Module 7: Study Guide: Carbohydrates, Fiber, Diabetes, Snacking & Desserts

Objectives

1. Identify primary sources of carbohydrates in the diet.
2. Describe the structure, digestion, transport, and regulation of the various forms of carbohydrates in the diet.
3. Describe carbohydrate needs and how carbohydrate functions in the body.
4. Distinguish sources that are high in complex carbohydrates and simple carbohydrates.
5. Describe the current scientific literature related to high fructose corn syrup.
6. Explain the different categorizations of diabetes in terms of symptoms, diagnostic criteria, target populations, and relevant lab values.
7. Review the NCEP and WHO criteria for metabolic syndrome.
8. Explain the holistic approach to type 2 diabetes remission.
9. List the three primary classifications of carbohydrates with an emphasis on their effect on glucose metabolism.
10. Explain the intricacies of fiber; where it comes from, how it functions in the body, and the specific health impacts attributed to soluble and insoluble varieties.
11. Identify RDA of fiber throughout the lifecycle.
12. Identify the components of a whole grain and explain the difference between whole and refined grains in regards to physical and nutritional composition.
13. Explain the science supporting Glycemic Index and Glycemic Load and any potential negative consequences caused by following diets based on these principles.
14. Summarize the evidence-based research pertaining to artificial and natural sweeteners.
15. Identify approaches to aid in controlling sugar intake, with a focus on portion size and frequency of intake.
16. Recognize substitutes for common snacks with items higher in fiber and lower in sodium and simple carbohydrates.

Carbohydrates

Carbohydrates are the body's main source of fuel. 45-65% of the diet should be CHO (900kcal of an 1800 kcal diet). At least half of these should be whole grain. Carbohydrates are in abundance in foods: grains and cereals, fruits, vegetables, milk products and table sugar (1 tsp sugar = 4 grams CHO = 16 calories).

- In between meal periods, serum glucose is primarily supplied by hepatic glycogen.
- Glycogenolysis and gluconeogenesis are dependent on the frequency of feeding.
- During overnight fasting state, hepatic glycogen is depleted, so gluconeogenesis becomes the primary source of glucose

Three types of carbohydrates: polysaccharides (mostly plant starches), disaccharides (e.g. sucrose and lactose) and monosaccharides (e.g.glucose and fructose). Polysaccharides require enzymatic cleavage of bonds to reduce sugars to monosaccharides.

Substrate	Enzyme	Product
amylose and amylopectin	α-amylase	maltose, maltotriose, and glucose
maltose, maltotriose	α-glucosidase	glucose
sucrose	sucrase	glucose and fructose
lactose	lactase	glucose and galactose

There are dozens of indigestible carbohydrates, polysaccharides (cellulose, soluble fiber, inulin, agar), and oligosaccharides (legumes), and disaccharides (lactose [in patients with lactose intolerance], and sucralose), found in the diet. This includes soluble and insoluble fibers.

Carbohydrate digestion begins in the mouth. Once digested, monosaccharides are absorbed via active transport (glucose and galactose) or facilitated transport (fructose). Glucose and galactose are transported via active symport with Na+ (driven by Na+, K+ ATPase). Fructose is transported via Na+ independent facilitated diffusion from the intestinal epithelial cells to the bloodstream and from the bloodstream to the cells.

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High Fructose Corn Syrup (HFCS)
There is some controversy about whether HFCS is a unique contributor to obesity. The use of HFCS has increased over the past several decades, and some scientists have hypothesized that its consumption has influenced the rate of obesity in the U.S. The total fructose in American diets has only increased by about one percent. However, energy intake increased by 18 percent, with carbohydrates specifically increasing by 41 percent.

There is not definitive evidence, however it is clear that the additional calories consumed in simple sugars do contribute to positive energy balance and concomitant weight gain. It is also unclear why HFCS would affect satiety or absorption and metabolism of fructose any differently than would sucrose.
It may surprise you that HFCS is quite similar to sucrose or table sugar, which is composed of 50 percent glucose and 50% fructose. HFCS has either has 42% or 55% fructose.

There are two ways to discuss this issue with patients: avoidance of added sugars in general or avoidance of highly processed foods because HFCS is a marker for them.

Ultra-Processed Foods
A 2019 randomized crossover trial took 20 adults with an average BMI of 27 in residence at NIH for two weeks and allowed them to eat as much as they wanted of meals matched in composition. They found that while they were eating the ultra-processed meals subjects consumed about 500 *more* calories a day and gained almost a kilogram of weight in two weeks. However, when they ate the unprocessed meals, subjects lost the same amount of weight they gained.

In a systematic review and metanalysis of cohort studies from 2-27 years in length, ultra-processed foods were associated with an increased risk of cardiovascular, heart-specific, as well as all-cause mortality.

