Dietary Impact on the Prevention and Management of Obesity

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"You don't drown by falling in water. You drown by staying there"—Anonymous

The nation is getting fatter and currently two-thirds of the UK population are overweight and 26.9% are obese (OECD 2017). The prevalence is set to almost double, with one in every two or three adults projected to be being obese by 2030 (Wang et al. 2011). The common thought is that this is due to the nation eating more and exercising less. The energy balance theory suggests that if people consume more calories than they burn, they will gain weight and if they eat fewer calories than they expend, they will lose weight. However, there are several problems with this theory:

1. It does not consider the difference between food calorimetry in a lab (determining the number of calories per gram of food) and food metabolism in the body (how calories are processed and either used as energy or stored).
2. Telling people to simply *eat less* is not the answer to sustainable weight loss. Reducing calorie intake (eating less) can slow ones basal metabolic rate, i.e. reduce the amount of calories the body burns, because the body thinks it is being deprived and goes into dietary starvation mode.
3. Advising people to *move more* as a sole strategy for weight loss is not the answer. Increasing physical activity can stimulate hunger hormones such as ghrelin, which will increase appetite (Cameron et al. 2016), and rarely compensates for excess calories consumed from food and drinks—you can't outrun a bad diet! (Malhotra et al. 2015)

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These flaws are why traditional diets, which often lead to weight loss in the short term, are ineffective in the longer-term. The weight regain frequency overshoots the initial weight resulting in the person being heavier after the diet than they were beforehand. The person often blames themselves for the failure and when they redeem the motivation to lose weight, they frequently do exactly the same but believe that they will just try harder. On each occasion that they attempt to lose weight with a reduced calorie, low fat high carbohydrate diet, they may further reduce their basal metabolic rate and this could result in their energy expenditure dropping to match the new energy intake and the reduced energy expenditure can be as much as 500 calories per day (Fothergill et al. 2016).

Some people find it helpful to monitor their calorie intake. On average, women require 2000 calories each day and men require 2500 calories. However, one limitation with calorie counting is the lack of recognition that weight gain is regulated by hormones and not calories. Hormones regulate fat storage (lipogenesis), fat usage (lipolysis), hunger, and satiety (Taubes 2013; Kersten 2001; Choi et al. 2010). It is much more important to consider the quality of foods consumed than count calories.

The food we eat contains several nutrients. Some nutrients provide energy (calories) and these are called macronutrients. The three main macronutrients are *carbohydrate, protein, and fat*. Micronutrients supply the body with nutrients but no calories. The two classes of micronutrients are *vitamins and minerals*. Our health is largely determined by the amount of nutrients the body absorbs. Too many or too few of certain nutrients can cause harm. Some nutrients are essential to life, meaning that the body cannot synthesise them and therefore they must be consumed. There are some essential fatty acids (from fat), amino acids (from protein), and many vitamins and minerals that are vital. Traditional wisdom believes that carbohydrate is essential, but this is not true because if we do not eat carbohydrate, we can make it in the body from either protein or fat. Humans can survive without an exogenous (dietary) supply of carbohydrate as 0.56 g of glucose can be derived from every 1 g of protein ingested and 0.1 g of glucose can be derived from every 1 g of fat ingested, a process called gluconeogenesis. Thus, the lower limit of dietary carbohydrate essential for life is zero, provided that adequate amounts of protein and fat are consumed (Institute of Medicine of the National Academies 2005).

One of the main hormones involved in internal fat regulation is insulin. There is emerging evidence that elevated insulin levels result in energy being trapped in fat cells (adipocytes), decreasing energy availability. Thus, if fewer calories are being consumed, the body has no option but to go into dietary starvation mode, stimulating hunger and conserving energy, i.e. slowing down the basal metabolic rate (Ludwig and Ebbeling 2018).

This chapter presents an alternative strategy to the low calorie, low fat diet for sustainable weight loss. It aims to address one of the underlying problems of fat storage and obesity: high insulin levels and insulin resistance. The amount and type of macronutrients consumed as well as eating frequency will impact insulin levels. Carbohydrate is the nutrient that elicits the greatest rise in insulin levels, this nutrient

should be restricted to tolerance levels, i.e. to a level whereby an individual is able to achieve their weight loss and health goals. Although protein generates the greatest satiety value, some proteins do directly rise insulin levels and therefore protein should be consumed in moderation. Fat has minimum impact on insulin levels and this nutrient should become the preferred energy source. However, fat calories can be supplied from either the diet or the adipose tissue. If weight loss is too rapid, this suggests that insufficient fat is being supplied from the diet and too much from the stored body fat. If weight loss plateaus, this would suggest that too much fat is being consumed and fat stores are being maintained.

Food Groups

The five main food groups that contribute to our daily intake are: fruit and vegetables; carbohydrates; milk and dairy; protein; fats.

