Fitness NUTRITION Coach

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Introduction

In choosing to study for the Fitness Nutrition Coach (FNC) credential you are embarking on a journey of discovery and enlightenment regarding food, and the nutrients contained therein, and how they interact with the human body to promote health and well-being. There are numerous topics to learn during this course that will broaden your understanding of how the human body functions. Starting with basic physiological processes of digestion through to the more complex individual chemical nutrients that we absorb, you will learn how they are utilised to stimulate growth, rebuild tissues, restore and save energy, fuel physical activity, and support the vast myriad of cellular functions necessary for a healthy working body.

The wider health and fitness industry has, for many decades, embraced the use of nutritional principles, diet, eating patterns and behaviour change to support clients in reaching their health and fitness goals. The vast majority of modern fitness professionals will likely apply some degree of nutritional guidance in support of their clients and members. The use of nutrition coaching can be a significant benefit to most fitness trainers and may even provide a higher level of service to those who have enhanced their knowledge and skills to the next level beyond the basic nutrition taught within most personal training or fitness coaching courses. Providing bespoke nutrition services to appeal to individuals who are seeking additional support can certainly be an attractive sales tool to bring in new customers and clientele. It could also be argued that fitness professionals providing weight management or hypertrophy services without influencing dietary change would be a significant oversight and would likely lead to poor results.

Scope of practice

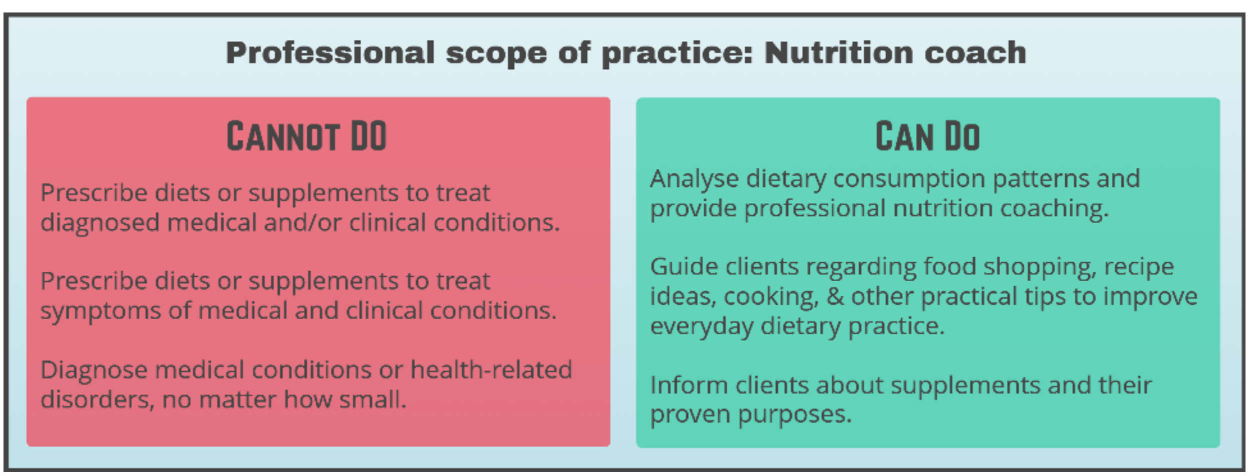
Scope of practice is defined as the qualified limits of your knowledge, skills and experience and is made up of the industry appropriate activities and services that are carried out within your professional role. It is incredibly important that all fitness professionals understand the range and scope for which they can practice concerning their nutritional knowledge and services. It can be very tempting when gaining further knowledge through reading a new book or learning information on the internet to want to share that new information and knowledge with clients and members alike. When acting in your professional role as a fitness industry expert it is imperative to remain within the boundaries of your relevant qualifications and professional certifications.

New information can be exciting to learn, but should not become part of your regular professional practice unless it is aligned with appropriate professional certifications and is in harmony with widely accepted, scientifically validated dietary guidelines

The accepted scope of practice for fitness industry professionals can be generally described as follows; Nutrition Coaches **can** provide food and nutritional advice for generally healthy individuals in respect to their eating habits and daily food and beverage consumption. Changes to eating patterns should be taught and coached in a principle-oriented manner to encourage gradual, consistent behaviour change that empowers the individual to take ownership of their daily habits and to make better food choices going forward.

After studying this text and passing the associated assessment, you will be awarded the respective credential of 'Nutrition Coach'. This title is associated with your proven competency of the subject matter of this text and may only be used with respect to providing nutritional advice that helps your client to better understand how and why their eating habits impact their fitness training programme and goals for improved health. Completion of this course does NOT qualify you as a dietician. There are differences in what you may do as a Nutrition Coach versus what a licensed professional is qualified to do. Once you have passed the assessment for this course, you will be a Nutrition Coach, able to offer the following services to your clients (as shown in this illustration 'Professional Scope of Practice: Nutrition Coach').

Please note the Do's and Don'ts regarding how you are able to serve your clients as a Nutrition Coach:



*This relates to a certified nutrition coach/advisor without a relevant nutrition degree or specific supplement certificate

Nutrition perspective

Teaching healthy dietary practices can be viewed from two separate perspectives. One perspective is to educate from the outside, in respect to the food and nutrients being consumed. This approach provides a distinction between nutritious, wholesome foods and low-quality 'junk' foods; identifying food sources rich in carbohydrates, proteins, and fats, ensuring sufficient micronutrients, and offering consumer advice regarding food labelling. The other perspective is from the inside or the internal physiological perspective. That includes education on how the body utilises different foods once ingested, as well as the foods' positive & negative effects on physical health and wellbeing once it is broken down into its influential chemical components. Understanding both the outside and the inside perspectives are important. However, since nutrition education from the 'outside' perspective is widely practised and made readily available, this course will provide a greater emphasis on the "inside" point of view to ensure a physiological systems-based understanding for providing nutritional advice.

Healthy eating

Most nutrition practitioners would agree that one of their primary objectives is to help their clients to eat in a manner that would be considered to be healthy. Healthy eating can be considered a consistent routine of consuming food and beverages that support the proper and optimal functioning of the human body and as a result deliver long-term, vibrant health and longevity. Despite significant advances through scientific research to determine exactly what comprises a healthy eating pattern for humans, this is still open to a certain level of healthy scientific scrutiny and debate. It is likely that a single, optimal dietary approach to service all the unique needs across a diverse population may never be revealed. However, there are several well-accepted dietary principles that appear to be true across all different populations and often form the backbone of national and international dietary guidelines.

These accepted dietary principles are:

- Eat a nutritionally sufficient diet from a variety of food sources
- Reduce saturated fat and refined sugar intake
- Eat vegetables in abundance and include fruit intake regularly
- Reduce total processed salt intake
- Keep well hydrated, but alcohol should only be consumed in limited amounts
- Manage energy balance as needed for weight maintenance or reduce excess weight

It is also important to recognise that within a culturally diverse population, as is found in most modern communities around the world today, there will be several other factors that feed into dietary choices beyond awareness of published healthy eating guidelines.

Cultural expectations, religious practices, personal or family dietary preferences, social pressures, ethics and morals, personal goals and objectives, body weight, physical activity habits, employment and working practices offer a few of the important and influential factors that will influence an individual's daily eating behaviours. A well-trained nutrition coach will explore and discuss these other related factors with a client to understand the client state of play in advance of dispensing nutritional advice.

Many individuals develop firmly ingrained eating habits and behaviours that they often unconsciously justify and defend to undermine change, even though they may intellectually understand the importance of altering diet to bring about the changes or improvements that they seek. Therefore, mastering good communication and behaviour change skills are also an important element to becoming an effective nutrition coach. Communication and coaching skills are so important to the modern nutrition coach that they will be the topic of an entire chapter that will be discussed later.

Chapter 1: General Nutrition

Nutrition defined

Before we can learn effectively on the subject of nutrition we first must clearly define what is meant by the term nutrition or nutrients. The Encyclopaedia Britannica defines nutrition as;

Nutrition: the assimilation by living organisms of food materials that enable them to grow, maintain themselves, and reproduce.

The Merriam-Webster dictionary defines nutrients as;

Nutrients: a substance or ingredient that promotes growth, provides energy, and maintains life.

Therefore, we can ascertain that providing the human body with the necessary food compounds, the substances that support and sustain life, is the fundamental process of nutrition. The study of nutrition centres around all of the various factors to do with food and dietary practice and how to manage these effectively. This sounds easy enough, but requires a significant amount of learning regarding human physiology and the chemistry of foods and how these impact and interact with the human body. This is compounded by the realisation that each human being may respond slightly differently to the same foods. This is all part of the process of guiding clients along their own personal nutrition journey.

Diet or starvation?

Strictly following a proper diet can at times be extremely difficult, if not impossible. It takes practice! It may take many months to completely change current poor eating habits into sustainable good habits. It may be helpful to suggest to a client that they work on their diet one meal at a time. Work on the first meal for a week, two weeks, or as long as it takes to make this particular meal rich in nutrition, then move on to the next. Patience is certainly a valuable virtue when practising dietary behaviour change.

Avoid associating the word diet with starvation! Not all diets require a reduction in food energy. A starvation mindset may affect individuals mentally and physically. Mentally, starvation takes its toll on willpower, which is a finite resource. There is an increased likelihood that a 'break down' of willpower occurs when operating from a 'starvation' mindset, which generally manifests itself as a binge or feast on junk food, that is later perceived as a personal failure, which in turn often carries guilt and shame. Such mental and emotional gymnastics are very taxing on an individual and may often lead to a decrease in self-worth. The irony is the individual started with the intention of improving themselves and the result is exactly the opposite.

Physiologically, when the body senses starvation, a chronic lack of food energy, it has the capacity to adapt its cellular processes and enter a phase sometimes referred to as 'survival mode'. This can be grossly simplified as an attempt to conserve body fat, the densest source of energy, in an attempt to increase the long-term chances of survival - a sensible thing to do if a widespread famine was to occur. Internal physiology has the ability to reduce the basic rate of energy expenditure, whilst utilising amino acids, blood proteins, muscle, and organ tissue as potential sources of energy to complement the shortfall during such extreme conditions. Severe dietary restriction, with very low energy intake, can cause the body to shift towards these types of survival-oriented adaptations. As a client learns more about their required diet, they may be surprised at the required daily energy intake needed to sustain optimal health. Daily energy needs can vary significantly between one individual and the next.

Hydration

When discussing diet, it is essential to mention the body's most immediate needs: oxygen and water. Adequate fluid intake is extremely vital to many internal body functions. For many individuals, their physical appearance drives their motivation to exercise and eat properly. Consider the following; in addition to muscle cannibalism, caused by starvation, and muscle atrophy (loss of muscle size), caused by inactivity, there is also the possibility of muscle shrinkage due to dehydration. A considerable amount of muscle mass is composed of fluid. When the body senses dehydration, it increases its efforts to retain the existing water it has within the body. During a period of dehydration, a portion of the fluids in the muscle will likely be given up to help with various hydration needs elsewhere in the body, thus reducing the size and appearance of the muscle tissue. Hydration will be addressed in much more detail later in this manual.

Processed 'junk' food

One of the features that strongly denotes a western-style diet is the presence of a large amount of heavily processed foods. Many processed foods are colloquially known as junk food, which carries the connotation of being poor quality food that does not provide adequate nutrition to support healthful, physical function. What exactly is junk food? Junk food has been defined as:

Junk food: A colloquial term for palatable but unwholesome food that is high in fat, salt, or sugar but deficient in protein, fibre, and vitamins.

Junk food offers very little to no benefit where nutritional value is concerned. What it does offer is a high level of energy-dense calories from processed sugar and fat, usually in the form of pre-packaged snacks and easily accessible 'fast foods'. Nutritionally speaking, it is not uncommon to find meals that require no preparation may likely be meals that are not worth eating. Unfortunately, the idea of 'no preparation' convenience food is the attraction for many people when it comes to quick and easily accessible meals.

We live in a day and age of instant gratification, which often translates to poor food choices and unhealthy eating habits. But there is hope. Habits can be slowly but surely changed when the right approach is taken. This can start by seeing 'fast' food as something other than what is on a drive-thru restaurant menu. Not all convenience food is unhealthy. Consider, for example, a piece of fruit or a salad, these are quick picks in terms of accessibility, and also have nutritional value. A change in eating habits starts with recognizing what junk food is. Sure, it may taste good, there's no denying that. In many cases, junk food has been specifically engineered to optimise taste, smell, texture, and palatability. However, when we consistently recognize it as 'junk' when we put it into our mouth, that is the beginning of the early steps to controlling the amount and the timing of its intake.

Not all processed foods fall under the black cloud of being 'junk' food. Technically, it is more accurate to refer to processed food using the well-accepted NOVA categorisation system. NOVA identifies four levels of food processing and places foods determined by their degree of industrial processing into each category.

NOVA Processed food categories		
Group	**Description**	**Example foods**
1. Unprocessed or minimally processed foods	Unprocessed: obtained directly from plants or animals and do not undergo any alteration following their removal from nature Minimally: natural foods that have been submitted to cleaning, removal of inedible or unwanted parts, fractioning, grinding, drying, fermentation, pasteurization, cooling, freezing, or other processes that may subtract part of the food, but which do not add oils, fats, sugar, salt or other substances to the original food.	• Frozen fruit or vegetables • Wholegrain rice or wheat • Eggs • Lentils, beans, or chickpeas • Dried fruit • Nuts & seeds • Fresh or dried herbs & spices • Fresh/frozen meat, poultry or seafood
2. Processed culinary ingredients	Products that are extracted from natural foods or from nature by processes such as pressing, grinding, crushing, pulverizing, and refining. They are used in homes and restaurants to season and cook food and thus create varied and delicious dishes and meals of all types	• Nut & seed oils • Butter • Lard • Coconut oil or cream • Sugar • Honey • Maple syrup • Sea salt • Corn starch
Group	**Description**	**Example foods**
3. Processed foods	Products that are manufactured by industry with the use of salt, sugar, oil or other substances (Group 2), that are added to natural or minimally processed foods (Group 1) to preserve or to make them more palatable. They are derived directly from foods and are recognized as versions of the original foods	• Canned legumes, vegetables in brine/vinegar • Tomato paste • Canned fruit in syrup • Bacon • Salt/sugared nuts & seeds • Salted, dried, smoked or cured fish/meat • Fermented cheeses • Fermented alcoholic beverages
4. Ultra-processed foods	Industrial formulations made entirely or mostly from substances extracted from foods (oils, fats, sugar, starch, and proteins), derived from food constituents (hydrogenated fats and modified starch), or synthesized in laboratories from food substrates or other organic sources (flavour enhancers, colours, and several food additives used to make the product hyper-palatable). Manufacturing techniques include extrusion, moulding and preprocessing by frying. Beverages may be ultra-processed. Group 1 foods are a small proportion of or are even absent from, ultra-processed products.	• Fatty, sweet, savoury or salted packaged snacks • Biscuits • Ice-cream • Chocolates & confectionery • Soft drinks • Energy drinks • Instant soups, noodles, sauces & seasonings • Margarine & spreads • Pre-prepared pizza & pasta • Chicken or fish nuggets • Packaged bread & bread rolls • Baked goods & pastries • Breakfast cereals

In the Western diet, the amount of food that falls into the fourth category, ultra-processed foods, is growing rapidly and at an average of 26.4% of the European diet (2017) and 57.9% of the US diet (2015), it already comprises too much of the typical modern diet to be supportive of optimal health and well-being. A shift towards less processed foods such as those identified in categories 1, 2 & 3 would certainly be of more value in promoting a more healthful diet and lifestyle. The NOVA categorisation system is not perfect as it certainly identifies some foods that have significant health value under categories 2 and 3 which may imply they are processed and therefore are not nutritious and vice versa. For example, refined and crystalline sugar is identified in category 2 but this has virtually no nutritional value whatsoever. Whilst in category 3 we can find fermented cheeses which have significant nutritional value but are listed under the processed foods banner, suggesting a lower nutrition option. Indeed, cheeses have a whole range of processing levels, from traditionally fermented, full-fat cheeses through to highly processed cheese spreads and burger slices. The value of this categorisation system is understanding the principles being taught and more broadly looking towards utilising less processed foods as components to a healthful diet. The main consideration to note is that there is a consistent trend towards increased obesity with greater consumption of ultra-processed foods as shown in the European chart below (2017). Obesity is a condition that negatively affects health, suggesting ultra-processed foods should not be considered to be supportive of health and their consumption should therefore be minimised or avoided.

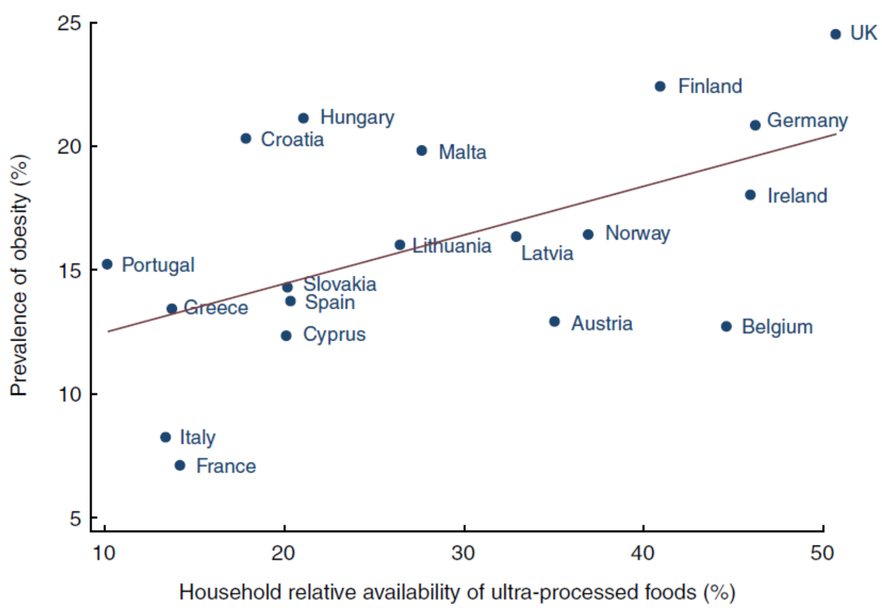


Fig 1 Regression of prevalence of obesity among adults *v.* household availability of ultra-processed foods (percentage of total energy) in nineteen European countries (1991–2008)

Healthy food

In contrast to the definition of 'junk food', health food or a healthy food diet was defined by Cena and Calder (2020).

Healthy foods/diet: natural foods consumed in appropriate proportions to support energetic needs without excess intake, while appropriately satiating hunger. They will also provide sufficient micronutrients to meet the physiological requirements of the body to sustain life and effective biological functions.

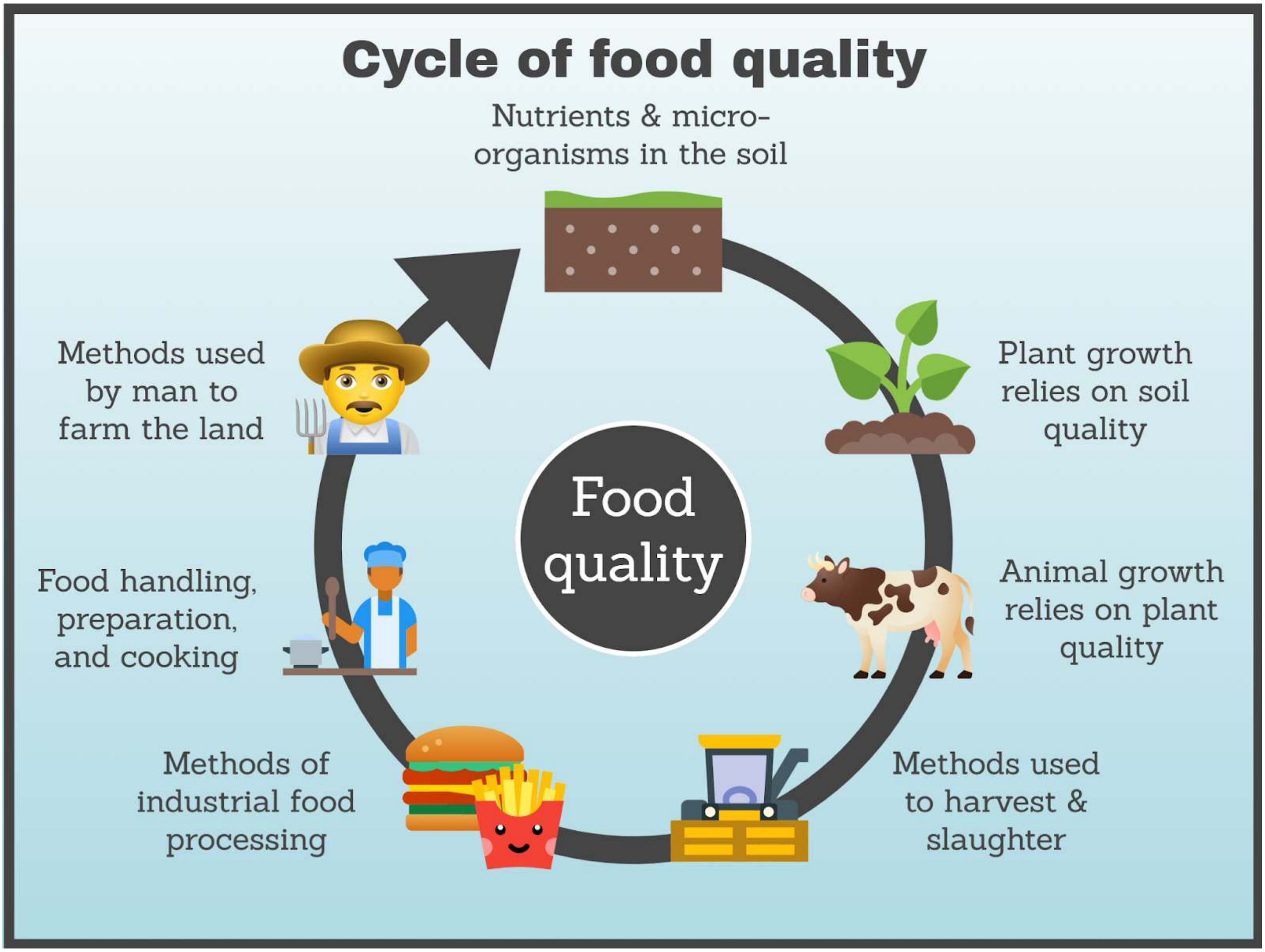
Healthy foods will likely include a wide range of unprocessed, natural, whole foods that are not high in refined sugar and salt, additives or preservatives, nor saturated or trans fatty acids. There may be other factors that play a part in a food's health status, such as the type and quality of farming, the quality of the originating soil, the living conditions and the welfare of the animals. Healthy food should not contribute to the risk of disease, decreased wellbeing, nor the overall morbidity or mortality of those who consume it. As the name suggests, it must contribute to and support overall health.

According to the U.S. Food and Drug Administration (FDA), "Health claims describe a relationship between food, food component or dietary supplement ingredient, and reduced risk of disease or health-related condition". Unfortunately, some controversy may exist as to the 'health' claim permissions, granted by the FDA, to food product manufacturers who can make claims of 'health' based on less than rigorous scientific evidence. It would be wise to use careful judgement in determining which foods are healthy, rather than rely on prevalent marketing of certain foods that attempt to increase their sales using a healthy status or health-related logo or checkmark.

The cycle of food quality

Understanding food quality is an important aspect of turning our focus towards optimal health. To fully understand what brings quality and nutrition to food, it is important to grasp the principles surrounding the cyclical nature of food production, where it begins, and the stages along the way that add nutritional value or that detract and take away some of that important nutritional value. This introduces the concept of the cycle of food quality. As human beings are at the top of the food chain, everything below us influences the nutrients that are received at the top.

The cycle of food quality begins in the soil and ends when humans eat the resulting food that is grown and produced. In modern agriculture, man often determines the soil quality too!



Nutrient density

Another commonly used method of determining food quality is referred to as nutrient density. Identifying the degree to which a food contains a range of specific nutrients must have a foundational factor for which to compare the concentration of existing nutrients against. The most commonly used factor for comparing the nutrient totals is measuring against a 100 calorie reference. However, the scientific method has not yet settled on a single, universal definition and research on nutrient density also uses comparisons per 100g of food, or the nutrient totals per typical serving size of the food item.

The nutritional score is usually taken as an average of the percentage daily value present for each of the measured micronutrients. Providing the comparisons are like-for-like, in terms of their base level factor, then each nutrient density score will provide a useful comparison of the total nutritional content present within any specific food item. In essence, the intention is that a nutrition density score can help to indicate and support the consumption of foods that contain higher levels of micronutrients and lower levels of total caloric energy. The table below serves as an example of nutrient density data, which lists commonly consumed fruits and vegetables.

Food	Nutrient density score	Food	Nutrient density score	Food	Nutrient density score
Watercress	100.00	Kale	49.07	Iceberg lettuce	18.28
Chinese cabbage	91.99	Dandelion green	46.34	Strawberry	17.59
Chard	89.27	Red pepper	41.26	Radish	16.91
Beet green	87.08	Arugula	37.65	Winter squash	13.89
Spinach	86.43	Broccoli	34.89	Orange	12.91
Chicory	73.36	Pumpkin	33.82	Lime	12.23
Leaf lettuce	70.73	Brussels sprout	32.23	Pink grapefruit	11.64
Parsley	65.59	Scallion	27.35	Rutabaga	11.58
Romaine lettuce	63.48	Kohlrabi	25.92	Turnip	11.43
Collard greens	62.49	Cauliflower	25.13	Blackberry	11.39
Turnip greens	62.12	Cabbage	24.51	Leek	10.69
Mustard green	61.39	Carrot	22.60	Sweet potato	10.51
Endive	60.44	Tomato	20.37	White grapefruit	10.47
Chive	54.80	Lemon	18.72	*(CDC 2014)*	

Not all nutrition scientists agree with using a nutrient density score that is essentially focused on inverse calorie density. It is fair to acknowledge that certain foods have high nutritional value but may also carry higher levels of fat, carbohydrate and total calories as well. For example, meat, nuts and seeds are all very high-calorie foods, but they can also pack a punch in terms of the nutrients they contain.

The classic calorie-oriented nutrient density score would rate these foods with a moderate to low nutrient density value because of their high-calorie load. However, if the nutrient density score has a base factor focused on the weight of the food per 100g or the typical serving size then these types of food tend to score a little better overall.

Another consideration in the nutrient density argument is the level of nutrient bioavailability in a specific food. Bioavailability refers to the capacity of the body and digestive system to extract and absorb the nutrients that are contained within the plant or animal food. Some plant foods may be rated high in nutrient density, but when we look at the bioavailability of some of those nutrients it is apparent that only a portion will become available to the body through digestion and absorption.

A great example of this is 100g of spinach leaves containing 58mg calcium for only 14 calories. This means that 100 calories of spinach will contain 414mg calcium. However, the bioavailability of calcium in spinach is only 5% which means that if an individual did manage to consume a full 714g of spinach leaves to account for 100 calories, they would only absorb 20mg of calcium from the spinach. A more common source of calcium in the diet is the higher calorie option of whole milk. 100g of whole milk contains 60 calories and 113mg of calcium. This means that 100 calories of milk (about 166g or 2/3 a glass) contain 188mg calcium. The calcium in whole milk has a bioavailability of 30%, so from this ⅔ glass of milk about 57mg of calcium will be digested and absorbed into the body. Therefore, despite the much higher total nutrient density score for spinach, we can see that per 100 calories milk has 3 times more bioavailability for calcium as does spinach. It is acknowledged we are only looking at a single specific nutrient in this example, but it does illustrate the importance of considering the typical bioavailability of nutrients in the food we eat.

The bottom line is that nutrient density is a valuable tool to help rate food quality from a nutritional perspective, but it is just a tool and can be leveraged where needed. However, it should not be the only consideration when selecting foods to eat as part of the daily diet. There are numerous other considerations to factor in.

Food labels

An important and very helpful skill to learn to develop is the ability to read and interpret food labels. The vast majority of food sold in supermarkets comes in some sort of packaging because food producers intend to increase sales and build their business. Therefore, food packaging serves as a means of advertising and promoting their products to increase sales. A lot of the information found on a food product is primarily to do with increasing the appeal of the product to encourage the customer to purchase. However, there are minimum legal requirements regarding what must be included on a food label. The following list of items must be included by law on a food label in both Europe and the USA:

1. The product should bear a statement of identity (common name of the product)
2. Net weight of the product
3. List of ingredients in the order of predominance by weight
4. Declaration of Allergens
5. Date of minimum durability e.g. best before date
6. Ideal storage conditions
7. Nutrition facts/information table
8. Name and address of the manufacturer or distributor
9. Country of origin

It is also important to recognise that within a culturally diverse population, as is found in most modern communities around the world today, there will be several other factors that feed into dietary choices beyond awareness of published healthy eating guidelines. Cultural expectations, religious practices, personal or family dietary preferences, social pressures, ethics and morals, personal goals and objectives, body weight, physical activity habits, employment and working practices offer a few of the important and influential factors that will influence an individual's daily eating behaviours. A well-trained nutrition coach will explore and discuss these other related factors with a client to understand the client state of play in advance of dispensing nutritional advice. The nutrition facts or information table found on the side or back of a food product package will provide even more useful information to ascertain the quality and contents of a food product. How a nutrition table is presented varies a little between the United States and Europe.

The following images provide examples of both nutrition tables:

Nutrition Information

Typical values	per 100g	per serving 40g	%RI*
Energy	1624kJ/386kcal	1279kJ/304kcal	15%
Fat	8.5g	8.8g	13%
of which saturates	1.5g	3.7g	19%
Carbohydrate	63.4g	39.8g	15%
of which sugars	0.8g	14.6g	16%
Fibre	6.7g	2.7g	
Protein	10.5g	15.0g	30%
Salt	0.03g	0.30g	5%

*Reference intake of an average adult (8400kJ/2000kcal)

Food label from the United Kingdom

Nutrition Facts

Serving Size 2/3 cup (55g)
Servings Per Container About 8

Amount Per Serving	
Calories 230	Calories from Fat 40
	% Daily Value*
Total Fat 8g	**12**%
Saturated Fat 1g	**5**%
Trans Fat 0g	
Cholesterol 0mg	**0**%
Sodium 160mg	**7**%
Total Carbohydrate 37g	**12**%
Dietary Fiber 4g	**16**%
Sugars 1g	
Protein 3g	
Vitamin A	10%
Vitamin C	8%
Calcium	20%
Iron	45%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.