UPF is associated with an increased risk of:
- All-cause mortality (HR = 1.21; 95% CI: 1.13, 1.30; I^2 = 21.9%; $p < 0.001$)
- CVDs-cause mortality (HR = 1.50; 95% CI: 1.37, 1.63; I^2 = 0.0%; $p < 0.001$)
- Heart-cause mortality (HR = 1.66; 95% CI: 1.50, 1.85; I^2 = 0.0%; $p = 0.022$)

No association with cancer-cause mortality was found (HR = 1.00; 95% CI: 0.81, 1.24; I^2 = 0.0%; $p = 0.976$)

Studying the effects of ultra-processed foods is a burgeoning fielding of research which is beginning to shed light on the mechanisms leading to unfavorable health. Fructose has been shown to promote liver fat and insulin resistance. Another study linked the non-nutritive sweetener sucralose to increased insulin secretion. The commercial emulsifier Carboxymethylcellulose was found to alter the gut microbiome in unfavorable ways. Overall, the nutrition profiles of ultra-processed foods tend to be high in sugar, sat, and fat and low in fiber, protein and vitamins and minerals.

Diabetes
Type 1 diabetes is immune-mediated and idiopathic; it accounts for only 5-10% of those with diabetes. It has also been termed insulin-dependent diabetes, type I diabetes, and juvenile-onset diabetes, and results from a cellular-meditated autoimmune destruction of the beta-cells of the pancreas.

Type 2 diabetes ranges from predominantly insulin resistance with relative insulin deficiency to an insulin secretory defect with insulin resistance. It accounts for 90-95% of those with diabetes and was previously referred to as non-insulin-dependent diabetes, type II diabetes, and adult-onset diabetes. Individuals have insulin resistance and usually have relative (rather than absolute) insulin deficiency. Increasingly, young adults and children are being diagnosed with type 2 diabetes, nearly 5,300 each year as of 2018.

Gestational diabetes mellitus is any degree of glucose intolerance with onset or first recognition during pregnancy.

There are other less common causes of diabetes, including genetic defects/syndromes, diseases of the exocrine pancreas (pancreatitis), endocrinopathies, drug-induced, infections and uncommon immune-mediated.

Unfortunately, if serum glucose is not well controlled it can create long-term effects. As the blood vessels become narrow and stiff, it can affect the heart, brain, eyes, mouth, kidneys and skin. In fact, people with diabetes are twice as likely to have heart disease and stroke.

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Condition	Hemoglobin A1c	Fasting Plasma Glucose (mg/dL)	2- Hour Glucose During OGTT (mg/dL)
Normal	<5.7%	<100	< 140
Impaired/Prediabetic	5.7-6.4%	100-125	140-199
Diabetes	≥6.5%	≥126	≥200

Oral glucose tolerance tests use a load of either 75 or 100 grams of glucose; two hour tests using 75 grams of glucose help discern impact of postprandial glucose on overall blood sugars. Unless the patient has unequivocal clinical symptoms of hyperglycemia, a second test is required to confirm diagnosis. The confirmatory test is preferably done the same day to provide appropriate treatment but can be delayed, if needed.
Beginning in 2024, the Center for Medicare and Medicaid Services (CMS) added the hemoglobin A1c as a covered screening test for diabetes. They also cover up to two screenings a year for beneficiaries at risk.

Risks factors for diabetes
• Symptoms: weight loss, urinary frequency, blurred vision
• Age 35 (10 years-old and older if overweight plus another risk factor)
    - Risk factors:
        - Family history of diabetes
        - African, Latino, Asian or Native American ancestry
        - History of vascular disease or hypertension
        - HDL cholesterol <35mg/dl and/or triglycerides >250 mg/dl
        - Individuals with polycystic ovarian syndrome (PCOS)
        - Physical Inactivity
        - Conditions associated with insulin resistance
    - History of prediabetes should be tested annually
    - Prior gestational diabetes tested every 3 years
    - People with HIV, people on high risk medications, people with history of pancreatitis

Hemoglobin A1c
Hemoglobin A1c provides a 90 day marker of diabetes control, with a normal level being less than 5.7%. It is a surrogate marker for risk of diabetic complications and is a useful assessment of glycemic control during clinical management. In 2009, the International Expert Committee made recommendations regarding the use of Hemoglobin A1c, which codified its use as a diagnostic as well as a therapeutic tool for monitoring control of blood sugar. Diabetes should be diagnosed when HbA1c is >6.5%. A repeat HbA1c test should be done for confirmation in asymptomatic patients. For patients already diagnosed with diabetes, 7.0% is a good goal for Hemoglobin A1c.

HbA1c is influenced by both pre- and postprandial glucose, and fasting glucose is influenced by hepatic glucose production and hepatic sensitivity to insulin. Because the pathophysiologic determinants of the fasting and preprandial glucose are different from postprandial, there are specific therapies needed to control fasting and pre-prandial glucose and to blunt increases in postprandial glucose levels.

Post-prandial glucose levels are influenced by the pre-prandial glucose, insulin secretory capacity of the pancreas in response to a meal, and insulin sensitivity in peripheral tissues. Due to this, postprandial glucose may give a more accurate picture of an individual's true level of metabolic control compared to fasting glucose.

Diabetes Remission

Metabolic Syndrome
Traditionally, medicine has been focused on "managing" type two diabetes. However, there is an emerging interest as well as body of evidence that shows it can also be put into remission when the dosing of the intervention is sufficient. The American College of Lifestyle Medicine argues that the possibility of remission should be a part of the discussion between providers and patients and, when appropriate, the goal.

We talk about diabetes remission rather than reversal because the treatments require patients to move towards a healthier lifestyle. If a patient reverts, the underlying insulin resistance will return. That being said, there is no standard

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definition for what constitutes full remission. The one most commonly used is from the American Diabetes Association and requires HgbA1c to be less than 6.5 for at least 3 months off all medications.