- *Fruit and vegetables* provide a variety of vitamins and minerals and fibre. Many of the vitamins are antioxidants that help to halt cell damage that leads to heart disease, stroke, and some cancers. Minerals are required for many essential functions in the body.
- *Carbohydrates* are a source of energy. Starchy foods supply the body with glucose whereas sugary foods supply both glucose and fructose. Natural unprocessed carbohydrate can also contribute fibre, calcium, iron, and B vitamins. However, processed and refined carbs are nutrient poor.
- *Protein foods* are essential for growth and repair of the body and increase feelings of fullness, following consumption.
- *Milk and dairy foods* provide us with calcium which is essential for healthy bones.
- *Fats* are nutrient dense, providing us with many essential nutrients, and they are also a great energy source. Fat often adds taste to food and creates satiety (the feeling of fullness).

Carbohydrate to Tolerance

All of the food groups can potentially contribute to your daily intake of carbohydrate, in the form of starch and/or sugars.

- Fruits contain natural fruit sugars and vegetables contain small amounts of starch.
- Carbohydrates such as bread, potatoes, rice, and cereals are sources of starchy carbohydrate. Sugary carbohydrates are obtained from drinking sugar-sweetened beverages, fruit juice, and sweet foods such as sugar, candy, biscuits, cake, and desserts.
- Protein foods, such as meat, fish, and eggs do not contain any carbohydrate unless they are processed in some way, for example, added breadcrumbs or batter. Protein such as pulses, e.g. beans and lentils contain starchy carbohydrate.

- Milk and dairy foods contain natural milk sugars called lactose (excluding hard cheese which is virtually carbohydrate free).
- Fats in their natural form, e.g. butter, lard, oil, fat on meat, cream, or cocoa solids are virtually carbohydrate free but as soon as fat is processed by adding flour and sugar to make biscuits or cake; sugar and milk to cocoa to make chocolate; or potato to make chips and crisps it becomes quite carbohydrate dense.

A small slice of bread contains around 15 g of carbohydrate. It is easy to compare the quantity of carbohydrates in other foods to that in a slice of bread. For example, three teaspoons of sugar, a small [130 g] apple or 300 ml of milk provide the same quantity of carbohydrate as a small slice of bread. Figure 16.1 illustrates some carbohydrate foods that may be consumed throughout day.

STARCH is made up from lots of units of glucose. The glucose is released into the blood at different rates depending on other nutrients present within the food.

GLUCOSE is a simple unit which is absorbed very quickly in the gut, causing a rapid peak in blood glucose levels.

SUCROSE, generally known as SUGAR, is made from glucose and fructose. It is used in drinks, confectionery, and baked goods.

FRUCTOSE, often called FRUIT SUGAR, is also found in fruit as well as being one of the building blocks of sucrose.

LACTOSE, another type of sugar which is found in milk and milk products, is often referred to as MILK SUGAR. It is made up of glucose and galactose. Some people may struggle to digest this type of sugar.

The building blocks of carbohydrates are as follows and are illustrated in Fig. 16.2 below.

When starchy food digests it is broken down into glucose which is released and absorbed into the blood stream causing a rise in blood glucose levels. Therefore, the more carbohydrate (starch or sugar) consumed, the greater the impact on glycaemia. Only 3–7 g of glucose is contained in the entire blood circulation at any one time in individuals with normal glucose tolerance and therefore the glucose needs to be cleared from the blood rapidly after a carbohydrate containing meal or snack. When blood glucose levels rise, insulin is released from the pancreas into the blood where it enables glucose to enter body cells where it can be converted into energy.

Fructose and galactose have a slightly different metabolic pathway. They are initially transported to the liver, converted into glucose and stored as glycogen. Between meals or overnight when blood glucose levels start to dip, the glycogen is broken down into glucose and is released into the blood to restore glucose levels to normal. The liver can release between 6 and 25 g of glucose per hour (Webster et al. 2016). When glycogen stores become full, any excess carbohydrate is then converted into fat, a process called de novo lipogenesis. The scientific name for fat is triglyceride. Therefore eating carbohydrate to excess results in the production of triglyceride that is either stored in the adipose tissue, in and around the organs such as the pancreas and liver, or in the blood, increasing blood triglyceride levels (Volk et al. 2014; Volek et al. 2012; Sevastianova et al. 2012).