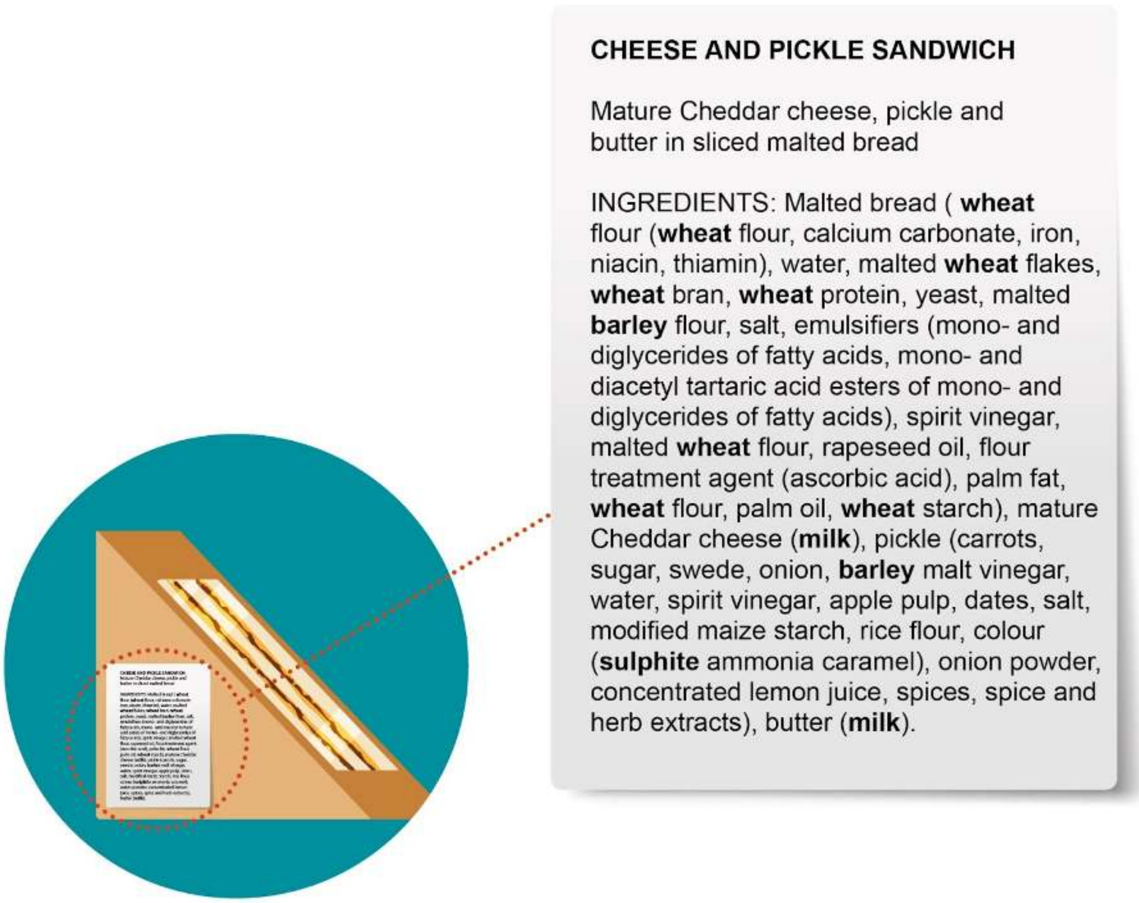
	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Food label from the United States

Some important differences worth pointing out between the way these regions are legally required to identify their nutrition information are as follows:

- In the US the data is based around a standard serving size whereas in Europe it is based primarily around the amount per 100g of product.
- In the US they must legally define the amount of cholesterol contained within a food product, this is not required in Europe.
- Both are required to label salt, but in the US they only have to identify the actual sodium content rather than the complete sodium chloride content in Europe.
- In the US they are required to list values for vitamin A, vitamin C, calcium, and iron.

In the United States and Europe, there is a legal requirement to list the ingredients within a food product. As you become more informed with regards to the more common ingredients used in foods, reading the ingredients list can be a very useful way to determine what is contained within food and the quality of that resulting food product. The law requires that ingredients are listed in descending order from the heaviest to the lightest within the product mix. It would not be unusual to identify less familiar ingredients within processed foods, but if they are identified near the bottom of the ingredients list, then they comprise a very small part of the food product. This is often the case with regards to common flavourings, additives and preservatives. Whilst these more chemical-sounding names can appear concerning, the small amounts present may suggest it is likely these compounds will have limited or minimal impact on health and well-being for the majority of people. It is important to note that some people have sensitivities to specific food ingredients and even small amounts can cause a negative reaction.



Balanced diet

Perhaps one of the most common phrases used in describing a good nutrition protocol is the term a ‘balanced diet’. The concept of a balanced diet revolves around the definition of what the word balanced actually means. The term balanced is defined as

Balanced: a state in which different things occur in equal or proper amounts or have an equal or proper amount of importance.

A balanced diet is also centred on striving to find a single dietary protocol that is appropriate for the provision of general guidelines across the widespread population. As many scientists do their best to try and provide this level of dietary advice other experts see this as an exercise in futility because of the unique levels of biological individuality between members of every population.

Assuming that a single dietary protocol is possible, consumption of foods from all of the different food groups, and in the right quantities, would be crucial to maintaining a balanced diet. Though the word 'diet' is often misconstrued in the context of a short-term food regimen that results in losing weight, it is accurately defined as a food or drink regimen that is regularly and habitually consumed for nourishment. There is a wide spectrum of different dietary protocols across the broad spectrum of sufficient to deficient. A good diet ultimately promotes good health and is a nutritional lifestyle, it is not a temporary refrain from otherwise poor eating habits. The most effective diet for good health must include multiple primary food groups because no single food group can provide all of the required daily nutrition for good health.

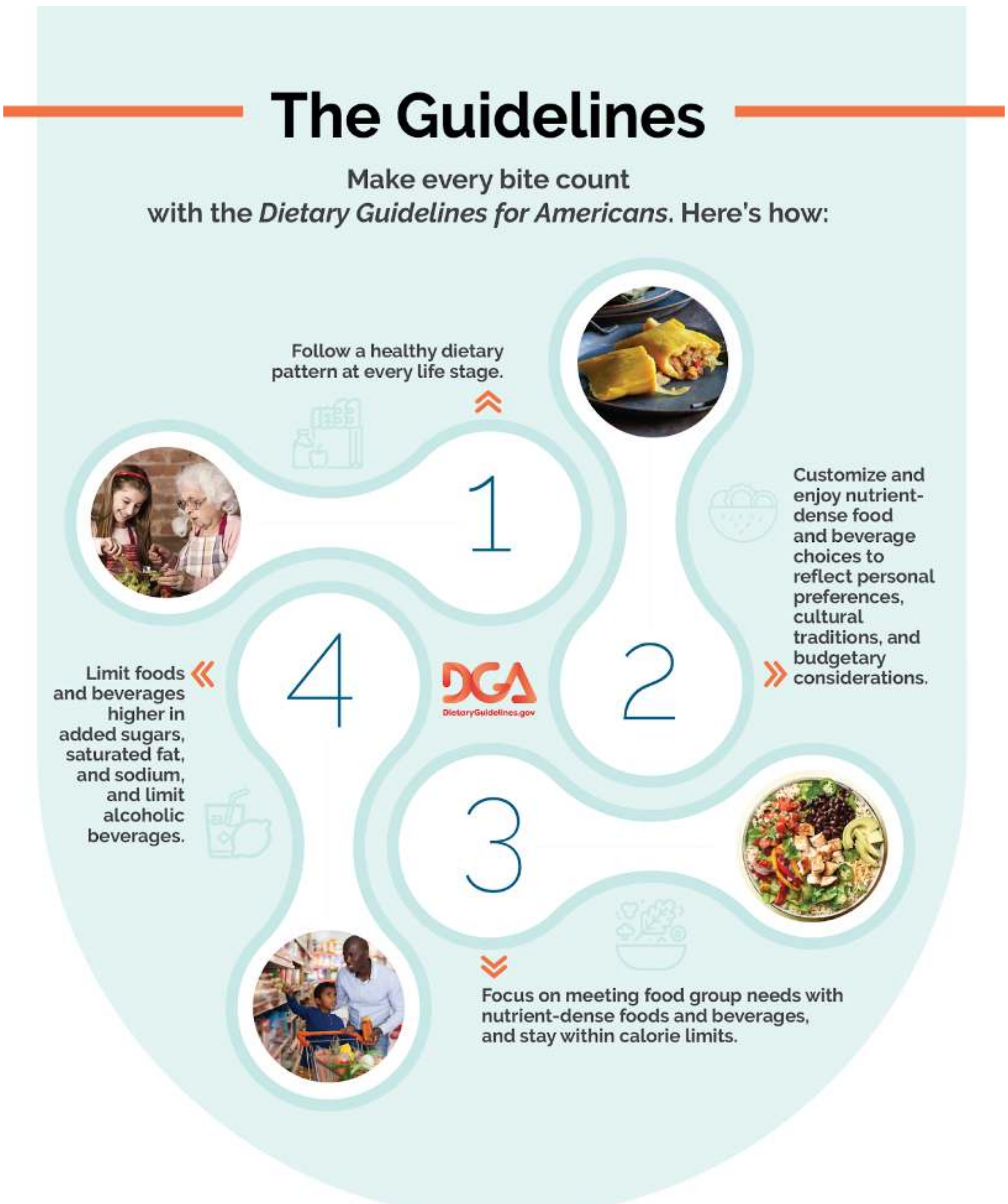
A balanced diet has the right proportions and sufficient quantities of macro-and micronutrients to meet the needs of the individual. Ensuring food is consumed from a broad variety of sources is necessary to make sure that nutrient deficiencies do not occur, or if they do occur, that they are not present for extended periods to initiate negative health effects. Each major, natural food category has important components that are necessary for maintaining bodily functions and sustaining good health. A truly balanced diet will take into account all of these variables, including multiple food groups, varied food sources, and individual differences in nutrient sufficiency. It is this level of complexity that makes defining a truly balanced diet particularly difficult on both a population and individual level. There are certainly many nutrition principles associated with a balanced diet that will continue to be true across broad populations, and it is these specific principles that should inform our current nutrition practice and our scientific inquiry going forward.

Population guidelines

Since the early 1980s, many governments around the world have strived to provide their citizens with dietary recommendations to help curb the growth of chronic health conditions and to support population-wide nutritional needs. These national and international nutrition guidelines have had a significant influence on consumer food choices, supermarket provision, food availability, manufacturer food formulation, nutrition education, medical recommendations and even political health decisions. Government dietary recommendations have likely had the most significant influence on population-wide eating behaviour in modern history.

Dietary Guidelines for Americans (2020-2025)

National nutrition guidelines in the United States of America have been revised and published every five years since their inception back in 1980. One of the main features of these dietary guidelines is the application of a visual infographic to help familiarise the general public with the nutrition guidelines in a simple and clear manner. The DGA infographic has morphed from the initial Food Pyramid, to the My Plate diagram, which has since been added to with a simplified 4-step dietary directive in 2020.



The executive summary of the DGA guidelines provides clarification on what is intended in terms of the application of each objective. The following information is drawn directly from the DGA summary publication (2020):

1. **Follow a healthy dietary pattern at every life stage.**

- For about the first 6 months of life, exclusively feed infants human milk.
- At about 6 months, introduce infants to nutrient-dense complementary foods.
- From 12 months through older adulthood, follow a healthy dietary pattern across the lifespan to meet nutrient needs, help achieve healthy body weight, and reduce the risk of chronic disease.

2. **Customize and enjoy nutrient-dense food and beverage choices to reflect personal preferences, cultural traditions, and budgetary considerations.**

- A healthy dietary pattern can benefit all individuals regardless of age, race, or ethnicity, or current health status. The Dietary Guidelines provides a framework intended to be customized to individual needs and preferences, as well as the foodways of the diverse cultures in the United States.

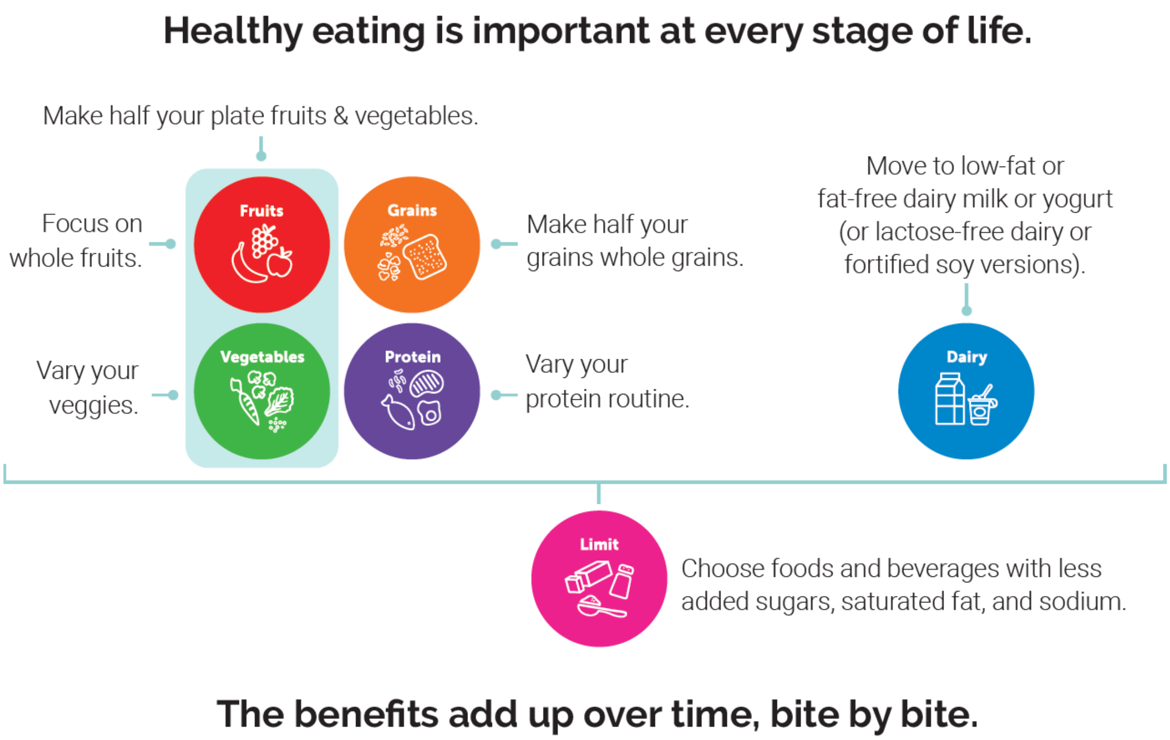
3. **Focus on meeting food group needs with nutrient-dense foods and beverages, and stay within calorie limits.**

- Nutrient-dense foods provide vitamins, minerals, and other health-promoting components and have no or little added sugars, saturated fat, and sodium. A healthy dietary pattern consists of nutrient-dense forms of foods and beverages across all food groups, in recommended amounts, and within calorie limits. The core elements that make up a healthy dietary pattern include:
    - Vegetables of all types—dark green; red and orange; beans, peas, and lentils; starchy; and other vegetables
    - Fruits, especially whole fruit
    - Grains, at least half of which are whole grain

- Dairy, including fat-free or low-fat milk, yoghurt, and cheese, and/or lactose-free versions and fortified soy beverages and yoghurt as alternatives
- Protein foods, including lean meats, poultry, and eggs; seafood; beans, peas, and lentils; and nuts, seeds, and soy products
- Oils, including vegetable oils and oils in food, such as seafood and nuts

4. Limit foods and beverages higher in added sugars, saturated fat, and sodium, and limit alcoholic beverages.

- At every life stage, meeting food group recommendations—even with nutrient-dense choices—requires most of a person's daily calorie needs and sodium limits. A healthy dietary pattern doesn't have much room for extra added sugars, saturated fat, sodium, or alcoholic beverages. A small amount of added sugars, saturated fat, or sodium can be added to nutrient-dense foods and beverages to help meet food group recommendations, but foods and beverages high in these components should be limited. Limits are
    - Added sugars—Less than 10% of calories per day starting at age 2. Avoid foods and beverages with added sugars for those younger than age 2.
    - Saturated fat—Less than 10% of calories per day starting at age 2.
    - Sodium—Less than 2,300 milligrams per day—and even less for children younger than age 14.
    - Alcoholic beverages—Adults of legal General Nutritionage can choose not to drink, or to drink in moderation by limiting intake to 2 drinks or less in a day for men and 1 drink or less in a day for women when alcohol is consumed. Drinking less is better for health than drinking more. Some adults who should not drink alcohol, such as women who are pregnant.



USDA Food and Nutrition Service (Dec 2020)

World Health Organization (WHO)

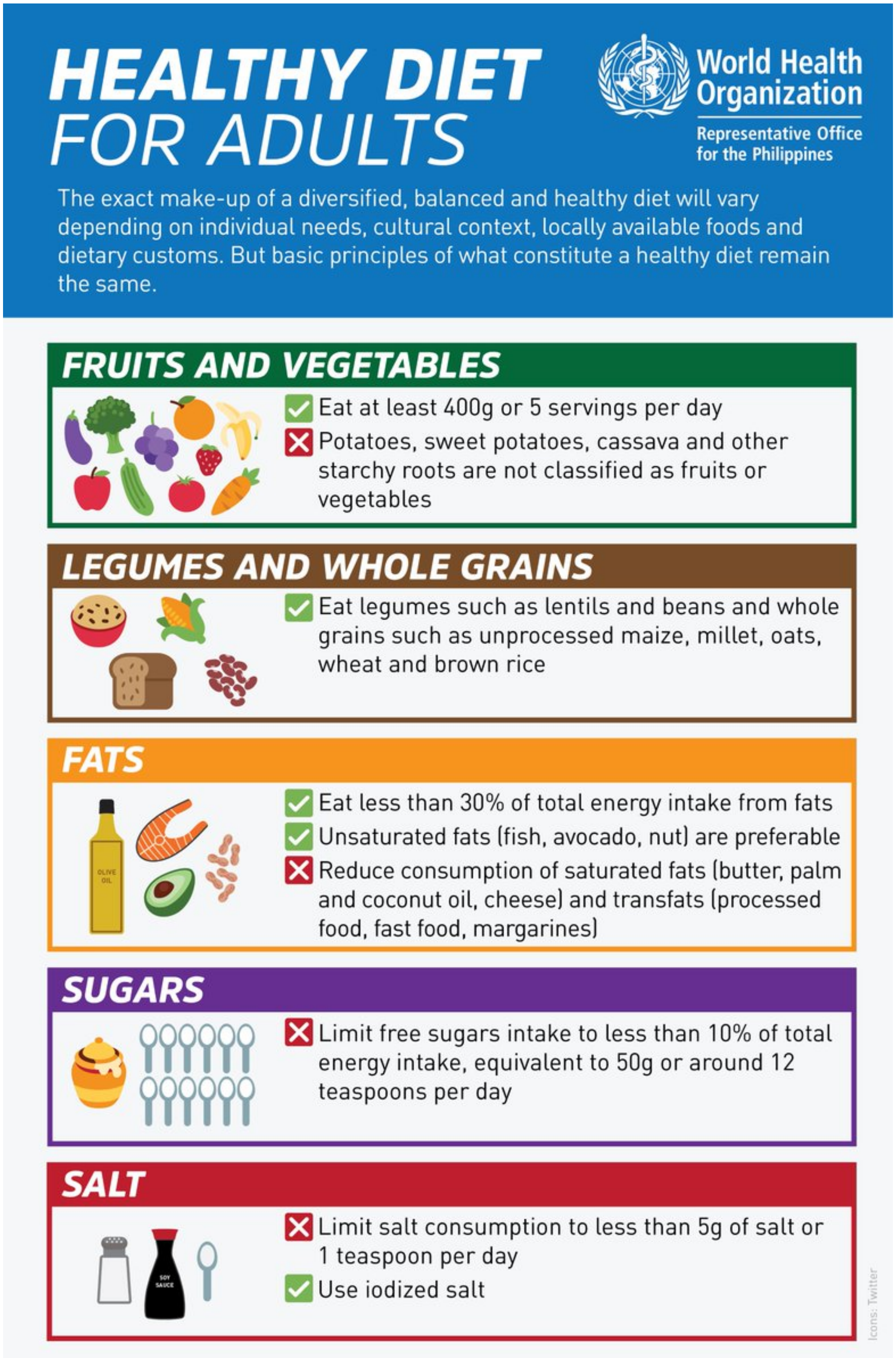
The World Health Organization has also provided a range of nutrition guidelines based on several of their published reviews of the scientific literature over the years and also through their access to a unique global perspective.

WHO states: Consuming a healthy diet throughout the life-course helps to prevent malnutrition in all its forms as well as a range of noncommunicable diseases (NCDs) and conditions. However, increased production of processed foods, rapid urbanization and changing lifestyles have led to a shift in dietary patterns. People are now consuming more foods high in energy, fats, free sugars and salt/sodium, and many people do not eat enough fruit, vegetables and other dietary fibre such as whole grains.

The exact make-up of a diversified, balanced and healthy diet will vary depending on individual characteristics (e.g. age, gender, lifestyle and degree of physical activity), cultural context, locally available foods and dietary customs. However, the basic principles of what constitutes a healthy diet remain the same.

WHO provided six key guidelines in April 2020 to direct adults in their dietary consumption. A summary of these healthy eating guidelines is as follows:

1. Adults should seek to regularly consume fruit, vegetables, legumes (e.g. lentils and beans), nuts and whole grains (e.g. unprocessed maize, millet, oats, wheat and brown rice).
2. Eat at least 400g (i.e. five portions) of fruit and vegetables per day, excluding potatoes, sweet potatoes, cassava and other starchy roots.
3. Aim to consume less than 10% of total energy intake from free sugars, which is equivalent to 50g (or about 12 level teaspoons) for a person of healthy body weight consuming about 2000 calories per day, but ideally is less than 5% of total energy intake for additional health benefits. Free sugars are all sugars added to foods or drinks by the manufacturer, cook or consumer, as well as sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates.
4. Aim to consume less than 30% of total energy intake from fats. Unsaturated fats (found in fish, avocado and nuts, and in sunflower, soybean, canola and olive oils) are preferable to saturated fats (found in fatty meat, butter, palm and coconut oil, cream, cheese, ghee and lard) and *trans*-fats of all kinds (found in baked and fried foods, and pre-packaged snacks and foods, such as frozen pizza, pies, cookies, biscuits, wafers, and cooking oils and spreads).
5. It is suggested that the intake of saturated fats be reduced to less than 10% of total energy intake and *trans*-fats to less than 1% of total energy intake. In particular, industrially-produced *trans*-fats are not part of a healthy diet and should be avoided.
6. Aim to consume less than 5g of salt (equivalent to about one teaspoon) per day. Salt that is consumed should be iodized.


HEALTHY DIET
FOR ADULTS
World Health Organization
Representative Office for the Philippines
The exact make-up of a diversified, balanced and healthy diet will vary depending on individual needs, cultural context, locally available foods and dietary customs. But basic principles of what constitute a healthy diet remain the same.
FRUITS AND VEGETABLES
Eat at least 400g or 5 servings per day
Potatoes, sweet potatoes, cassava and other starchy roots are not classified as fruits or vegetables
LEGUMES AND WHOLE GRAINS
Eat legumes such as lentils and beans and whole grains such as unprocessed maize, millet, oats, wheat and brown rice
FATS
Eat less than 30% of total energy intake from fats
Unsaturated fats (fish, avocado, nut) are preferable
Reduce consumption of saturated fats (butter, palm and coconut oil, cheese) and transfats (processed food, fast food, margarines)
SUGARS
Limit free sugars intake to less than 10% of total energy intake, equivalent to 50g or around 12 teaspoons per day
SALT
Limit salt consumption to less than 5g of salt or 1 teaspoon per day
Use iodized salt
Icons: Twitter

Dietary guidelines around the world

A recent review of food-based dietary guidelines found 90 countries around the world openly published recommendations for their citizens to follow. The review authors, Herforth et al. (2019), state that;

'*Most countries with food-based dietary guidelines (87%) publish a food guide, the official term for a graphic representation of the guidelines. Food guides are intended to provide dietary guidance to the general public by conveying through pictorial images the concepts of variety, proportionality, and adequacy/moderation to meet population dietary needs. Among the 78 countries with food guides, with very few exceptions they include various food groups, usually illustrated with photographs or drawings of numerous example foods in each group*.'

It may be of value to summarise some of the information discovered in this review of the food-based dietary guidelines (FBDG) to pick out the most dominant dietary messages that are being shared around the globe in the name of good nutrition for the benefit of the wider public health. Here are some quick facts regarding the 78 published and illustrated food guides from around the globe:

- 95% convey proportionality between food groups
- 35% include recommended quantity or number of servings
- 40% use a pyramid shape to illustrate their guide
- 27% use a circle or plate to illustrate their guide
- 51% opt for a division of food into 5 different food groups
- 89% include direction for consumption of fats/oils
- 71% include direction for consumption of sugar/sweets
- 56% include direction for consumption of water
- 49% include direction on regular exercise/physical activity

More specifically a review of the key nutritional messages shared through the 78 published food-based dietary guidelines (FBDG) from around the world (2019) may help you to appreciate the scale of nutrition guidance provided globally and the prevailing opinion of thousands of experts from around the world who have been consulted prior to publication of such important public health advice within each country.

Topic	Included in FBDG*	Quantity included in FBDG*	Other key observations
Starchy staples	82%	14%	44% refer to whole grains 59% set starches as the largest food group
Fruits and vegetables	93%	51% recommend 5-a-day (400g)	69% refer to ↑ daily intake 42% advise eating a variety 10% specify fresh sources
Protein foods	74%	38%	50% refer to both plant & animal protein foods 34% refer to eating lean meat 27% refer to consuming fish 23% ↓ or moderate meat intake
Legumes and nuts	58%	N/A	56% provide specific advice about legumes 30% countries group legumes with vegetables Only 19% provide specific advice about nuts
Dairy	75%	14%	31% dairy grouped with protein foods 35% advise daily dairy intake 29% refer to low-fat dairy
Fats and oils	89%	N/A	53% refer to ↓ total fats 44% refer to the quality of fats 43% refer to ↓ saturated fats 18% promote intake of healthy fats 29% advise unsaturated instead of saturated
Topic	Included in FBDG*	Quantity included in FBDG*	Other key observations
Limiting foods	100%	N/A	90% recommend ↓ salt 89% recommend ↓ fat 84% recommend ↓ sugar 28% recommend ↓ processed foods 23% recommend ↓ red, cured, or processed meats

**FBDG = Food-based Dietary Guidelines*

***All data has been drawn from A global review of food-based dietary guidelines by Herforth et al. (2019)*

It is also interesting to note that this review compared the Food-based Dietary Guidelines from these 78 countries around the globe and how closely they align their national recommendations to the official advice given by the World Health Organization as discussed previously in this manual. It is clear from the statistics that WHO dietary advice is highly influential.

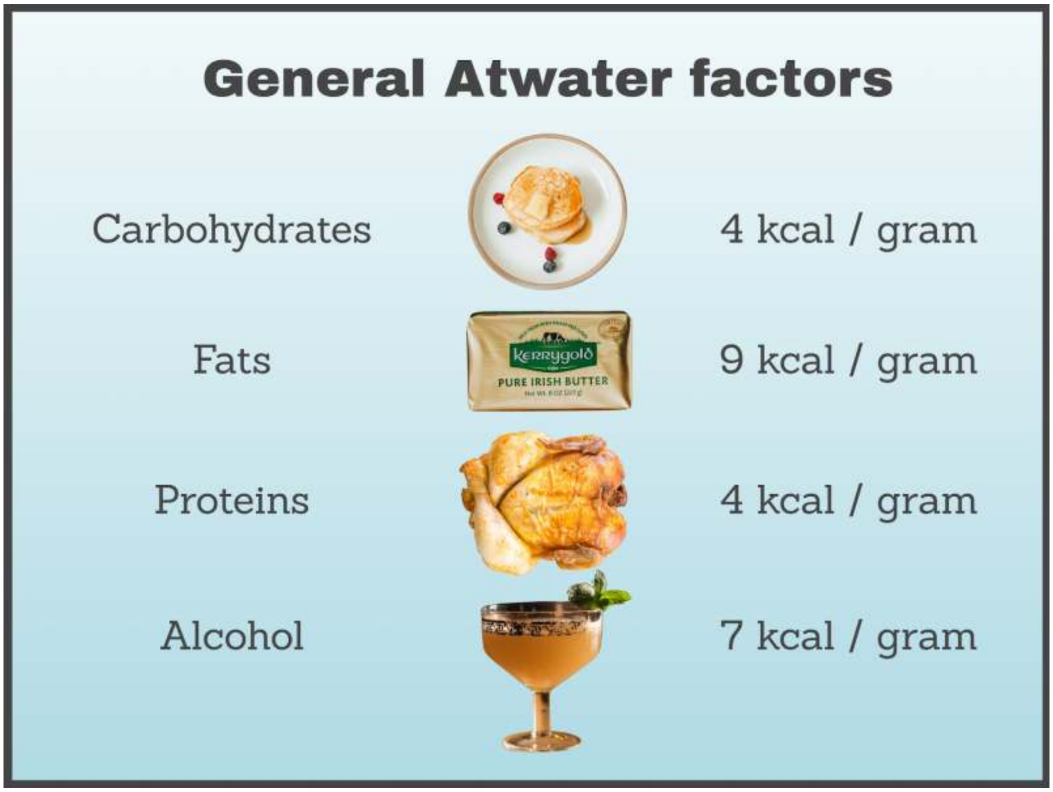
- 100% align with WHO advice to consume fruit and vegetables
- 96% align with WHO advice to consume legumes
- 94% align with WHO advice to limit the intake of free sugars and total fats
- 91% align with WHO advice to limit the intake of salt
- 53% align with WHO advice to consume whole grains
- 51% align with WHO advice to consume 5 or more fruits and vegetables per day (400g)
- 36% align with WHO advice to consume nuts

Key learning points: Introduction & Chapter 1

- Fitness nutrition coaches must only provide advice and coach clients within the professional limits of their recognised scope of practice. Prescribing supplements, dictating detailed diet plans, or directing dietary intake to manage specific diagnosed health conditions should be avoided.
- All nutritional advice dispensed by fitness nutrition coaches should conform to widely accepted dietary principles.
- Be aware of the definition for the terms 'nutrition' and 'nutrients'.
- Be aware of the definition for the terms 'junk food' and 'healthy foods/diet'.
- Processed foods have been identified using 4 distinct categories as defined by the NOVA system:
    - Unprocessed or minimally processed foods
    - Processed culinary ingredients
    - Processed foods
    - Ultra-processed foods
- Consumption of ultra-processed food consumption is strongly associated with increasing obesity rates across Europe.
- The cycle of food quality provides an important, basic flow chart mapping the stages of food production and food processing that can positively or negatively affect food quality.
- The system of scoring a food according to its nutrient density compared to its calorie density is a common method of evaluating a food's potential health contribution.
- The legal requirements for labelling packaged foods, especially the nutrition information/facts and the ingredients list, provide a valuable source of information that can assist in determining the nutritional quality of a specific food item.
- National population guidelines have been created by many governments beginning in the early 1980s. As of 2019 at least 90 countries around the world have published dietary guidelines.
- The US Dietary Guidelines for Americans were the very first government nutrition guidelines and are revised and updated every 5 years.
- The World Health Organization has provided a broader set of 6 influential guidelines to direct the eating habits of global adult populations.