Other organizations have proposed that this be divided into "full remission" which signifies a normal HgbA1c and "partial remission" which signifies a HgbA1c in the pre-diabetic range. Timelines for this also differ, ranging from 3 months to a year before remission can be achieved.

Two major areas have surfaced as potential paths to remission: bariatric surgery and lifestyle interventions. We have several trials showing us that surgery can put patients with type 2 diabetes into remission. A recent 2024 long-term study published in JAMA found that diabetes remission was achieved for 7 years in 18.2% of those with type 2 diabetes who had the procedure. As participants were followed out to 12 years after surgery, 12.7% of participants were still able to maintain remission. Of course, bariatric surgery entails not only the surgery but a significant change in lifestyle to maintain the gains of the procedure. There are also significant complications of the surgery that patients need to consider in making a choice.

Recent advancements in the efficacy and safety of prescription weight loss drugs in combination with lifestyle interventions may have the potential to also provide a pathway to type 2 diabetes remission, but research is needed to confirm this.

Lifestyle interventions are now being given more attention and there is a realization that dosing is key to success in achieving remission. Looking at lifestyle, diet is a major factor in achieving remission and has the most robust data. We have also seen that a multifaceted approach, such as that used by the Diabetes Prevention Program (DPP), has achieved impressive results and is potentially the most effective approach. Research using a multifaceted approach that includes physical activity, stress reduction, sleep and other factors in addition to diet is limited as it is much harder to do.

Trials involving the DPP showed that 58% of those completing the program were able to reverse their pre-diabetes. Particularly encouraging was that the numbers were even better for those 60 years old and older – they were able to reduce their incidence by 71%. Finally, a 10 year follow up showed that the intervention was able to decrease the risk of developing diabetes by 34%.

Let's look at the data focused on diet. In this 2020 review of successful dietary interventions for diabetes, 5 trials were included. The trials lasted between 8 weeks to 4 months and entailed very low energy diets, with successful remission rates (almost 50%) from 600-1100 kcal/day.
The Sarathi study did also recommend 1 hour of brisk walking daily. Of the group, this study had the most modest caloric restriction and was still successful, likely due to the physical activity component. However, several trials that focused on physical activity without sufficient caloric restriction have not been successful in inducing remission.

Successful models use weekly interaction for about 4-6 months and then taper down but continue engagement. This is similar to the approach taken by the Diabetes Prevention Program. An intensive approach is favored when the goal is remission. Better outcomes are seen in those with shorter duration of disease. This makes sense because in those who have had type 2 diabetes for longer periods, the beta cells of the pancreas have likely been more damaged and the overall function of the pancreas is likely decreased.

Caloric deficiency is also a key aspect found in most trials although there have been some studies comparing two isocaloric groups and showing that the use of high fiber foods can have an independent impact on insulin resistance. Finally, successful trials include close monitoring with support groups and/or coaching to assist with behavior change.

Physical activity is also an independent factor in reducing insulin resistance.
The usual mechanism of bringing glucose into a muscle cell is through insulin binding to the insulin receptor substrate. The insulin binding activates a cascade of reactions that ultimately lead to glut 4 allowing glucose to be brought into the cell.
Alternatively, we can bring glucose directly into the cell without insulin by moving our bodies. Muscle contraction also sparks a chain of reactions that can then cause glut 4 activation and uptake of glucose into the cell. This is called the non-insulin dependent pathway.

How do we best use exercise in the context of a patient with type 2 diabetes? Keep in mind insulin sensitivity is increased for 48 hours after a single episode of exercise. While it can be most beneficial to exercise within an hour of a meal to bring down any potential glucose spike, exercise at ANY time is good!

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Studies show that long-term exercise reduces HgbA1c approximately 0.5-0.7% compared to controls. This finding is independent of weight loss. Interestingly, aerobic and resistance training have comparable impacts so this is where patient preference factors into the care plan. Finally, special care needs to be taken to avoid any intense activity, especially after a meal. The reason for this is that vigorous activity is a stressor on the body that increases hormones such as adrenaline that increase plasma glucose for about an hour. For long-term benefit, low-intensity to moderate exercise after meals is safest to prevent any glucose spikes.

Sleep is also a key component to diabetes remission. A recent meta-analysis of prospective studies reported the lowest risk of diabetes for 7–8 hours per day of sleep and an increased risk by 9% for each 1-hour shorter sleep duration. A decreased glucose disposal rate is observed after one night of 4 hours of sleep!

This inpatient study depicts how quickly insulin sensitivity can change due to poor sleep. Healthy participants were randomized to sleep 4 hours or 8 hours a night in this crossover trial. After only 5 days of sleeping 4 hours a night, insulin sensitivity was reduced by 25. Poor sleep causes an increase in stress hormones such as cortisol which increases resistance by multiple mechanism. Interestingly in this study, glucose levels of participants stayed the same but we can see that it took 20% higher plasma levels of insulin to maintain those same glucose levels.

Separate from insulin sensitivity, sleep is independently associated with improved weight loss.
Sleep not only impacts cortisol levels it can also affect hormonal signaling around hunger. Studies consistently show a drop in leptin and an increase in ghrelin with sleep deprivation. While we don't burn significantly more calories by being up for more hours, our bodies actually do feel more hungry.
Another study corroborated these findings by showing that women who self reported better sleep were 33% more likely to succeed in weight loss efforts.