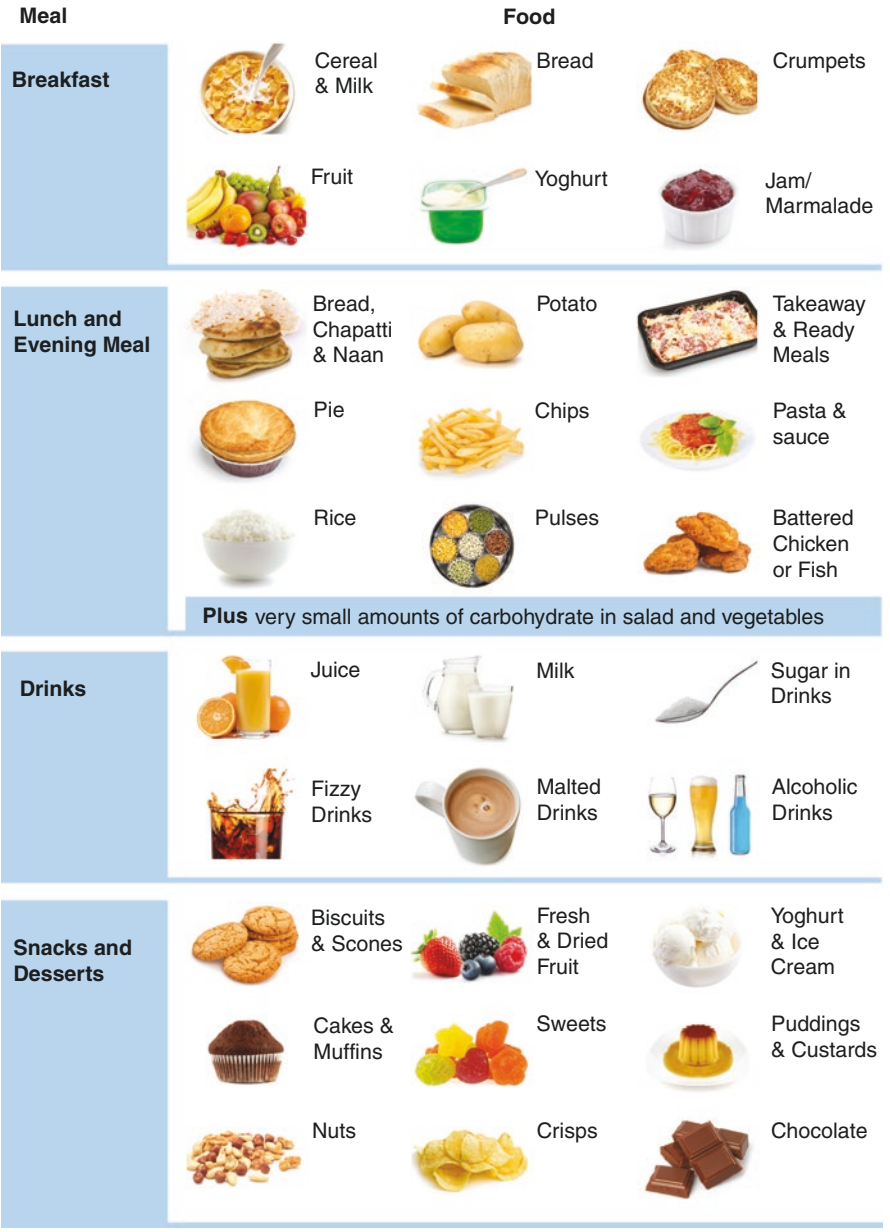

Fig. 16.1 Sources of carbohydrate

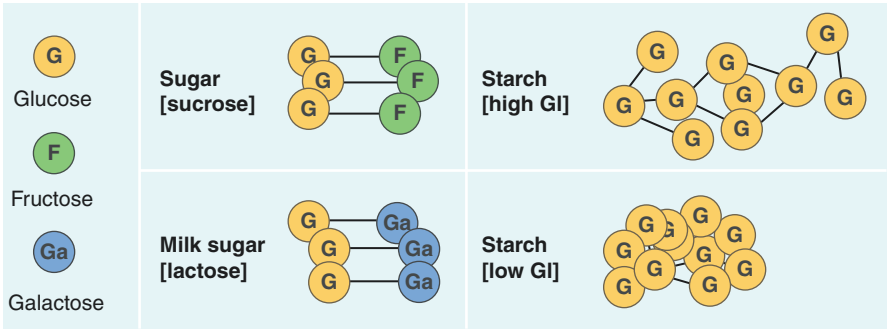

Fig. 16.2 Building blocks of carbohydrate

Glycaemic Index

Different carbohydrate foods have varying effects on blood glucose and can be ranked using the glycaemic index (GI). As stated above, a small slice of bread, three teaspoons of sugar, a 130 g apple and 300 ml milk all contain the same amount of carbohydrate—15 g. However, the speed in which they release the glucose and raise blood glucose levels and thus, insulin levels, is very different. Bread has the quickest impact because the modern milling process grinds the grain to a very fine consistency so that the glucose can be rapidly released in the digestive track and adsorbed into the blood, causing a greater peak in insulin levels. Some breads such as granary and wholegrain release glucose slightly slower because they have not been processed to the same extent. As a general rule of thumb, the more processed the food, the quicker it digests and releases its glucose. Lucozade™, glucose tablets, old potatoes, processed and refined cereals such as Cornflakes™ and Rice Krispies™ and rice are also quick-releasing carbs.