Chapter 2: Macronutrients

Macronutrients are the major food compounds that provide the body with energy. Food energy is usually measured in units of energy called calories (or less commonly kilojoules). What is colloquially referred to as a calorie when discussing nutrition is more accurately called a kilo-calorie (kcal). There are 1000 calories in a kilo-calorie. However, it is the kilo-calorie (kcal) unit of measurement that is normally used to report the amount of energy provided by a specific food source. There are three major macronutrient categories, however, there are four dietary compounds that provide the body with energy, namely carbohydrates, fats, protein, and alcohol.

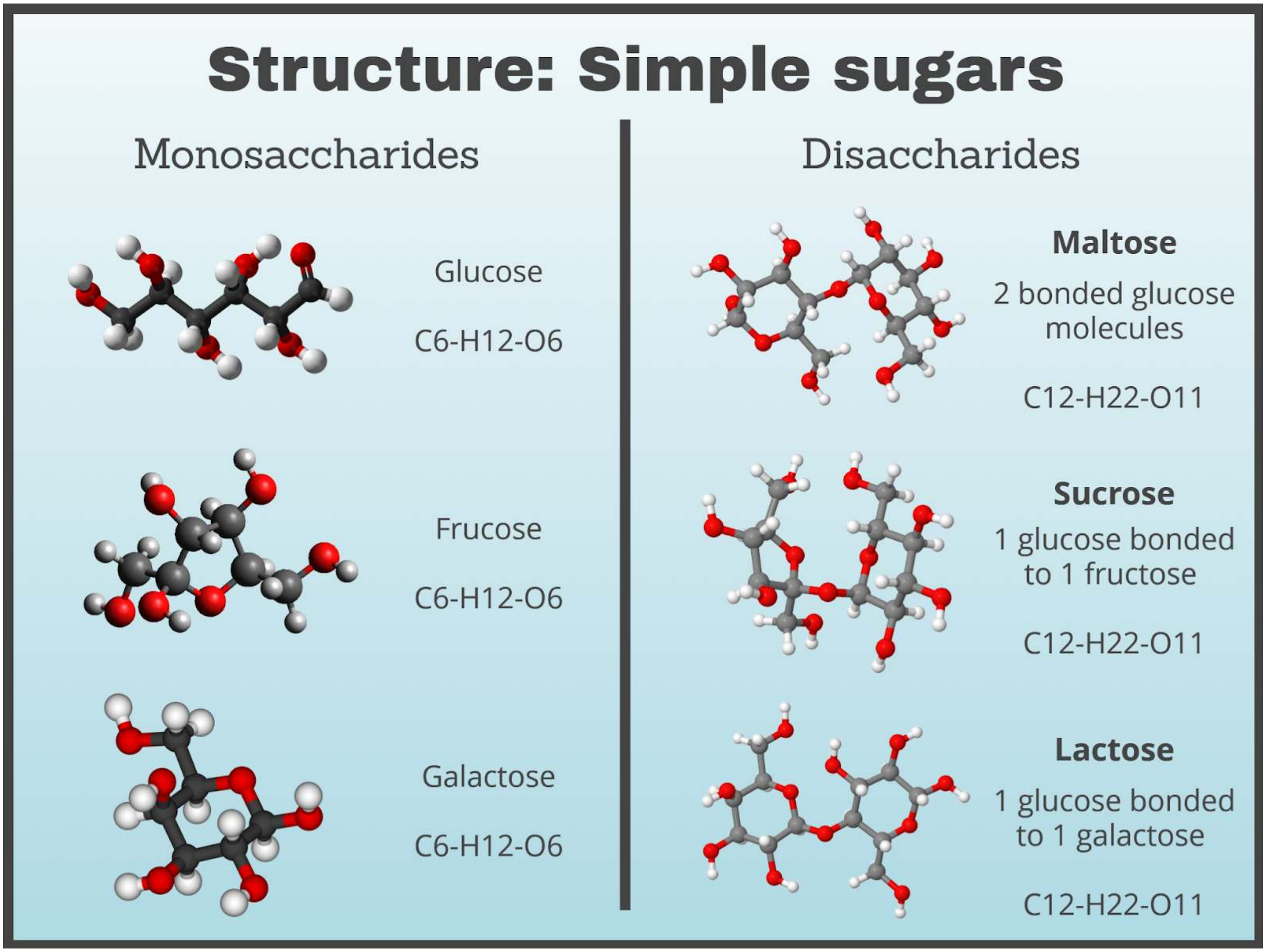


Carbohydrates

Commonly referred to as either simple or complex, carbohydrates play an important role in energy provision for every part of the human body. They are compounds that are made up of varying types of sugars, or saccharides, and are classified by the number of sugar units. Carbohydrates are the only fuel source that can be utilised by the cells without the presence of oxygen, and this makes them the preferred fuel for higher intensity physical activity. However, it is also important to understand that carbohydrates contribute to cellular energy provision consistently throughout the daily cycle.

Simple carbohydrates

Simple carbohydrates are made up of one or two saccharide molecules. Simple sugars include glucose (dextrose), galactose, fructose (fruit-derived sugar), maltose, sucrose (refined white sugar), and lactose (milk sugar). They are composed of mono-saccharide or di-saccharide units, i.e. single or double sugars. All three disaccharide structures include a molecule of glucose.



Another lesser-known category of mono and disaccharide simple carbohydrates are polyols or polyhydric alcohols. Polyols are essentially sugar alcohols, though not in the same sense that alcohol is a common intoxicating drink. The alcohol component refers to their chemical hydroxyl group formulation rather than to a type of drink. There are four major polyols that are commonly used in modern industrial food manufacturing.

- Sorbitol (2.6 kcal/g)
- Mannitol (1.6 kcal/g)
- Xylitol (2.5 kcal/g)
- Erythritol (0.2 kcal/g)

Due to their lower caloric values polyols are commonly used in low-calorie products as they carry only 5 - 65% of the available carbohydrate energy into the body. Polyols carry the same absolute amount of energy as most other carbohydrate units, but our reduced capacity to digest and absorb them influences their ultimate caloric contribution. Most food products containing polyols will also carry a warning that excess consumption could lead to laxative effects as a result of their highly fermentable nature by gut bacteria. The remaining, partially digested polyol compounds are excreted out of the bowel and this is what accounts for their reduced caloric values. In moderation, polyol consumption can help provide for a sweet taste but with a decrease in absorbed calories by the body. Polyols provide between 30-100% of the sweetness level found in standard, refined white sugar (sucrose). Polyols also are not associated with cavity formation in the teeth as bacteria in the mouth do not feed on them. Polyols also have a lower impact on the metabolic parameters relating to blood sugar balance as a result of reduced glycaemic response.

Food sources: Simple sugars

Simple carbohydrates can be found in a wide variety of foods. An oversimplification is that simple sugars are unhealthy and should be avoided. This binary thinking is often confused with added refined sugar, which is prevalent in many modern processed foods today. It would be more accurate to state that too much refined sugar added to the diet may have a negative impact on health. Refined, added sugars increase caloric load without providing any additional micronutrients or fibre, they are literally 'empty calories'. In contrast, there are indeed healthier sources of simple sugars in the diet, such as the simple sugars contained within whole fruit or wholesome cow's, sheep, or goat's milk. Fruit contains simple sugars, but in most cases has a lower calorie density, contains micronutrients in varying quantities, and also includes fibre. Animal sourced milk varieties contain lactose sugar, but it is delivered along with proteins and fats, and they have micronutrients in varying quantities.

Sweetness

One of the primary reasons that simple sugars are used so extensively in industrial food manufacture is to impart a sweet taste to the food product. Sweetness is a taste sensation that indicates the presence of energy-rich carbohydrates to our biology and as such, it has powerful biopsychological and hedonic appeal. Even newborns have been found to respond more keenly to liquid food when it has a higher sweet taste suggesting that we are biologically primed for detecting sweetness. It has been shown in scientific research that children and adolescents inherently prefer sweeter foods than adults, with a decline evident once the rapid growth in childhood and puberty ceases. Therefore, it has been proposed that this drive for sweet foods may be associated with the need for increased calorie intake to support growth and maturation.

Unfortunately, our modern abundant food supply combined with an excess of processed, sweetened foods has far exceeded the underlying biological need for energy. Modern dietary intakes show an excess in simple sugars and sweetened food consumption, especially among children and teens. Enjoyment of sweetened foods has been shown to increase consumption, which from a commercial perspective means more product sales and greater profits for the food manufacturer.

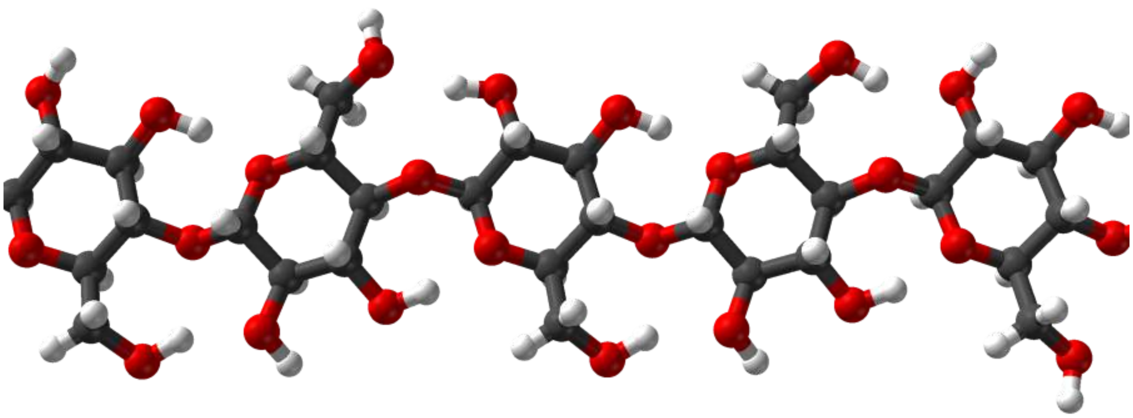
Sugar / Sweetener	Relative sweetness	Sugar / Sweetener	Relative sweetness
Sucrose	1.0	High fructose corn syrup (HFCS 55)	1.0 - 1.1
Maltose	0.4 - 0.5	Inverted syrup (Golden syrup)	0.8 - 1.0
Lactose	0.2 - 0.4	Agave syrup (55-90 fructose)	1.4
Fructose	1.5 - 1.7	Sorbitol	0.5 - 0.6
Glucose	0.6 - 0.75	Erythritol	0.5 - 0.6
Galactose	0.3 - 0.65	Xylitol	0.95 - 1.0
Honey	1.0	Mannitol	0.6
Maple syrup	0.6	Steviol Glycoside	40 - 300
Molasses	0.9	Acesulfame K	200
Isomalt	0.5	Aspartame	180
Coconut sugar	0.9	Sucralose	600

**Sugars and sweeteners are listed with their comparative level of sweetness in relation to standard sucrose (white refined cane or beet sugar) which is given a reference value of 1.0*

Complex carbohydrates

All larger, complex structure carbohydrates are ultimately composed of smaller building blocks of simple sugars, the mono and disaccharides. Complex structure carbohydrates are composed of at least four or more molecules of sugar and usually contain a common, indigestible form of carbohydrate known as fibre. Complex carbohydrates are commonly found in three structural forms:

1. Oligosaccharides: medium-length chains of single sugars (4 - 10) bound together e.g. maltodextrin, stachyose & raffinose.
2. Polysaccharides: very long chains of single sugars (more than 10) bound together into long complex forms e.g. amylose (unbranched), amylopectin (branched) & glycogen (highly branched).
3. Fibre: complex, long-chain carbohydrates that cannot be broken down by human digestive enzymes, but may be partially fermented in the large intestine by gut bacteria e.g. cellulose, pectin, gums & mucilages.



Structure of cellulose, a polysaccharide chain

A common perspective is that complex carbohydrates are better than simple carbohydrates, but this is overly simplified and can lead to misrepresentation of different foods. Complex carbohydrates provide for longer-term, sustainable energy in comparison to simple sugars. Usually, the unprocessed, natural food sources of complex carbohydrates will provide beneficial vitamins, minerals and fibre. Though the same can be said for the unprocessed, natural food sources of simple carbohydrates, like fruit and dairy. A useful guideline would be to emphasize carbohydrate-rich foods selected from whole, unprocessed sources, as opposed to processed or refined sugars and starches which have limited nutritional value.

Whether carbohydrate foods are complex or simple in structure, they ultimately are digested and broken down to glucose, fructose, or galactose before absorption in the blood. Once absorbed, this increases blood sugar and serves as an energy source for cells throughout the body, including muscles, organs, and the brain. Even though fibre is not digested and absorbed into the bloodstream, it still has two very beneficial functions; firstly, providing bulk and roughage to help improve food transit through the digestive tract, and secondly, plant cellulose and other fibre types serve as food to the numerous beneficial gut bacteria which slowly ferment the fibre during its storage time in the large intestine.

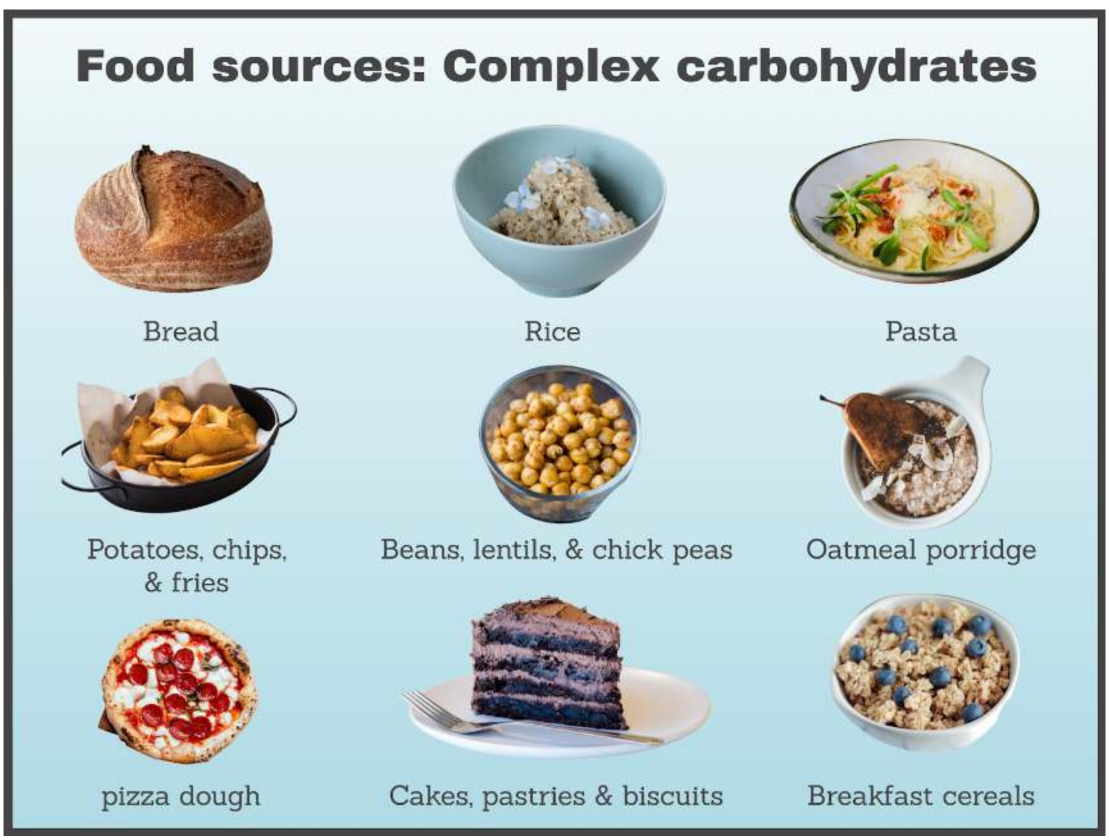
Food sources: Complex carbohydrates

Many of the foods widely available for consumption throughout the world are composed of complex carbohydrates as the primary macronutrient. Grains, starchy tubers & roots, legumes, pulses, corn, squashes, peas, and a range of other vegetables provide the vast majority of complex carbohydrate food sources. A very simplistic perspective is that complex carbohydrate food sources are the healthier choice. This may not always be true as it does not take into account industrial processing that often takes place between harvesting and the consumption of the resulting food product by humans.

White, refined wheat flour and original whole grain wheat

It is increasingly common that complex carbohydrate foods have been refined and processed prior to consumption. Processing of grains removes the nutrient-rich germ, and the fibre or bran from the grain, leaving behind the white carbohydrate-rich endosperm, which is full of calories but tends to have a much lower micronutrient content. The majority of micronutrients in each grain tend to be located in the small germ and the outer fibrous layer. Processed and refined grains, which are very common in Western diets, will carry a rich source of energy, but unfortunately, they will be relatively low in micronutrient value compared to the original unprocessed version.

Whether processed or unprocessed, complex carbohydrate-rich, starchy foods serve as a staple energy source to the vast majority of human populations around the globe. They are the biggest component of dietary calories in most modern nations. Just 3 staple food sources, corn (maize), rice, and wheat make up 51% of the world's caloric intake! Corn is a staple food in Africa, the US, and Europe. Rice consumption has spread around the globe and is estimated to provide daily sustenance for 1.6 billion people. Wheat, more specifically wheat flour, provides 15% of the world's calorie intake. Other important staple global foods rich in complex carbohydrates are the tubers and root crops; cassava, potatoes, sweet potatoes, and yams.



Fibre

Plants produce rigid compounds that help to form the shape and underlying structure of the plant. These rigid compounds are generally referred to as fibre. Only plant food contains fibre, it is not present in animal foods. Fibre is present within plants in two forms:

- Soluble fibre: pectins, gums & mucilages
- Insoluble fibre: cellulose and lignin

When plants are consumed, the fibre contained within them is not digested, broken down and absorbed into the bloodstream. Both types of fibre soluble and insoluble simply pass through the digestive tract from the entrance to exit. This does not mean that they have no beneficial purpose for the health of human beings. Soluble fibre helps to slow the emptying of the stomach which delays the absorption of glucose. Some types of soluble fibre may even help to reduce the absorption of a type of waxy fat known as cholesterol. We will learn more about cholesterol later in this chapter. Insoluble fibre provides bulk to the food passing through the digestive tract, helping with digestive transit, and with faecal formation in the large intestine and its eventual removal from the bowel.

Fibre type	Components	Health effects	Food sources
Insoluble fibre	Cellulose Hemicellulose Lignin	Provides bulk and roughage aiding digestive transit Increases faecal bulk, which may ease bowel movements	The outer firm/woody parts of all plants, especially whole grain wheat, barley, rye, brown rice, & seeds etc.
Soluble fibre	Pectins Gums Mucilages	Delays stomach emptying Slows glucose absorption May help reduce cholesterol absorption	Apples, bananas, citrus fruits, carrots, oats, barley, beans, corn, potato, psyllium seeds etc.

Digestion of carbohydrates

The breakdown of carbohydrates begins in the mouth with chewing to mechanically break apart the food, but also through the release of saliva which contains an important enzyme called amylase. Enzymes are biological catalysts that help to speed up reactions between substances. Amylase is a compound that works on the breakdown of carbohydrates from larger molecules, such as starches and polysaccharides, into smaller molecules such as oligosaccharides, disaccharides and monosaccharides. Through chewing and the action of the tongue, the food is formed into a small mass, or bolus, which is swallowed down the oesophagus and into the stomach where is held for up to 4 hours as it is further digested through the combined actions of the churning of the stomach, the acidic gastric juices, and more enzymatic action from amylase.

When the food exits the stomach into the small intestine it is a liquid known as chyme. In the first section of the small intestine, the duodenum, Pancreatic juices are released into the tract so that further chemical digestion can take place due to the presence of pancreatic amylase. This results in carbohydrates that have been completely broken down into their simplest form, monosaccharides, such as glucose, fructose, and galactose. These basic carbohydrate units are then absorbed through the intestinal wall as the chyme passes through the length of the jejunum and ileum. These single sugars are absorbed into the bloodstream and the digestion of carbohydrates is complete.

Metabolic response to carbohydrates

Successful digestion of carbohydrate foods, whether from simple sugars or complex carbohydrates, will increase blood glucose levels. How the body responds to this rise in blood glucose can be referred to as its metabolic response. To maintain effective health and functioning, blood glucose levels must be carefully managed within a relatively narrow range. An average 70kg individual will have only 4g of glucose in their bloodstream, but this small amount of glucose is constantly in a state of flux between storage cells and cells that need energy. Whilst the body can store much larger amounts of glucose in the form of glycogen (a polysaccharide) within primarily muscle and liver tissue, it maintains only a small amount of glucose at any one time in the blood. Health is negatively affected when blood glucose drifts excessively high for sustained periods, or if it drops too low, even for short periods. The body has biochemical systems in place to try and maintain a more even balance with regard to blood sugar.

Blood glucose is very easily measured using a modern glucose meter. A blood glucose score of between 4.0 mmol/L (72 mg/dL) before food intake (fasting) and 7.8 mmol/L (140 mg/dL) 2 hours after a meal would be deemed within the normal range. A randomly tested blood glucose score, within 2 hours of consuming a meal, would need to fall below a score of 11.1 mmol/L (200 mg/dL) to be considered in the normal range. Measurements outside of these glucose scores would be considered either pre-diabetic or diabetic.

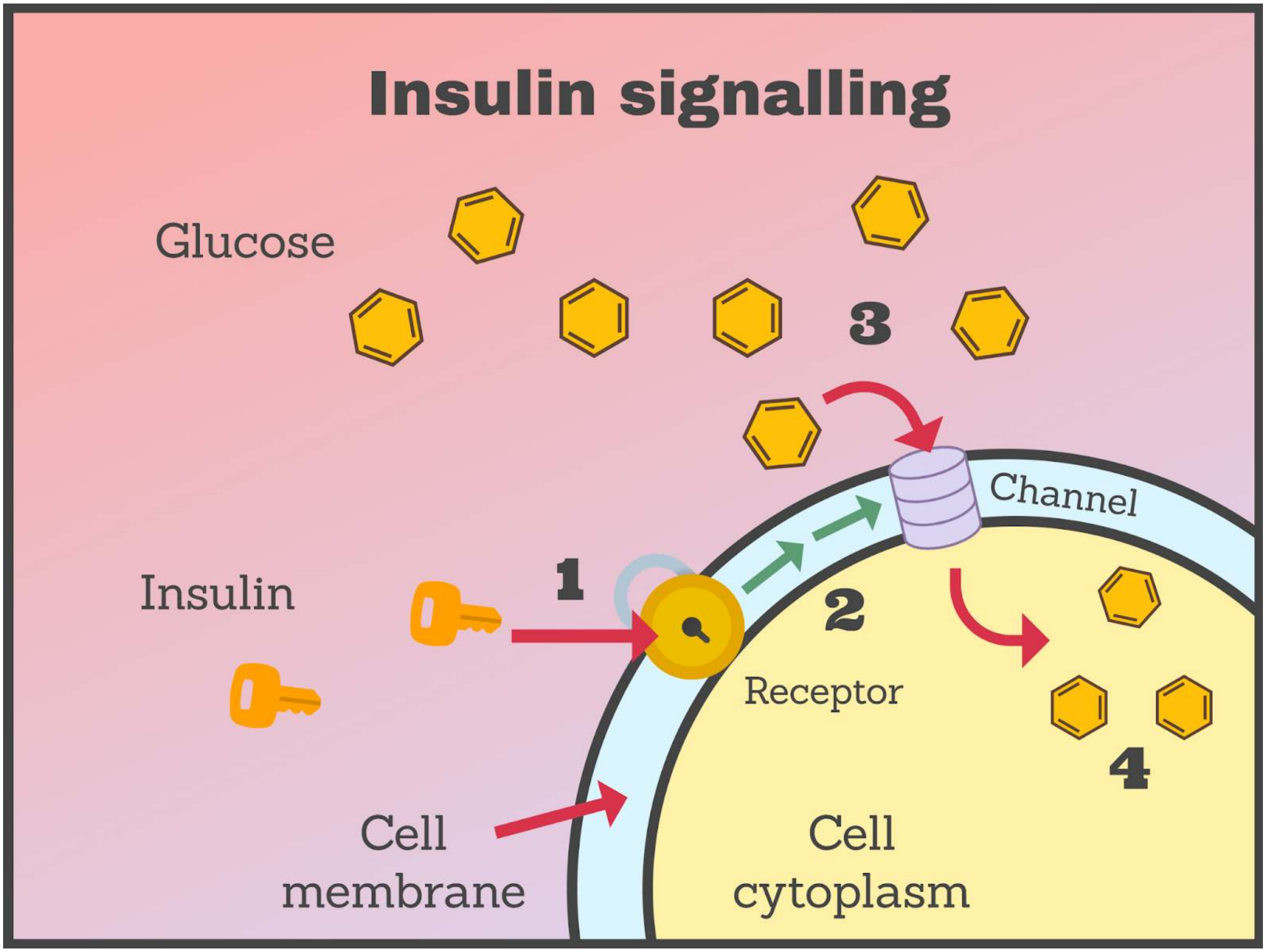
Plasma glucose test	Normal	Pre-diabetes	Diabetes
8-hour fasting	Below 5.5 mmol/L (100 mg/dL)	5.5 - 6.9 mmol/L (100 - 125 mg/dL)	≥ 7.0 mmol/L (≥ 126 mg/dL)
2 hours post-meal	Below 7.8 mmol/L (140 mg/dL)	7.8 - 11.0 mmol/L (140 - 199 mg/dL)	≥ 11.1 mmol/L (≥ 200 mg/dL)
Within 2 hours of eating a meal	< 11.1 mmol/L (< 200 mg/dL)	N/A	≥ 11.1 mmol/L (≥ 200 mg/dL)

Following consumption of a meal and a rise in blood glucose, the body will quickly take the necessary action to restore blood glucose back within a desirable range. Blood glucose is controlled through the release of a hormone from the pancreas known as insulin. Insulin is a biological messenger that is transported in the bloodstream. The response can be described in 4 simple steps:

1. Insulin signals to the cells of the body by binding with specific cellular receptors
2. Upon insulin binding, the cells are stimulated to open their gated channels
3. The open channels create a concentration gradient between blood and the cells
4. This allows glucose to freely enter the cell to be utilised for energy production

When there is too much blood glucose to be utilised by the cells at a given point in time, then this surplus of glucose will be redirected into larger-chain glycogen formation and stored within muscle tissues and liver cells. This backup glycogen store is a valuable resource for the body to turn to when blood glucose levels inadvertently drop too low and the body needs to replenish its waning glucose supplies.

When blood glucose drops below a certain threshold this will be identified by the body and the pancreas is stimulated to release another hormone called glucagon. The role of glucagon is to stimulate the liver to break down stored glycogen. Glycogen is dismantled once again into its component parts and glucose is released into the bloodstream increasing levels back to the normal range once again.



Glycaemic index & load

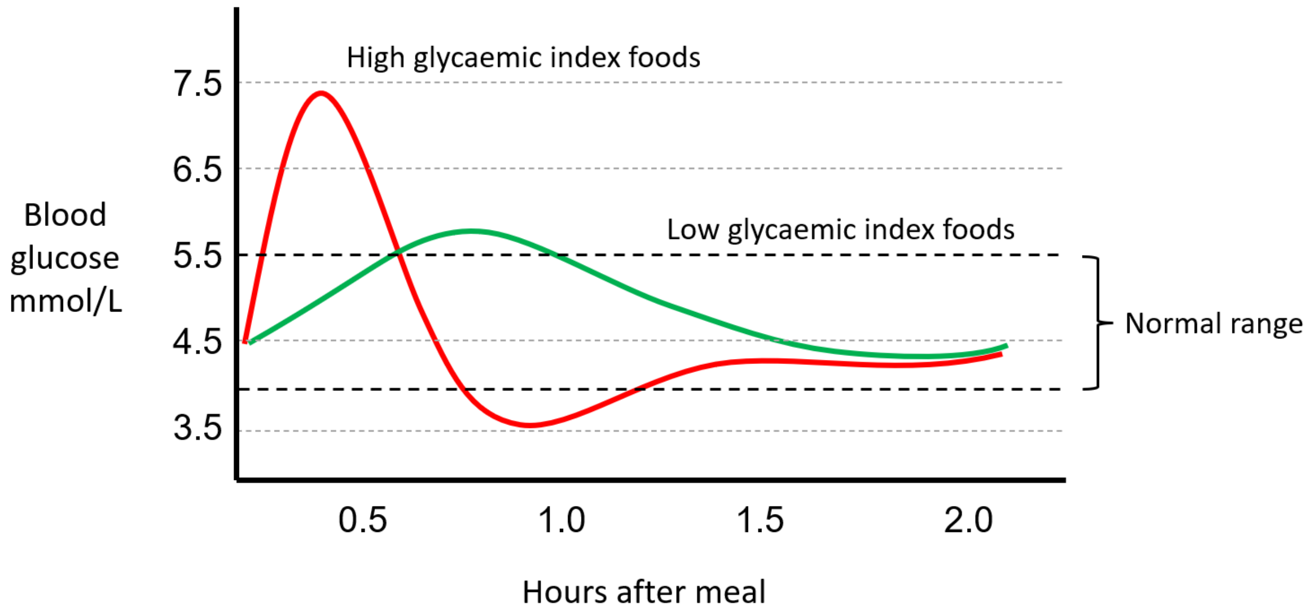
In an attempt to help diabetics manage their blood sugar levels scientists have devised several different systems that score foods to help provide a more predictable blood glucose response after a meal. Two of these methods are known as the glycaemic index and the glycaemic load. Even though these were originally identified as systems for managing diabetes, there are benefits for using both of these glycaemic scoring systems in the everyday management of dietary habits.

