2a, Grade B).[35]

    j. Pulses (i.e. beans, peas, chickpeas, lentils) to improve body weight (Level 2, Grade B)[36] improve glycemic control, (Level 2, Grade B),[37] established lipid targets, including LDL-C, (Level 2, Grade B),[38] systolic BP (Level 2, Grade C),[39] and reduce the risk of coronary heart disease (Level 3, Grade C).[40]

    k. Vegetables and fruit to improve diastolic BP (Level 2, Grade B),[41] glycemic control (Level 2, Grade B),[42] reduce the risk of type 2 diabetes (Level 3, Grade C)[43] and cardiovascular mortality (Level 3, Grade C).[44]

    l. Nuts to improve glycemic control, (Level 2, Grade B)[45] established lipid targets, including LDL-C (Level 3, Grade C),[46] and reduce the risk of cardiovascular disease (Level 3, Grade C).[47]

    m. Whole grains (especially from oats and barley) to improve established lipid targets, including total cholesterol and LDL-C (Level 2, Grade B).[48]

    n. Dairy foods to reduce body weight, waist circumference, body fat and increase lean mass in calorie-restricted diets but not in unrestricted diets (Level 3, Grade C)[49] and reduce the risk of type 2 diabetes and cardiovascular disease (Level 3, Grade C).[43]

5. Adults living with obesity and impaired glucose tolerance (prediabetes) should consider intensive behavioural interventions that target a 5%–7% weight loss to improve glycemic control, blood pressure and blood lipid targets (Level 1a, Grade A),[50] reduce the incidence of type 2 diabetes, (Level 1a, Grade A),[51] microvascular complications (retinopathy, nephropathy, and neuropathy) (Level 1a Grade B)[52] and cardiovascular and all-cause mortality (Level 1a, Grade B).[52]

6. Adults living with obesity and type 2 diabetes should consider intensive lifestyle interventions that target a 7%–15% weight loss to increase the remission of type 2 diabetes (Level 1a, Grade A)[53] and reduce the incidence of nephropathy (Level 1a, Grade A)[54] obstructive sleep apnea (Level 1a, Grade A),[55] and depression (Level 1a, Grade A).[56]

7. We recommend a non-dieting approach to improve quality of life, psychological outcomes (general well-being, body image perceptions), cardiovascular outcomes, body weight, physical activity, cognitive restraint and eating behaviours (Level 3, Grade C).[57]

KEY MESSAGES FOR PEOPLE LIVING WITH OBESITY

- Nutrition is important for everyone, regardless of body size or health. Your health is not a number on a scale. When you are ready to make a change, choose behaviour-related goals to improve your nutrition status and health (medical, functional, emotional health) (Table 2).
- There is no one-size-fits-all healthy eating pattern. Choose an eating pattern that supports your best health and one that can be maintained over time, rather than a short-term "diet." Talk to your healthcare provider to discuss the advantages and disadvantages of different eating patterns to help achieve your health-related goals.
- How you eat is as important as what and how much you eat. Practice eating mindfully and promote a healthy relationship with food.
- "Dieting" or severely restricting the amount you eat may cause changes to your body that can lead to weight regain over time.
- See a registered dietitian for an individualized approach and ongoing support for your nutrition and health-related needs.

Introduction

People living with obesity[1] and people with larger bodies are often stigmatized and scrutinized for their food choices, portions and eating behaviours.[1–3] Much of the social marketing efforts, public health and clinical messaging around food and eating behaviours has focused on "eating less" or choosing "good" foods. As a result of these messages, dieting and weight-loss focused outcomes perpetuate the notion that weight loss and/or "health" can be achieved purely by caloric restriction, food deprivation and/or "dieting" practices. These simplistic narratives often neglect the evidence that weight loss may not be sustainable long-term, not because of personal choices or lack of willpower, but rather from strong biological or physiological mechanisms that protect the body against weight loss. The diet industry and weight loss focused research field has thus falsely advertised diet or food and eating habits as the culprit for weight gain, contributing to the bias and stigma reviewed in the *Reducing Weight Bias* in *Obesity Management Practice and Policy* chapter. A paradigm shift is needed in all aspects of nutrition and eating behaviour research, policies, education and health promotion to support people of all weights, body shapes and sizes to eat well without judgment, criticism or bias regarding food and eating behaviours.

This chapter provides evidence-informed information on nutrition interventions conducted in clinical and/or epidemiological studies in the context of obesity management for adults. Caution is needed when interpreting much of the nutrition-specific evidence as weight loss is often a primary outcome in nutrition-related studies, and most studies have used the definition of obesity according to body mass index (BMI) classifications instead of the current definition (Obesity is a chronic, progressive and relapsing disease characterized by the presence of adiposity that impairs health and social well-being) reviewed in the summary article of these guidelines (published in the *Canadian Medical Association Journal*) chapter and the Assessment of People Living with Obesity chapter. Recommendations and key messages in this chapter are specific for people living with obesity and may not be applicable or appropriate for people with larger bodies who do not have health impacts from their weight. Furthermore, this chapter is specific for primary care providers (i.e., general practitioners) and to support coordination of care with regulated nutrition professionals in Canada (i.e., registered dietitians [RD] or registered dietitian/nutritionist [RDN], diététistes [Dt.P. or P.Dt.]). Future research should assess nutrition-related outcomes, health-related outcomes and behaviour changes instead of weight loss outcomes alone across all weight spectrums.

Traditional nutrition interventions for obesity have focused on strategies that promote weight loss through dietary restriction. Although a caloric deficit is required to initiate weight loss, sustaining lost weight may be difficult long term due to compensatory

mechanisms that promote positive calorie intake by increasing hunger and the drive to eat.[64–66] Providers, policy makers, patients/clients and the general public should be aware that nutrition interventions affect everyone differently, and therefore there is no one best nutrition approach or intervention.[67] As such, some people may favour an approach that is macronutrient-based (consisting of higher, moderate or lower intake of carbohydrates, protein and/or fat), caloric restricted, food-based or non-dieting. Nutrition and healthy eating are important to the health and well-being of all Canadians, regardless of weight, body size or health status. In the context of obesity management, the best nutrition approach is one an individual can maintain long term to achieve health-related and/or weight-related outcomes.[9] Table 1 and Figure 2 provide an overview of the various nutrition interventions used to influence weight change, health and quality of life indicators, as well as advantages and disadvantages of each.

Individualized medical nutrition therapy

Nutrition interventions should use a shared decision-making approach to improve overall health, promote a healthy relationship with food, consider the social context of eating and promote eating behaviours that are sustainable and realistic for the individual. An RD should be involved in the assessment, delivery and evaluation of care wherever possible. MNT provided by a registered dietitian has demonstrated improvements in weight outcomes (body weight and BMI), waist circumference, glycemic control, reduction in LDL-C, triglycerides and blood pressure.[6–8]

Systematic reviews and meta-analyses of randomized controlled trials have shown that individualized nutrition consultation by a registered dietitian decreases weight by an additional -1.03 kg and BMI by -0.43 kg/m^2 in participants with BMI ≥25 kg/m^2 compared with usual care or written documentation.[6] In adults living with type 2 diabetes, MNT by a registered dietitian resulted in significant reductions of HgA1c, weight, BMI, waist circumference, cholesterol and systolic blood pressure reported by systematic reviews and meta-analyses.[8] In addition, MNT delivered by an RD to individuals and/or group-based sessions for the prevention of type 2 diabetes has also found a weight loss range of -1.5 to -13 kg (3–26% weight loss) with a pooled effect of -2.72 kg by meta-analysis.[7] Table 1 provides outcomes measures for weight and health parameters when using individualized MNT by an RD.