Sugar is classed as a medium-releasing carbohydrate as well as most sugar containing foods such as jam and fizzy drinks. This is because sugar or sucrose (to give its correct name) contains equal amounts of glucose and fructose. Fructose is stored in the liver either as glycogen or triglyceride so only 50% of the sucrose molecule directly impacts on blood glucose and insulin. This does not imply that sugar is healthier as the amount of sugar consumed has the greatest impact. There is emerging evidence that fructose can be detrimental to health by stimulating insulin resistance and non-alcoholic liver disease by stimulating hepatic de novo lipogenesis (accumulation of fat within the liver) (Jensen et al. 2018). Other medium-releasing foods include Weetabix™, shredded wheat, new potatoes, sweet potatoes, and basmati rice.

If carbohydrate food breaks down slowly, there will be a slower rise in blood glucose levels, which will allow the body to handle the glucose load better, without stimulating the same surge in insulin. Examples of slow-releasing carbohydrates include: many vegetables; milk and yoghurts; nuts, seeds, and pulses; steel-cut porridge and some mueslis.

There are many factors that can account for the GI of different foods and these are summarised below:

Physical form: Generally, the more processed a food, the higher its GI. For example, instant oatmeal has a GI of 79, whereas steel-cut rolled oats has a GI of 55.

Food combinations: When carbohydrate foods are eaten as part of a meal, the GI of the meal changes based on the average of all the GI values factored together.

Cooking time: Longer cooking times may increase the glycaemic impact of a food by breaking down the starch or carbohydrate and allowing it to pass through the body more quickly when consumed. Pasta cooked al dente (for 5–10 min) has a slightly lower GI than pasta cooked longer.

Acidity: The more acidic a food is (e.g., pickled food or those containing vinegar or lemon juice), the lower the GI. For example, sourdough bread, which uses a lactobacillus or lactic acid culture as part of the leavening process, has a lower GI than white bread.

Physical entrapment: The fibrous coat around beans, seeds, and plant cell walls in whole grains acts as a physical barrier, slowing access of digestive enzymes to break down the carbohydrate. Thus, many whole grains and legumes have a lower GI.

Protein/fat: Adding protein or fat, which have minimal effects on glycaemic excursions, to a high-GI food will decrease the GI of that food. For example, adding cheese to a slice of bread would decrease the GI.

Soluble fibre: In general, the higher the food is in viscous or soluble fibre, the lower its GI will be. By increasing the viscosity of the intestinal contents, the interaction between the starch and the digestive enzymes is slowed, resulting in slower and lower glycaemic excursions. Beans are a great example of a food high in soluble fibre.

Replacing some high-GI foods with low GI foods has been shown to lead to health improvement (Thomas 2009; Schulze et al. 2004). Despite the quantity of carbohydrate remaining as the primary focus, it is also useful to consider the type of carbohydrate. Glycaemic load can be calculated by multiplying the glycaemic index of a food by the grams of carbohydrates consumed. The International Tables of Glycaemic Index and Glycaemic Load lists information for more than 2400 food items and are acknowledged as the go-to source for the most scientific information (Atkinson et al. 2008).

The Level of Carbohydrate Restriction

The UK Reference Intake for carbohydrate is 260 g per day. This quantity of carbohydrate may be above the tolerance range for some people, eliciting hyperinsulinaemia (high insulin levels) and weight gain. A Mediterranean dietary approach contains up to 200 g per day of wholesome slow-releasing carbs. A low carbohydrate diet contains less than 130 g, whereas a very low carbohydrate, ketogenic diet, contains fewer than 50 g per day (Feinman et al. 2015). If an individual consumes carbohydrate above their personal threshold, this may lead to hyperinsulinaemia,