Glycaemic index (GI) is a measure of how quickly the carbohydrates present in the food will impact the glucose levels in the blood. The score is determined by comparing the rate of glucose uptake from a specific food item to the rate of uptake of a standard control food, usually white bread or pure glucose. The rapid uptake of the control food is set at a standard score of 100 and all other foods are given a score in relation to this standard food. The majority of foods are scored somewhere between 0 and 100. The weakness with regards to GI is that it does not take into account the amount of the carbohydrate that was consumed, it only provides a rate of absorption. Therefore, a large banana with the same degree of ripeness as a very small banana will have virtually identical GI scores, even though significantly different amounts of carbohydrates were consumed.

6 dietary factors will affect the GI score of food:

1. The ripeness of the fruit/vegetable - increased ripeness tends to have higher GI
2. The dominant type of sugar present - sucrose (68), lactose (46), or fructose (17)
3. The dominant type of complex carbohydrate - amylose, amylopectin, or fibre
4. Method and length of cooking - hot slow oven (high) versus quick microwave (low)
5. Inclusion of other macronutrients at the same time - protein & fats will lower GI
6. The total amount of carbohydrate consumed - larger consumption lowers GI

High GI foods provide their glucose to the bloodstream at a rapid rate, but the effects are often short-lived and may result in a low blood glucose dip due to insulin over-response. In a healthy individual, this can be quickly resolved through a restorative glucagon surge. Low GI foods provide their glucose to the bloodstream in a slower more sustained manner which is more easily managed by the initial insulin response without the need for an over-correction.



Glycaemic load (GL) is considered by some experts to provide the answer to the weakness of glycaemic index. GL is determined by multiplying the amount of carbohydrate consumed with the accepted GI score, then dividing by 100. The value of the GL is that it indicates both the rate and the size of the blood glucose response that is likely to occur following consumption of a specific food. Consider the following fictitious example using two foods with identical GI but different serving sizes:

- Food A: GI of 50 x serving size 75g carbohydrates / 100 = **GL 37.5**
- Food B: GI of 50 x serving size 20g carbohydrates / 100g = **GL 10**

This GL calculation example illustrates that food B will have a much smaller total impact on blood glucose than food A despite the fact they both have identical GI scores. After both meals, glucose will enter the bloodstream at the same rate, but food A has 3.75 times the amount of carbohydrate which will continue to raise blood glucose for significantly longer than food B.

The following glycaemic index and glycaemic load table will provide useful guidance when applying food choices regarding carbohydrate content. It should be noted that these tables do not provide specific nutritional value as they are not a measure of micronutrient status. It is still possible that foods that are rated high or low may still be a valuable source of beneficial micronutrients. This is just one indicator that can be used to grade the metabolic response of carbohydrate foods.

Ranking	Glycaemic index (GI)	Glycaemic load (GL)
Low	< 55	< 10
Medium	55 - 69	10 - 19
High	≥ 70	≥ 20

The following table of commonly consumed foods has been listed in accordance with the glycaemic index and glycaemic load. The foods are grouped to indicate similar foods in respect to carbohydrate content:

- Foods containing basic simple sugars
- Breakfast cereals
- Starchy, complex carbohydrate staples
- Fruits and fruit juice
- Snack foods

CHO source	GI	GL	CHO source	GI	GL	CHO source	GI	GL
Glucose	100	10	White bread	78	12	Apple	34	5
Fructose	17	2	Wholemeal bread	65	8	Apple juice	42	12
Sucrose	70	7	Bagel	71	25	Green banana	36	9
Honey	64	14	White rice	78	28	Ripe banana	52	14
Maple syrup	54	10	Brown rice	76	26	Orange	39	4
Cola	58	15	Instant noodles	57	17	Orange juice	50	11
Cornflakes	83	21	Baked potato	84	22	Popcorn	72	8
Weetabix	75	16	French fries	65	19	Potato chips	54	11

It is interesting to note the variation in GI and GL amongst foods that are from the same category, some of which is inherent in the food, some primarily due to differences in food processing methods. The difference in scores between glucose and fructose is substantial despite the fact they're both monosaccharides.

There is a difference in scores between white and wholemeal bread but it may not be as significant as you might expect with very similar glycaemic indices. The main difference is in the GL which is lower in wholemeal bread, suggesting it carries fewer total carbohydrates due to the fibre content. White and brown rice are remarkably similar despite the presence of fibre in brown rice. Whereas apples and oranges compared to their respective freshly squeezed juices show a significantly greater GL for the juice option which allows for more carbohydrates to be quickly consumed without the flesh of the fruit and its fibre present.

Carbohydrate consumption recommendations

Recommendations for the consumption of carbohydrate foods vary significantly around the world. However, the following guidelines for adults represent widely accepted recommendations in the western world. As carbohydrates are an important fuel source for exercise, there are also recommendations related to the amount of exercise and activity being undertaken. It is important to understand that these recommendations are appropriate as a population guide. All dietary recommendations, including these specific ones on carbohydrates, should be adapted carefully to the specific needs of the individual or client being coached and supported.

General population carbohydrate guidelines:

- Minimum combined simple/complex carbohydrate intake of 50g/day (100g/day for pregnant or lactating women)
- Typical total carbohydrate intakes for adults range from 200 - 400g/day
- Consume at least 5 portions (400g) of fruit and vegetables per day spread across daily meals and snacks
- Consume 3-5 portions of wholemeal cereals, bread, potatoes, pasta, and rice.
- Emphasize whole-grain complex carbohydrates over refined, processed carbohydrates

Activity / Exercise recommendations:

- General fitness (30-60 mins per session over 1-3 days/week):
    - Consume 45 - 55% total calories from carbohydrate foods
        - Females total 2000 kcal/day: consume 900-1100 kcal carbohydrate/day
        - Males total 2500 kcal/day: consume 1125-1375 kcal carbohydrate/day
    - Bodyweight calculation: 3-5g x weight in kg = total carbs g/day

- Moderate to high intensity/volume fitness (1-3 hours per session, 4-6 days per week):
    - Consume 55 - 65% total calories from carbohydrate foods
        - Females total 2000 kcal/day: consume 1100-1300 kcal carbohydrate/day
        - Males total 2500 kcal/day: consume 1375-1625 kcal carbohydrate/day
    - Bodyweight calculation: 5-8g x weight in kg = total carbs g/day

Other carbohydrate recommendations:

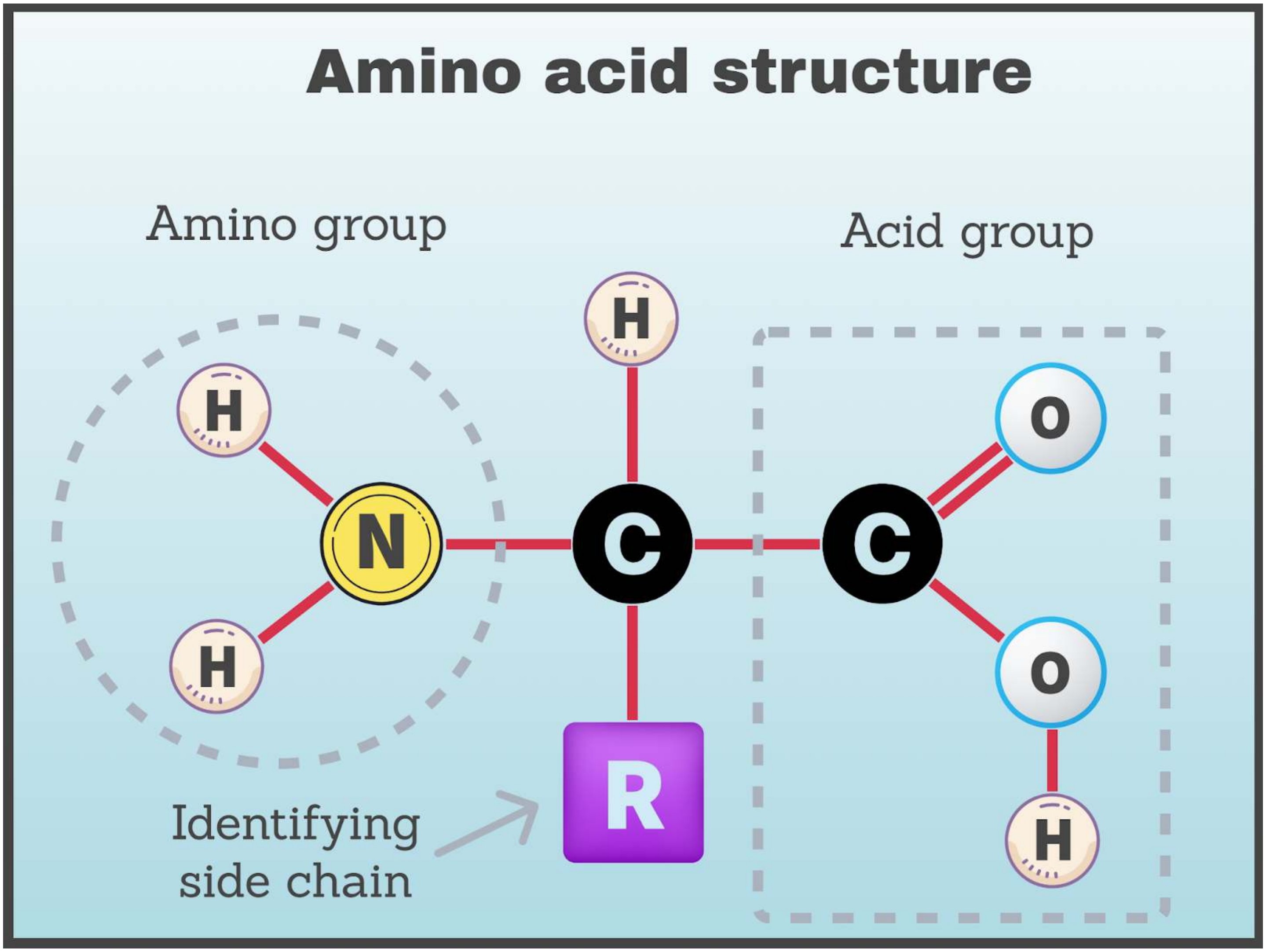
- Maximum added refined sugar intake of no more than 10% daily calories
    - Females total 2000 kcal/day: maximum 200 kcal or 50g sugar/day
    - Males total 2500 kcal/day: maximum 250 kcal or 63g sugar/day
- Reduction to only 5% of calories from added refined sugars is also recommended for further health benefits
- Total daily fibre intake of a minimum of 25g/day

Proteins

Proteins are fundamental structural and functional chemical compounds that are found in virtually all cells of the human body. Beyond water, which is the most abundant substance, proteins account for 16% of total body weight on average, making it the second most abundant compound found within the body. Half of all the protein found in the body can be accounted for or within 3 types of tissue; collagen (bones, joints, tendons, skin, & hair), haemoglobin (red blood cells), and muscle tissue (actin & myosin filaments). Even at this early stage on the topic, it is clear how essential protein is to the health and well-being of a fully functioning body.

Protein structure

The basic building block that proteins are made from is a nitrogen-based structure known as an amino acid. Whilst there are a variety of different kinds of amino acids, they all have the same basic, central chemical structure which identifies them as amino acids. The central structure is composed of a nitrogen-containing amino group, a carboxylic acid group, and a long sidechain sometimes called the R group.

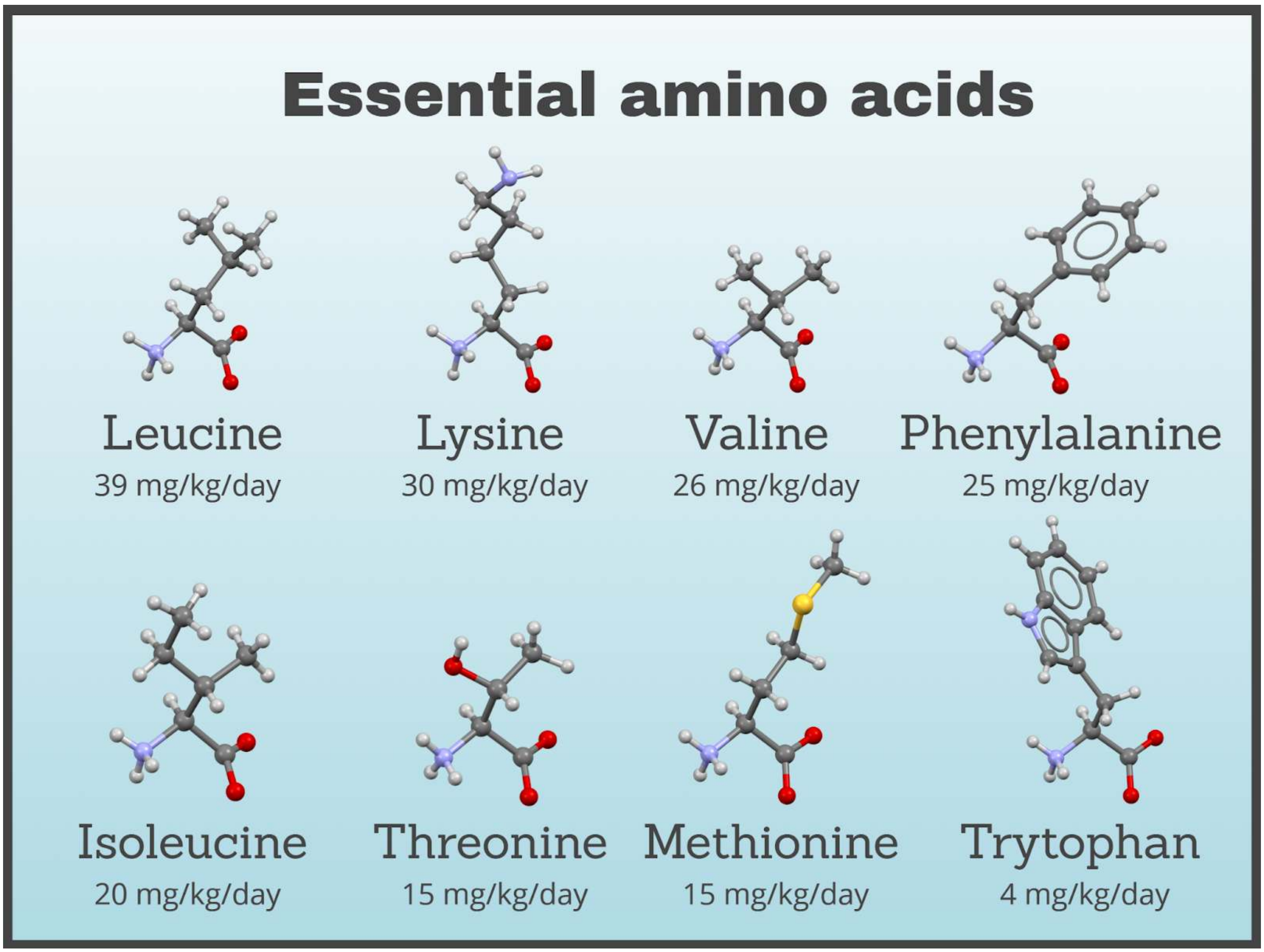


Amino acids within food and the tissues of the body are normally combined to form larger units called peptides and even longer complex chains called proteins. The naming and structures of these units are as follows:

- 2 amino acids = di-peptide
- 3 amino acids = tri-peptide
- 4-10 amino acids = oligo-peptide
- 10+ amino acids = poly-peptide

The majority of naturally occurring polypeptides are composed of chains of 50 amino acids or more. When a long polypeptide chain becomes folded in upon itself in a 3-dimensional structure, this is when the scientific nomenclature begins to refer to them as proteins. Proteins often contain 2 or more polypeptide chains bound together and folded into complex 3-dimensional shapes. The shapes that are formed by different proteins are very important because this is how the body recognises them and it is also an important factor in the function each specific protein can serve. To simplify, **shape determines function**. Protein functions will be discussed a little later in this chapter. There are a total of 20 different amino acids that are found in food and that the body can use to create the various proteins that are needed for health and physiological function.

Essential amino acids



**WHO/FAO 2007*

Cells of the body can create a range of amino acids providing they have enough of the primary supply necessary. This primary supply is categorised as the essential amino acids. 8 amino acids are considered to be essential to the diet as the body is unable to make these on its own. The remaining 12 amino acids are considered to be either non-essential or conditionally essential. The term, non-essential may sound like the other amino acids are not important, this is incorrect. By ensuring sufficient consumption of all amino acids, including the non-essential forms, will provide better nutritional sufficiency and will also help to spare the essential, dietary dependent amino acids from being readily converted to the other forms. The term 'essential' merely identifies their necessity in the diet, not a level of hierarchy for all amino acid forms.

Seven of the non-essential amino acids can become conditionally essential under certain conditions, such as premature birth, in early childhood, or as a result of certain pathophysiological circumstances, such as severe catabolic distress. As the non-essential amino acids are not necessary in the diet and can be produced, if needed, by the cells of the body, there have been no minimum daily intake levels determined. The remaining amino acids can be classified as follows:

Conditionally essential amino acids	Non-essential amino acids
Histidine Arginine Cysteine Glutamine Glycine Proline Tyrosine	Alanine Aspartic acid Asparagine Glutamic acid Serine

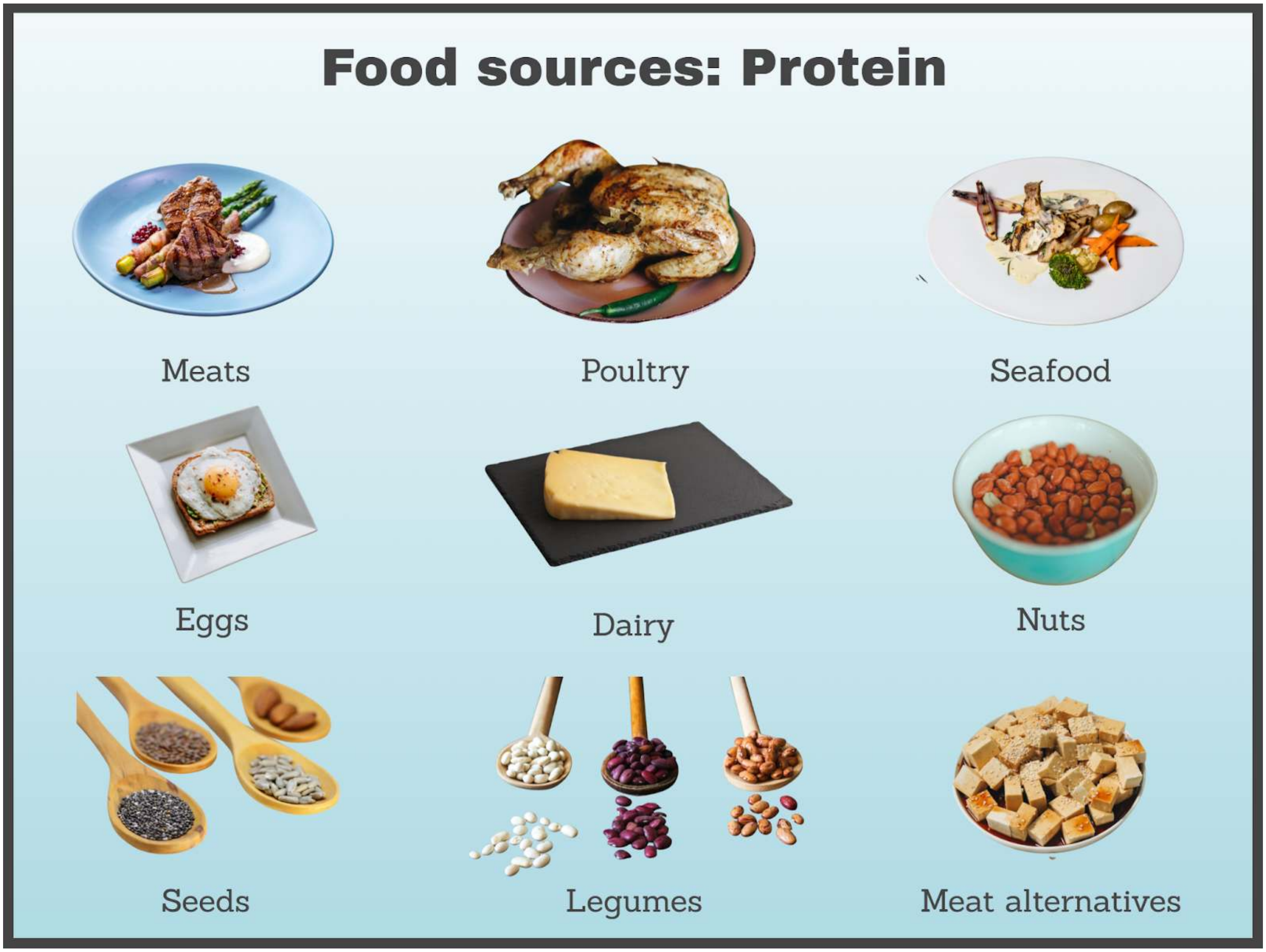
Functions of protein

As stated earlier, the shape of a peptide or protein denotes its potential function in the body. With an estimated 100,000 structural variations and different types of protein in the body, this would suggest that there are numerous functions to match. Rather than attempt to list all the various functions of protein in the body, it is easier to categorise them into 8 broader purposes:

1. **Structural** - proteins like collagen provide structure throughout the body in the bones, tendons, and joints, while keratin is present in the skin, hair, and nails.
2. **Contractile** - deep in the microscopic structure of skeletal muscle two specific types of protein are responsible for the contractile nature of muscle tissue, namely actin and myosin.
3. **Circulatory** - contained within the red blood cells is an important protein called haemoglobin that helps transport oxygen throughout the body. The blood also contains other important proteins, fibrin and fibrinogen, that are responsible for blood clotting when damage to the body occurs.
4. **Hormonal** - whilst there are several different categories of hormones, two categories are specifically derived from proteins; the peptide hormones, including oxytocin and vasopressin, and the protein hormones, like insulin and glucagon.
5. **Immunological** - within the bloodstream there are a variety of other important protein-derived cells that play a vital role in fighting infection, overcoming disease, and preventing future illness. The range of white blood cells and the presence of alerting antibodies in the circulatory system provide this essential immunological protection.
6. **Catalytic** - throughout the body from cells to systems there are numerous catalytic hormones called enzymes that help to speed up biological reactions that benefit our physiology. From digestion to blood clotting and energy metabolism to protein synthesis, enzymes play a vital role in physiological functioning.
7. **Fluid balance** - specific proteins in the blood, such as albumin, help to maintain the appropriate balance of fluids between the blood and the tissues of the body. The force of blood pressure in the vessels has the effect of squeezing the fluids out of the blood vessels into the tissue. Proteins present in the blood help to attract fluids to remain within the bloodstream and sustain an appropriate level of blood pressure.
8. **Energetic** - whilst the other two macronutrients are the dominant energy providers, proteins still provide a minor daily contribution towards the energy levels of the body. Proteins can be converted by the liver into usable glucose when required.

Dietary sources of protein

Protein is present in a wide variety of foods in varying quantities. Naturally occurring foods do not only contain protein. Pure protein foods have been subjected to industrial processing to extract and separate the protein. It is more appropriate to refer to protein-rich foods, meaning foods that have a naturally higher concentration of protein. Most naturally occurring protein-rich foods will contain either fats, or carbohydrates, or both macronutrients.



Typically protein-rich foods are separated into animal and plant sources. Despite the obvious difference of where the food product came from, the main composition difference between plant and animal foods is in the amount of protein present. In the majority of cases, animal-based foods are a more dense source of protein. Plant-based protein sources are commonly combined with carbohydrates and/or fats, with protein being the less dominant constituent of that food product. As a direct weight comparison, plant-based foods are less protein-dense.

Protein-rich animal foods	Protein-rich plant foods
Meats: beef, lamb, pork, goat, bison, buffalo, land game (venison, rabbit, wild boar)	Nuts: walnuts, almonds, pistachios, cashews, Brazils, hazelnuts, macadamia, pecans, pine, chestnuts
Poultry: chicken, duck, turkey, goose, ostrich, game birds (pheasant, pigeon, guinea fowl, grouse, quail)	Seeds: sesame, pumpkin, sunflower, flax, chia, hemp, poppy
Seafood: White & oily fish, fish roe (eggs), and shellfish (crab, lobster, shrimp, clams, mussels, scallops etc.)	Legumes: soya beans, peanuts, lentils, chickpeas (garbanzo beans), peas, split peas, beans
Eggs: chicken, duck, goose, quail, ostrich, pheasant, turkey etc.	Meat alternatives: Tempeh, tofu, textured vegetable protein, mycoprotein etc.
Dairy: cheeses and yoghurt from cows, goats, sheep, buffalo or camels milk etc.	Whole grains: Kamut, teff, quinoa, wild rice *Typically carbohydrate-rich - these are higher in protein

Digestion of protein

The breakdown of protein begins in the mouth with chewing to mechanically break apart the food. Whilst the release of saliva occurs in the mouth to help moisten the food, the enzymes present in saliva do not start any chemical breakdown of protein. Through chewing and the action of the tongue, the food is formed into a small mass, or bolus, which is swallowed down the oesophagus and into the stomach where can be held for up to 4 hours as it is further digested through the combined actions of the churning of the stomach, the acidic gastric juices, and the action of important protein-digesting enzymes. The primary enzyme in the stomach is called pepsin, which speeds up the chemical breakdown of large protein molecules, into small protein chains, then smaller peptide molecules. Pepsins require an acidic pH below 3.5 to operate effectively. The extent of chemical protein digestion in the stomach is somewhat limited.

When the food exits the stomach into the small intestine it has changed into a liquid known as chyme. In the first section of the small intestine, the duodenum, alkaline pancreatic juices are released into the tract so that further chemical digestion can take place due to the presence of pancreatic enzymes, trypsin and peptidase. The action of these 2 enzymes results in proteins and peptides that have been completely broken down into their simpler forms, tripeptides, dipeptides, and amino acids. These basic protein units are then absorbed through the intestinal wall as the chyme passes through the length of the other sections of the small intestine, the jejunum and ileum. These single amino acids are absorbed into the bloodstream and the digestion of proteins is complete.

Bioavailability of protein

A scientific review of protein digestibility rates by Pinckaers et al (2021) stated:

'...recent data in humans have shown that ~ 85–95% of the protein in egg whites, whole eggs, and chicken is absorbed, compared with only ~ 50–75% of the protein in chickpeas, mung beans, and yellow peas. The lower absorbability of plant-based proteins may be attributed to anti-nutritional factors in plant-based protein sources, such as fibre and polyphenolic tannins.'

The longest-standing rating of protein digestibility is called the biological value (BV) scale. BV is a measure of the amount of nitrogen, a component of amino acids, that is absorbed through food consumption compared to the remaining amount that is excreted out of the body. Applying careful calculations and comparing it to the BV of other food sources provides a means of identifying how much dietary protein is utilised by the body. The scale for BV is from 0 (lowest) to 100 (highest). Despite this, BV is now widely considered to be an outdated measure of protein digestibility, but as it is still in common use it would be wise not to ignore it completely, but to be aware of its weaknesses and limitations. BV assumes that all nitrogen in the diet comes only from protein and that all amino acids consumed and absorbed are used to create new proteins within the body. A small amount of protein each day will likely be utilised for energy metabolism rather than contribute to the primary protein functions.

The most commonly used scale for protein digestibility is called the Protein Digestibility Corrected Amino Acid Score or PDCAAS for short. The PDCAAS operates on a scoring system from 0 (lowest) to 1 (highest). The advantage of the PDCAAS scale over BV is that along with protein bioavailability, it also uses a profile of amino acids contained within the food, comparing them against the daily requirements for essential amino acid requirements. Despite this being the widely accepted bioavailability scale used today, it still has some limitations, specifically that all results on this scale have a maximum score of 1. This means that certain foods which could have scored higher than 1 will still be limited to that maximum score. Therefore, some foods appear on PDCAAS to be equally capable of delivering protein to the body when, in fact, there is still variation between their actual bioavailability level.

To overcome the weaknesses of BV and PDCAAS, a revised system was proposed in 2013 called the Digestible Indispensable Amino Acid Score (DIAAS). The DIAAS runs on a 0 to approximately 1 scoring system similar to PDCAAS. The difference is that DIAAS does not place a maximal value of 1.0 on the scoring system, therefore some foods are rated higher than 1 as they provide high levels of bioavailability. The DIAAS system measures the true absorption of protein at the ileum rather than through evaluation of the excreted faeces as in the PDCAAS system.

Food	BV	PDCAAS	DIAAS
Whey protein	96	0.99	1.00
Chicken egg	94	1.00	1.13
Cow's milk	90	1.00	1.16
Beef	92	1.00	1.12
Soy flour	81	0.89	0.98
Chicken breast	79	1.00	1.08
Whitefish	76	-	1.00
Rice	83	0.62	0.60
Pea protein	-	0.75	0.62
Whole wheat	64	0.50	0.45
Roasted peanuts	-	0.51	0.43

What has become clear over the years of research is that providing a scientifically accurate protein bioavailability score that has merit in the real world of combined meals and varied dietary intake, is very difficult to achieve. For reference, the table provides a comparison of scores for all 3 protein bioavailability systems across a small range of both animal and plant foods.