Finally, an interesting study that needs more research showed that sufficient sleep also impacts the type of weight that is lost – meaning that those with sufficient sleep are likely to lose a higher percentage of that weight as fat compared to those who lose weight while sleep deprived.

A 2022 study of 80 overweight, sleep deprived adults, half were randomized to education on sleep hygiene while the other half continued their normal sleep patterns of less than 6.5 hours a night. With just that intervention, those in the education group increased their sleep by 1.2 hours on average. Moreover, they automatically decreased their caloric intake and found they had lost almost 2 pounds in 2 weeks!
The bottom line is that diabetes remission should be a goal discussed with patients, particularly those newly diagnosed. Regardless if bariatric surgery is a part of the treatment, lifestyle changes are fundamental to any plan for managing insulin resistance. A multifactorial approach to diabetes can help set our patients up for success by balancing caloric intake, hormonal levels and making use of the non-insulin dependent pathway. We need more studies to help us develop effective protocols that assist patients in making these changes in a supportive environment.

Reducing Risk of Developing Type 2 Diabetes
Currently 88 million American adults have slightly elevated blood sugar or prediabetes. Most are not even aware they have it. They are more likely to develop diabetes, heart disease, and strokes. The good news is that changing to a healthy diet, exercising, and maintaining a healthy body weight can reverse this trend.

Over 34 million Americans currently have diabetes. One in five do not even know they have it. Diabetes is now the seventh leading cause of death. Unfortunately, diabetes has doubled over the last 20 years in American Adults. This has led to over $300 billion spent on diabetes and its complications. That is 1 out of every 7 dollars spent each year in the U.S. on healthcare. It is increasing at an alarming rate - 26% in the last five years.

When looking at prevention, the NIDDK-sponsored Diabetes Prevention Program (DPP) and ongoing DPP Outcomes Study (DPPOS) are major studies that changed the way people approach type 2 diabetes prevention worldwide. The DPP performed a randomized control trial of over 3,000 participants with pre-diabetes who were placed into one of 3 groups: a lifestyle change group, where participants were coached in weight loss and exercise programs; a Metformin Group, where participants took 850 milligrams of Metformin twice a day and given advice on diet and physical activity, and a placebo group.

After 15 years, DPP Lifestyle Change Program participants continued to have a delay in the development of diabetes by 27 percent compared with participants who took a placebo, while participants who continued to take metformin had a delay in the development of diabetes by 18 percent compared.

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Current literature on weight loss for patients with obesity recognizes that 42% of adults following behavioral interventions can achieve approximately 5% to 10% weight loss. However, GLP-1 receptor agonists use leads to 8% to 21% weight loss, and bariatric surgery around 25% to 30% weight loss.

According to the 2024 Standards of care from the American Diabetes Association, healthy eating patterns and regular physical activity are the cornerstones of lifestyle risk reduction for type 2 diabetes.
The Mediterranean diet, DASH diet are promoted along with low carbohydrate diets, and vegetarian or plant-based.
Although not approved by the FDA for use in diabetes prevention, Metformin may be considered for a select population at risk.

Metabolic Syndrome
Diagnosis from metabolic syndrome according to the NCEP Criteria requires that three or more of the following be present:

NCEP Criteria	Male	Female
Waist Circumference	≥ 40”	≥35”
HDL	<40 mg/dL	<50 mg/dL
Triglyceride Level	≥ 150 mg/dL	
Systolic BP	≥ 130 mmHg	
Diastolic BP	≥ 85 mmHg	
Fasting plasma glucose	≥ 100 mg/dL	

These risk factors have an overlap that includes lipid abnormality, elevated blood pressure, overweight/obesity, and elevated fasting plasma glucose.

The World Health Organization’s (WHO) definition of metabolic syndrome includes central adiposity and microalbuminuria in its criteria for diagnosis.

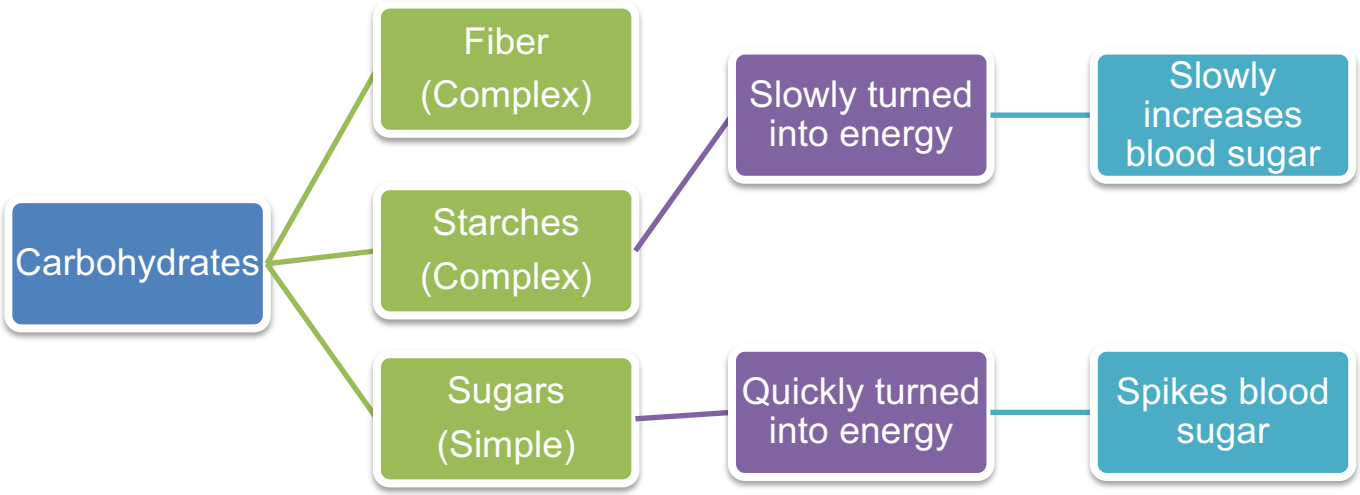
WHO criteria	Male	Female
Blood Pressure	≥ 140/90 mmHg	
Triglycerides	≥ 1.695 mmol/L	
HDL	≤0.9 mmol/L	≤1.0 mmol/L
Waist : Hip Ratio	> 0.9	>0.85
BMI	> 30 kg/m^2	
Urinary Albumin Excretion Ratio	≥ 20µg/min	
Albumin : Creatinine Ratio	≥30 mg/g	