Nutrition interventions

Nutrition interventions that are safe, effective, nutritionally adequate, culturally acceptable and affordable for long-term adherence should be considered for adults living with obesity.[5] Healthcare providers should adapt nutrition interventions and/or adjunct therapy to meet their patient/clients' individual values, preferences and treatment goals. However, to date, no single best nutrition intervention has been shown to sustain weight loss long-term, and literature continues to support the importance of long-term adherence, regardless of the intervention.[9,68]

Definitions of Terms Used in This Chapter

Obesity: Historically, obesity has been defined using a body mass index (BMI) of ≥ 30 kg/m^2. The Assessment of People Living with Obesity chapter reviews the limitations and biases associated with using this BMI definition. Although increased body fat can have important implications for health and well-being, the presence of increased body fat alone does not necessarily imply or reliably predict ill health. For this reason, evidence reviewed in this chapter that included participants with overweight or obesity using BMI categories (≥ 25 kg/m^2 or ≥ 30 kg/m^2, respectively) without any reported adiposity-related health and social well-being impairments are referred to as "people with a BMI ≥ 25 kg/m^2" (descriptive characteristics of size, not health). The Canadian Adult Obesity Clinical Practice Guidelines define obesity as "a complex chronic disease in which abnormal or excess body fat (adiposity) impairs health, increases the risk of long-term medical complications and reduces lifespan." We use this definition rather than weight or BMI by referring to "adults living with obesity" using people-first language[1] and in support of changing the narrative about obesity.[3,4] We recognize that this may be controversial and acknowledge that further research is needed to compare nutrition interventions using new definitions of obesity; however a diagnosis of obesity in clinical practice requires a comprehensive assessment to mitigate unintentional weight bias or stigma that may exist if using BMI alone.

Obesity management: The term "obesity management" is used to describe health-related improvements beyond weight-loss outcomes alone. If weight loss occurred as a result of the intervention, this should not be the focus over the health and quality of life (QoL) improvements.

Medical Nutrition Therapy: Medical nutrition therapy (MNT) is an evidence-based approach used in the nutrition care process (NCP) of treating and/or managing chronic diseases, often used in clinical and community settings, that focuses on nutrition assessment, diagnostics, therapy and counselling. MNT is often implemented and monitored by a registered dietitian and/or in collaboration with physicians and regulated nutrition professionals. For these guidelines, MNT will be used as a standard language in nutritional therapeutic approaches for obesity interventions.

Nutrition interventions: This term is used instead of "diet" to refer to evidence-based, nutrition-related approaches for improving health outcomes instead of weight-loss focused ideals that are often associated with the term "diet."

Caloric restriction

Studies on caloric restriction generally fall into three categories: moderate calorie (1300–1500 kcal/day), low-calorie (900–1200 kcal/day) and very low-calorie (< 900 kcal/day), with intervention periods ranging from three months to three years.

A randomized clinical trial of women (25–75 years old) with BMI 37.84 +/- 3.94 kg/m^2 found prescribing 1000 versus 1500 kcal/day along with behavioural treatment produced greater weight loss at six months, but there was significant weight regain at 12 months as compared with the 1500 kcal/day group.[69] At 12 months, a significantly greater percentage of participants prescribed 1000 kcal/day had body weight reductions of 5% or more than those assigned 1500 kcal/day.[69] However, a 1000 kcal/day prescription may be more difficult to sustain, especially for individuals for whom the caloric reduction is 50% or more from their usual intake.[69]

A randomized clinical trial of older adults (≥ 65 years old) who were advised to reduce their caloric intake by 500 kcal/day below their estimated caloric needs with a minimum intake of 1000 kcal/day had a significant decrease in body weight (4%) at 12 months, as well as significant improvements in blood glucose and HDL-cholesterol.[70]

A systematic review and meta-analysis of randomized control trials using very low-calorie diets (VLCD), with or without meal replacements, for weight loss found using a VLCD within a behavioural weight loss program produced greater weight loss at 12 months (-3.9 kg) and 24 months (1.4 kg) than a behavioural program alone.[71] There was no evidence a VLCD intervention without behavioural support is effective.[71]

Although MNT that achieves a caloric deficit can result in weight loss in the short-term (6–12 months), the weight change is often not sustained over time. Furthermore, the common recommendation that a caloric deficit of 500 kcal/day or 3500 kcal/week would produce 1 lb (0.45 kg) of weight loss is not valid, in that weight loss is not linear.[72,73] Polidori and colleagues first quantified the amount of calorie intake compensated for weight loss changes in free living humans and estimated that appetite increased by ~100 kcal/day for every kilogram of weight lost, contributing to weight gain over time.[74] Caloric restriction may in some individuals lead to pathophysiological drivers to promote weight gain via increased hunger, appetite and decreased satiety.[66] In addition, caloric restrictions may have negative consequences for skeletal health[75] and muscle strength,[76] contributing to the role of individualizing nutrition interventions that are safe, effective and meet the values and preferences of the patient/client. Indirect calorimetry should be considered if energy expenditure and/or caloric targets are indicated.[58]

Macronutrient-based approaches

Macronutrients are the main source of calories in the diet. The dietary reference intakes (DRIs) are a comprehensive set of nutrient reference values for healthy populations that can be used for assessing and planning eating patterns. (For more information, refer to: https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/dietary-reference-intakes.html) The dietary reference intakes permit wide acceptable macronutrient distribution ranges. They allow, for example, 45% to 65% of calories from carbohydrate, 10% to 35% of calories from protein and 20% to 35% of calories from fat (with 5% to 10% of calories derived from linoleic acid and 0.6% to 1.2% of calories derived from alpha linolenic acid).[77]

Several macronutrient-based approaches have been investigated within and outside these ranges. Researchers have evaluated, for instance, low carbohydrate diets that substitute fat and protein at the expense of carbohydrate but include adequate protein (15%–20% of calories). Studies have also investigated extremely low-carbohydrate (≤10% of calories) variants, including variants like the ketogenic diet which are extremely high in fat (≥75% of calories). No meaningful advantages of one macronutrient distribution over another have reliably been shown. A network meta-analysis was undertaken of 48 randomized controlled trials (involving 7,286 participants) that provided dietary advice to consume varying macronutrient distributions under free-living conditions. This meta-analysis showed no differences in weight loss at six months and 12 months of follow-up between diets categorized broadly by their macronutrient distribution as low carbohydrate, moderate-macronutrient, or low-fat, or categorized by their 11 popular diet names encompassing a wide range of distributions.[9] Subsequent large randomized controlled trials have confirmed these findings.[78]

The lack of meaningful differences between different macronutrient distributions has been shown to extend to cardiometabolic risk factors. Systematic reviews and meta-analyses of randomized trials have investigated glycemic control in people with diabetes (inclusive of people with BMI ≥25 kg/m^2). These trials have failed to show that the early improvements seen in glycemic control at six months are sustained at 12 months on low-carbohydrate diets (≤40% of calories from carbohydrate or 21g–70g) in which the carbohydrate has been replaced with fat and/or protein.[79] Researchers have also assessed the effects of low-carbohydrate diets that replace carbohydrate with protein in people with or without diabetes who have a BMI ≥25 kg/m^2. They report a similar attenuation of effects on fasting blood glucose and triglycerides and lack of effect on blood pressure and C-reactive protein over follow-up periods that extend beyond 12 months.[80] Any improvements in triglycerides and HDL-C have also been found to come at the expense of increases in the more atherogenic and established lipid targets for cardiovascular risk reduction, LDL-C, non-HDL-C and apo B.[79,81] According to available randomized controlled trials, the most important determinants of achieving any benefit over the long-term are adherence to any one macronutrient distribution and clinic attendance.[9,80,82,83]

This data from randomized controlled trials is supported by evidence from large prospective cohort studies that allow macronutrient exposures to be assessed in relation to downstream clinical outcomes of cardiometabolic diseases. No single approach

appears superior, with harm observed at the extremes of intake. A systematic review and meta-analysis were undertaken of five prospective cohort studies involving 432,179 participants over a median follow-up of 25 years. The evidence showed a U-shaped relationship between carbohydrate and mortality, with lower-carbohydrate (< 40% of calories) and higher carbohydrate (>70% of calories) diets associated with increased mortality, and the wide range between (40–70% of calories) associated with lower mortality.[84] The Prospective Urban and Rural Epidemiological (PURE) cohort study involved 135,335 participants from 18 low-, middle- and high-income countries; the participants were free of cardiovascular disease. PURE did not show an adverse association with lower-carbohydrate interventions, an demonstrated only that higher carbohydrate interventions (>70% of calories) were associated with increased cardiovascular and all-cause mortality over 10 years of follow-up.[85]

The quality of the macronutrients substituted appears to be a more important consideration than the quantity. The Eco-Atkins randomized trial showed that a lower-carbohydrate intervention (26% of total calories) reduced LDL-C in 47 participants with BMI >27 kg/m^2 and hyperlipidemia over four weeks, during which foods were provided, and another six months during which foods were self-selected.[86,87] This intervention replaced refined, high-glycemic index carbohydrate sources with high-quality unsaturated fat from nuts and canola oil and plant-based protein from soy and pulses.