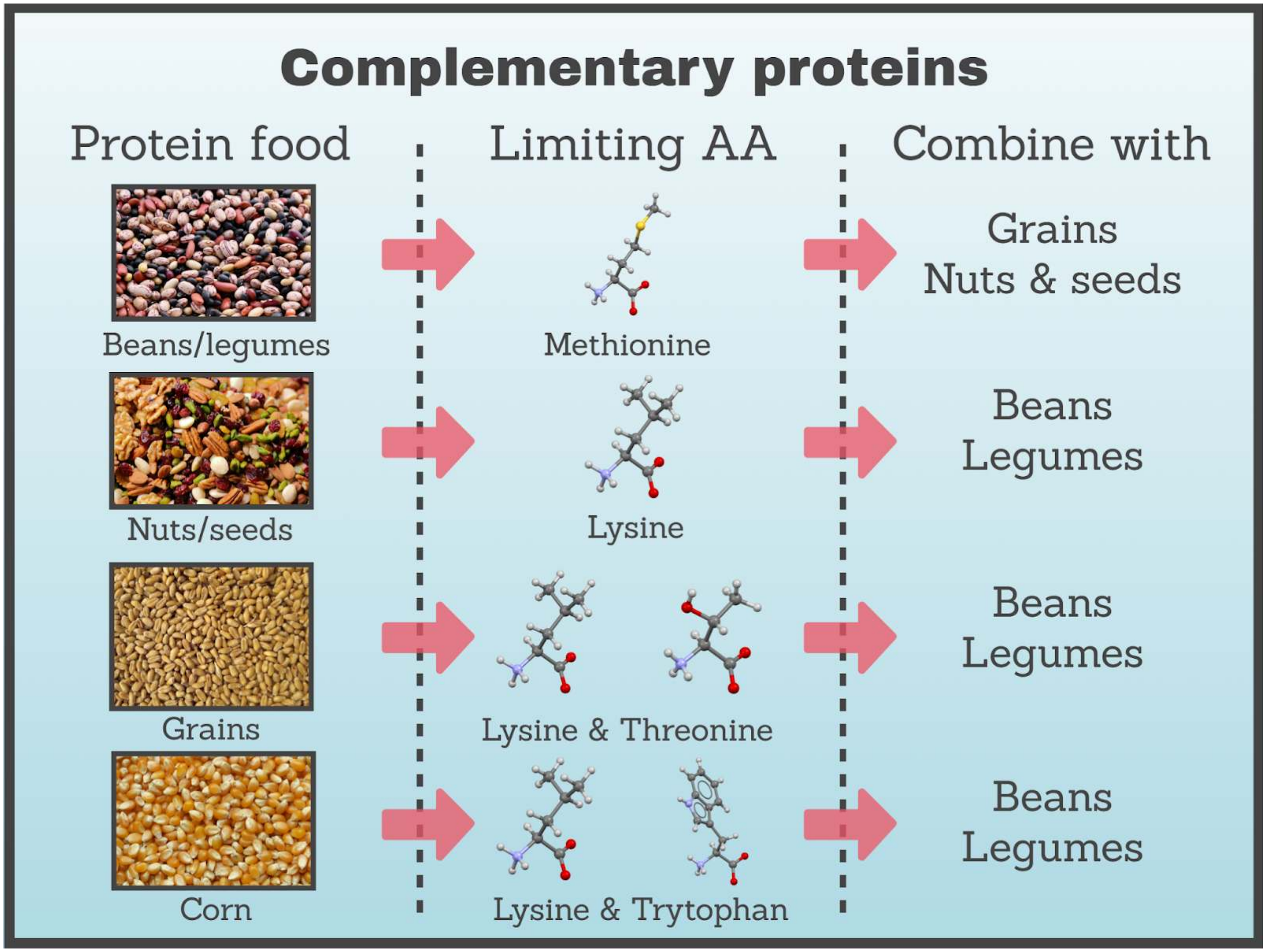
Complete and incomplete proteins

A common method used to categorise protein-rich foods is in reference to their level of completeness of the 8 essential amino acids. The two general categories are as follows:

- **Complete protein:** foods contain adequate amounts of all of the essential amino acids with respect to the set daily requirements for each amino acid.
- **Incomplete protein:** foods do not contain adequate amounts of the essential amino acids with respect to the set daily requirements for each amino acid. Incomplete proteins will usually have 1 or more limiting amino acids that fall substantially short of the daily requirements.

Generally speaking, primarily animal derived protein-rich foods are considered complete, although there are a few plant sources that get very close to this status. Plant-derived protein-rich foods are usually categorised as incomplete sources. The terms complete or incomplete may be considered a form of protein hierarchy, but this is simply not the case. The protein and resulting digested amino acids provided from either animal or plant foods are just as valuable to the body regardless of the source of food they originally came from. Therefore, the value of applying the terms complete or incomplete to a food source has more to do with the ease with which a full complement of EAA’s can be consumed. Complete protein foods can usually provide the full complement of EAA’s within a standard portion size of a single source.

Incomplete proteins usually require larger portion sizes from at least 2 complementary protein sources to reach the full complement of required EAA’s. The key is to identify the limiting amino acids within the particular protein-rich food source and then combine it with another food that contains the required amino acids. This method of complementing proteins is commonly used amongst vegetarian or vegan groups to ensure they achieve the necessary protein sufficiency requirements for the important EAA’s.



Amino acid sufficiency

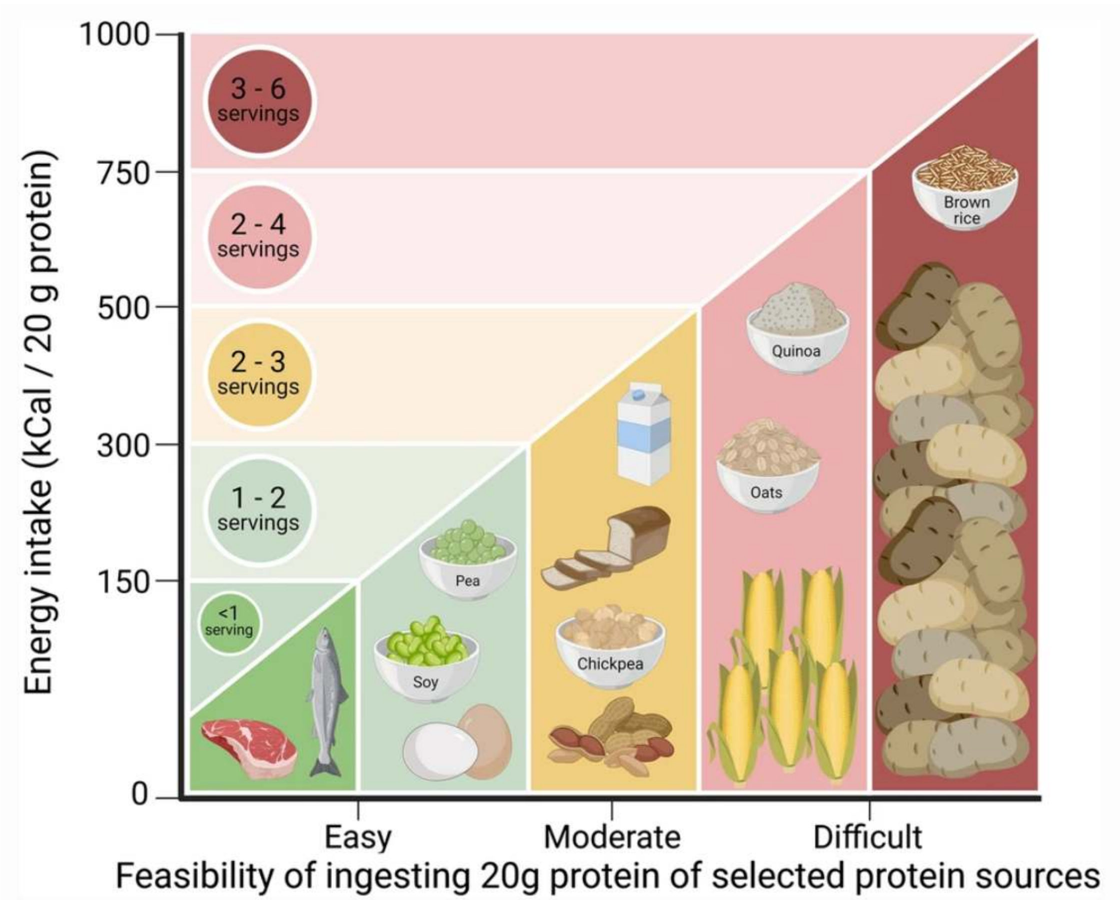
Complementing incomplete proteins is a useful strategy to make up for the shortfall in amino acids, but it is only half of the battle. The other consideration concerning essential amino acids is to ensure that the serving size of the food selected will provide sufficient protein and amino acids to meet the daily requirements. This is referred to as amino acid sufficiency. As a general rule, the essential amino acids are present in animal proteins at a higher volume than that typically found in plant proteins. This has an impact upon the serving size required to meet amino acid sufficiency levels across all 9 essential amino acids.

To be able to determine the minimum serving size to meet the EAA required sufficiency levels, the limiting amino acid for a given food must be identified. The limiting amino acid will have the lowest percentage amount of the daily minimum requirement. A simple calculation can be made to determine the necessary serving size of a given protein-rich food source to ensure that the limiting amino acid reaches the required daily sufficiency level. The table below provides a series of examples to determine the required serving size for protein-rich food sources to meet all EAA sufficiency levels.

Protein-rich food source	Protein g/100g	Limiting amino acid	% daily value 70kg individual	Required serving size to reach sufficiency
Chicken egg	12.5g	Methionine	36.1%	277g or 5-6 large eggs
Chicken breast	31.0g	Phenylalanine	70.0%	142g or 1 medium chicken breast
Tuna (canned)	23.6g	Phenylalanine	52.7%	189g or 1.2 small cans tuna fish
Sirloin beef steak	19.9g	Phenylalanine	43.7%	228g or 1 small steak
Blanched almonds	21.9g	Methionine	18.5%	541g or 3.6 small bags of almonds
Walnuts	15.2g	Lysine	20.2%	495g or 2.5 small bags of walnuts
Green lentils	9.0g	Methionine	7.3%	1363g or 3.4 tins of green lentils
Kidney beans	8.7g	Methionine	12.4%	807g or 2 tins of kidney beans
Black beans	15.2g	Methionine	21.8%	405g or 1 tin of black beans
Wild rice	4.0g	Lysine	8.1%	1235g or 4.9 small bags of wild rice

It is clear from the table that protein-rich animal foods generally provide a more substantial amount of EAA's than plant foods and as such the required serving sizes to achieve EAA sufficiency are manageable in a single meal in most cases. Protein-rich plant foods tend to have overall lower amounts of EAA's, with the limiting amino acid often being substantially lower than the other amino acids. This helps to demonstrate why they are classified as incomplete proteins.

In most cases, the serving sizes for protein-rich plant foods required to reach EAA sufficiency are much larger and usually beyond what would be appropriate to consume in a single meal, or even within a full day in most cases. It must be noted that this is a comparative view only. It is not necessary to achieve a full day's requirement of EAA's in a single meal or from a single food source. It is manageable to consume all the minimum EAA requirements through a range of protein-rich foods spread across the meals of a single day whether eating mostly plant or mostly animal foods, or even a combination of both. Vegetarian and vegan diets do require a little more care to ensure that the right mix of complementary plant foods is eaten in sufficient amounts to reach the minimum EAA requirements. A higher intake of plant foods to ensure protein and amino acid sufficiency will often lead to a higher intake of total calories as well. Calorie intake needs to be managed carefully in conjunction with achieving target protein consumption.



Categorical representation of the feasibility of consuming 20 g protein provided by ingesting the whole food source (x-axis), with the amount of food that needs to be consumed expressed as servings with the concomitant energy intake equivalent (y-axis). Serving sizes: meat/salmon: ~ 100 g, egg: ~ 120 g (2 eggs), soy: ~ 100 g, pea: ~ 150 g, chickpea: ~ 150 g, peanut: ~ 50 g, bread (wheat): ~ 70 g (2 slices), milk: ~ 200 mL, corn: ~ 150 g, oats ~ 40 g (raw), quinoa: ~ 75 g (raw), brown rice: ~ 75 g (raw), potato: 175 g. Pinckaers et al (2021)

Protein consumption recommendations

National dietary guidelines tend to provide direction on food group intake, portion sizes, fruits and vegetables, and limiting sugar, fat, salt, and alcohol consumption. Whilst these national guidelines are very important they rarely provide specific direction on protein consumption beyond the basic protein-rich food serving suggestions e.g. two portions of fish per week. The following series of recommendations will help to provide further clarity on the requirements for protein for the general adult population, for more exercise specific advice and some additional considerations.

General population protein guidelines:

- Aim to consume 2 portions per day of protein-rich foods selected from meat, poultry, fish, eggs, beans, and nuts.
- Aim to consume 3 portions per day of protein-rich animal dairy options, including cheese, yoghurt and milk. *Note: most plant-based dairy alternatives usually provide very little protein and are not a like-for-like replacement to animal dairy*.
- Recommended daily allowance of protein for sedentary adults is 0.8-1.0g per kilogram body weight per day (g/kg/day) e.g. 70kg individual needs 56-70g protein per day
- Choose protein-rich foods from unprocessed or minimally processed sources and vary protein intake across a range of animal and plant-based options each day/week.

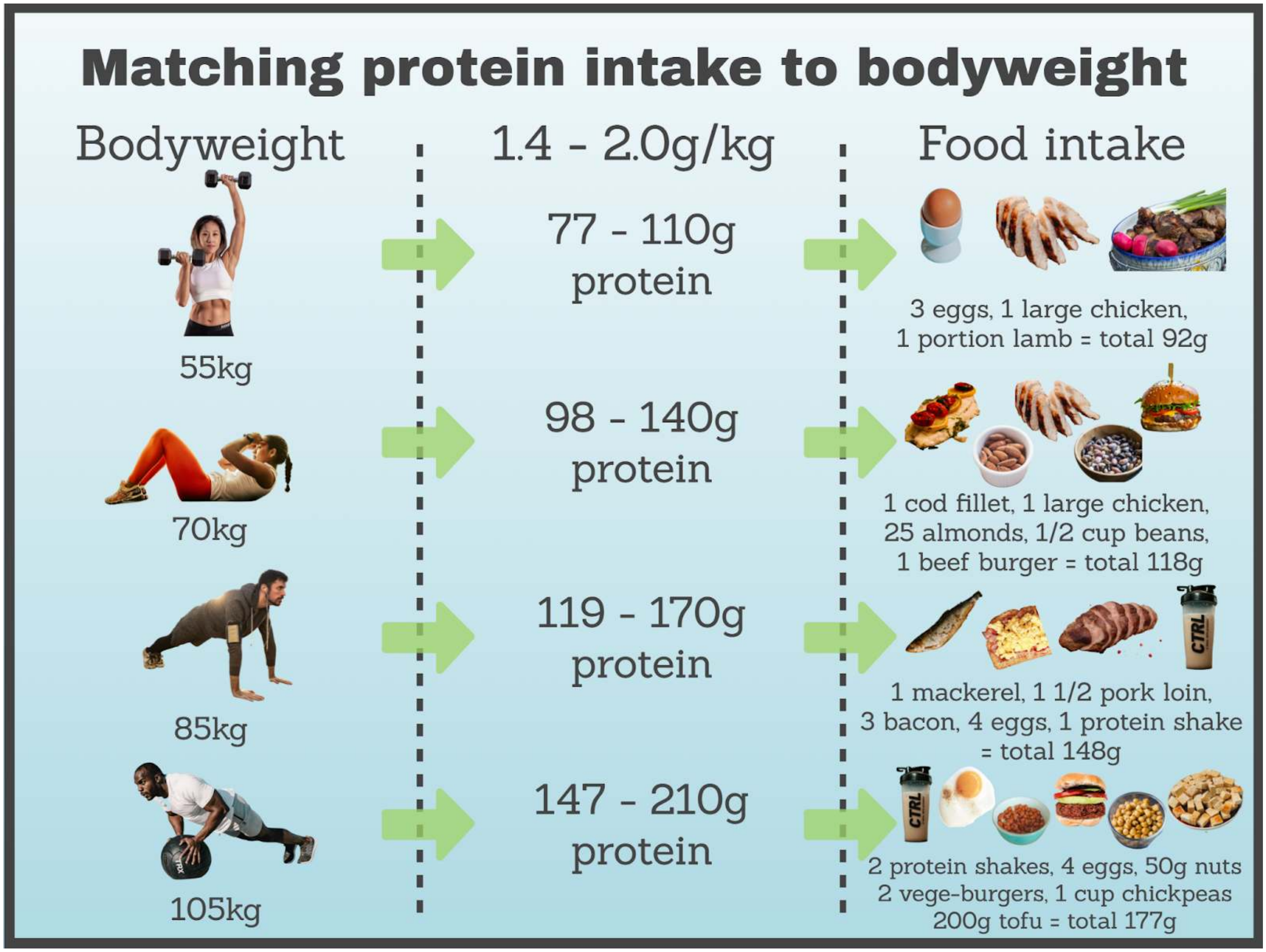
Activity / Exercise protein recommendations:

- Overall a daily protein intake in the range of 1.4–2.0g/kg/day is sufficient for most regularly exercising and physically active individuals e.g. 70kg active individuals need 98-140g protein per day.
- Individuals undertaking high volume or high-intensity exercise regularly will require higher protein intakes to minimise muscle catabolism and maintain muscle protein synthesis and repair. Protein consumption should target 1.7-2.2g/kg/day e.g. 70kg highly active individuals need 119-154g protein per day.
- Some evidence suggests higher protein intakes (2.2-2.5g/kg/d) may have a positive influence on maintaining nitrogen balance in resistance-trained individuals.

- Recommendations regarding acute protein intake per serving to maximize muscle protein synthesis are dependent upon age and recent resistance exercise history. General recommendations are 0.25g of high-quality protein per kg of body weight, or an absolute dose of 20–40g. A 70kg individual would seek to consume at least 17.5g protein per serving.
- Protein consumption for active exercising individuals should ideally be evenly distributed, every 3–4 hours, across the day to help maintain muscle protein synthesis.

Other protein considerations:

- Following exercise the small increase in stimulus for muscle growth and repair lasts at least 24 hours, slowly diminishing the longer the time passes after exercise. Protein consumption around exercise needs to account for this longer time frame.
- Ensure adequate daily intake of all the essential amino acids by including sufficient complete protein sources, or if emphasizing plant-based dietary sources, using a range of complementary protein-rich foods to ensure sufficiency.
- Where diet or personal circumstances make it difficult to consume sufficient protein through whole, natural foods, consider utilising a high-quality protein supplement to assist the diet in reaching the required consumption target.



Fats and oils

Fats and oils, scientifically known as lipids, are nutrient-dense compounds composed primarily of carbon and hydrogen atoms connected in long molecular chains. Dietary fat consumption is an essential component of healthy nutritional practice. Unfortunately, over the last few decades, dietary fat has been strongly demonised in the scientific literature and national dietary guidelines. However, as science has progressed in knowledge, its stance on the exclusion of dietary fat has eased considerably. Dietary fat is now known to be an important dietary component for optimising human health. However, there are some complexities around the inclusion of dietary fat that will be discussed throughout this section.

A nutrition coach must be able to identify which fats and oils to recommend for consumption and which fats and oils to exclude from the diet to help promote optimal human health. Fats are normally defined as those that are firm at room temperature, whereas oils are typically liquid.

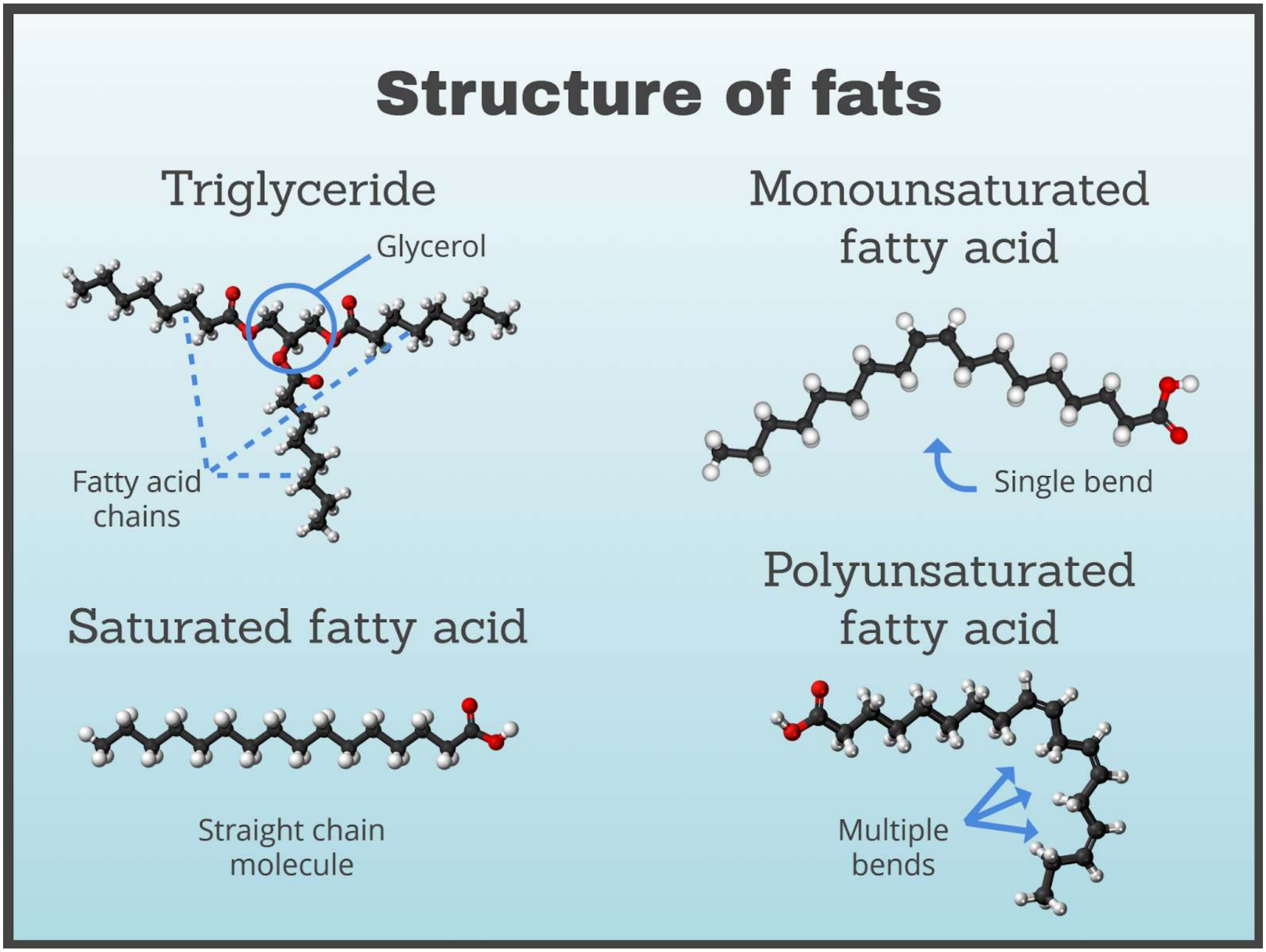
Structure of dietary fat

Fat as a nutritional molecule is present in the diet is found in two major chemical forms:

1. Triglycerides
2. Sterols, e.g. cholesterol

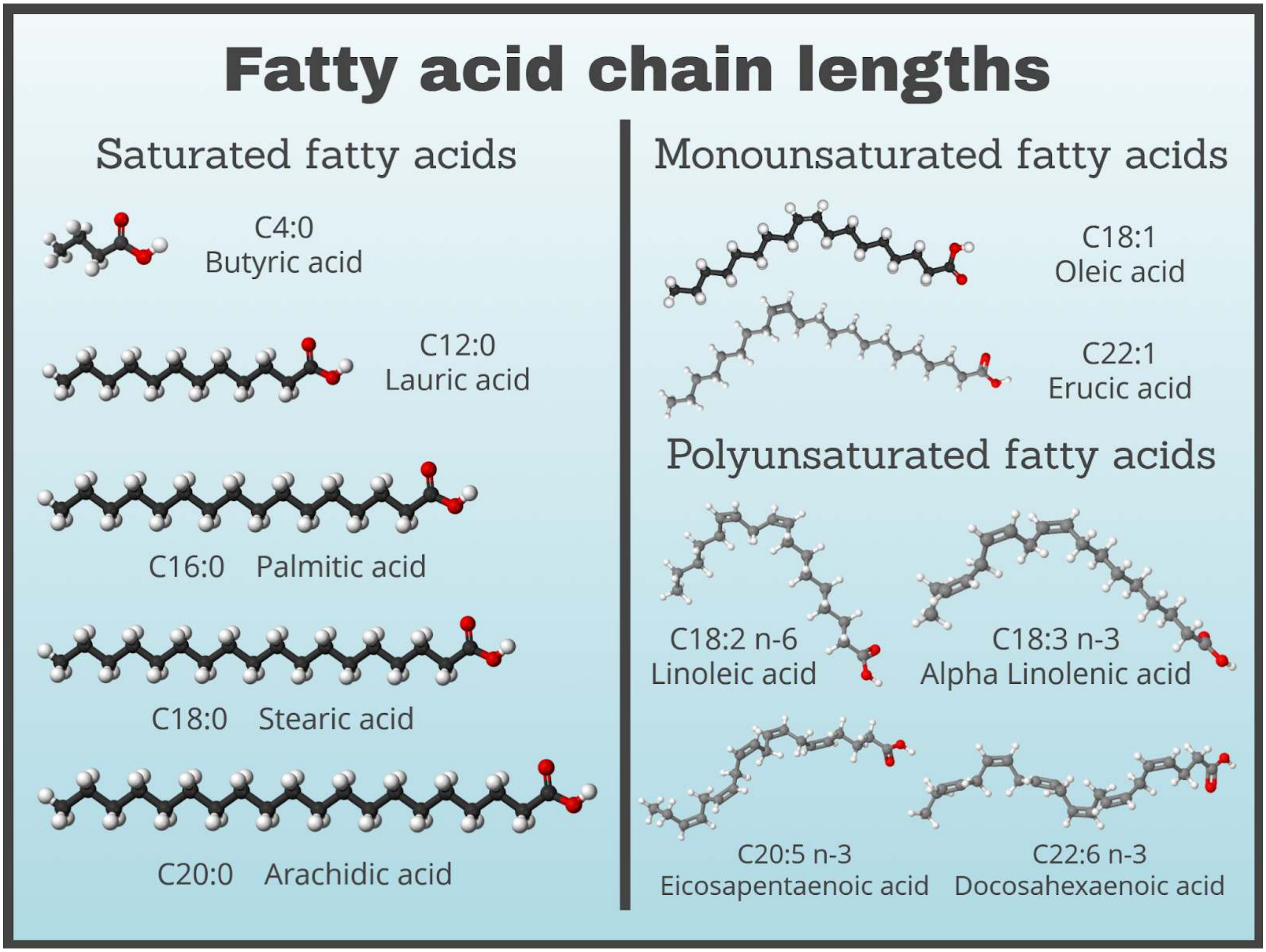
Cholesterol is less common in the diet, but it will be addressed later to review its role in circulatory function and heart health. The vast majority of dietary fats are naturally present in the triglyceride chemical form within food, and also when stored within the human body. However, the scientifically named categories of dietary fat refer to the long chains contained within the triglyceride molecule. As the name suggests a triglyceride has 3 components, or chemical chains, that are attached by a small carbohydrate anchoring molecule called glycerol. The shape and chemical structure of the molecular chains, known as fatty acids, serve as the basis for the 3 major categories of dietary fats; saturated, monounsaturated, and polyunsaturated fatty acids.

A straight-chain fatty acid indicates that all possible bonds along the length of the carbon chain are connected to hydrogen atoms and thus the chain is saturated or full, hence the name saturated fatty acid. The bends that are present in the chemical structure of the mono and polyunsaturated fatty acids occur due to a lack of hydrogen atoms at a specific point along the length of the chain that results in a double-strength bond between two neighbouring carbon atoms. These double bonds alter the shape of the molecule and attest to the fact that the carbon chain is not fully saturated with hydrogen atoms. This is why they are referred to as unsaturated fatty acids.



In addition to the different chemical shapes that fatty acids present with, they are also composed of differing length carbon chains between 4 and 24 carbons long. These different chain lengths combined with the varying molecular shapes provide a clear naming process for all types of fatty acids present in the food supply.