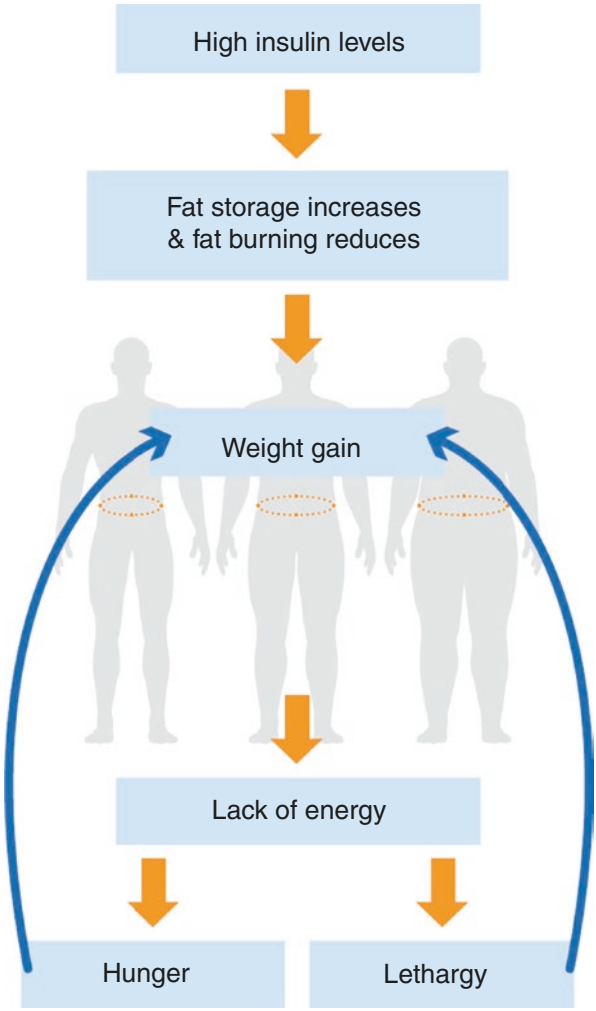

Fig. 16.3 The consequence of hyperinsulinaemia

hunger, and sedentary behaviour (see Fig. 16.3) ultimately increasing the risk of developing obesity, non-alcoholic liver disease, and Type 2 diabetes (Sevastianova et al. 2012; Chiu et al. 2014; Georgoulis et al. 2014).

High insulin levels, and the resulting lipogenesis, cause the cells to resist the action of insulin. This is defined as insulin resistance (Henry et al. 1993) (see Fig. 16.4). This exacerbates the problem resulting in a vicious cycle of hyperinsulinaemia, insulin resistance, and an inability to utilise stored energy resulting in per person experiencing hunger, lethargy, and potentially further weight gain.

Insulin levels are not routinely measured in the UK and therefore the only way to ascertain whether high insulin levels and insulin resistance are present is by monitoring the metabolic syndrome indicators (Alberti et al. 2005). If three or more

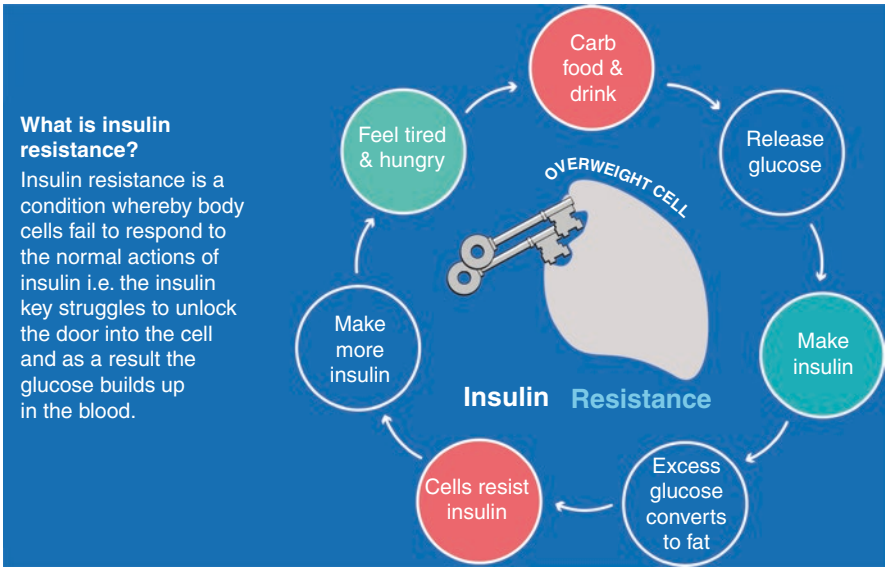

Fig. 16.4 Aetiology of insulin resistance

of the five indicators are outside the international cut points, it suggests that that individual is experiencing hyperinsulinaemia and insulin resistance (see Fig. 16.5). Considering the amount and type of carbohydrate consumed can improve these indicators.

Protein in Moderation

Protein should be a central part of a complete diet for adults. While physical growth occurs only for a brief period of life, the need to repair and remodel muscle and bone continues throughout life. Maintaining the health of muscle and bone is an essential part of the ageing process and critical to maintain mobility, health, and the active tissues of our body. Protein requirements increase during periods of reduced food intake such as weight loss or during periods of recovery after illness or during ageing. Protein needs for adults relate to body weight. Dietary protein need is often presented as a percentage of energy intake. The Reference Nutrient Intake (RNI) is set at 0.75 g of protein per kilogram bodyweight per day in adults (SACN 2011). Protein requirements are frequency promoted as being 15–20% of energy intake but protein needs are actually constant across all energy intakes. So at low energy intakes, protein needs to be a higher percentage of total calories and at high energy intakes protein can be reduced as a percentage of total calories.