Systematic reviews and meta-analyses of randomized controlled trials of interventions that focus on the quality of the fat or protein separately have also shown advantages. Researchers have also investigated isocaloric replacement of refined carbohydrate sources with high-quality monounsaturated fatty acids (MUFAs) from canola oil and olive oil[88] or animal protein with sources of plant-based protein.[89,90] These studies have shown improvements in multiple cardiometabolic risk factors in people with diabetes and a BMI ≥25 kg/m^2, over average follow ups of 19 weeks and eight weeks, respectively.[88] Similarly, dairy whey protein supplements substituted for largely other protein sources and/or carbohydrate have shown reductions in body weight and fat mass, and improvements in blood pressure, blood glucose and blood lipids over follow-up ranging from two weeks to 15 months in people with BMI ≥25 kg/m^2.[91] Other systematic reviews and meta-analyses of randomized cardiovascular outcomes trials have shown that the beneficial effect of low saturated fatty acids (SFAs) diets on cardiovascular events is restricted to the replacement of saturated fatty acids with polyunsaturated fatty acids,[92] especially mixed n-3/n-6 sources such as soybean oil and canola oil.[93]

The importance of the quality of macronutrients has been seen in the observational evidence from prospective cohort studies. Pooled analyses of the Harvard prospective cohort studies and large individual prospective cohort studies have evaluated the incidence of cardiovascular disease. These analyses suggest that replacement of SFAs with high-quality sources of MUFAs (from olive oil, canola oil, avocado, nuts and seeds) and high-quality sources of carbohydrates (from whole grains and low-glycemic index carbohydrate foods) is associated with decreased incidence of coronary heart disease.[94,95] Whereas the substitution of animal fat or animal protein for carbohydrate was associated with an increase in mortality, the replacement of carbohydrate with plant-based unsaturated fats and protein is shown to be associated with a reduction in mortality.[84] The source of carbohydrate has also been shown to be important. An analysis of the PURE study showed that the source of carbohydrate may modify the association. The highest intake of carbohydrate (from sources such as legumes and fruit) was associated with lower cardiovascular mortality and all-cause mortality.[96]

Taken together, the available evidence related to macronutrients suggests that there is a wide range of acceptable intakes, emphasizing the role of individualized MNT. The data also suggest that quality may be a more important focus than quantity in the evaluation of the relationship between macronutrient distributions and cardiometabolic outcomes. This theme is reflected in the subsequent discussions of dietary patterns and food-based approaches.

Dietary fibre

High intakes of dietary fibre are recommended for the general population. The DRIs have set an adequate intake (AI) for total fibre from naturally occurring, added or supplemental sources of 25 g/day and 38 g/day for women and men 19–50 years of age, respectively, and 21 g/day and 30 g/day for women and men ≥51 years of age, respectively.[77] Several advantages have been shown for dietary fibre. The World Health Organization (WHO) commissioned a series of systematic reviews and meta-analyses of prospective cohort studies, inclusive of people without acute or chronic diseases (including individuals with prediabetes, mild to moderate hypercholesterolaemia, mild to moderate hypertension, or metabolic syndrome). The evidence showed that higher intakes of total dietary fibre were associated with decreased incidence of diabetes, coronary heart disease and mortality, stroke and mortality, colorectal cancer, and total cancer and mortality. The authors did not observe differences in risk reduction by fibre type (insoluble, soluble or soluble viscous) or fibre source (cereals, fruit, vegetables or pulses).[97] Meta-regression dose response analyses showed that benefits were associated with intakes greater than 25 g–29 g per day.[97] Similar results have been shown in systematic reviews and meta-analyses of prospective cohort studies that did not exclude people with diabetes.[98]

Despite the lack of interaction by fibre type and source in the prospective cohort studies, the evidence from randomized controlled trials differs. This data supports the benefits of dietary fibre on intermediate cardiometabolic risk factors and suggests these are restricted largely to fibre from a soluble viscous fibre. Soluble viscous fibre is the only fibre supported by Health Canada with approved health claims for lowering cholesterol from oats, barley, psyllium and polysaccharide complex (glucomannan, xanthan gum, sodium alginate),[99–101] and postprandial glycemia in the case of the polysaccharide complex (glucomannan, xanthan gum, sodium alginate).[102] Systematic reviews and meta-analyses of randomized controlled trials have evaluated specific types of soluble viscous fibre. The evidence from oats (beta-glucan), barley (beta-glucan),

psyllium, konjac mannan (glucomannan) and fruit and vegetables (pectin) shows improved glycemic control by HbA1c and fasting blood glucose, insulin resistance by HOMA-IR, blood pressure, and blood lipids, including the established therapeutic lipid targets LDL-C, non-HDL-C and apo B.[103–108] The studies also highlighted that insoluble fibre, other than contributing to stool bulking,[109] has not shown cardiometabolic advantages in comparison with low-fibre controls or in direct comparisons with viscous soluble fibre, where it is often used as a neutral comparator of soluble viscous fibre.[110–113]

Mixed fibre interventions emphasizing high intakes of dietary fibre from a combination of types (insoluble, soluble, and soluble viscous) and sources (cereals, fruit, vegetables and/or pulses), however, have shown cardiometabolic advantages. The WHO commissioned a series of systematic reviews and meta-analyses of randomized controlled trials inclusive of people without acute or chronic diseases (including individuals with prediabetes, mild to moderate hypercholesterolaemia, mild to moderate hypertension, or metabolic syndrome), and earlier pooled analyses of randomized and non-randomized controlled trials in people with diabetes have evaluated mixed fibre interventions. These have shown that mixed fibre interventions result in reductions in body weight and improvements in HbA1C, postprandial glycemia, blood pressure and blood lipids.[97,114] Dose thresholds for benefit are unclear but generally support optimal benefits at intakes of ≥ 25 g/day of total fibre in mixed fibre interventions providing 10 g/day to 20 g/day of soluble viscous fibre.[97,114]

Low-calorie sweeteners

Recent syntheses of the evidence for low-calorie sweeteners and health outcomes have come to different conclusions. Important sources of disagreement appear to be the failure to account for the nature of the comparator in the interpretation of randomized controlled trials and the high risk of reverse causality in the models favoured by prospective cohort studies.[115–117]

Systematic reviews and meta-analyses of randomized controlled trials and individual randomized controlled trials investigating the effect of low-calorie sweeteners in substitution for water, placebo or matched weight-loss diets (conditions under which there is no caloric displacement) have not shown weight loss or improvements in cardiometabolic risk factors,[118,119] with few exceptions.[120]

Systematic reviews and meta-analyses of randomized controlled trials and individual randomized controlled trials have also evaluated the effect of the intended substitution of low-calorie sweeteners for sugars or other caloric sweeteners (conditions under which there is caloric displacement, usually from sugar-sweetened beverages). This research has shown the expected modest weight loss and attendant improvements in cardiometabolic risk factors (blood glucose, blood pressure and liver fat) in people with BMI ≥25 kg/m^2.[119,121–123] Similar disagreements are seen depending on the models used in the prospective cohort studies.