- Short-chain saturated fatty acids are 3-6 carbon molecules
- Medium-chain saturated fatty acids are 8-14 carbon molecules
- Long-chain saturated and unsaturated fatty acids are 16-24 carbon molecules



Fatty acid nomenclature starts with listing the number of carbon atoms in the chain e.g. C16, followed by the number of double bonds in the chain e.g. C16:1**. The final number (n-3) indicates the location of the first double bond in the chain identified from the omega end of the molecule (opposite to the red coloured carboxylic acid end).*

Function of fats

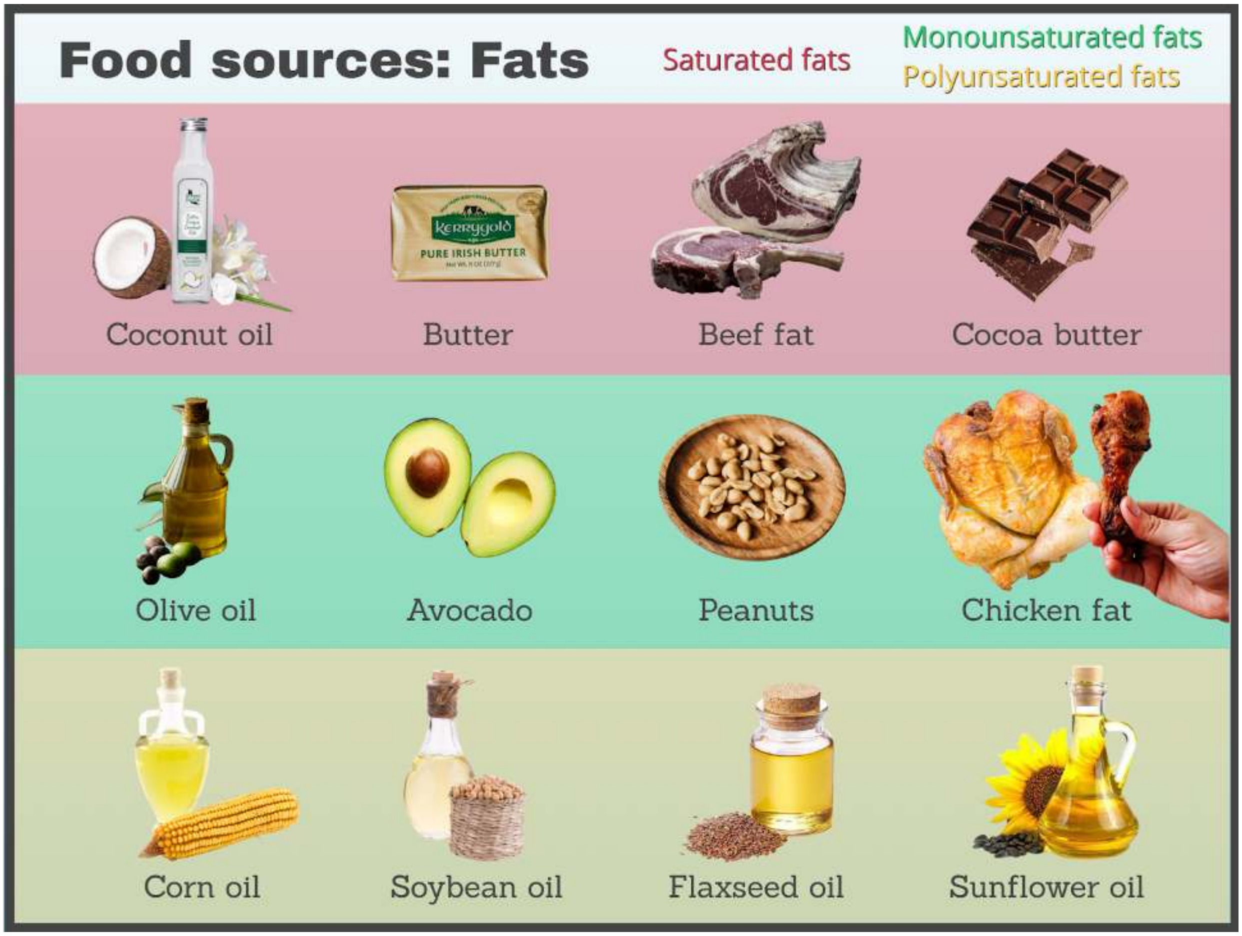
The presence of fats within food serves as a dense energy source, but it also absorbs many fat-soluble vitamins and other beneficial plant compounds known as phytochemicals. These fat-soluble nutrients can only be stored within the food and delivered to the body in the presence of fats. Food that is very low in fat will be, by default, very low in fat-soluble nutrients. Once dietary fats are digested and absorbed into the body they have a wide variety of functions to promote health and wellbeing.

- They are a vital component for the formation of virtually all cell membranes in the body through the use of phospholipids.
- Surrounding the nerves is a thin fatty, insulating layer known as the myelin sheath which helps to increase the rate of nerve signal conduction.
- Cholesterol, a type of waxy fat, is essential in the formation of important steroid hormones e.g. oestrogen, testosterone, and cortisol.
- A thin layer of fat is deposited around major organs to serve as a nearby energy source, but also to provide a certain level of protection.
- The subcutaneous adipose tissue (layer of fat under the skin) serves as an energy store, but also helps protect the body from knocks and bumps, provides insulation from the cold, and gives the body shape and contour.
- Fats serve as the primary source of energy to fuel the body during times of low to moderate activity.

Dietary sources of fat

Fats are ubiquitous in the diet across many different types of food from plant and animal sources. A common misconception is that animal foods contain saturated fats and plant foods contain unsaturated fats. This is an oversimplification that has been used for years to help inform the wider population from a public health perspective to consume more unsaturated fats. The reality is that most foods containing fat are composed of all three variations, saturated, monounsaturated, and polyunsaturated in differing amounts. Therefore, when food is referred to as being rich in saturated fat, what is meant is that saturated fatty acids are dominant within the chemical profile for the fat contained within that food. The same could be said for foods that are identified as being rich in either mono or polyunsaturated fats. These foods would have a predominance of mono or polyunsaturated fatty acids within the chemical profile of the fat contained in those specific foods.

The easiest way to understand the various fatty acid profiles is to refer to the detailed tables that follow *(figures derived from Know your fats, Enig, 2000)*. Note that these tables also refer to two forms of unsaturated fatty acids known as the omega-3 and omega-6 categories. These are subcategories of the polyunsaturated fats column. These are known as essential fatty acids and will be discussed in detail later.



Fats/oils rich in saturated fatty acids

Name of fat or oil	% Sat	% Mono	% Poly	% Omega 3	% Omega 6
Coconut oil	91%	6%	3%	-	-
Palm Kernel oil	84%	14%	2%	-	-
Cow's butter	66%	30%	4%	1%	3%
Cocoa butter	60%	38%	2%	-	-
Lamb tallow	54%	35%	5%	-	5%
Beef tallow	49-54%	42-48%	3-4%	-	3%
Palm oil	49%	40%	10%	-	9%
Human milk fat	48%	33%	16%	-	-

**Omega 3 & 6 columns are a subcategory of polyunsaturated fatty acids (PUFA) that defines the types of PUFA present*

Fats/oils rich in monounsaturated fatty acids

Name of fat or oil	% Sat	% Mono	% Poly	% Omega 3	% Omega 6
Olive oil	15%	73%	10%	>1%	9-10%
Avocado oil	22%	60%	18%	1%	17%
Goose fat	29%	59%	11%	-	11%
Canola oil (LEAR)	6%	56-66%	29-36%	10%	19-26%
Cod liver oil	21%	57%	20%	15%	1%
Duck fat	35%	50%	15%	-	14%
Chicken fat	30-32%	48-50%	18-23%	-	-
Peanut oil	22%	46%	31%	-	31%
Lard	44%	45%	11%	-	11%
Turkey fat	29%	44%	33%	-	23%

Fats/oils rich in polyunsaturated fatty acids

Name of fat or oil	% Sat	% Mono	% Poly	% Omega 3	% Omega 6
Evening primrose oil	9%	9%	82%	-	82%
Rapeseed oil	4%	16%	80%	10%	14%
Safflower oil	8%	13%	78%	-	78%
Hemp seed oil	8%	12%	78%	19%	59%
Flaxseed oil	9%	17%	74%	60%	14%
Grapeseed oil	11%	16%	73%	1%	72%
Sunflower oil	13%	18%	69%	-	69%
Walnut oil	9%	23%	66%	12%	54%
Soybean oil	15%	22%	62%	-	61%
Corn oil	14%	27%	59%	1%	57%
Sesame oil	15%	41%	43%	-	43%

**Omega 3 & 6 columns are a subcategory of polyunsaturated fatty acids (PUFA) that defines the type of PUFA present*

Essential fatty acids

Within the category of polyunsaturated fatty acids, there are two specific types that the body is not able to synthesise on its own, therefore, both types of fatty acid must be consumed within the diet. As they are solely obtained through the diet they are referred to as essential fatty acids, meaning they are essential for inclusion within regular eating patterns. This is the only way the body can obtain these fats. The term essential does not place them on a hierarchy any higher or lower than other types of fat. Their inclusion in a regular diet is only required at a very low intake level. The two categories of essential fatty acids (EFA’s) are known as omega-3 and omega-6 polyunsaturated fatty acids. There are 5 main dietary essential fatty acids.

- Omega 3: Alpha-linolenic acid (ALA)
- Omega 3: Eicosapentaenoic acid (EPA)
- Omega 3: Docosahexaenoic acid (DHA)
- Omega 6: Linoleic acid (LA)
- Omega 6: Arachidonic acid (AA)

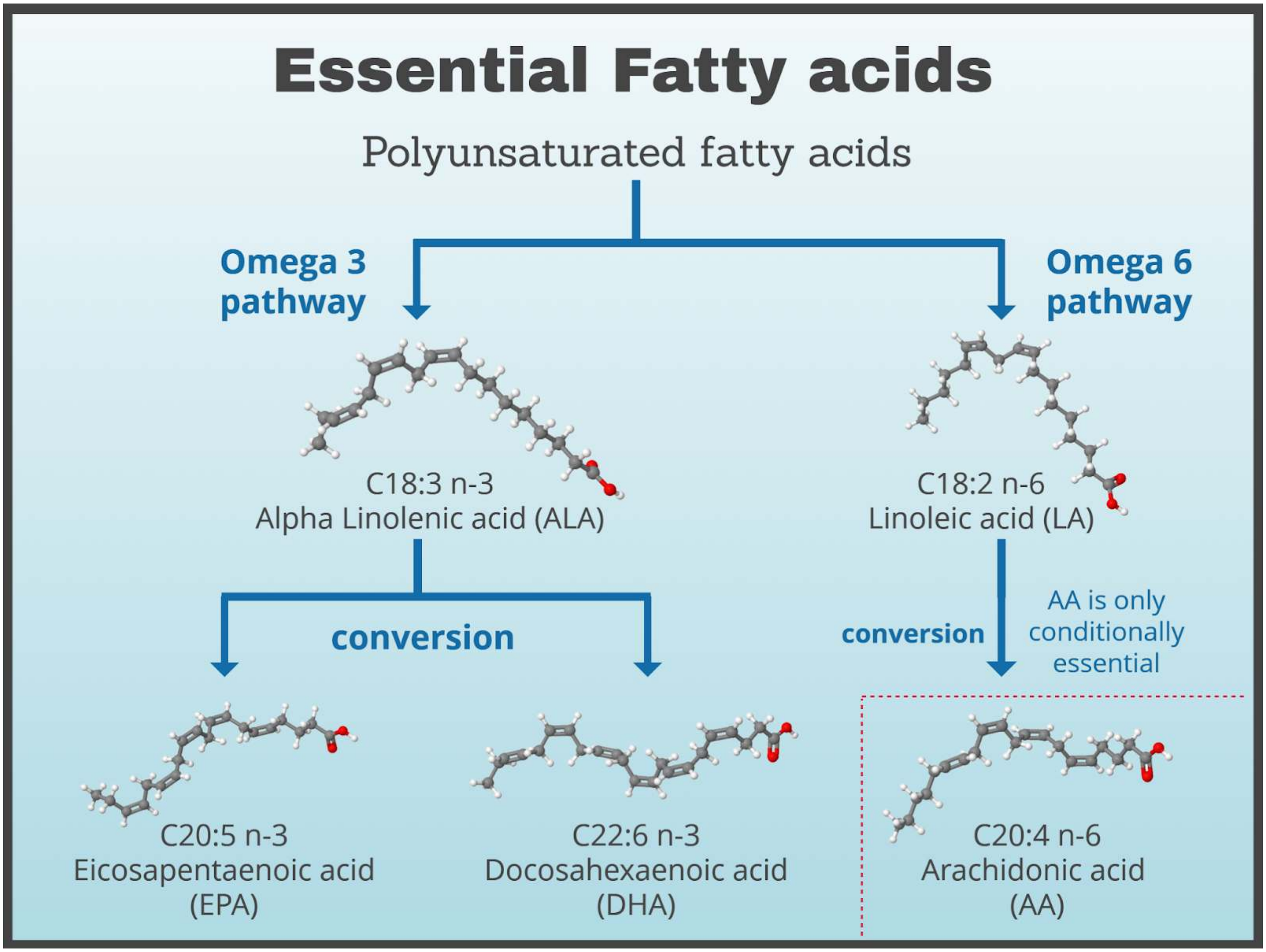
EFA´s are only required in small amounts to support optimal cardiovascular health and general wellbeing.

Omega 3 alpha-linolenic acid (ALA)

- Adult males: adequate intake is 1.6g/day
- Adult females: adequate intake is 1.1g/day
- National guidelines typically advise a combined EPA & DHA intake of at least 250mg/day
- Consume 2 portions of oily fish per week e.g. salmon, herring, mackerel, or sardines

Omega 6 linoleic acid (LA)

- Adult males: adequate intake is set at 17g/day
- Adult females: adequate intake is set at 12g/day



**Arachidonic acid becomes conditionally essential if there is a dietary lack of linoleic acid that prevents conversion.*

Functions of EFA's

Essential fatty acids (EFA´s) serve several very important functions at a cellular level in the body, primarily producing important compounds called eicosanoids. These compounds are long-chain fatty acids that have an important role in inter and intracellular communication, helping to control and modulate different cellular functions. Prostaglandins are an important category of eicosanoids that oversee vital functions in the body, such as regulating blood pressure, mediating immune response through inflammation, and regulating the menstrual cycle.

The omega 3 and omega 6 fatty acids have some functions that oppose one another and as such serve in some ways like a switch to dial-up or dial-down certain physiological processes. Especially for immune response, inflammation, blood clotting, and blood vessel dilation, the omega 3 and 6 fatty acids are antagonistic and generally promote opposing functions.

Omega 3 fatty acids **ALA, DHA, EPA**	**Omega 6 fatty acids** **LA, AA**
Form cell membranes & receptors Reduce blood clotting Regulate dilation of artery walls Reduce blood pressure Reduce inflammation Support brain health and development Promote heart and circulatory health Improve skin health Improve joint health	Regulate metabolic processes Contribute to bone health Support reproductive health Stimulate immune response & inflammation Enhance blood clotting Promote blood vessel constriction Alleviate symptoms of premenstrual syndrome (PMS)

Essential fatty acid ratios

As EFA´s modulate a range of different physiological functions this has given rise to scientific investigation regarding the right balance of EFA´s in our modern diet. Research has shown that Western nations are significantly overconsuming omega 6 fatty acids and are often deficient in omega 3 fatty acid intake. The omega 3 (**Ω**3) to omega 6 (**Ω**6) consumption ratio has been identified as approximately 1:20-50 in most Westernised nations. A review of the different types of dietary fat that are rich in omega 6 quickly confirms that the vast majority are widely used vegetable and seed oils in the home and within industrial food production e.g. sunflower, grapeseed, cottonseed, soybean, canola/rapeseed, corn, sesame, & peanut oils. Whereas dietary fats rich in omega 3 fatty acids are much less common e.g. oily fish, cod liver oil, fish oils, hemp seed, and flaxseed oils.

Evolutionary science suggests that palaeolithic man likely ate an **Ω**3:**Ω**6 ratio closer to 1:1-2. This may have been in large part due to the absence of modern industrially processed vegetable and seeds oils in the diet of early man. This significant shift in omega 6 dominant fat consumption has been proposed as one of the major dietary factors that have contributed to the rapid rise in chronic inflammatory conditions, such as, coronary heart disease, high blood pressure, diabetes, arthritis and other autoimmune conditions.

Research suggests that when modern population groups revert to an **Ω**3:**Ω**6 ratio between 1:2 and 1:5 that improvements in health outcomes result, including suppression of chronic disease, reduced inflammation, and improved cardiovascular health.

The most important step to shifting dietary intake towards the beneficial ratio would be to reduce the intake of polyunsaturated omega 6 vegetable and seed oils that are typically dominating the dietary fat intake of modern Western diets. This step alone will contribute significantly towards attaining an **Ω**3:**Ω**6 ratio closer to 1:5. It would also be beneficial to include small amounts of omega 3 fats, especially from marine sources where possible to provide important EPA and DHA. If including animal sources of omega 3 is not possible, then freshly crushed flaxseeds, hemp or chia seeds, or their fresh oils would also be beneficial in providing ALA, some of which can be converted to EPA and DHA.

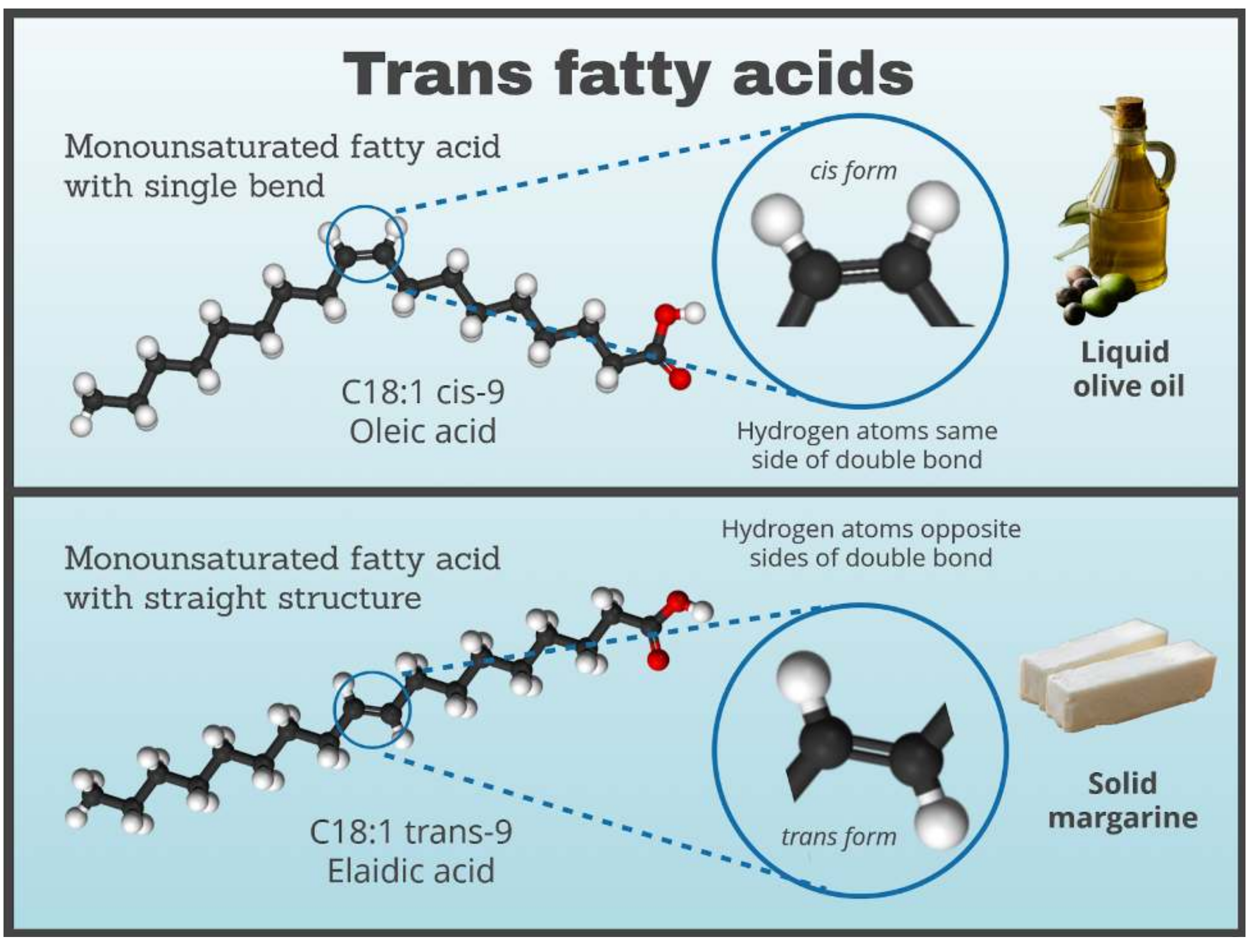
Digestion of dietary fats

The breakdown of fats begins in the mouth with chewing to mechanically break apart the food, however, there are no enzymes released in saliva that address the chemical digestion of fats. Through chewing and the action of the tongue, the food is formed into a small mass, or bolus, which is swallowed down the oesophagus and into the stomach where food may be held for up to 4 hours as it is further digested through the combined actions of the churning of the stomach, the acidic gastric juices. Once again there is no chemical digestion of fats within the stomach.

When the food exits the stomach into the small intestine it is a liquid known as chyme. In the first section of the small intestine, the duodenum, two different liquids are released into the digestive tract to manage the chemical digestion of dietary fats. The gallbladder is a small store for a compound produced by the liver, known as bile. Bile is an emulsifier that breaks the fat down into small globules so that the fats can mix more effectively with the watery chyme mixture. Pancreatic juices are also released into the tract so that chemical digestion can take place due to the presence of pancreatic lipase. The presence of these two compounds results in triglycerides that are completely broken down into their simplest form, monoglycerides, free fatty acids, and glycerol. These basic molecular units are then absorbed through the intestinal wall as the chyme passes through the length of the jejunum and ileum. The fatty acids and glycerol are absorbed into the bloodstream and the digestion of dietary fats is complete.

Trans fatty acids

A small amount of trans fatty acids occur in nature, but the vast majority of trans fatty acids in the modern Western diet are a result of industrial food manufacture. The vast majority of dietary oils are liquid at room temperature, especially mono and polyunsaturated fats. Whether a fat is solid or liquid at room temperature is dependent on its chemical shape. Straight chain saturated fats can pack tightly together and thus are firm at room temperature. Bent chain mono and polyunsaturated fats cannot pack tightly together and thus are liquid at room temperature. The more bends within the chemical structure of the oil, the lighter and less viscous the oil becomes. Dietary guidelines have recommended a shift away from hard form saturated fats over the last 5 decades, which led to the food industry applying a chemical alteration technique to convert liquid oils into solid fats to replace butter as the most commonly used dietary fat. Solid fats also have many desirable properties over liquid oils when it comes to industrial food manufacture. This alteration technique is known as hydrogenation.



Liquid oils are heated in large pressurised vats in the presence of a catalyst, whilst hydrogen gas is bubbled through the mixture. The gas interacts with the oil causing a chemical alteration to take place within the bends of the molecules changing the formation of the double bonds. This molecular change creates trans fatty acids, which straightens the bends allowing the molecules to pack tightly together when cooled. This is the basic premise behind margarine manufacture. Most margarine is partially hydrogenated to achieve a desirable balance between firmness and spreadability. If oils were fully hydrogenated the resulting product would be hard and waxy and not very useful for direct consumption or industrial purposes either. Soft spreadable margarine may typically contain between 1-17% trans fatty acids, whilst harder margarine and shortening can be as high as 35%. However, things are changing.

Since the early 1990´s there has been a sustained and strong scientific directive to significantly reduce manufactured trans fats from the diet due to strong evidence regarding their role in cardiovascular disease and heart attack. In the decades since many governments around the globe have taken action on trying to minimise the inclusion of trans fats in the food chain. At the time of writing the European Commission does not allow foods for human consumption to contain more than 2g/100g of trans fatty acids. Since 2018 the American Food and Drug Administration has banned the use of partially hydrogenated oils in food and continues to recommend that trans fatty acid consumption be as low as possible. These significant steps have led to manufacturers re-formulating margarine to remove partially hydrogenated oils and now many companies promote the fact that their margarine is free of all trans fatty acids. Trans fat consumption within US and European populations has been decreasing ever since, but it is not yet completely eradicated. Avoiding foods that include partially hydrogenated oils within their ingredients list is still highly recommended.

Cholesterol

Sterols are one of the primary categories of dietary fat, with cholesterol being the most well-known type. Decades of scientific research has created a strong connection between cholesterol and cardiovascular health that has made it very well known, even amongst the general public. Cholesterol is unlike triglyceride as it has a 4-carbon ring molecular structure and it is found only in animal-sourced foods. Even the very rich sources of dietary cholesterol, such as eggs and liver, still only contain small amounts in comparison to other dietary fats. Despite the negative reputation that has developed regarding cholesterol, its importance to human health and wellbeing cannot be overstated, it is essential to a wide range of physiological cellular functions, such as:

- New cell membrane formation - the human body replaces more than 300 billion cells per day and cholesterol is vital to strengthening the phospholipid bilayer that is part of every new cell that is replicated.
- Formation of vitamin D when its precursor under the skin, 7-dehydrocholesterol, is exposed to UVB rays from sunlight.
- Synthesis of bile acid in the liver accounts for ~ 500mg cholesterol utilised per day.
- Synthesis of important steroid hormones e.g. oestrogen, progesterone, testosterone, cortisol, & aldosterone.

Food (100g)	Total fat (g)	Saturated fat (g)	Cholesterol (mg)
Chicken egg yolk	26.5 g	9.6 g	1234 mg
Turkey egg, whole	11.9 g	3.6 g	933 mg
Duck egg, whole	13.9 g	3.7 g	884 mg
Caviar	17.9 g	4.1 g	588 mg
Lamb´s kidneys	3.6 g	1.2 g	565 mg
Chicken´s liver	6.4 g	2.0 g	564 mg
Lamb's liver	8.8 g	3.4 g	501 mg
Whole fried egg	15.3 g	4.3 g	457 mg

Lipoproteins

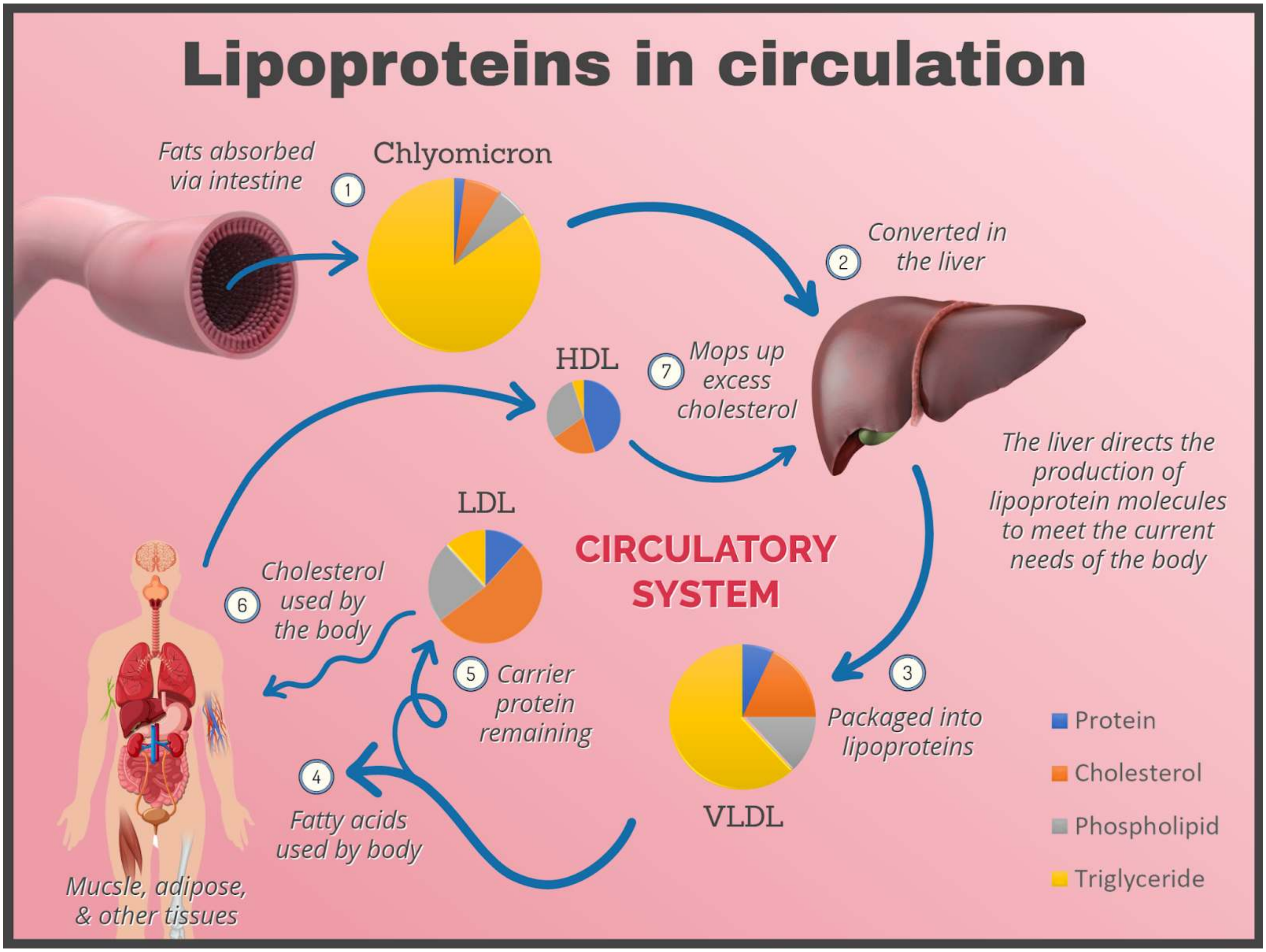
Cholesterol molecules are not transported around the bloodstream on their own, neither are triglycerides. Blood is composed largely of plasma, which is a watery medium. Fats are hydrophobic, meaning they do not mix easily with water, therefore, fats could not be transported in isolation in the blood without significantly clogging the system. The body has developed a series of protein transport molecules for carrying fats/lipids through the blood, these carrier molecules are known as lipoproteins. Lipoproteins are water-soluble and provide a perfect solution to transporting fats through the circulatory system. There are several different types of lipoproteins identified by the size of the various molecules and by the type of fats they are carrying at any given point in time.

- Chylomicrons
- Very low-density lipoproteins (VLDL)
- Low-density lipoproteins (LDL)
- High-density lipoproteins (HDL)

Each lipoprotein plays a specific role in transporting triglycerides and cholesterol around the body through the circulatory system. Following successful digestion, triglycerides are bound up into molecules called chylomicrons. These are the largest of the lipoprotein carriers and they are composed primarily of large amounts of triglyceride contained within a small protein and phospholipid shell. The chylomicrons are transported through the circulatory system to the liver. The liver is a very important organ as it manages and directs the formation and cleanup of lipoprotein molecules throughout the body. The chylomicrons are repackaged into a slightly smaller molecule known as a very-low-density lipoprotein (VLDL), containing triglycerides and cholesterol, which then enters circulation. The VLDL molecules deliver triglycerides to the cells of the body as required, such as muscle or adipose tissue and other important organs where they will either be stored or utilised for energy production.