1 in 3 adults in the U.S. has metabolic syndrome
Patients with Metabolic Syndrome:
- incur a 2-fold risk of atherosclerotic CVD
- incur a 5-fold risk of type 2 diabetes

Mortality risk:
- Heart disease mortality Hazard ratio (HR) 1.44(95% CI 1.25-1.66)
- Diabetes mortality HR 5.15 (95% CI 3.15-8.43)
- All-cause mortality HR of 1.24 (95% CI 1.16-1.33)

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Metabolism

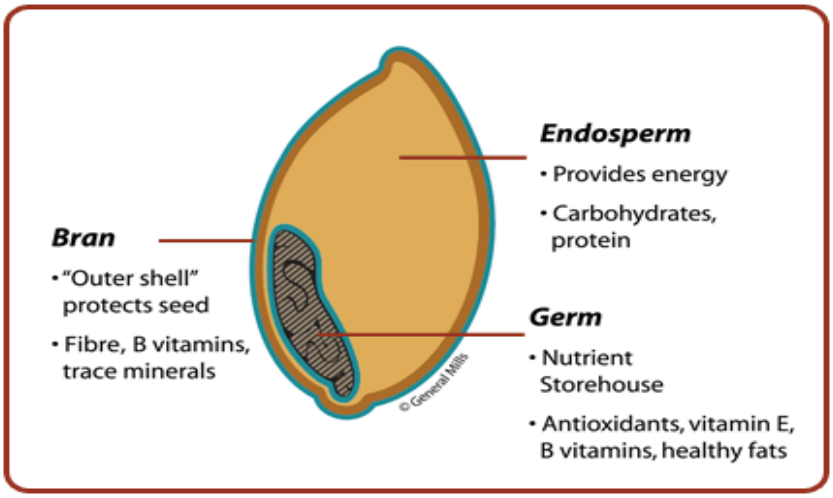


As shown by the diagram, sugars and starches are the only energy-yielding carbohydrates. To compensate for the spike in blood sugar due to simple carbohydrates, the pancreas releases insulin to bring glucose levels down to normal level. Complex carbohydrates are the preferred source of fuel for the body, especially for patients with Type 1 and Type II diabetes, because it gradually increases the body's blood sugar levels and still has fiber and nutrients attached.

Foods that are high in simple carbohydrates include sugars and refined CHO such as white flour, table sugar, corn starch, molasses, and agave nectar, but also occur naturally as fructose, which is found in fruits and vegetables, honey, and lactose in milk products. Complex carbohydrates include products that are whole wheat or whole grain, such as whole wheat flour, whole grain pasta, bread and cereal, along with brown rice, oats, millet, quinoa, legumes, and more.

Grains

A refined grain simply means that the bran and germ have been removed (this means it's a simple carbohydrate). A whole grain contains all three parts: the bran, germ and endosperm. The bran is where fiber, B vitamins and some minerals are found. The germ contains many nutrients and antioxidants, such as unsaturated fats, B vitamins and Vitamin E. The endosperm is the energy yielding part of the grain and is composed mostly of starch and has little nutrition.



To compensate for the loss of nutrients many refined grains are enriched with vitamins and minerals.
Unfortunately, the fiber, one of the most important nutrients, is rarely added back. Whole wheat flour, for example, provides more nutrients in baked goods.

Fiber

The bran is the part of the grain that contributes fiber to the diet. Fiber has many benefits including regulating bowel function and promoting digestive health, helping to prevent certain cancers (colorectal), regulating blood glucose levels, and helping to feel satiated, which all are important to stay healthy and control Type 2 Diabetes.

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Our fiber needs change as we age.

- Women: 28 grams per day (2,000 kcal)
- Men: 34 grams per day (2,400 kcal)
- Women over 50: 22 grams per day (1,600 kcal)
- Men over 50: 28 grams per day (2,000 kcal)

Americans generally only get half of the recommended fiber because of the lack of fresh fruit, vegetables and whole grain consumption. A good way to keep up with fiber consumption is to find sources that have at least 5 grams of fiber.