Systematic reviews and meta-analyses of prospective cohort studies and individual large prospective cohort studies that have modelled baseline or prevalent intake of low-calorie sweeteners have shown an association with weight gain and an increased incidence of diabetes and cardiovascular disease.[118,119] Other studies have used analytical approaches to mitigate reverse causality by modelling change in intake or substitution of low-calorie sweetened beverages for sugar-sweetened beverages. This research has reported associations with weight loss and a decreased incidence of diabetes, cardiovascular disease, and all-cause mortality[116,124,125] in populations inclusive of people with BMI ≥25 kg/m^2. Taken together, these different lines of evidence indicate that low-calorie sweeteners in substitution for sugars or other caloric sweeteners, especially in the form of sugar-sweetened beverages, may have advantages like those of water or other strategies intended to displace excess calories from added sugars.

Dietary patterns

Several interventions using specific dietary patterns have shown advantages for weight loss and maintenance with improvements in cardiometabolic risk factors and associated reductions in obesity-related complications (Table 1). The Mediterranean dietary pattern is a plant-based dietary pattern that emphasizes a high intake of extra virgin olive oil, nuts, fruit and vegetables, whole grains and pulses; a moderate intake of wine, fish and dairy; and a low intake of red meats. This dietary pattern has shown weight loss and improvements in glycemic control and blood lipids compared with other dietary patterns in people with type 2 diabetes.[10] These improvements have been reflected in benefits in important clinical outcomes. The PREvención con DIeta MEDiterránea (PREDIMED) study was a large Spanish multicentre randomized trial which was recently retracted and republished.[11] PREDIMED investigated a calorie-unrestricted Mediterranean dietary pattern, supplemented with either extra virgin olive oil or mixed nuts, compared with a control diet (calorie-unrestricted low-fat American Heart Association) in 7447 participants at high cardiovascular risk. More than 90% of the participants had a BMI ≥25 kg/m^2. The researchers concluded that the Mediterranean dietary pattern reduced major cardiovascular events by ~30%, diabetes incidence by 53% (single-centre finding), and increased reversion of metabolic syndrome by ~30%, with little effect on body weight over a median follow-up of 4.8 years.[11–14,126]

Numerous other dietary patterns have been investigated for their effects on body weight, cardiometabolic risk factors, and obesity-related complications. These include:

- Low-glycemic index: A dietary pattern that emphasizes the exchange of low-glycemic index foods (temperate fruit, dietary pulses, heavy mixed grain breads, pasta, milk, yogurt, etc.) for high-glycemic index foods.[20–25,127–129]

- Dietary approaches to stop hypertension (DASH): A dietary pattern emphasizing a high intake of fruit, low-fat dairy, vegetables, grains, nuts, and dietary pulses and a low intake of red meat, processed meat, and sweets.[27,28]

- Portfolio: A plant-based dietary pattern emphasizing the intake of a portfolio of cholesterol-lowering foods (e.g. nuts; plant-based protein from soy and pulses; viscous fibre from oats, barley and psyllium; and plant sterols, plus MUFAs from extra virgin olive oil or canola oil), all of which have Food and Drug Administration (FDA), Health Canada and/or European Food Safety Authority approved health claims for cholesterol-lowering or cardiovascular disease risk reduction.[19]

- Nordic: A Nordic dietary translation of the Mediterranean, Portfolio, DASH and National Cholesterol Education Program dietary patterns. Nordic emphasizes foods typically consumed as part of a traditional diet in Nordic countries.[29–33,130,131]

- Vegetarian: A plant-based dietary pattern that includes four main variants (lacto-ovo vegetarian, lacto vegetarian, vegetarian and vegan).[16–18]

Systematic reviews and meta-analyses have shown that these different dietary patterns improved cardiometabolic risk factors in randomized controlled trials. They are associated with decreased incidence of diabetes and cardiovascular disease in large prospective cohort studies inclusive of people with a BMI ≥25 kg/m^2.

Meal replacements

Partial meal replacements are used to replace one to two meals per day as part of a calorie-restricted intervention. These calorie-restricted interventions have been shown to reduce body weight, waist circumference, blood pressure and glycemic control compared with conventional, calorie-restricted weight loss diets in a systematic review and meta-analysis of nine randomized control trials in people with a BMI ≥25 kg/m^2 and type 2 diabetes over a median follow-up of six months.[34] Another systematic review and meta-analysis of 23 randomized control trials reported programs that include partial meal replacements achieved greater weight loss at one year compared with weight loss programs without use of partial meal replacements, with or without behavioural change support.[132] These results are consistent with an earlier meta-analysis.[133] At one year, attrition rates were high, but better for the partial meal replacement group compared with the calorie-restricted group (47% vs. 64%, respectively) with no adverse effects.[133]

Meal replacements have also shown advantages as key features of intensive lifestyle intervention programs targeting ≥5% – 15% of weight loss. The largest comprehensive lifestyle intervention in people with type 2 diabetes, the Look AHEAD (Action for Health in Diabetes) trial, targeted ≥7% weight loss using meal replacements (with instruction to replace two meals per day with liquid meal replacements and one snack per day with a bar meal replacement) during weeks three to 19 on the intensive lifestyle intervention. Higher adherence to the use of meal replacements was associated with approximately four-times greater likelihood of achieving the ≥7% weight loss goal at one year, compared with participants with lower adherence at one year,[134] contributing to better glycemic control and less health-related complications over the 9.6 years of follow-up.[50,54,56] The more recent Diabetes Remission Clinical Trial (DiRECT) included total liquid meal replacements for the first 12–20 weeks of the intensive lifestyle intervention program. DiRECT showed a nearly 20-fold greater likelihood of achieving diabetes remission at 12 months of follow-up in participants living with obesity and type 2 diabetes.[53] Full meal replacements as part of intensive lifestyle programs are discussed in the Commercial Products and Programs in Obesity Management chapter.

VLCDs using meal replacements include medical supervision and extensive support (nutrition, psychological, exercise counselling) as part of the intervention. Long-term studies using VLCD interventions with partial meal replacements reported weight outcomes of -6.2% at year one and -2.3% at three years in those who attended over three years and did not have added pharmacotherapy treatment.[135] As previously reported, weight loss or weight cycling can lead to biological compensatory mechanisms that can promote long-term weight gain in some people.[64–66] Despite lack of weight maintenance long term, without treatment, higher weight trajectories could be expected. Therefore, adding other treatments (e.g. pharmacotherapy and/or surgery for appetite regulation) over time could be considered to support obesity management rather than weight loss alone.

Note: In Canada, meal replacement products for use in calorie-restricted interventions are regulated by the Canadian Food and Drug Regulations. (https://laws-lois.justice.gc.ca/eng/regulations/c.r.c.,_c._870/FullText.html)

Intermittent fasting

Intermittent fasting includes a variety of meal timing approaches that alternate periods of extended fasting (no intake, or less than 25% of needs) and periods of unrestricted intake. Intermittent fasting is also described as time-restricted feeding, alternate-day fasting or intermittent energy restriction; however, there are multiple variations reported in the literature.[59] There was limited evidence in human physiology and metabolism studies. In a systematic review and meta-analysis of randomized controlled trials, Cioffi et al. (2018)[35] identified 11 trials (eight-24 weeks) which found comparable outcomes between interventions using intermittent energy restriction compared with continuous energy restriction (weight, fat mass, fat free mass, waist circumference, glucose, HbA1C, triglycerides and HDL-C). Intermittent energy restriction was identified to reduce fasting insulin levels (pooled difference -0.89 uU/mL) compared to controls; however, the study authors questioned the clinical significance of this as there were no differences in glucose, HbA1C or HOMA-IR. Adherence was similar between continuous and intermittent energy restriction groups, with higher attrition rates and adverse events in the intermittent energy restriction groups.[35] Similar results for weight loss and glycemic control were reported in two recent papers (one systematic review and meta-analysis, and a systematic review) published after the literature review for this chapter (June 2018).[59,60]

Food-based approaches

Several dietary patterns emphasizing specific food-based approaches have shown advantages (Table 1). These include pulses (beans, peas, chickpeas, and lentils),[36–40] fruit and vegetables,[41,42,44] nuts,[45–47,136–138] whole grains (especially from oats and barley) [43,48,97,107,139,140] and dairy.[49,141–143] These food-based approaches have shown weight loss and/or weight maintenance, with improvements in cardiometabolic risk factors, in randomized controlled trials. There is also evidence of associated reductions in the incidence of diabetes and cardiovascular disease in large prospective cohort studies inclusive of people with a BMI ≥25 kg/m^2.