Once triglycerides are offloaded, the remaining molecule is smaller with a larger percentage of cholesterol forming its contents. This cholesterol packed molecule is known as low-density lipoprotein (LDL). Cholesterol is a vital component of the body with many different functions. LDL molecules travel through the circulation delivering cholesterol to the cells of the body as required to meet the unique and specific functions that cholesterol is involved with. Because cholesterol is such an important molecule the body also has a system for cleaning up excess cholesterol and returning it to the liver for recycling as bile acids or other purposes. Some excess cholesterol may be excreted. The liver produces a small dense molecule, known as high-density lipoprotein (HDL), that is sent out into circulation where it essentially ‘mops up’ any excess cholesterol not being used by the tissues, returning it to the liver once again.

The diagram shows the basic flow of triglycerides and cholesterol through the circulation employing various lipoprotein carriers.



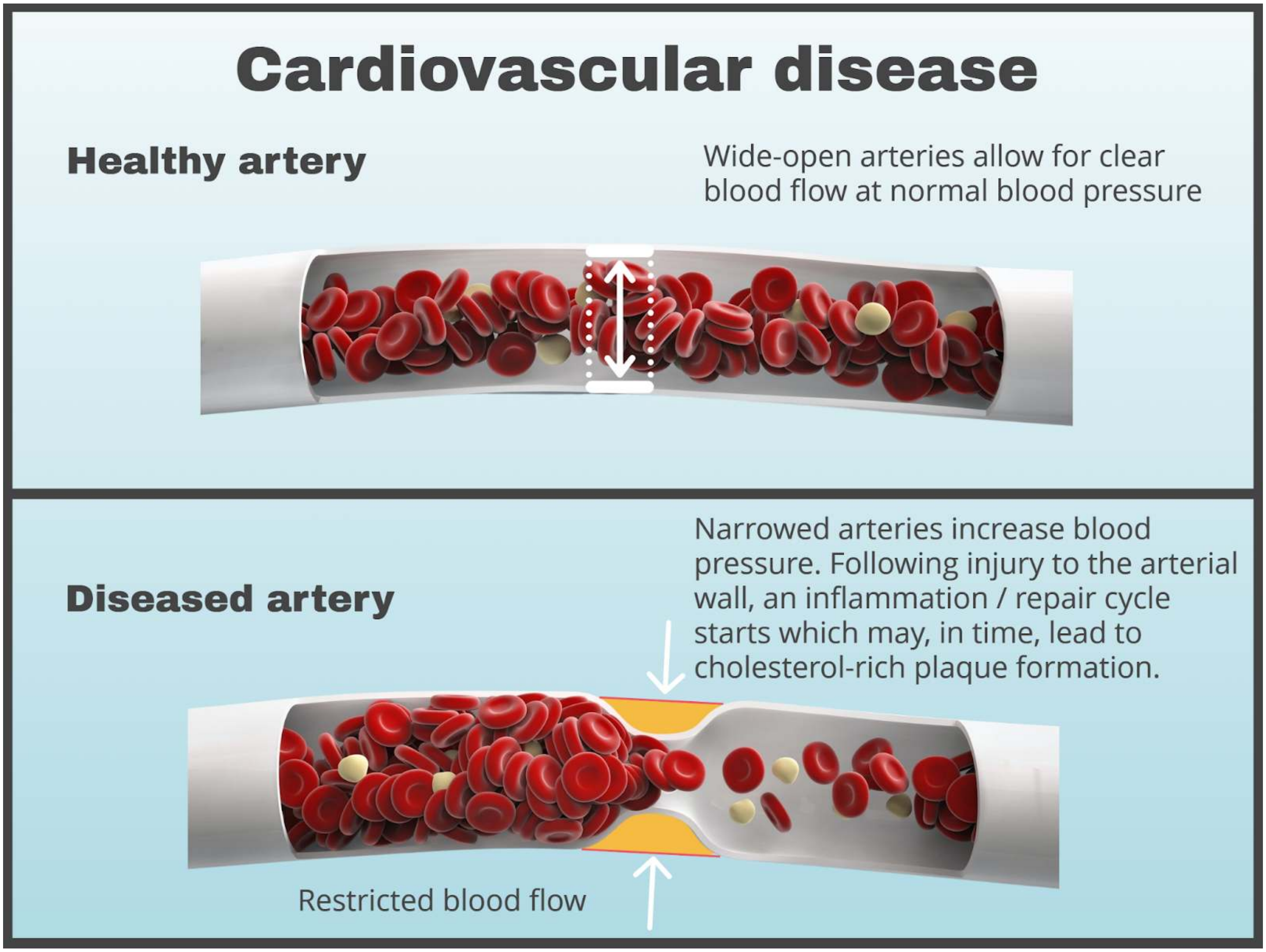
Cholesterol and heart health

The majority (up to 70%) of cholesterol transported around the body is delivered using LDL particles. The cells of the body will only accept cholesterol until their specific needs are met and then their LDL receptors no longer respond to LDL passing through systemic circulation. This can lead to a build-up of circulating LDL, especially if the amount being deposited into the bloodstream is more than the volume that HDL can remove and return to the liver. Elevated levels of LDL (‘bad’ cholesterol) with simultaneous low levels of HDL (‘good’ cholesterol) have been strongly associated with increased levels of cardiovascular disease. Alongside several modifiable risk factors, this can lead to an increased risk of a heart attack. The risk factors that are associated with an increased risk of cardiovascular disease are oultined in the following table.

Modifiable risk factors	Non-modifiable risk factors
• Diagnosed with diabetes mellitus • Elevated blood cholesterol • Excess body fat • Elevated blood pressure • Sedentary lifestyle • Smoking • Unhealthy diet	• Family history of CVD under 60 yrs • Older age • Male • Ethnicity or race e.g. African American, Mexican, Asian Indian, Chinese, or Filipino

For many years this evidence led to dietary restriction guidelines that advocated low cholesterol intakes below 300 mg per day. In more recent years, dietary restriction of cholesterol has been removed from most national guidelines as the amount of cholesterol consumed in the diet has been found to have very little impact on the amount of circulating cholesterol in the body. It has been known for many years that the vast majority of LDL cholesterol in circulation is produced by the liver through VLDL production and then the resulting conversion to LDL. Therefore, the diet-heart hypothesis has evolved to focus on the dietary components that stimulate the liver to produce more cholesterol.

Scientific evidence indicates that saturated and trans fatty acids are two of the major dietary components that stimulate the liver and contribute to elevated LDL cholesterol levels. Saturated fats increase both LDL and HDL levels in the blood, whereas trans fatty acids have been shown to increase LDL and decrease HDL levels. This dual-action of saturated fat to influence both the 'good' HDL and the 'bad' LDL cholesterol carriers, has led some scientists and researchers to state that saturated fats are neutral with regards to their impact on cardiovascular disease. As trans fatty acids have a clear-cut, negative impact on both cholesterol markers there is no doubt that this industrially manufactured form of fatty acid should be avoided as much as possible. Consuming sufficient daily fibre, especially double fibre, amounting to at least 25 grams per day has also been shown to help lower LDL without having any negative impact on HDL. Engaging in regular physical activity has also been shown to influence lipoprotein profiles positively in conjunction with the other beneficial effects that exercise has on heart and circulatory health overall.



Cholesterol numbers

The following chart outlines the meaningful numbers to be able to understand a full blood cholesterol analysis. Typical cholesterol testing is performed following an extended fast without food for 8-12 hours to allow blood lipids to normalise without the influence of meals and active digestion. There is no single figure that indicates a good or bad cardiovascular profile. Careful analysis and review of all cholesterol and triglyceride numbers will be used by a qualified doctor to determine cardiovascular health risk.

Important note: A nutrition coach **should not** professionally assess or diagnose cardiovascular risk.

Total cholesterol mmol/L	Total cholesterol mg/dL	Classification
< 5.2	< 200	Desirable
5.2 - 6.2	200 - 239	Increased risk
≥ 6.2	≥ 240	High
LDL cholesterol mmol/L	**LDL cholesterol mg/dL**	**Classification**
< 2.6	< 100	Desirable
2.6 - 4.1	100 - 159	Increased risk
≥ 4.1	≥ 160	High
HDL cholesterol mmol/L	**HDL cholesterol mg/dL**	**Classification**
< 1.0 males, < 1.3 females	<40 males, <50 females	Low
≥ 1.0 males, ≥ 1.3 females	≥ 40 males, ≥ 50 females	Desirable
Triglycerides mmol/L	**Triglycerides mg/dL**	**Classification**
< 1.7	< 150	Desirable
1.7 - 2.3	150 - 199	Increased risk
≥ 2.3	≥ 200	High

Dietary fat consumption recommendations

General population dietary fat guidelines

- Total fat consumption should not exceed 30% of total calorie intake.
    - Females total 2000 kcal/day: consume < 600 kcal fats/day
    - Males total 2500 kcal/day: consume < 750 kcal fats/day
- Saturated fat consumption should not exceed 10% of total calorie intake.
    - Females total 2000 kcal/day: consume 200 kcal sat fat/day
    - Males total 2500 kcal/day: consume 250 kcal sat fat/day

- Trans fatty acid intake should be avoided as much as possible.
- Foods and oils rich in monounsaturated fats are preferred for maintaining heart health.
- Foods and oils rich in polyunsaturated fats may be consumed in smaller amounts, but care should be taken regarding total calorie intake.
- Essential fatty acids should be consumed in small amounts and have a **Ω**3:**Ω**6 ratio of 1:2 - 1.5.

Activity/exercise dietary fat recommendations

- Maintenance of energy balance, replenishment of intramuscular triglyceride stores and adequate consumption of essential fatty acids are important for athletes
- It is generally recommended that active individuals and athletes consume approximately 30% of calories from healthy fats
- During regular, high volume, endurance training dietary fat intake can safely be increased up to a maximum of 50% of calories
- During active weight management for athletes or intermediate-advanced regular exercisers, dietary fat consumption between 0.5 - 1.0 g/kg/day
    - 65 kg female: consume 32.5 g (293 kcal) - 65 g (585 kcal) fat per day
    - 85 kg male: consume 42.5 g (383 kcal) - 85 g (765 kcal) fat per day

Other dietary fat recommendations

- Dietary fats are best eaten as part of healthy whole foods in preference to isolated and extracted oils e.g. whole avocado instead of avocado oil, whole salmon instead of fish oils etc.
- Reduce consumption of industrially separated and extracted vegetable/seed oils, especially those high in omega 6 fatty acids e.g. canola, rapeseed, soy, grapeseed, sunflower, corn, & sesame oils

Key learning points: Chapter 2 macronutrients

Carbohydrates

- Atwater factors: Carbohydrates & Proteins 4 kcal/g, Fats 9 kcal/g, Alcohol 7 kcal/g
- Simple carbohydrates:

- Monosaccharides: glucose, fructose, & galactose
- Disaccharides: sucrose, maltose, & lactose

- The sweetness of food is a strong biopsychological factor that influences food consumption behaviour in childhood and adolescence which diminishes somewhat during adulthood.
- Complex carbohydrates:

- Starches: oligo and polysaccharides
- Fibre:

- Soluble: pectins, gums, & mucilages
- Insoluble: cellulose & lignin

- The primary purpose of carbohydrates is to be used for cellular energy production.
- Carbohydrates increase blood glucose which stimulates an insulin response to direct glucose into cells for use or storage as glycogen or fat.
- The potential impact of carbohydrate foods on blood glucose levels can be determined by using the glycaemic index or glycaemic load as a guide.
- Be aware of the carbohydrate consumption recommendations for the general population and active individuals/athletes.

Proteins

- Proteins are composed of amino acid building blocks
- 8 amino acids are considered essential to the diet, with 7 considered conditionally essential, and 5 considered non-essential.

- Proteins provide a wide range of functions, including; structural, contractile, circulatory, hormonal, immunological, catalytic, fluid balance, & energetic.
- Protein-rich foods are prevalent from both animal and plant sources. Animal sourced foods are generally considered complete and provide an abundance of all 8 essential amino acids.
- Plant sources of protein-rich foods are generally considered incomplete as they often have at least 1 or more limiting essential amino acids. It is possible to compensate for limiting amino acids by carefully combining two plant protein food sources that help to complement the essential amino acids.
- Be aware of how to provide sufficient daily amino acids by managing protein serving sizes and balancing carefully against daily caloric needs.
- Be aware of the protein consumption recommendations for the general population and active individuals/athletes. Know how to calculate protein needs based on body weight.

Dietary fats

- Dietary fats are composed of triglycerides and sterols (cholesterol).
- Categories of fat are defined by the dominant type of fatty acid chain e.g. saturated, monounsaturated, or polyunsaturated. Fats can also be identified based on the fatty acid chain length and the presence of double bonds, which form bends, in the molecule.
- Fats have a range of important functions including cell membrane formation, nerve cell insulation, formation of steroid hormones, cellular energy, protection of organs, & providing shape to the body.
- All naturally occurring dietary fats contain a varied range of fatty acids, with the dominant category, present defining the overall type e.g. Olive oil contains 15% saturated, 73% monounsaturated, & 10% polyunsaturated fatty acids which categorises it as a dominant monounsaturated source of fat. Learn the food sources for each type of fat.
- Essential fatty acids (EFA) are all polyunsaturated oils. EFA's have 2 categories, omega 3 and omega 6 fats. EFA's are essential to the diet because the body cannot synthesize them. Western diets provide an excess of omega 6 dietary fats and a lack of omega 3 fats. EFA's should be consumed in an **Ω**3:**Ω**6 ratio of 1:2 - 1:5.

- Trans fatty acids have a straight-chain structure but still contain at least 1 carbon double bond. Most trans fatty acids are industrially produced through the manufacture of partially hydrogenated oils. Trans fats should be avoided as scientific evidence strongly links these with cardiovascular disease.

- Cholesterol is a waxy fatty compound produced primarily by the liver. Dietary cholesterol has little impact on circulating blood cholesterol. Saturated fat and trans fat consumption stimulate an increase in cholesterol formation within the blood.
- Lipoproteins carriers allow for fats to be soluble and transportable in the blood. Low-density lipoproteins (LDL) carry the most cholesterol and are considered an important marker for cardiovascular disease. High-density lipoproteins (HDL) are beneficial carriers that help to clear cholesterol out of circulation.
- Important cholesterol numbers are:

- Total cholesterol <5.2 mmol/L (<200 mg/dL)
- LDL <2.6 mmol/L (<100 mg/dL)
- HDL males >1.0 mmol/L (>40 mg/dL)
- HDL females >1.3 mmol/L (>50 mg/dL)

Chapter 3: Micronutrients & Hydration

The term micronutrients refer to the nutrients that do not provide energy to the cells of the body but are required in very small amounts to sustain health and wellbeing. Micronutrients can generally be separated into 3 categories:

1. Vitamins
2. Minerals
3. Phytochemicals

First a quick word on phytochemicals. These are a range of widely available plant compounds that are beneficial to human health, such as carotenoids, and polyphenols. Consuming a wide variety of brightly coloured plant produce will provide a plentiful supply and benefit health. Unfortunately, further discussion is beyond the scope and primary purpose of this text.

Vitamins

The first vitamin was discovered back in 1912 by a Polish chemist called Casimir Funk, who discovered the nutrient currently known as thiamine (vitamin B1) when analysing the chemical content of rice bran. Funk coined the term 'vita-amine' which means a nitrogen-containing compound vital for life. In the years that followed similar micronutrients were discovered and the name was adapted to become 'vitamin' when it was realised that not all of these nutritional compounds could be correctly categorised as amine. A vitamin is a complex organic compound that helps to regulate important metabolic processes within the cells and tissues of the body.

Cellular enzymes (biological catalysts) can be uni or bi-directional, and some enzymes are inducible, which means they are 'switched on' because a certain reactant is present. Vitamins are often necessary for a certain enzyme to work effectively, and are therefore known as cofactors or coenzymes. Vitamins aid in the continuation of cellular reactions necessary for healthy metabolic processes to occur.

The following list of characteristics are relevant to vitamins:

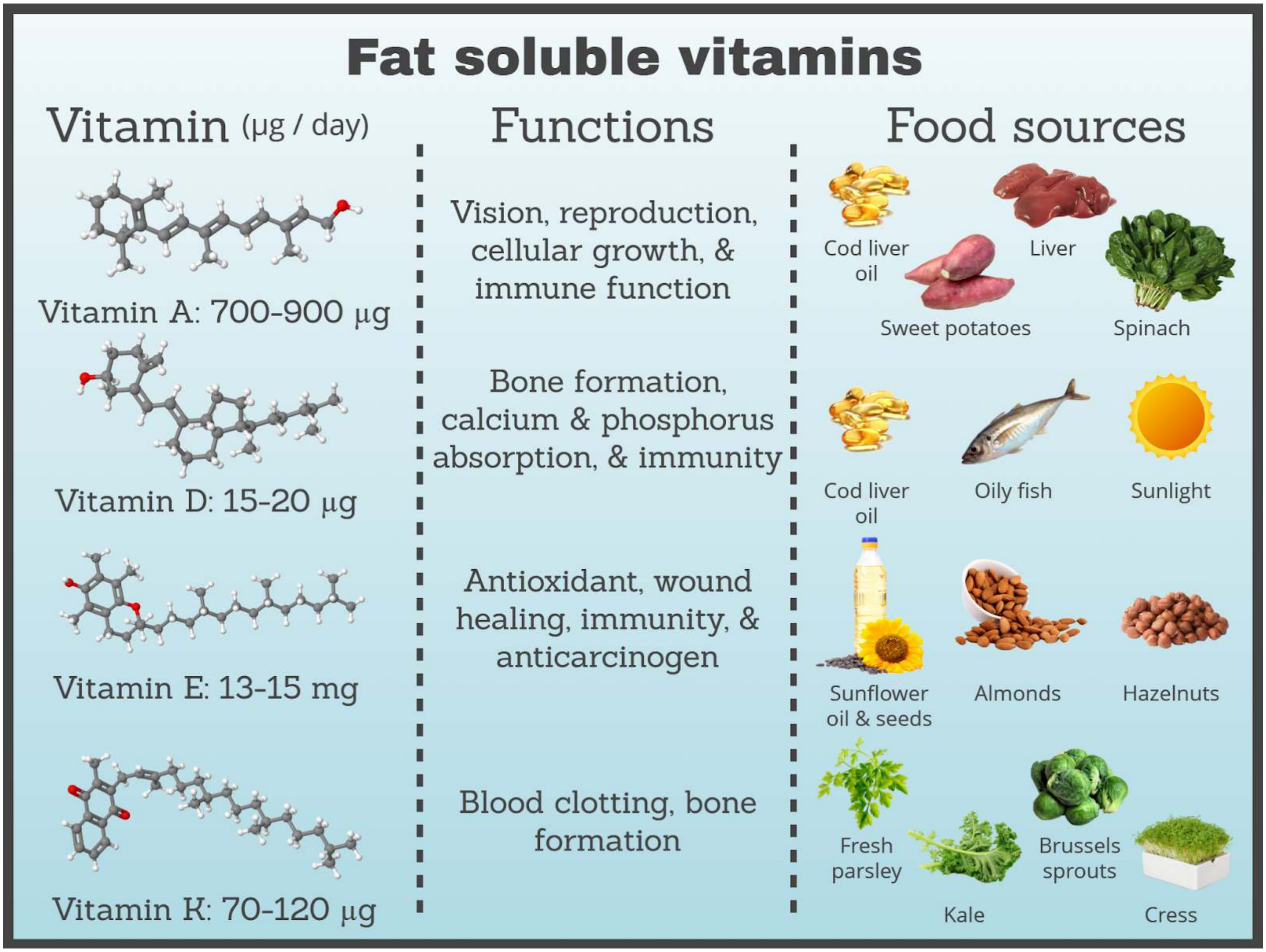
- Vitamins are essential nutrients that must be included in the diet because either the body cannot synthesize them, or if it does synthesize them it cannot make enough to maintain good health.
- Vitamins are present in a wide range of commonly eaten foods.
- Deficiency symptoms result when a vitamin is consistently excluded from the diet.
- Health is restored if a deficient vitamin is added back into the diet.

Since 1912 a total of 13 vitamins and some vitamin-like compounds have been discovered and are deemed essential for human health. These vitamins are categorised into 3 major classifications; fat-soluble vitamins, water-soluble vitamins, and vitamin-like compounds.

Fat-soluble vitamins	Water-soluble vitamins	Vitamin-like compounds
Vitamin A Vitamin D Vitamin E Vitamin K	Thiamine (B1) Riboflavin (B2) Niacin (B3) Pantothenic acid (B5) Pyridoxine (B6) Biotin (B7) Folate (B9) Cobalamin (B12) Vitamin C	Choline Inositol

Fat-soluble vitamins

Fat-soluble vitamins will only be present in foods containing fat where they are successfully stored and available for consumption, digestion and absorption. The chemical structure of fat-soluble vitamins has similarities with the structure of dietary fats which makes them compatible compounds and allows for solubility. The capacity to store fat-soluble vitamins makes it possible to over-consume these nutrients and potentially cause a toxic effect. It is widely accepted that excess quantities do not enhance cellular function. Consider the analogy of filling a glass. An excess amount will spill over. Fat-soluble vitamins should be consumed within an ideal range.



Vitamin A

Vitamin A is also known as retinol. It has several important functions within the body including supporting the immune system, helping to protect the body against cardiovascular disease and cancer, healthy reproduction, and it is also needed for the maintenance of healthy, vibrant skin. Historically, retinol is most well-known for supporting healthy functioning of the eyes and preventing a deficiency disorder known as night blindness. A similar compound, known as beta-carotene, is usually combined with vitamin A data shown on food labels. This makes it impossible to know from a food label how much preformed vitamin A and beta-carotene are present in a food product as it will only display the combined amount on the label. This is allowed because beta-carotene can be converted into the fully active form of vitamin A or retinol.

Beta-carotene comes from a family of compounds known as the carotenoids which also include lutein, zeaxanthin, alpha-carotene, and lycopene as the most well-known and researched carotenoids. These other carotenoids also help protect against cardiovascular disease, strengthen the immune system, and support healthy eye function amongst other things.

Effects on exercise performance: no research studies indicate that vitamin A supplementation provides any performance benefit.

The table below shows the top 6 vitamin A food sources, 3 retinol and 3 beta-carotene sources.

Vitamin A requirements for adults 18+ years old: **700 - 900 µg/day**

Vitamin A-rich food source	Calories / 100g	Vitamin A / 100g
Cod liver oil *(retinol)*	902 kcal	30004 µg
Beef liver *(retinol)*	191 kcal	9515 µg
Pork liver *(retinol)*	134 kcal	6494 µg
Sweet potatoes *(beta-carotene)*	92 kcal	5765 µg
Carrots *(beta-carotene)*	35 kcal	5110 µg
Spinach *(beta-carotene)*	34 kcal	3618 µg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin A and beta-carotene are eggs, dairy products, pumpkin, kale, kohlrabi, Romaine lettuce, parsley, papaya, apricots, and cantaloupe.

Vitamin D

Whilst vitamin D is a nutrient that is present in small amounts in certain foods, scientists believe that it is not a true vitamin for two reasons; firstly, the vast majority of vitamin D is formed through exposure to sunlight, and secondly, it's active form has hormone-like effects in the body.

Vitamin D helps to protect the body against weak bones, several forms of cancer, diabetes mellitus, and cardiovascular disease. Vitamin D is also necessary for effective muscle function and sustaining mental health and wellbeing. The classic vitamin D deficiency disease is rickets.

Vitamin D is present in two forms; vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Approximately 90% of all active vitamin D3, the active form, is produced as a result of sun exposure on the skin. Exposure to the rays of the sun (UVB wavelength) generates vitamin D through the conversion of a naturally occurring precursor under the skin called 7-dehydrocholesterol (7-DHC). This is converted into pre-vitamin D3, which is then rearranged into the active form of vitamin D3. How much vitamin D is produced when the skin is exposed to sunlight depends upon a range of environmental and other factors, including

- Time of day - the higher or lower the sun is in the sky.
- Season of the year - the change in angle of sunlight as a result of the change in the tilt of the earth across the year.
- Geographical latitude - northern or southern latitudes increase the distance for sunlight to pass through the atmosphere, whereas equatorial latitudes reduce the distance.
- Altitude - the distance above sea level affects the intensity of the sun's rays.
- Length of sunlight exposure - more sunlight on the skin stimulates more conversion.
- Skin exposed to the sun - total surface area of skin receiving sunlight.
- The colour or pigmentation of the skin - melanin (dark pigment) in the skin reduces UVB rays that pass through to cause vitamin D conversion.

When less UVB sunlight is available for conversion of 7-DHC to vitamin D3, such as during winter, located in northern or southern latitudes, or due to darker skin pigmentation, then reliance on dietary sources for adequate vitamin D becomes a greater priority. There are 6 recognised skin types with the darker pigmentation, types 5 & 6, requiring 3-6 times more sun exposure to achieve the same relative vitamin D conversion. This also makes their reliance on dietary sources even more important.

Effects on exercise performance: no research studies indicate that vitamin D supplementation provides any performance benefit. However, in athletes/exercises who are susceptible to weak bone tissue (osteoporosis), vitamin D combined with calcium supplementation may prevent further bone loss.

The top 6 dietary sources of vitamin D all come from seafood sources, as shown in the table.

Vitamin D requirements for adults 18+ years old: **15 - 20 µg/day**

Vitamin D-rich food source	Calories / 100g	Vitamin D / 100g
Cod liver oil	902 kcal	250 µg
Wild herring	158 kcal	41 µg
Canned salmon	166 kcal	19 µg
Wild halibut	186 kcal	15 µg
Canned sardines	186 kcal	12 µg
Wild mackerel	205 kcal	9 µg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin D are sea bass, swordfish, tuna, sardines, cod, and fortified dairy products.

Vitamin E

Vitamin E is composed of several different compounds, including alpha, beta, delta, and gamma-tocopherol. However, the vast amount of available scientific research has been performed using the alpha-tocopherol variation, which is the most common. Vitamin E is well known for its powerful antioxidant properties that help to reduce the ageing process and extend the life of cells, thus improving overall tissue and organ health. Vitamin E has also been shown to benefit wound healing and reduce scar formation. It has been shown to boost disease resistance, serve as an anticarcinogen, and strengthen the immune system. Vitamin E deficiency may result from fat malabsorption with symptoms including loss of neurological control, blindness, and poor immune function.

Effects on exercise performance: numerous studies have shown that vitamin E supplementation can help reduce exercise-induced oxidative stress and therefore may aid in exercise recovery.

The top 6 dietary sources of vitamin E come from oils, nuts and seeds, as shown in the table.

Vitamin E requirements for adults 18+ years old: **13 - 15 mg/day**

Vitamin E-rich food source	Calories / 100g	Vitamin E / 100g
Wheat germ oil	884 kcal	149 mg
Sunflower oil	884 kcal	41 mg
Almond oil	884 kcal	39 mg
Sunflower seeds	592 kcal	36 mg
Whole almonds	575 kcal	26 mg
Flaxseed oil	884 kcal	17 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin E are corn, olive, and soybean oil, peanuts, sardines, nuts, legumes, and dark green leafy vegetables

Vitamin K

Vitamin K is available in the diet from a range of sources but it is also produced by the gut microflora that ferments fibre within the large intestine and in so doing helps produce certain nutrients, including vitamin K and biotin, which are then absorbed into the bloodstream. This beneficial pairing between humans and bacteria is known as a symbiotic relationship. The major role of vitamin K is in helping to produce a substance called prothrombin which is an important coagulation factor that helps to bring about blood clotting. Vitamin K is also a beneficial factor, alongside vitamin D, calcium and phosphorus, in the formation of strong bones. Vitamin K has two dietary forms; vitamin K1 (phylloquinone) only found in plants, and vitamin K2 (menaquinone) only produced by gut bacteria. Both forms are beneficial to the body. Whilst rare, vitamin K deficiency symptoms include an increased time for blood clotting to occur.

Effects on exercise performance: in elite female athletes, vitamin K supplementation has been shown to increase indicators of bone remodelling and may aid in strengthening bone tissue.

The top 6 dietary sources of vitamin K come from green vegetables, as shown in the table.

Vitamin K requirements for adults 18+ years old: **70 - 120 µg/day**

Vitamin K-rich food source	Calories / 100g	Vitamin K / 100g
Fresh parsley	36 kcal	1640 µg
Swiss chard	19 kcal	830 µg
Kale	28 kcal	817 µg
Cress	32 kcal	532 µg
Spinach	23 kcal	483 µg
Watercress	11 kcal	250 µg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin K are turnip greens, broccoli, green cabbage, green beans, tomatoes, liver, and free-range egg yolks.

Water-soluble vitamins

Water-soluble vitamins consumed in food are readily digested, absorbed, and transported around the body in the blood and cellular fluids, but this means they are also subject to liver and kidney filtration and can be easily excreted from the body. Therefore, it is unlikely toxicity will occur, but more likely that a shortfall can occur if the daily diet is deficient in a specific water-soluble vitamin.

Vitamin B1: Thiamin

Thiamin was the first vitamin to be discovered in 1912. It forms part of the vitamin B complex family of nutrients. The B vitamins play an essential role in the metabolism of carbohydrates. The brain and the nervous system are the first to show signs of thiamine deficiency because they rely so heavily on carbohydrates as their primary fuel source. The deficiency disease for thiamin is called beriberi.

Effects on exercise performance: no research studies indicate that vitamin B1 intake at normal dietary levels provides any performance benefit.

The top 6 dietary sources of vitamin B1 come from nuts and seeds, as shown in the table.

Vitamin B1 requirements for adults 18+ years old: **1.1 - 1.3 mg/day**

Thiamin-rich food source	Calories / 100g	Thiamin / 100g
Yeast extract spread	158 kcal	9.7 mg
Spirulina seaweed	290 kcal	2.4 mg
Flaxseeds	534 kcal	1.6 mg
Tahini	592 kcal	1.6 mg
Sunflower seeds	584 kcal	1.5 mg
Pine nuts	629 kcal	1.2 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin B1 are organs meats (liver), ham, green peas, soybeans, peanuts, brown rice, baked beans, egg yolks, poultry, and tuna fish.