There are two types of fiber: soluble and insoluble. Soluble fiber is dissolvable in water, lowers cholesterol (LDL levels), and can be found in oats, peas, beans, apples, citrus, carrots, and barley. Insoluble fiber aids in digestion and increases stool bulk and is found in whole wheat flour, wheat bran, nuts, beans, and vegetables, such as cauliflower, green beans, and potatoes. Both soluble and insoluble fiber help to maintain glycemic control in diabetics. Eating whole grains does not solely come from bread and pasta; look to other grains such as amaranth, barley, bulgur, corn products, faro, and spelt for more exciting options.

Portion Size

Often a full sandwich offers excessive carbohydrates from grains, especially considering restaurant portion sizes. Discuss portion sizes with patients. If it aligns with the patient's preferences and lifestyle, consider pairing half a sandwiches on whole grains with either a soup or salad.

Also advise patients on starchy versus non-starchy vegetables. Ensure patients with diabetes get plenty of non-starchy vegetables in their diet.

Starchy:
• Potatoes
• Corn
• Green peas
• Squash

Non-Starchy:
• Asparagus
• Broccoli
• Cauliflower
• Mushrooms

Glycemic Index

The glycemic index is a measuring system developed to rank foods by the rate at which they raise blood sugar levels in a 2-3 hour period based on a scale of 1-100 (100=quickest spike in glucose levels: pure glucose; 1=slowest to impact blood sugar levels: broccoli). Many advocates argue that patients with diabetes or who are trying to lose weight will be more successful by utilizing this scale, as lower glycemic meals result in greater weight loss and satiety levels. Others question its validity because it does not completely account for the nutritional content of the items and may promote obesity. Some scales place bananas and snickers bars around the same level, and watermelon has a higher score than table sugar. Another issue is that different sources give foods varying ratings on the scale and the ripening or cooking process may change the index by as much as 30%.

Glycemic Load

The glycemic load was developed to counter the issues with the glycemic index; multiply the GI of a food times its grams of carbohydrate (10 or under is considered a good choice). While this is a better system, it still does not take into account that individuals have different responses to high or low glycemic foods and other factors can affect glucose metabolism (various vitamins and minerals).

For select patients who already have a nutrient dense diet, there are some further culinary modifications that may enhance glycemic response. Research has shown that combining carbohydrates (especially those with a high glycemic index [GI]) with fat or fiber helps. However, more research is needed to confirm protein. Adding vinegar or pickled food may be beneficial but the research has not determined a therapeutic dose.It may be beneficial to reduce cooking time and/or the amount of cooking water to increase the concentration of resistant starches, but this may not align with patients' taste preferences. Another way to increase resistant starches is through cooling methods.

For most patients, educating on reducing sugar sweetened beverages, portion sizes and replacing simple carbohydrates with complex ones will offer much greater benefits to their health.

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Nutritive Sweeteners
Often natural forms of sweeteners are viewed as healthy. However, honey only offers a health advantage to sugar if you use much less of it. While it does have culinary advantages such as adding flavor, moisture, and color, it can still spike blood sugar. Although pure maple syrup is almost completely sucrose, the sweeter taste and complexities of flavor create the overall affect with lesser amounts when compared to table sugar. Pure forms are preferrable but can be expensive and thus it is not advised for all patients. When substituting for sugar, start by using at least 1/4 less maple syrup and bake at 25 degrees lower temperatures to avoid burning.

Agave Nectar has been touted as a “natural” sweetener with people believe that it is a healthy sugar.
In truth, agave is just as processed as high fructose corn syrup.
It is made by commercially processing the blue agave plant to make fructose which is clearly harmful when consumed by itself. The agave is actually higher in fructose than high fructose corn syrup at around 90%, while high fructose corn syrup contains 55% fructose.

Sugar alcohols approved by FDA as bulk sweeteners:
Xylitol
Erythritol
Manitol
Sorbitol
Maltitol
Isomalt
Lactitol
Hydrogenated Starch Hydrolysates

Another category of nutritive sweeteners that can substitute for table sugar are sugar alcohols or polyols.
Though they are found naturally in some fruits and vegetables, commercially they are derived from sugars and starch. They are considered carbohydrates with less calories and even lower when paired with non-nutritive sweeteners. They confer the health benefits of no glucose surge response and are safe when consumed in moderation. Excessive consumption results in GI upset or laxative effect. It is important to note that more studies on the long-term safety of erythritol are warranted after recent research points to a significantly increased risk of heart attacks and stoke.

Sugar alcohols that have many culinary advantages. They provide more bulk and texture, important for many baked goods. Further, they keep moisture in as well as prevent browning at high temperatures.
Sugar alcohols are used in cakes, cookies, and pies as well as puddings, frozen desserts, and even ice cream. In addition, sugar-free jams, frosting, and candies often use them. In fact, at high concentrations, sugar alcohols produce a cooling sensation found in some chewing gum.

Non-nutritive Sweeteners
Non-nutritive sweeteners hold many advantages that stem from providing sweetness in usually much smaller amounts without the burden of calories or creating a surge in blood glucose. Though some controversy still exists over non-nutritive sweeteners and an association with increased body weight. This association is often found in observational studies. Higher quality studies in the form of randomized control trials have shown non-nutritive sweeteners aid in weight loss. However, other reviews of the literature show little benefits of non-nutritive sweeteners. Many reviews are driven by older artificial sweeteners such as saccharin and aspartame.