Intensive lifestyle intervention programs

Intensive lifestyle intervention (ILI) programs consist of resource-intensive, comprehensive, multi-modal behavioural interventions that are delivered by interprofessional teams (e.g. physicians, RDs, nurses and kinesiologists). These programs combine nutrition interventions with increased physical activity. The intensity of follow-up varied from weekly to every three months, with gradually diminishing contact over the course of the program. ILI programs that target ≥5% to 15% weight loss have shown sustained weight loss with marked improvements in cardiometabolic risk factors and obesity-related complications. Large, randomized controlled trials have shown that ILI programs improve glycemic control, blood pressure and blood lipids in adults living with obesity who have impaired glucose tolerance prediabetes[144–146] or type 2 diabetes.[50] These randomized controlled trials have also shown important clinical benefits of ILI programs, including:

- Type 2 diabetes;[51,52,144–147]
- Microvascular complications (retinopathy, nephropathy, and neuropathy);[52]
- Cardiovascular mortality, and all-cause mortality in adults living with obesity who have impaired glucose tolerance;[52] and
- Increases in the remission of type 2 diabetes;[53] and
- Reductions in the incidence of nephropathy,[54] obstructive sleep apnea[55] and depression[56] in adults with a BMI ≥25 kg/m^2 who have type 2 diabetes.

The available evidence suggests an overall benefit of different ILI programs in adults living with obesity. However, the feasibility of implementing these programs is dependent upon the availability of resources and access to an interprofessional team to achieve the target weight loss outcome (i.e., ≥5% to 15%).

Non-dieting approaches

Non-dieting approaches include an umbrella of concepts described in the literature that offer healthcare providers alternatives to weight-loss focused interventions.[148] These approaches often reject weight-loss or dieting practices and typically use concepts of mindfulness in response to internal hunger, satiety, cravings and appetite instead of caloric restriction or cognitive restraint. Components of a non-dieting approach may include the following concepts: weight neutral, weight inclusive, mindful eating, mindfulness-based interventions, size or body acceptance, and/or Health at Every Size® (HAES®).

Evidence is limited for non-dieting approaches. A systematic review and meta-analysis of nine studies (involving 1194 participants, BMI ≥25 kg/m^2 and follow-up over three–12 months) compared weight-neutral approaches to weight-loss interventions. Authors concluded that the two RCTs and seven non-randomized comparative studies found no significant differences in weight loss, BMI changes, cardio-metabolic outcomes (including blood pressure, glycemic control, lipid profile) or self-reported depression, self-esteem, QoL or diet quality. Small differences were found in self-reported bulimia and binge-eating behaviours.[61] One systematic review examined the Health at Every Size approach. HAES® does not support the medicalization or pathological narrative that obesity is a disease. It's a philosophy centred on respecting body shape and size diversity, health, and promoting eating and exercise behaviours based on non-weight centric goals.[149] The review found this approach improved QoL and psychological outcomes (general well-being, body image perceptions) with mixed results for cardiovascular outcomes (blood lipids, blood pressure), body weight, physical activity, cognitive restraint and eating behaviours.[57]

Another systematic review of randomized and non-randomized trials found various non-dieting approaches have evidence to positively influence eating behaviours (including disordered eating patterns), biochemical outcomes, fitness, diet quality, body image and mental health.[57,150]

Mindfulness-based interventions targeting self-awareness, specifically hunger, satiety and taste satisfaction, have been found to be effective for binge eating behaviours,[151–153] eating disorders,[151] positively affecting eating behaviours[148] and weight loss.[154,155] However, caution is needed when interpreting results from non-dieting approaches. There are various non-diet interventions reported in literature with a lack of control groups, a high risk of bias in trials, and inconsistent valid tools used to measure outcomes. Nonetheless, interventions focusing on non-weight loss or weight-neutral outcomes may have less impact on weight stigma and may support health behaviours across all weight spectrums, emphasizing the role non-dieting approaches could have on individualized nutrition interventions.

Clinical nutrition implications for acute weight-loss

In many clinical settings (primary care, acute or tertiary care, long-term care, etc.), some individuals living with obesity may benefit from acute weight loss. Acute weight loss can be desirable for the preservation of life, prevention of organ failure and/or for improving

functional QoL (i.e., compromised activities of daily living). Despite the risk for possible negative consequences of weight loss (i.e. weight gain, increased appetite, lean mass loss, etc.), acute weight loss via nutrition interventions may be a necessary and/or preferred treatment option as with other acute interventions. For example, someone with an ischemic bowel may require multiple bowel resections, resulting in parenteral nutrition support, intravenous vitamins/minerals, changes to macronutrient needs and lifelong monitoring of health, which may include monitoring weight for indicators of malnutrition. Likewise, someone with end-stage renal disease that requires renal replacement therapy may require medical nutrition therapy and food choice adjustment to maintain electrolytes, kidney function and organ preservation. Like obesity, nutrition interventions may be indicated for improvements in weight outcomes or cardiometabolic factors. Healthcare providers should use non-judgemental approaches when educating patients/clients about the benefits and risks of any nutrition intervention, including weight-loss interventions. Likewise, family members and/or the public should not judge or scrutinize individualized interventions indicated or selected by the patient/client and their healthcare provider.

Healthcare providers should practice caution, though, if using nutrition interventions for acute weight loss, as some individuals may be at high risk for malnutrition and/or sarcopenic obesity.[156–159] For example, weight reduction for people with knee osteoarthritis is often recommended to reduce pain and decrease the risk of infection for surgery (rates are higher in patients with BMI >30 kg/m^2 after total knee replacement).[160] However, BMI is not a good indicator of health or body composition, and weight reduction may not improve risk or outcomes due to muscle weakness, muscle mass loss, or sarcopenic obesity or malnutrition due to inadequate oral intake.[160] Nutrition interventions therefore should be used for optimizing nutritional, medical and functional health rather than facilitating weight loss specific goals. Conducting a comprehensive assessment (as outlined in *the* Assessment of People Living with Obesity chapter) and collaborating with a registered dietitian is recommended for the safety and efficacy of using nutrition interventions in acute weight loss.

Other considerations

Micronutrient deficiencies

People living with obesity are at increased risk for micronutrient deficiencies including but not limited to vitamin D, vitamin B12 and iron. The prevalence of vitamin D deficiency in obesity has been reported to be as high as 90%,[161] theorized by decreased bioavailability of vitamin D as it is sequestered in adipose tissue[162] or due to volumetric dilution.[163] Systematic reviews and meta-analyses of randomized clinical trials indicate that higher adiposity levels (% fat mass or fat mass) is associated with lower serum vitamin D 25(OH) D levels,[164–166] suggesting the need for healthcare providers to monitor vitamin D levels as part of routine assessment for obesity. Vitamin D supplementation has not been effective in treating obesity or for improving cardiometabolic outcomes as shown by meta-analyses of randomized clinical trials.[165,167,168] However, vitamin D supplementation for correction and/or prevention of deficiency (< 50 nmol/L as defined by the Institute of Medicine[169]) is recommended, especially in individuals at higher risk for vitamin D deficiency (Table 3).

Restrictive eating patterns, obesity treatments (e.g. medications, bariatric surgery) and drug-nutrient interactions may also result in micronutrient deficiencies, specifically vitamin B12 and iron deficiencies.[161,170,171] There is also growing evidence for thiamine (vitamin B1) and magnesium deficiencies.[172] Vitamin B12 deficiency has been shown to be associated with higher BMI categories,[173] however, interpretation of observational studies is cautioned due to large heterogeneity within studies. Poor iron status has also been associated with obesity with a 1.31-fold increased risk for iron deficiency in people living with obesity.[170] Assessment including biochemical values can help inform recommendations for food intake, vitamin/mineral supplements, and possible drug-nutrient interactions (Table 3).