Protein is an important part of good nutrition at every meal. Vitamins and minerals can fulfil nutrient needs on a once-per-day basis but for protein the body has no ability to store a daily supply. To maintain healthy muscles and bones for adults, at

Fig. 16.5 Definition and cut points for the metabolic syndrome

Metabolic Syndrome

The metabolic syndrome is deined as having three or more of the risk factors below. The international cut points are:

Increased waist size: Greater than 94 cm in Caucasian men and greater than 80 cm in Caucasian women, or greater than 90 cm in South Asian men and greater than 80 cm South Asian women

Raised triglycerides: Greater than 1.7 mmol/l (or on medication to reduce triglycerides)

Reduced HDL-cholesterol: Less than 1.03 mmol/l in men; less than 1.29 mmol/l in women (this is different to the standard HDL-C cut points, see page 160)

Raised blood pressure: Systolic greater than 130 mmHg; Diastolic greater than 85 mmHg (or on medication to reduce blood pressure)

Raised fasting glucose: Fasting plasma glucose greater than 5.6 mmol/l

Source: X-PERT Health

least 30 g of protein should be consumed at more than one meal (Layman 2009). Breaking a fast (overnight or after intermittent fasting) is an important meal for dietary protein because the body is in a catabolic state. Protein is also critical for regulation of appetite and daily food intake (Weigle et al. 2005).

However, consuming protein to excess can be detrimental for two reasons:

1. Some proteins can directly stimulate insulin.
2. Surplus protein cannot be stored and some may be converted to glucose, further stimulating insulin.

Fat to Satiety

Fat is an indispensable building material for every single cell. It also serves as the primary energy reserve in humans and animals. The storage and transportation form of fat is called triglyceride. Each triglyceride molecule is composed of one glycerol and three fatty acid molecules. Free fatty acids are also components of cell membranes, precursors for many biologically active molecules, and direct substrates for energy production.

There are three different types of fat. The terms saturated, monounsaturated, and polyunsaturated fats refer to the number of double bonds between carbon atoms (see Fig. 16.6).

There are 36 types of saturated fatty acids (SFA) differing in chain length from 3 to 38 carbons, 8 types of monounsaturated fatty acids (MUFA), 16 to 24 carbons

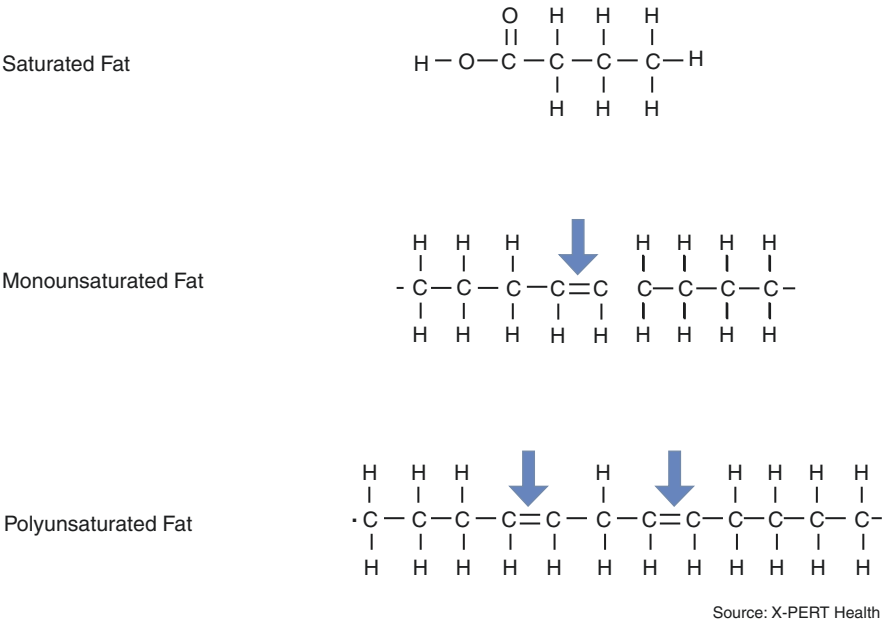

Fig. 16.6 Three classes of fatty acids

with one double bond, and 10 types of polyunsaturated fatty acids (PUFA), 18 to 22 carbons with two to six double bonds. Saturated fats, which are mostly from animal sources, have single bonds between the carbons and all the carbons are bonded to the maximum number of hydrogens possible. The chains in these fatty acids are straight and can pack closely together making these fats solid at room temperature. Oils, mostly from plant sources, have some double bonds between some of the carbons causing bends or "kinks" in the shape of the molecules and are called unsaturated fats. Because of the kinks, unsaturated fats cannot pack as closely together making them liquid at room temperature. These bonds can easily be oxidised and this can make the oil rancid. To control this, food manufacturers sometimes use hydrogenated vegetable oils. Hydrogenation is a chemical process that adds hydrogen atoms to the available double bonds in the vegetable oil converting "cis" double bonds to "trans" double bonds, producing *trans* fatty acids (Willett and Ascherio 1994).