As of 2021, the American Diabetes Association recognizes non-nutritive sweetened beverages as an acceptable short-term substitute for sugar sweetened ones when consumed in moderation. They conclude that non-nutritive sweeteners are helpful at decreasing carbohydrate and calorie intake as long as people do not compensate by adding calories from other sources.

Non-nutritive Sweeteners: Artificial Sweeteners
Artificial sweeteners have little to no calories. Some pass completely through the body.
Looking at the third column on the table, sweetness intensity for each is compared to table sugar. For example, saccharin is 200 to 700 times sweeter than sugar. As such, less is needed in products. The FDA has deemed all of these as safe for use within the ADI or acceptable daily intakes listed as milligrams per kilogram of body weight daily. Although some do have bitter aftertastes at high concentrations, others have closer taste profiles to table sugar (sucrose).

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There has been some research on the link between artificial sweeteners, disease, and weight management. Some research suggests that artificial sweeteners may increase the risk of cancers, while others argue against the fact; the findings, at this time, are inconclusive. At the same time you can easily find a wide variety of myths about the proposed ravages of artificial sweeteners but the claims are not backed by sound science. In the last few years we have seen studies that link use of artificial sweeteners to weight gain. These are mostly observational studies and some research with animal models but, again, we don't have sound conclusions to prove that they actually cause more weight gain than their high caloric alternatives.

A large, prospective cohort study in France showed a correlation between the artificial sweeteners aspartame, acesulfame potassium and sucralose and cerebrovascular disease risk.
It is reasonable to recommend artificial sweeteners to your patients but in moderation. Occasional use in coffee or tea is very reasonable, but moving away from artificially sweetened products is the best strategy.

Artificial Sweetener	Brands	Sweetness Intensity	ADI (mg/kg bw/d)	Taste
Saccharin	Sweet Twin® Sweet'N Low®	200-700x	15	Bitter at high levels
Aspartame	Nutrasweet® Equal®	200x	50	Like sucrose; no aftertaste
Acesulfame Potassium	Sweet One® Sunett®	200x	15	Bitter aftertaste
Sucralose	Splenda®	600x	5	Same flavor at high temperatures
Neotame	Newtame®	7,000-13,000x	0.3	Like sucrose; no aftertaste
Advantame		20,000x	32.8	Like sucrose; no aftertaste

Non-nutritive Sweeteners: Natural
Unlike artificial sweeteners, natural non-nutritive sweeteners are derived from foods. Some are high intensity sweeteners such as Reb M, Steviol glycosides and Luo Han Guo Fruit extracts, so very little is needed. In fact, they often fall under the category of a natural flavoring agent.

Allulose and tagatose provide the bulk and strength of sweetness similar to sugar.

Allulose is considered a rare natural sugar. Derived from sucrose or fructose, it has similar mouthfeel and texture of sugar with less sweetness. Allulose shows promising health benefits, largely in animals studies, but also in human ones. In fact, a randomized, double-blind, placebo control trial of 121 overweight and obese Koreans were given low- and high-doses of Alllulose beverages twice a day compared to a control group who drank Sucralose beverages. This was done for 12 weeks and afterward, Allulose participants lost weight, body fat percentage and abdominal subcutaneous fat significantly more than the control group. The participants given larger doses of Allulose (14 grams/day versus 8 grams) had more reductions, showing the more Allulose the more benefit.
Further, a systematic review and meta analysis on allulose discovered it reduced the glucose surge after a meal by 10%. More studies are needed, but this is one non-nutritive sweetener to keep an eye on. It has potential to be a game-changer for non-nutritive sweeteners.

Another popular non-nutritive sweetener is stevia. It is a purified form extracted from the leaves of stevia plants and is generally recognized as safe by the USDA. Whole leaf or crude extracts should not be used due to concerns about health effects.

Several studies targeting people with type 2 diabetes have found benefits from their consumption of stevia. One randomized control study of people with type 2 diabetes using Stevia in their tea for eight weeks found it did not increase blood sugar levels. In fact, a small crossover study comparing stevia to corn starch consumption even found stevia to lower blood sugar levels[3]. Though a metanalysis of 9 randomized control trials found stevia did not lower (or raise) blood sugar levels, but it significantly lowered systolic blood pressure. Although more research is needed, it seems Stevia may offer health benefits, especially for people with type 2 diabetes.

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Natural Sweetener	Brands	Sweetness Intensity	ADI (mg/kg bw/d)	Taste
Allulose	All-u-lose Anthony's Allulose Wholesome Allulose	0.7x	Not specified	Like sucrose, slight bitterness
Tagatose	Sweet Health Tagatose	0.9x	Not specified	Like sucrose; no aftertaste
Reb M	Tasteva M Bestevia Reb M Avansya Reb M	200-300x	4	Like sucrose; no aftertaste
Steviol Glycosides	Truvia® PureVia® Enliten®	200-400x	4	Bitter at high levels
Luo Han Guo Fruit Extracts	Nectresse® Monk Fruit in the Raw® PureLo®	120-250x	Not specified	Can be fruity; aftertaste at high levels

Sugary Drinks
It is very important to point out the large role that sugary beverages play in diabetes and obesity. People often assume that consuming calorie dense fruit juice is healthy and a good way to increase fruit intake. Sports drinks are also perceived as healthy and hydrating, but for both drinks people do not realize the amount of sugar they are actually consuming. Reinforce to patients that many sugar sweetened drinks are packaged with multiple servings (i.e., 1 serving is 8oz but bottle contains 16-20oz). When giving sugary drinks to children, parents should either just give water, or water down the soda or fruit juice.