Disordered eating patterns

Healthcare providers may be hesitant to recommend restricting intake or VLCDs, as an early literature review found the development of eating disorders in college-aged women was associated with a history of intentional caloric restriction for weight loss.[174] Current evidence shows mixed results, however, as limited studies have specifically assessed whether "dieting" practices (for pursuit of an ideal body weight or shape, drive for thinness and goals of weight loss) precipitate eating disorders (such as binge eating disorder or disordered eating behaviours). Epidemiological data over a 20-year longitudinal study indicated that eating disorders, drive for thinness, use of diet pills, laxatives and dieting methods to control weight declined in adult women but increased for adult men.[175]

A systematic review[176] found very low-calorie diets can be used without exacerbating existing eating disorders or binge eating episodes in medically supervised programs. Da Luz et al.[176] found binge eating decreased in VLCD interventions. A prospective randomized control trial found no disordered eating behaviours, no binge eating disorder and decreased symptoms of depression in caloricly restricted groups (1200 kcal–1500 kcal/day with conventional food, or 1000 kcal/day with full meal replacements) when compared to a non-caloric restricted approach.[177] Symptoms of poor self-esteem and negative body image thoughts declined in all three groups over time. Furthermore, a review paper of cross-sectional and prospective studies on dietary restriction and the development of eating disorders or disordered eating behaviours confirmed minimal to no evidence to support the causation.[178] Caution is recommended when interpreting findings from this report, as study intentions were not designed to specifically investigate dieting and eating disorders or disordered eating behaviours in people living with obesity.

A recent systematic review by the Australian National Eating Disorder Collaboration concluded that professional obesity management

interventions (using medical nutrition therapy, physical activity, behaviour therapy, pharmacotherapy or surgical interventions) does not precipitate eating disorders or increase risk for eating disorders in people with BMI ≥25 kg/m^2.[63] However, eating disorders are often underdiagnosed and untreated, and some evidence suggesting that people with eating disorders are more likely to seek weight-loss interventions.[62] Healthcare providers should consider referral to mental health professionals and/or eating disorder programs for assessment and treatment if symptoms are suspected. (Refer to the Role of Mental Health in Obesity Management chapter).

Assess risk for malnutrition prior to bariatric surgery

Limited high-quality evidence has reviewed preoperative malnutrition status in patients seeking bariatric surgery. Nonetheless, observational studies have indicated that patients living with obesity have a higher risk for inadequate nutritional status[156,179,180] and malnutrition.[156–158] A large, multicentre, retrospective, observational study (n=106,577) found that ~6% of patients undergoing bariatric surgery were malnourished and had increased risk of death or serious morbidity (DSM) and 30-day readmission rates.[157] This study also found that >10% weight loss prior to surgery was associated with nine times higher rates of death or serious disease conditions in patients with mild malnutrition and ten times higher death or serious disease conditions in those with severe malnutrition.[33] Similarly, a retrospective cohort study[158] concluded that 32% of the cohort (n= 533) had malnutrition prior to surgery. Higher BMI was associated with increased risk for malnutrition. Post-operative nausea and vomiting was associated with preoperative malnutrition. Preoperative evaluation and collaborative support from an RD are recommended for all patients considering bariatric surgery.[161,181] Refer to the Bariatric Surgery: Selection and Preoperative Work-up chapter for further bariatric surgery considerations.

Limitations and opportunities

To support evidence-based practice, guideline chapter authors examined the literature to find the highest-quality evidence to inform graded recommendations. High-quality evidence was identified for specific nutrition-related topics including MNT delivered by an RD, specific dietary patterns, certain food-based approaches, and intensive lifestyle interventions. There was limited evidence for non-dieting approaches. Gaps in the literature included assessment of baseline nutrition status and social determinants of health. Most studies with a nutrition component were short- to medium-term interventions, limiting our knowledge of long-term outcomes.

Studies using BMI >25 kg/m^2 as inclusion criteria to select participants for obesity interventions may be confounded with healthy people with larger bodies and misrepresent clinical outcomes for people with the chronic disease of obesity, and may not identify those at nutrition risk.

Weight loss was a common outcome measure of intervention studies; however, the reason for weight change is difficult to ascertain. The success or failure of the intervention on weight outcomes is confounded by the physiological defense mechanisms in response to adiposity changes, as discussed in the Science of Obesity chapter.

To move nutrition and obesity practice forward, we suggest the following:

- Develop assessment tools for the primary care environment to support the use of a health-complication-centric definition of obesity, rather than relying on anthropometric measures for BMI categories.
- Improve accuracy of nutrition interventions for people with obesity with measurements of energy, macro/micronutrient needs and body composition.
- Nutrition is about more than the food we eat. Explore the relationships with food, food security, internalized weight bias, weight stigma and/or discrimination, eating behaviours and social determinants of health as part of patient care and research.
- Include the patient/client voice in nutrition research and patient care to help align the interventions for people living with obesity and people with larger bodies with their lived experiences.

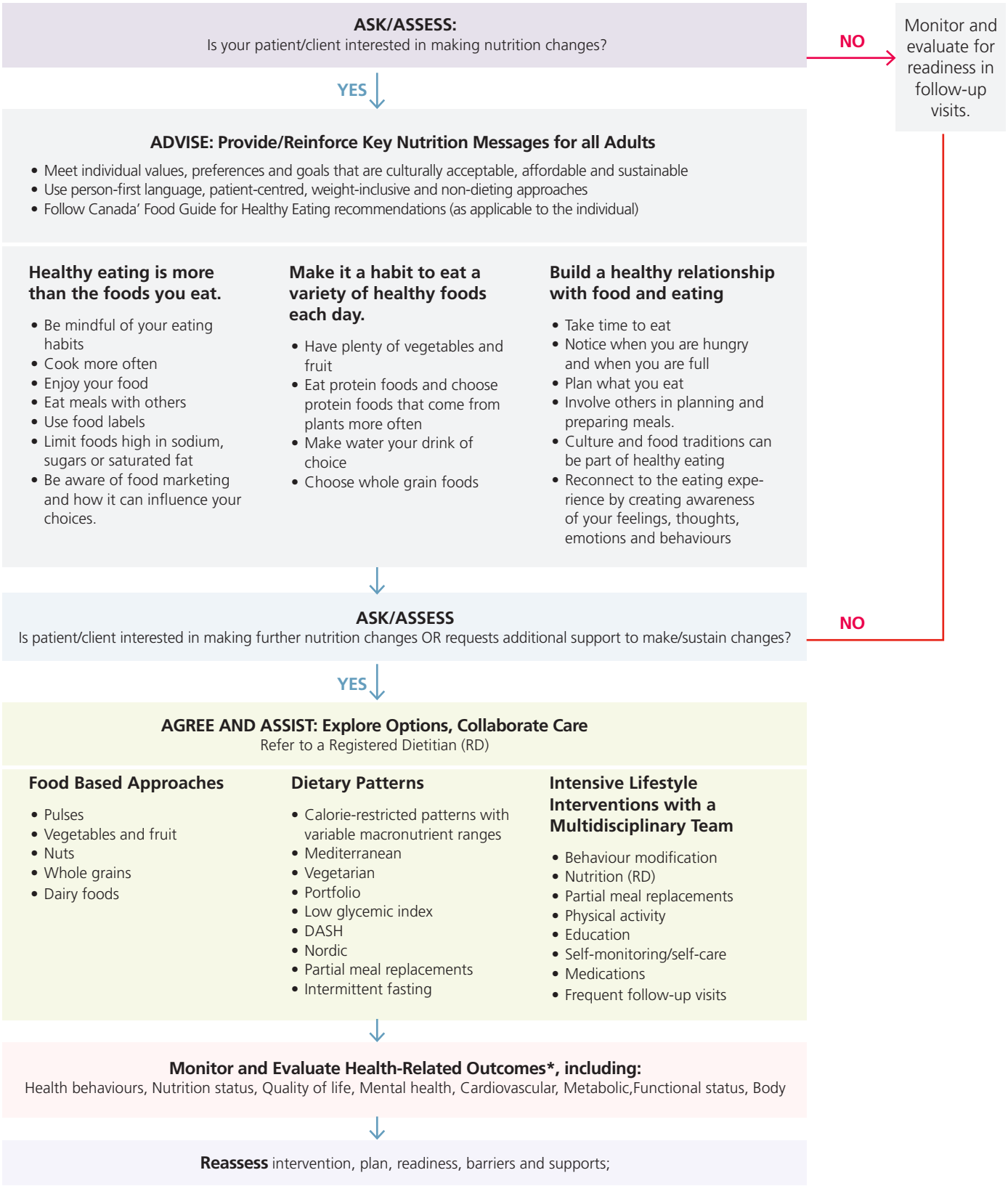
Evidence continues to emerge that impacts our understanding of nutrition and chronic disease. Providers may look to enhance their professional knowledge on emerging evidence in nutrition-related topics, including:

- Neurophysiologic pathways that affect hunger, appetite and reward;
- Metabolic adaptation of caloric restriction;
- Gut microbiota;
- Nutrigenomics and personalized nutrition;
- Social determinants of health; and
- Mental health.

Conclusion

Nutrition interventions show benefits with cardiometabolic outcomes, including glycemic control, hypertension, lipid profile and cardiovascular risk (Table 1 and Figure 1). MNT and coordination of care with an RD can help patients/clients improve health and QoL. Finding a nutrition approach a patient/client can incorporate into their lives that is nutritionally adequate, culturally acceptable, affordable, enjoyable and effective for lifelong health improvements (Figure 2) should be the focus of all nutrition interventions.

Figure 1: Medical Nutrition Therapy for Obesity Management – Quick Reference Guide[182,183]



*Refer to Table 2: Health Indicators for Evaluating Nutrition Interventions with Patients/Clients

Figure 2: Summary of Clinical Outcomes for Nutrition Interventions

	Hunger, satiety	Blood pressure	Blood lipids	Weight	Waist circumference	Body composition	CVD, CHD morbidity, mortality	Risk CVD	Glycemic control	Risk T2DM	Metabolic Syndrome	Quality of life	Depression
Medical Nutritional Therapy (RD)	■	■	■	■	■				■				
Intensive lifestyle interventions	NR	■	■	■			■		■		■		
Calorie restriction		■	■	■		■			■	■			
Lower carbohydrate				■									
Dietary fibre (25–29 mg)		■	■	■		■	■		■				
Low-calories sweeteners				■			■						
Higher protein (25–40%)	■		■	■		■							
Increased protein + calorie restriction			■	■		■							
Whey protein supplement		■	■	■		■			■				
Replace fat or carb with protein					■								
Lower fat				■									
Mediterranean			■				■		■	■	■		
Vegetarian			■	■			■		■	■			
Portfolio		■	■				■						
Low glycemic index			■	■			■			■			
DASH			■	■	■		■		■	■			
Meal replacements		■		■					■			■	
Intermittent fasting				■									
Pulses		■	■					■	■				
Vegetables and fruits		■					■		■	■			
Nuts			■				■		■				
Whole grains			■										
Dairy				■	■	■				■			
HAES®	■		■									■	■
Mindfullness-based approaches				■					■				

Table 1: Summary of Nutrition Interventions used in Obesity Management

Intervention	Outcomes/Impact		Advantages	Disadvantages
	Health and quality of life	Weight change		
Medical nutrition therapy by a registered dietitian (RD)	↓ 0.43% HgAlc ↓ 2.16 cm waist circumference ↓ 4.06 mg/dL cholesterol ↓ 8.83 mg/dL triglycerides ↓ 4.43 mg/dL LDL-C ↓ 7.90 mmHg systolic blood pressure ↓ 2.60 mmHg DSP	↓ 1.03 kg[6] For T2DM: ↓ 1.54 kg[8] For T2DM prevention: ↓ 2.72 kg[7]	Use RDs as an adjunct or stand-alone therapy option for improvements in cardiometabolic and weight outcomes	Access to RDs trained in obesity management may be limited; fee for services from private practice providers
Intensive lifestyle interventions	T2DM incidence 58%[51] ↓ 0.22 A1c, ↓ 1.9 mmHg systolic blood pressure, ↑ 1.2 mg/dL HDL-C[50] ↓ Cardiovascular disease (HR 0.67) and all-cause mortality (HR 0.74)[52] ↑ Remission of T2DM[53] ↓ Nephropathy incidence (HR 0.69)[54] ↓ Obstructive sleep apnea incidence[55] ↓ Depression (HR 0.85)[56]	↓ 8.6% 1 yr ↓ 6% 13.5 years[50]	Multi-modal approach with intensive counselling and strategies provides support to individuals for longer-term behaviour change and successful outcomes	Requires significant resources across multiple healthcare disciplines
Dietary pattern approaches				
Calorie restriction*	↓ Blood pressure, lipids, glucose[69,184,185] ↓ Bone density[75] ↓ Muscle strength[76] ↓ BMR[186]		Large initial weight loss[69,71,135,187]	Difficult to sustain, weight regain expected, long-term weight loss <5%[69,71,135,187]
Lower carbohydrate		↓ 8 kg at 6 mo; ↓ 6–7 kg at 1 year[9]		
Dietary fibre (25 g to 29 g)	Higher intakes: ↓ Cardiovascular disease mortality 15–30% ↓ Coronary heart disease, stroke incidence ↓ T2DM ↓ Systolic blood pressure ↓ Total cholesterol[97]	Higher intakes ↓ weight	Fibre supplements may help ↓ weight short-term[108,188–192]	
Low-calorie sweeteners	May ↓ weight and cardiometabolic disease[118,193]		As a replacement for sugar (e.g. SSB) may help ↓ weight[121]	Randomized control trials do not support use for obesity management[118]
Higher protein (25%–40% of calories from protein), no calorie restriction prescribed	↓ TG (-0.60 mmol/L)[80] Carb-to-protein ratio of 1.5:1 ↓ Chol, LDL[194] No change (with or without exercise) for HDL, FBG, fasting insulin[194]	↓ 0.39 kg BW ↓ 0.44 kg FM[80]	Greater satiety[195] Women with MetSyn had ↓ weight, ↓ fat mass with HP vs. low-fat/high carb[194]	No differences in other lipids or lean mass, attrition rates 30–40%[80]