All fats have equal calories (9 calories per gram) but they work differently in the body. No food contains 100% of one type of fatty acid or triglyceride but we tend to categorise foods as having either greater proportions of either saturated, polyunsaturated, or monounsaturated. Contrary to popular belief, pork fat (lard) has more unsaturated fat than saturated fat and beef fat (dripping) has equal amount of saturated and unsaturated fat. Olive oil, although classified as a monounsaturated oil, contains 14% saturated fat (see Fig. 16.7).

The number of carbon atoms in fatty acid chains is also important. Most of the fatty acids in living organisms have an even number of carbons. Fatty acids with less than six carbons in their chains may collectively be called short-chain fatty acids.

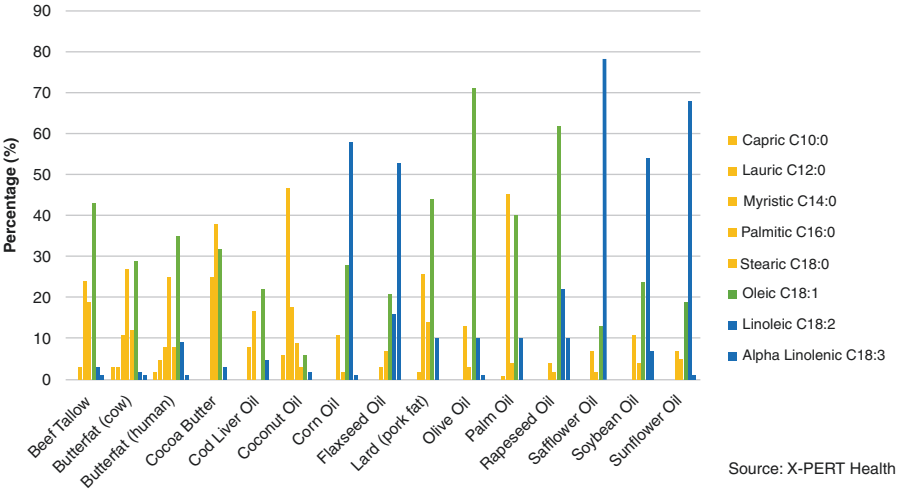

Fig. 16.7 MUFA (green), SFA (yellow), and PUFA (blue) composition of fats and oils

Those with 6 to 12 carbons are medium-chain fatty acids, those with 14 to 22 carbons are long-chain fatty acids, and those with over 22 carbons are the very-long-chain fatty acids. Short- and medium-chain fatty acids are rapidly oxidised as fuel rather than stored as fat, whereas long-chain fatty acids are more likely to be stored in adipose tissue.

The foods which are the main sources of saturated fat are butter, ghee, cream, cheese, and chocolate. Foods high in omega-6 polyunsaturated fat are oils like sunflower, safflower, sesame, corn, soya, linseed, or grapeseed and spreads labelled "high in polyunsaturates". Foods high in omega-3 polyunsaturated fat is oily fish such as salmon, mackerel, and sardines; nuts and seeds such as walnuts, Brazil nuts, pine nuts, sunflower, and sesame seeds. The foods that are the main sources of monounsaturated fat are olive and rapeseed oil. However, it is better to purchase extra virgin or cold-pressed varieties as the standard versions have been highly processed with the use of heat and solvents that can destroy the beneficial properties of the oil. This also applies to spreads made out of these oils. Monounsaturated fat is also found in peanut or groundnut oils, butter and lard, and in nuts such as peanuts, almonds, cashews, Brazil nuts. Monounsaturated fat is more stable in the body than polyunsaturated fat, which is more prone to oxidation. Oxidation causes free radicals that can lead to cell damage increasing the risk of heart disease and cancer.

Dietary fat (triglycerides) cannot be absorbed by human cells directly. They must be broken down first through a series of processes that require enzymes called lipases. Dietary fat is mainly transported in a protein transporter called a chylomicron.

There is no evidence for the beneficial effects of reduced or modified fat diets in the prevention of heart disease (Harcombe et al. 2016). Recommending higher intakes of omega-6 polyunsaturated fatty acids in replacement of saturated fats is not associated with risk reduction. Recent research indicates that saturated fat, particularly in dairy products and coconut oil, can improve health (Khaw et al. 2018; Forouhi et al. 2014; Gao et al. 2013). The evidence of omega-6 polyunsaturated fatty acids (PUFAs) promoting inflammation and augmenting many diseases continues to grow, whereas omega-3 PUFAs seem to counter these adverse effects (Ramsden et al. 2010). The replacement of saturated fats in the diet, with carbohydrates, may have resulted in increased obesity and its associated health complications (Dehghan et al. 2017; Grasgruber et al. 2016). The adverse health effects that have been associated with saturated fats in the past are most likely due to other factors and there is a need for a re-evaluation of existing dietary recommendations that focus on minimising dietary saturated fats.