It is best to recommend that patients drink water, coffee (not coffee drinks like Starbucks), or tea, and to avoid sugary drinks. While there is not definitive research on the optimum consumption of fluids, a goal of 6-8 cups of fluid/day is accepted and even more should be consumed with vigorous exercise.

Names for Table Sugar
There are 50 different names for table sugar: Dextrose, Fructose, Galactose, Glucose, Lactose, Maltose, Sucrose, Granulated Sugars, Beet sugar, Brown sugar, Cane juice crystals, Cane sugar, Castor sugar, Coconut sugar, Confectioner's sugar, Corn syrup solids, Crystalline fructose, Date sugar, Demerara sugar, Dextrin, Diastatic malt, Ethyl maltol, Florida crystals, Golden sugar, Glucose syrup solids, Grape sugar, Icing sugar, Maltodextrin, Muscovado sugar, Panela sugar, Raw sugar, Table sugar, Sucanat, Turbinado sugar, Yellow sugar, Agave Nectar/Syrup, Barley malt, Blackstrap molasses, Brown rice syrup, Caramel, Carob syrup, Corn syrup, Evaporated cane juice, Fruit juice, Fruit juice concentrate, Golden syrup, High-Fructose Corn Syrup (HFCS), Honey, Invert sugar, Malt syrup, Maple syrup, Molasses, Rice syrup, Refiner's syrup, Sorghum syrup, Treacle

In 2018 the FDA released the most recent rules on what accounts for added sugar on nutrition labels.
The rules outline that concentrated fruit or vegetable juice only counts as added sugar when more sugar than would be expected of the same volume of 100 percent juice of the same type is added. Because 100% cranberry juice is so tart, manufacturers must add considerably more sugar and therefore must count this under added sugar even when if they are using concentrated juice. However, fruit juice concentrates used for the fruit portion of jams, jellies, and preserves are not considered added sugar by the FDA requirements for labeling.

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Beverage	Average Sugar Content (grams)	Teaspoons of Sugar per Serving
Coke (12 oz)	39	10
Cranberry Juice Cocktail (12 oz)	48	12
Orange Juice (12 oz)	40	10
Sports Drinks (12 oz)	36	5
Chocolate Milk (12 oz)	24	6
Red Bull (8 oz can)	27	7
Vitamin Water (20 oz bottle)	33	8
Arizona Iced Tea (24 oz can)	72	18
Snapple Iced Tea (16 oz bottle)	46	11
Minute Maid Lemonade (20 oz bottle)	67	17
Capri Sun Pacific Cooler (6.75 oz pouch)	18	5

Remember: 4 grams sugar = 1 teaspoon

Cutting Down on Sugar Consumption

Although the American Heart Association recommends limiting added sugar to 6 teaspoons for women and 9 teaspoons, the average American consumes far more – 23 teaspoons daily! Once a person begins to reduce the amount of sugar they consume, their cravings for sugars also decrease over time. To start reducing the amount of sugar in the diet, remove added sugars from recipes (use naturally sweet fruit purees and/or add dried fruit) and replace high sugar, empty calorie foods with lower sugar, nutrient dense counterparts. Many nutrient and fiber-packed, naturally sweet fruits and other foods are a great alternative to junk food, such as unsweetened fruit purees, dried fruit, and nuts/nut purees.

Advise patients on healthy alternatives to sugar sweetened beverages. Sparkling water, often with a hint of flavor without adding sugar or calories, are becoming increasingly popular. In fact, globally almost 30 billion dollars in 2020 was spent on sparkling water and it is expected to increase 12.6% annually. Patients can even come up with their own signature flavor of sparkling water. Making concentrates of tea such as hibiscus give a touch of color and flavor without the added sugar and calories.

Alcohol

Alcohol is considered to be part of the Mediterranean diet and is generally consumed at meals. The “dose” is a therapeutic window with consuming some but not too much alcohol. Females can have about one glass a day, and males two. It does not matter what type of alcohol it is. This does not mean that if you do not currently drink you should start now. It is also important to know that the average of two drinks per day does not add up to saving weekly consumption for 14 drinks on Saturday night. Binge drinking is clearly unhealthy.

Snacking

Portion size is extremely important when it comes to meals and snacking. If a patient has a strong sweet tooth, suggest frozen berries, low fat dairy products, fruit based desserts, or grilled or poached fruits. For salt cravings, sunflower seeds, dill pickles, lightly salted nuts, lightly salted popcorn, hummus, veggie sticks, or low-fat cheese are great options. For crunchy cravings, try vegetables, fruits, unsalted rice cakes, popcorn, or unsalted nuts.

When choosing snacks, look for ones that are nutrient dense with less than 10 g of sugar, 5 or more grams of fiber, 1 gram or less of saturated fat, and low in sodium. Watch for key words like “whole grain/whole wheat” in the beginning of the ingredient statement. Emphasize reading labels to compare sugar, sodium, fiber and saturated fat.

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