Dietary pattern approaches				
Increased protein (1.1 g/kg or 30% protein intake), with calorie restriction	Short-term (12 +- 9.3 weeks): ↓ TG[195]	30% protein intake: No difference in wt loss, ↑ lean mass[196] ↓ Weight[197] 1.1 g/kg protein intake: short-term (12 +- 9.3 weeks): ↓ Weight ↓ Fat mass Less ↓ fat-free mass,[195]	Greater satiety[195]	Short term (12 +- 9.3 weeks)[195] Limited health data collected
Whey protein supplement (20–75 g/day, 2 weeks – 15 months)	↓ Cardiovascular disease risk factors (systolic blood pressure, DBP, HDL, TChol, glucose[91]	↓ Weight (mean diff -0.56 kg) ↓ Fat mass (mean diff -1.12 kg[91] ↓ Lean mass (mean diff -0.77 kg)	Benefits found with or without calorie restriction[91]	Lack of evidence to guide dose or length of time for use[91]
Increase protein to replace other macronutrients	Replace some carbohydrate ↓ Waist circumference over 5 years[198] Replace some fat No effect[198]	No effect on long-term weight outcomes[198]		
Lower fat		↓ 8 kg at 6 mo; ↓ 6–7 kg at 1 yr[9]		
Mediterranean	↓ A1C 0.45, ↓ TG 0.21 mmol/L, ↑ HDL-C 0.07 mmol/L[10] ↓ Cardiovascular events (HR 0.69–0.72)[11] ↓ T2DM risk 52%[12,13] ↑ Reversion of MetSx[14]	Little effect on weight or waist circumference[11]		
Vegetarian	↓ A1C 29%, ↓ LDL-C 0.12 mmol/L, ↓non-HDL-C 0.13 mmol/L[16] ↓ T2DM incidence (OR 0.726)[17] ↓ Coronary heart disease incidence (RR 0.72) ↓ Coronary heart disease mortality (RR 0.78)[18]	↓ 2.15 kg <6 mo[16]		Risk of vitamin/ mineral deficiencies (iron, calcium, zinc, vitamin B12, vitamin D)
Portfolio	↓ LDL-C 17% ↓ Apo B 15% ↓ Non-HDL-C 14%, ↓ CRP 32%, ↓ systolic blood pressure 1%, ↓ 10-yr coronary heart disease risk 13%[19]	No change		Individuals may find it difficult to meet the recommended food component targets**
Low-glycemic index	↑ HDL-C[199] ↓ T2DM risk[24] ↓ Coronary heart disease[25]	↓ 2.5 kg 18 months[200]		
Dietary Approaches to Stop Hypertension (DASH)	↓ CRP 1.01[28] ↓ LDL-C 0.20 mmol/L ↓ A1C 0.53% ↓ T2DM risk RR 0.82 ↓ Cardiovascular disease risk RR 0.80 ↓ Coronary heart disease risk RR 0.79 ↓ Stroke risk RR 0.81[27]	↓ 1.42 kg, ↓ waist circumference 1.05 cm in 24 weeks[26]		
Partial meal replacements*	↓ Blood glucose in DM[201] ↑ HRQOL[202] ↓ Systolic blood pressure 4.97 mmHg ↓ DBP 1.98 mmHg ↓ A1C 0.45% at 24 weeks[34]	↓ 2.37 kg ↓ Waist circumference 2.24 cm at 24 weeks[34]	Large initial wt loss	Wt regain 3 year weight loss < 5%[202]
Intermittent fasting		↓ 0.61 kg at 24 weeks[35]		

Food-based approaches				
Pulses	↓ FBG 0.82[37] ↓ LDL-C 0.17 mmol/L[38] ↓ Systolic blood pressure 2.25 mmHg[39] ↓ Coronary heart disease risk RR 0.86[40]	↓ 0.34 kg at 6 weeks[36]		
Vegetables and fruit	↓ DBP 0.29 mmHg[41] ↓ A1C 5.7%[42] ↓ T2DM risk 42%[43] ↓ Cardiovascular mortality HR 0.95[44]			
Nuts	↓ A1C 0.07% ↓ FBG 0.15 mmol/L[45] ↓ LDL-C 7.4%[46] ↓ Coronary heart disease risk HR 0.74			
Whole grains	↓ total cholesterol (TC) 0.12 mmol/L ↓ LDL-C 0.09 mmol/L[48]			
Dairy Foods (with calorie restriction)	↓ T2DM risk 42%[43]	↓ 0.64 kg BW ↓ 2.18 cm waist circumference ↓ 0.56 kg FM ↑ 0.43 kg lean mass[49]		
Non-dieting approaches				
Health at Every Size (HAES®)	↓ LDL-C ↑ Body image perceptions ↑ Quality of life (QOL) scores (depression) ↑ Eating behaviour scores ↓ Hunger ↑ Aerobic activity	No change in BMI or weight loss	↓ Weight bias	Evidence limited to women with BMI>25 or disordered eating patterns.
Mindful eating	↓ 3.1 mg/dl (↓ 0.2 mmol/L) in blood glucose[203] prevention of increasing FG over time	↓ 3.3% weight at post-treatment ↑ 3.5% weight in follow-up[154] ↓ 4.2–5.0 kg (4.3–5.1%) mean weight at 18 mo[203]	↓ Sweet food intake[204]	Lack of consistency for validated mindfulness tools

LDL-C: low-density lipoprotein C; BMI: body mass index; FG: fasting glucose; TC: total cholesterol; HDL; high density lipoprotein; A1C; kg: kilogram; BW: body weight; FM: fat mass; T2DM: type 2 diabetes

*These are typically combined with extensive behavioural modification support.

** The Portfolio dietary pattern = 1g to 3 g/day plant sterols (plant-sterol containing margarines, supplements), 15 g to 25 g/day viscous fibres (gel-forming fibres, such as from oats, barley, psyllium, legumes, eggplant, okra), 35–50 g/day plant-based protein (such as from soy and pulses) and 25 g to 50 g/day nuts (including tree nuts and peanuts).

Table 2: Health Indicators for Evaluating Nutrition Interventions with Patients/Clients

Health Improvement	Health indicator	Example
Cognitive improvements	Memory, concentration, attention, problem solving, sleep hygiene	Ask client/patient to rate each of these health outcomes using a 0–10 scale, where 0 is low/poor and 10 is high/great: Energy level Stress Sleep hygiene Mobility Strength Pain Bowel health Mood Relationship with food Hunger Cravings Overall health
Functional improvements	Strength, flexibility, mobility, coordination, physical activity capacity, endurance, pain	
Medical improvements	Cardiometabolic, endocrine, gastrointestinal, wound care, nutrient deficiencies, changes to medications	
Body composition improvements	Body fat, muscle mass, bone health, waist circumference	
Appetite-related improvements	Hunger, satiety, cravings, drive to eat, palatability of foods	
Mental health	Disordered eating behaviours, self-esteem, self-efficacy, emotional regulation, mood/anxiety, addiction	

Healthcare providers are encouraged to use health and quality of life (QoL)-related goals for evaluating effectiveness of nutrition interventions. Ask clients/patients what health improvements they are hoping to achieve by following or changing their nutrition approach helps to redirect weight-centric outcomes with asking what health improvements this weight change means to them. Examples: energy level, cognitive improvements, functional improvements, cardiometabolic improvements, mental health and quality of life (mobility, self-hygiene, etc.),

Table 2: Health Indicators for Evaluating Nutrition Interventions with Patients/Clients

Micronutrient	Screen for Deficiency Risks	Drug or Nutrient Interactions
Vitamin D	1. Elevated adiposity 2. Medical conditions associated with fat malabsorption: • Crohn's disease • Ulcerative colitis • Celiac disease • Liver disease • Cystic fibrosis • Short-bowel syndrome 3. Previous bariatric surgery (RYGB, SG, BPD, DS) 4. Low intake of calcium-rich foods 5. Limited sun-light exposure (i.e. Night-shift workers, wearing long-sleeved clothing, northern climate) 6. Darker skin pigmentation	• Corticosteroids • Orlistat • Cholestyramine • Phenobarbital • Phenytoin
Vitamin B12	1. Elevated adiposity 2. Medical conditions: • IBD (Crohn's disease, ulcerative colitis) • Type 2 diabetes (long-term use of metformin) • GERD • Positive Helicobacter pylori • Pernicious anaemia • Alcoholism 3. Restrictive eating patterns: • Vegetarian eating patterns • VLCD/meal replacements • Lower carbohydrate intake 4. Previous bariatric surgery (LAGB, RYGB, SG, BPD, DS)	• Metformin • Proton-pump inhibitors
Iron	1. Elevated adiposity 2. Medical conditions: • Crohn's disease • Ulcerative colitis • Celiac disease • Liver disease • Peptic ulcers • Chronic kidney disease 3. Restrictive eating patterns: • Vegetarian eating patterns • Low protein intake • VLCD/meal replacements 4. Frequent blood donors 5. Blood loss (menstruation, GI tract bleeding) 6. Previous bariatric surgery (LAGB, RYGB, SG, BPD, DS)	• Interactions with calcium, polyphenols (coffee/tea) • Excessive zinc intake (lozenges) • NSAIDs • Proton-pump inhibitors • H2 blockers

The summary of the Canadian Adult Obesity Clinical Practice Guideline is published in the Canadian Medical Association Journal, and contains information on the full methodology, management of authors' competing interests, a brief overview of all recommendations and other details. More detailed guideline chapters are published on the Obesity Canada website at www.obesitycanada.ca/guidelines.

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