When carbohydrate intake is restricted and moderate protein consumed, fat either supplied from the diet or utilised from body fat stores becomes the primary fuel for energy. Individuals who aim to maintain their body weight will need to

increase dietary fat (if following a low carb, high fat dietary approach). Individuals who wish to lose weight, will fuel from their stored fat. It is recommended that dietary fat is obtained from foods that have been minimally processed such as extra virgin olive oil or cold-pressed rapeseed, coconut oil, avocado, eggs, butter, lard, dripping, and tallow.

Eating Frequency

We have changed from a nation consuming three meals per day with no snacks to grazing throughout the day. Increased frequency of eating and the consumption of a large amount of quick-releasing carbohydrate can cause repeated surges in blood glucose and insulin. Moreover insulin levels should be able to return to a fasting state between meals.

A longer overnight fast and reduced frequency of eating has been shown to be beneficial to health Reducing eating frequency to three or fewer meals per day will help to reduce insulin levels and insulin resistance (Hankey et al. 2015; Davis et al. 2016; Kahleova et al. 2017) (see Fig. 16.8).

Eating the same amount over a shorter period of time (6 hours compared to 12) has also been shown to be beneficial for insulin regulation and sensitivity (Sutton et al. 2018).

Summary

Adopting a low calorie, low fat diet may still lead to consuming carbohydrate above ones' personal threshold level. The resulting high insulin levels promote lipogenesis (fat storage) and prevent lipolysis (fat usage). This can be described as starvation in the mist of plenty where there is excess energy stored as fat within the body but it cannot be utilised as an energy source. As calories consumed are also being restricted, there is insufficient energy to fuel the body. The body then compensates and goes into dietary starvation mode and slows down the basal metabolic rate to conserve energy. Thus, although a low calorie diet may be successful in the short term, the weight loss will eventually plateau and weight regain is a frequent consequence. The "eat less, move more" message is less likely to lead to sustainable weight loss. Recognition that obesity is a hormonal condition and considering the type of food consumed and frequency of eating will treat the underlying cause of obesity, namely hyperinsulinaemia and insulin resistance. Eating carbs to tolerance and consuming moderate protein will enable the body to fuel on fat (dietary and stored) leading to sustainable fat loss, preserved metabolic rate, and improved health status.

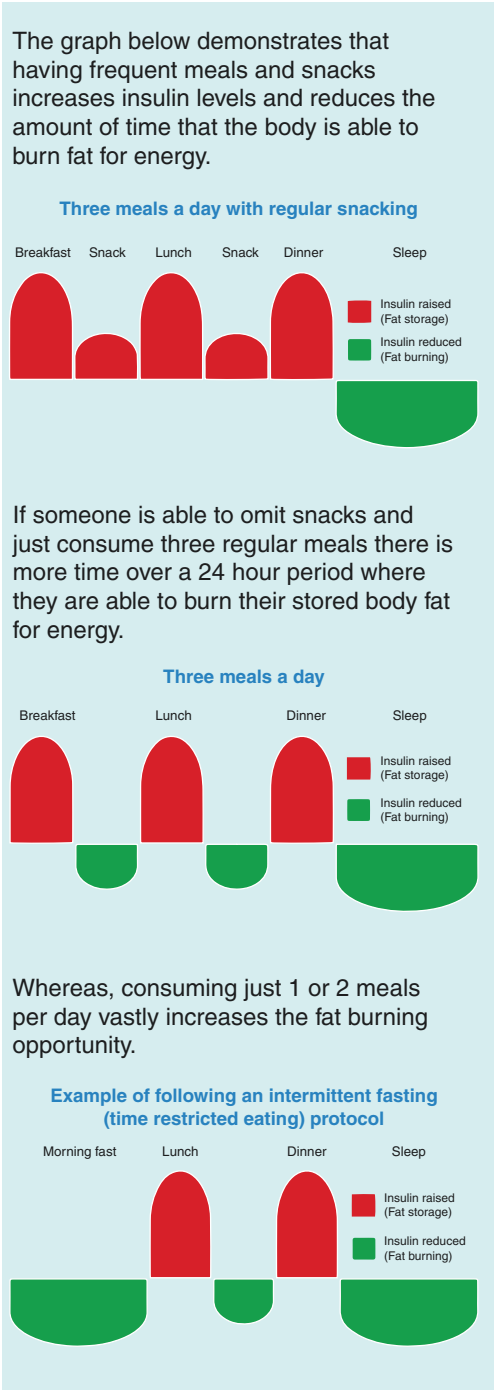

Fig. 16.8 Frequency of eating on insulin levels

Source: X-PERT Health

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