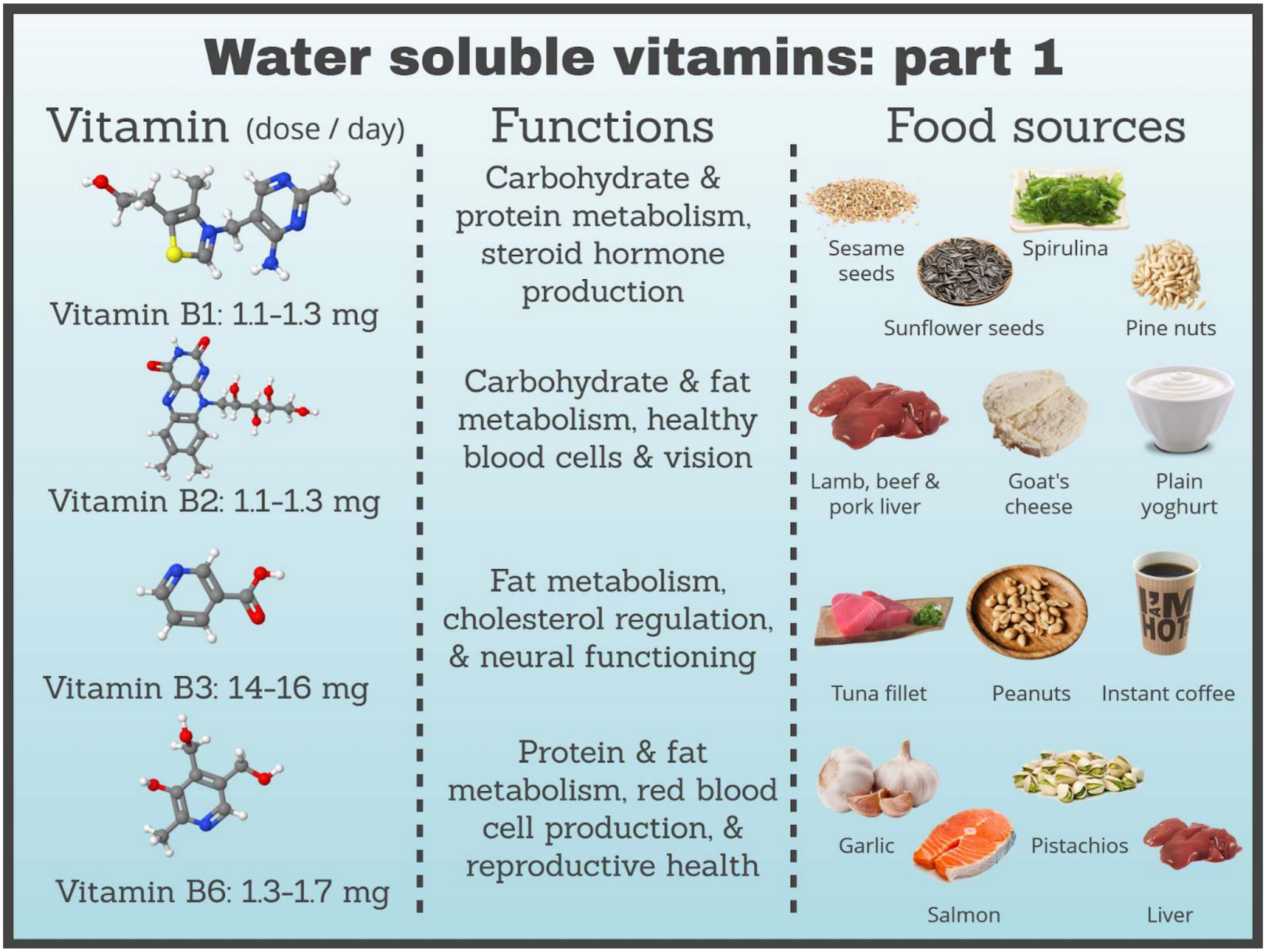
Vitamin B2: Riboflavin

Riboflavin was first discovered in 1935 and plays an important role in the oxidation and metabolism of all the macronutrients, especially in the provision of energy for physical activity. It is necessary for the regulation of thyroid hormone and is involved in tissue repair following damage or injury, and the formation of healthy iron-rich red blood cells. Riboflavin helps the eyes adapt to different intensities of light, and one of the symptoms of deficiency is the development of light sensitivity. Deficiency of vitamin B2 causes early symptoms of dry cracked mouth and a purple inflamed tongue.

The top 6 dietary sources of vitamin B2 come from organ meats, sea vegetables, and dairy, as shown in the table. Vitamin B2 requirements for adults 18+ years old: **1.1 - 1.3 mg/day**

Riboflavin-rich food source	Calories / 100g	Riboflavin / 100g
Yeast extract spread	158 kcal	14.3 mg
Lamb's liver	238 kcal	4.6 mg
Spirulina seaweed	290 kcal	3.7 mg
Beef & pork liver	134 - 191 kcal	3.0 mg
Beef kidneys	158 kcal	3.0 mg
Goat's cheese	452 kcal	1.2 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin B2 are venison, cheese, yoghurt, goat's milk, eggs, poultry, fish, beans, spinach, avocados, asparagus, broccoli, and Brussels sprouts.



Effects on exercise performance: no research studies indicate that vitamin B2 intake at normal dietary levels provides any performance benefit.

Vitamin B3: Niacin

Vitamin B3 comes in two different forms, niacin and niacinamide. Niacin is an important coenzyme in many important biochemical functions, especially in maintaining healthy skin, the health of the digestive tract and the nervous system. Niacin is also involved in the regulation of dietary fats, including cholesterol and lipoproteins.

The classic deficiency disease related to vitamin B3 is called pellagra, characterised by dermatitis, diarrhoea, and dementia.

Effects on exercise performance: supplementation of vitamin B3 may negatively impact performance by blunting the use of fatty acids for fuel.

The top 6 dietary sources of vitamin B3 come from a range of sources, as shown in the table.

Vitamin B3 requirements for adults 18+ years old: **14 - 16 mg/day**

Niacin-rich food source	Calories / 100g	Niacin / 100g
Yeast extract spread	158 kcal	97 mg
Instant coffee	241 kcal	28.2 mg
Salmon fillet with skin	345 kcal	22.8 mg
Tuna fillet	132 kcal	18.8 mg
Beef liver	191 kcal	17.5 mg
Peanut butter	650 kcal	16.4 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin B3 are beef, pork, poultry, milk, cheese, whole wheat, corn, eggs, broccoli, tomatoes, mushrooms, and carrots.

Vitamin B6: Pyridoxine

Pyridoxine is one of the most widely utilised vitamins in the human body contributing as a coenzyme in numerous reactions involved with amino acid and essential fatty acid metabolism. It is an essential nutrient for supporting physical growth and the maintenance and repair of the structures of the body. Pyridoxine helps to facilitate the use of iron in haemoglobin as well as the formation of red blood cells, both of which are essential to the transportation of oxygen around the body. It also plays an important role in female reproductive health and fertility, helping to ease symptoms of premenstrual syndrome, and may ease morning sickness during pregnancy. Pyridoxine requirements increase 3-fold during pregnancy and lactation. Symptoms of vitamin B6 deficiency include dermatitis, anaemia, depression, and confusion.

Effects on exercise performance: research studies indicate that in athletes receiving sufficient dietary vitamin B6, supplementation did not provide any physiological performance benefit.

The top 6 dietary sources of vitamin B6 come from a range of sources, as shown in the table.

Vitamin B6 requirements for adults 18+ years old: **1.3 - 1.7 mg/day**

Pyridoxine-rich food source	Calories / 100g	Pyridoxine / 100g
Garlic powder	332 kcal	2.9 mg
Pistachio nuts	557 kcal	1.7 mg
Sunflower seeds	584 kcal	1.3 mg
Yeast extract spread	158 kcal	1.3 mg
Fresh garlic	149 kcal	1.2 mg
Tuna fillet	132 kcal	1.0 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin B6 are eggs, meat, chicken, herring, salmon, cod, walnuts, potatoes, spinach, broccoli, sweet red peppers, avocados, carrots, peas, bananas, and cantaloupe.

Vitamin B12: Cobalamin

The presence of cobalamin was first discovered in 1926, but the nutrient was not isolated until nearly 2 decades later. It is involved in several very important functions, including the successful formation of red blood cells in the bone marrow, the metabolism of a substance called homocysteine that is linked to cardiovascular disease, and also the production of the insulating myelin sheath that protects the long nerve cells. Vitamin B12 is only truly available from animal-sourced foods and is not present in plant foods in a bioavailable form for humans. Bacteria, fungi and algae are exceptions and can synthesize B12. The classic deficiency disease for vitamin B12 is called pernicious anaemia and its symptoms include weight loss, pale skin, weakness, and mental disturbance. This deficiency is a little more common than many of the others and typically appears in alcoholics, the elderly, and occasionally in strict vegetarians and vegans who have not been supplementing their diet with B12.

Effects on exercise performance: research studies indicate that in athletes receiving sufficient dietary vitamin B12, supplementation did not provide any physiological performance benefit.

The top 6 dietary sources of vitamin B12 come only from seafood and organ meats, as shown in the table.

Vitamin B12 requirements for adults 18+ years old: **1.4 - 2.4 µg/day**

Cobalamin-rich food source	Calories / 100g	Cobalamin / 100g
Clams	148 kcal	98.9 µg
Lamb's liver	238 kcal	85.7 µg
Beef liver	191 kcal	70.6 µg
Duck liver	136 kcal	54.0 µg
Oysters	137 kcal	35.0 µg
Beef kidneys	158 kcal	24.9 µg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin B12 are beef, venison, herring, mackerel, salmon, sardines, crab meat, scallops, shrimp, egg yolk, milk, cheese, and cottage cheese.

Vitamin B7: Biotin

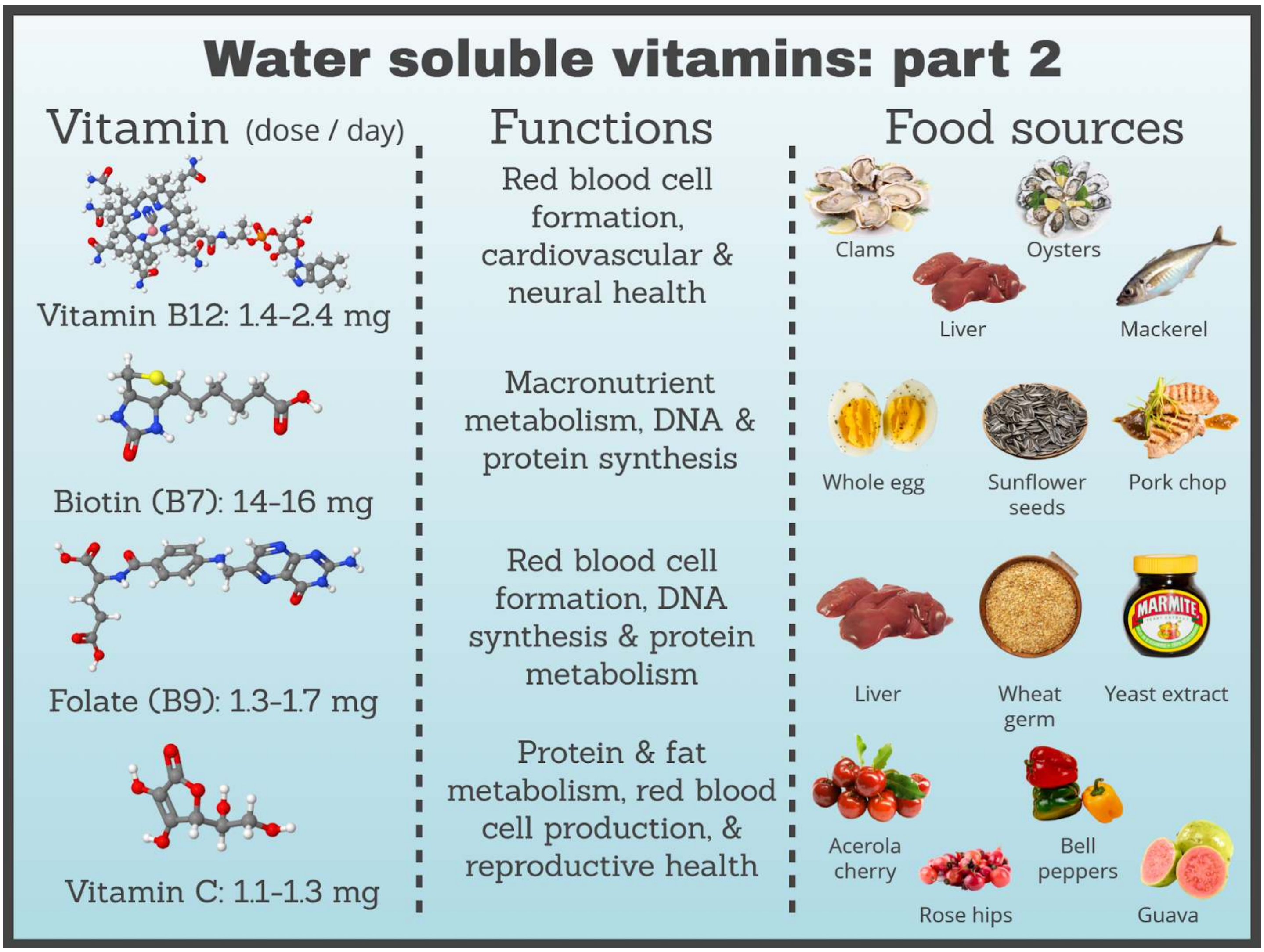
Biotin is an important coenzyme that is involved in many metabolic reactions concerning carbohydrates, fats and proteins, especially those involved with energy production. It is also involved in protein formation and DNA synthesis. Technically, it does not meet all the criteria for a true vitamin as it is produced in the intestine by gut bacteria during fermentation of fibre, which does not make it truly essential to the diet. Deficiency symptoms for biotin include dermatitis and hair loss. Most dietary biotin is found bound to proteins.

The top 6 dietary sources of vitamin B7 come from a range of foods, as shown in the table.

Vitamin B7 requirements for adults 18+ years old: **30 - 40 µg/day**

Biotin-rich food source	Calories / 100g	Biotin / 100g
Beef liver	191 kcal	36.7 µg
Whole egg	155 kcal	20.0 µg
Sunflower seeds	584 kcal	7.6 µg
Salmon canned	139 kcal	5.9 µg
Porkchop	323 kcal	4.5 µg
Almonds	581 kcal	4.4 µg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin B7 (biotin) are lamb and pork liver, eggs, milk, cheese, peanuts, soybeans, sunflower seeds, and mushrooms.



Vitamin B9: Folate

Folate belongs to a range of compounds of which folic acid is one, however, folic acid is a synthetic variation that is most commonly found in supplemental form. Folate works closely with vitamin B12 in the metabolism of amino acids, it also aids protein formation and the production of DNA. Folate helps in the production of red blood cells and is an essential nutrient recommended during pregnancy to prevent neural tube birth defects, such as spina bifida, and ensure normal growth of the foetus.

Effects on exercise performance: research studies indicate that in athletes receiving sufficient dietary vitamin B9 and also in folate-deficient athletes, supplementation did not provide any physiological performance benefit.

The top 6 dietary sources of vitamin B9 come from different types of liver, as shown in the table.

Vitamin B9 requirements for adults 18+ years old: **330 - 400 μg/day**

Folate-rich food source	Calories / 100g	Folate / 100g
Yeast extract spread	158 kcal	1010 μg
Duck/Goose liver	135 kcal	738 μg
Chicken liver	167 kcal	578 μg
Lamb's liver	238 kcal	400 μg
Toasted wheat germ	382 kcal	352 μg
Beef liver	175 kcal	253 μg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin B9 (folate) are legumes, asparagus, broccoli, spinach, kale, beet greens, and whole wheat.

Vitamin C: Ascorbic acid

Vitamin C has one of the longest histories of any modern vitamin with early experiments to help sailors prevent scurvy happening in the 1700s, the solution being the use of citrus fruits to provide, as we now know, the necessary vitamin C.

Vitamin C is most well known for its antioxidant properties and its ability to strengthen the immune system, however, it has many more functions that are not widely known. These functions include supporting the adrenal glands to produce corticosteroid hormones that help to manage stress, the proper formation of the connective tissue, collagen, found all through the body, the proper formation and repair of bone tissue, the formation of bile, and in the absorption of iron into the body. While citrus fruits are well known to be good sources of vitamin C, many other plant foods have higher vitamin C content.

Effects on exercise performance: research studies indicate that in athletes receiving sufficient dietary vitamin C, supplementation did not provide any physiological performance benefit. However, there is evidence that vitamin C supplementation may decrease the incidence of upper respiratory tract infections following periods of intense training. Although not directly related to increased performance, there is evidence that vitamin C supplementation may decrease the incidence of upper respiratory tract infections following periods of intense physical training.

The top 6 dietary sources of vitamin C come from fruits and vegetables, as shown in the table.

Vitamin C requirements for adults 18+ years old: **75 - 110 mg/day**

Vitamin C-rich food source	Calories / 100g	Vitamin C / 100g
Acerola cherry	32 kcal	1677 mg
Rosehip	162 kcal	426 mg
Green chilli peppers	40 kcal	242 mg
Guava	68 kcal	228 mg
Sweet bell pepper	28 kcal	183 mg
Lychees	277 kcal	183 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of vitamin C are papaya, broccoli, strawberries, Brussels sprouts, cauliflower, lemons, kale, kiwi fruit, cantaloupe, oranges, grapefruit, tomatoes, raspberries, and pineapple.

Minerals

The rocks and metals found in the earth are the same substances that form the minerals in our diet. The human body needs 15 minerals provided by the diet to help sustain essential functions and contribute to health and wellbeing. The minerals are divided into 2 major groups, the macro-minerals and the trace minerals. Macro-minerals are required in the diet in larger amounts, >250 mg per day. Whereas the trace minerals are only required in small amounts, <20mg and in many cases, even smaller microgram amounts are required.

Minerals serve many functions in the body, with some helping to build structures like bone, others serving as charged inorganic ions, molecules carrying a positive or negative charge, to assist in blood clotting or maintaining fluid balance, for example. Many minerals serve as cofactors that help to activate enzymes (biological catalysts) to perform their various functions. Minerals are found in both plant and animal foods, but the bioavailability of the mineral through digestion and absorption may affect how much of a mineral is absorbed from food. Plant foods contain compounds that bind minerals within the plant structure, such as phytic acid or oxalic acid. These reduce the availability of minerals for absorption within the digestive tract and remain bound, ultimately resulting in excretion from the bowel. In some cases, cooking plant foods helps to reduce the impact of phytic or oxalic acid and thus increases mineral bioavailability. Animal foods generally concentrate minerals in higher amounts which are readily available for digestion and absorption without the impact of antinutrients.

Macro-minerals

Potassium

The cells of the human body contain more potassium than any other mineral. It exists most often as a positively charged ion within the fluids of the body. It is especially found in high amounts in nerve and muscle cells to help with neural stimulation and muscle firing. Potassium is also important for supporting effective kidney function. Potassium is strongly associated with lower blood pressure levels and therefore contributes positively to cardiovascular health. It also has an important influence on maintaining cellular fluid balance.

The image of chloride is sodium chloride (salt) as chloride is a charged inorganic ion and is usually combined with another element rather than existing on its own.

Effects on exercise performance: research studies indicate that in athletes receiving sufficient dietary potassium, supplementation did not provide any physiological performance benefit, nor does it appear to prevent the incidence of muscle cramping.

The top 6 dietary sources of potassium come from fruits, vegetables, & beans, as shown in the table.

Potassium requirements for adults 18+ years old: **3500 - 4700 mg/day**

Potassium-rich food source	Calories / 100g	Potassium / 100g
Sun-dried tomatoes	258 kcal	3427 mg
Yeast extract spread	158 kcal	2600 mg
Cocoa powder	228 kcal	2509 mg
Dried apricots	320 kcal	1850 mg
Lima beans	338 kcal	1724 mg
Kidney beans	330 kcal	1490 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of potassium are dairy products e.g. cheese & yoghurt, meat, poultry, fish, spinach, corn, coconut water, sweet potato, papaya, cantaloupe, banana, peaches, grapes, and kiwi fruit.

Chloride

In food, chloride is normally bound to another substance, such as sodium or potassium chloride, in preference to existing as free chloride. Once in the body and dissolved in the blood, the intra, and extracellular fluid, chloride dissociates (separates) and becomes a negatively charged ion that helps to manage fluid balance throughout the body. Chloride also helps to produce the hydrochloric acid within the gastric juices of the stomach, it plays a role in the overall acid-base balance of the blood, it assists with nerve transmission and the immune fighting capacity of white blood cells. Western diets typically include excess sodium chloride (refined salt), which is 40% sodium and 60% chloride, making a chloride deficiency highly unlikely. If extreme bodily fluid losses do occur, then chloride deficiency is possible with fatigue and loss of appetite being the prominent symptoms.

Dietary sources of chloride come primarily from refined table salt (61 g/100g), but also unrefined salt, seaweed, tomatoes, rye, celery, lettuce, and olives.

Chloride requirements for adults 18+ years old: **2300 - 3100 mg/day**

Sodium

Most naturally occurring foods are fairly low in sodium, but as sodium chloride, refined salt, is added to the vast majority of industrially processed foods to boost taste and flavour, this has resulted in substantial increases in sodium consumption in the last century. Most savoury fast foods and snacks will be high in sodium. Unlike most micronutrients where the focus is on trying to reach the required daily intake, with sodium the focus is typically on reducing intake to meet the recommended levels.

Effects on exercise performance: increasing salt (sodium chloride) availability during heavy training in high-heat conditions has been shown to help maintain fluid balance and to prevent hyponatremia (low sodium levels)

Beyond added salt, some of the highest sodium-containing foods include broth/stock cubes, fish sauce, gravy granules, salted fish, canned anchovies, miso soup, soy sauce, yeast extract spread, salted tofu, salted snack foods, French fries, dried soups, ready-made sauces, hotdogs, deli meats, cured meats & bacon, cheeses, and pickled foods.

Sodium requirements for adults 18+ years old are limited to **1500 - 2000 mg/day**

Calcium

The average human body contains approximately 1.2 kg of calcium, the majority of which is stored within bone tissue and teeth. There are small amounts maintained within the fluids surrounding our cells, especially muscle tissue which requires calcium to initiate muscle contraction. It is widely known that calcium is needed for strong bone tissue. The body is constantly re-modelling the bones with structural replacement occurring at approximately 600-700 mg of bone tissue per day in healthy adults, which amounts to about 10% of total bone tissue per year. Calcium also plays a role in blood clotting, nerve transmission, cell metabolism, immune response, and maintaining healthy blood pressure. Calcium deficiency is observed in the chronic disease osteoporosis.

Effects on exercise performance: research studies indicate that in athletes receiving sufficient dietary calcium, supplementation did not provide any physiological performance benefit.

The top 6 dietary sources of calcium come from dairy and seeds, as shown in the table.

Calcium requirements for adults 18+ years old: **900 - 1200 mg/day**

Calcium-rich food source	Calories / 100g	Calcium / 100g
Poppy seeds	525 kcal	1438 mg
Parmesan cheese	456 kcal	1376 mg
Swiss cheese	357 kcal	1071 mg
Gruyere cheese	413 kcal	1011 mg
Sesame seeds	565 kcal	989 mg
Low-fat mozzarella	149 kcal	961 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of calcium are yoghurt, sardines (with bones), turnip greens, kale, broccoli, bok choy, soybeans, and almonds.

Phosphorus

Phosphorus is the second most abundant mineral in the human body after calcium with approximately 600 - 700 mg contained within an average body. 80-90% of the phosphorus is bound up in the structure of bones and teeth where the ratio of calcium to phosphorus is about 2:1. The importance of phosphorus to the cells and tissues of the body cannot be understated with functions including activating enzymes involved in cellular energy production, producing cell membranes, DNA formation, regulating acid-base balance, muscular contraction, nervous transmissions, hormone secretions, and protein synthesis. Deficiency is rare, but if it does occur it will lead to loss of bone and decreased bone mineralisation.

Effects on exercise performance: well-controlled research studies indicate that athletes receiving sodium phosphate supplementation demonstrated an increased performance in aerobic energy system endurance-related activities.

The top 6 dietary sources of phosphorus come from seeds and dairy, as shown in the table.

Phosphorus requirements for adults 18+ years old: **550 - 700 mg/day**

Phosphorus-rich food source	Calories / 100g	Phosphorus / 100g
Dried pumpkin seeds	541 kcal	1074 mg
Sunflower seeds	619 kcal	1158 mg
Chia seeds	490 kcal	948 mg
Poppy seeds	525 kcal	870 mg
Parmesan cheese	456 kcal	807 mg
Tahini	592 kcal	790 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of phosphorus are meat, fish, cereal grains, milk, yoghurt, nuts and beans.

Magnesium

Magnesium is a very important mineral that has been identified to be involved in more than 300 different biochemical reactions in the human body. Along with calcium, phosphorus and vitamin D, magnesium is necessary for strong teeth and bones. The muscles require magnesium to switch off muscular contraction and bring the muscle tissues to a state of rest. Magnesium plays a role in sleep and the formation of the sleep initiating hormone, melatonin. It also helps with managing the muscular tone of the blood vessels and can positively influence blood pressure, and it helps support enzyme activity that is essential for releasing energy in cellular metabolic reactions. Symptoms of magnesium deficiency include irritability, weakness, loss of appetite, muscular twitching, and more severely rapid heart rate, muscle tension, and disorientation.

Effects on exercise performance: research studies indicate that in athletes receiving sufficient dietary magnesium, supplementation did not provide any physiological performance benefit. In athletes with a magnesium deficiency, there is some evidence of improved performance.

The top 6 dietary sources of magnesium come from nuts and seeds, as shown in the table.

Magnesium requirements for adults 18+ years old: **F = 300 mg/day, M = 420 mg/day**

Magnesium-rich food source	Calories / 100g	Magnesium / 100g
Dried pumpkin seeds	541 kcal	535 mg
Cocoa powder	228 kcal	499 mg
Flaxseeds	534 kcal	392 mg
Brazil nuts	656 kcal	376 mg
Sesame seeds	565 kcal	356 mg
Poppy seeds	525 kcal	347 mg

To encourage nutrition and dietary variety, other foods that serve as good sources of magnesium include salmon, spinach, green beans, black & kidney beans, baked beans, brown rice, almonds, and sunflower seeds.

Sulphur

Sulphur is a necessary mineral in the diet, but it is an inorganic compound that is bound to the amino acids, methionine and cysteine, as well as the vitamin B7 (biotin) and B1 (thiamine). Therefore, if adequate protein and B vitamins are consumed, then by default the body will be receiving more than adequate levels of sulphur. For this reason, there is no set daily intake level set for sulphur consumption. Sulphur is essential to the activity of many enzymes and antioxidants. Sulphur deficiencies are incredibly rare unless there is a significant protein deficiency first.

Trace minerals

Trace minerals are essential for human health but are only required in even smaller amounts, much less than the macro-minerals. Trace minerals are typically consumed in amounts below 20mg, with many only required in microgram amounts. Despite these very small intakes, they perform important functions to support our physiology. 8 trace minerals must be included regularly in our diet.

The following table provides a quick reference overview of the 8 trace minerals, their various physiological functions, and a range of dietary sources.

Trace mineral	Functions	Rich dietary sources	Daily intake requirements
Iron	Component of haemoglobin that carries O_2, immune function, energy production	Red meat, liver, poultry, clams, eggs, spirulina, spinach, pumpkin seeds, cocoa powder, soybeans, & lentils	M = 8 mg/day F = 18 mg/day
Zinc	DNA replication, night vision, stress response, immune function, taste, blood sugar balance	Oysters, beef liver, tahini, pumpkin seeds, beef, lamb, venison, yoghurt, sesame & poppy seeds	F = 8 mg/day M = 11 mg/day
Manganese	Enzyme function for energy metabolism, bone & connective tissue growth & repair, the health of nerves, blood sugar balance	Mussels, Hazelnuts, pecans, pine nuts, mussels, rye flour, poppy seeds, brown rice, oats, chickpeas, pineapple, raspberries	F = 1.8 mg/day M = 2.3 mg/day
Copper	Iron metabolism, support antioxidant enzymes, connective tissue synthesis, thyroid function, preserve myelin sheath of nerves	Beef, lamb & duck's liver, squid, lobster, spirulina, shiitake mushrooms, sesame seeds, cocoa powder, cashew nuts	900 µg

**Daily intake requirements include both male (M) and female (F) amounts. In all cases, male intakes are larger except for iron, where women need twice as much as men to combat the monthly blood losses of menstruation.*

Trace mineral	Functions	Rich dietary sources	Daily intake requirements
Iodine	Thyroid gland health and thyroid hormone formation	Dried seaweed/kelp, wild cod, sardines, scallops, shrimp, tuna, yoghurt, cheese & eggs	150 µg
Selenium	Potent antioxidant properties, thyroid hormone production, reduce arthritic joint inflammation	Brazil nuts, pork & beef kidney, lamb's liver, chicken skin, oysters, cod, salmon, mussels, sardines, shrimp, tuna	55 µg
Molybdenum	Component of certain coenzymes to form proteins and DNA, also supports detoxification processes	Beef liver, peas, black-eyed beans, lima beans, milk, banana	45 µg
Chromium	Maintains healthy blood sugar levels, enhances cellular insulin action, supports cholesterol metabolism	Egg yolk, brewer's yeast, beef, cheese, liver, oats, wholemeal wheat & rye bread, chillies, & oysters	F = 20 - 25 µg/day M = 30 - 35 µg/day

Water & hydration

The human body is completely reliant on water to function efficiently, evidenced by the rapid decline in health and wellbeing if water is not consumed regularly. Without water intake, the body will die within just a few days, whereas it is possible to survive weeks without food intake, although the experience would be unpleasant. The human body is composed of between 50-75% water depending on age, gender and body composition. Muscle tissue contains approximately 70% water, while fat tissue only holds about 20% water. Therefore, more water is retained in lean muscular bodies, than sedentary bodies with low muscle mass and higher body fat.

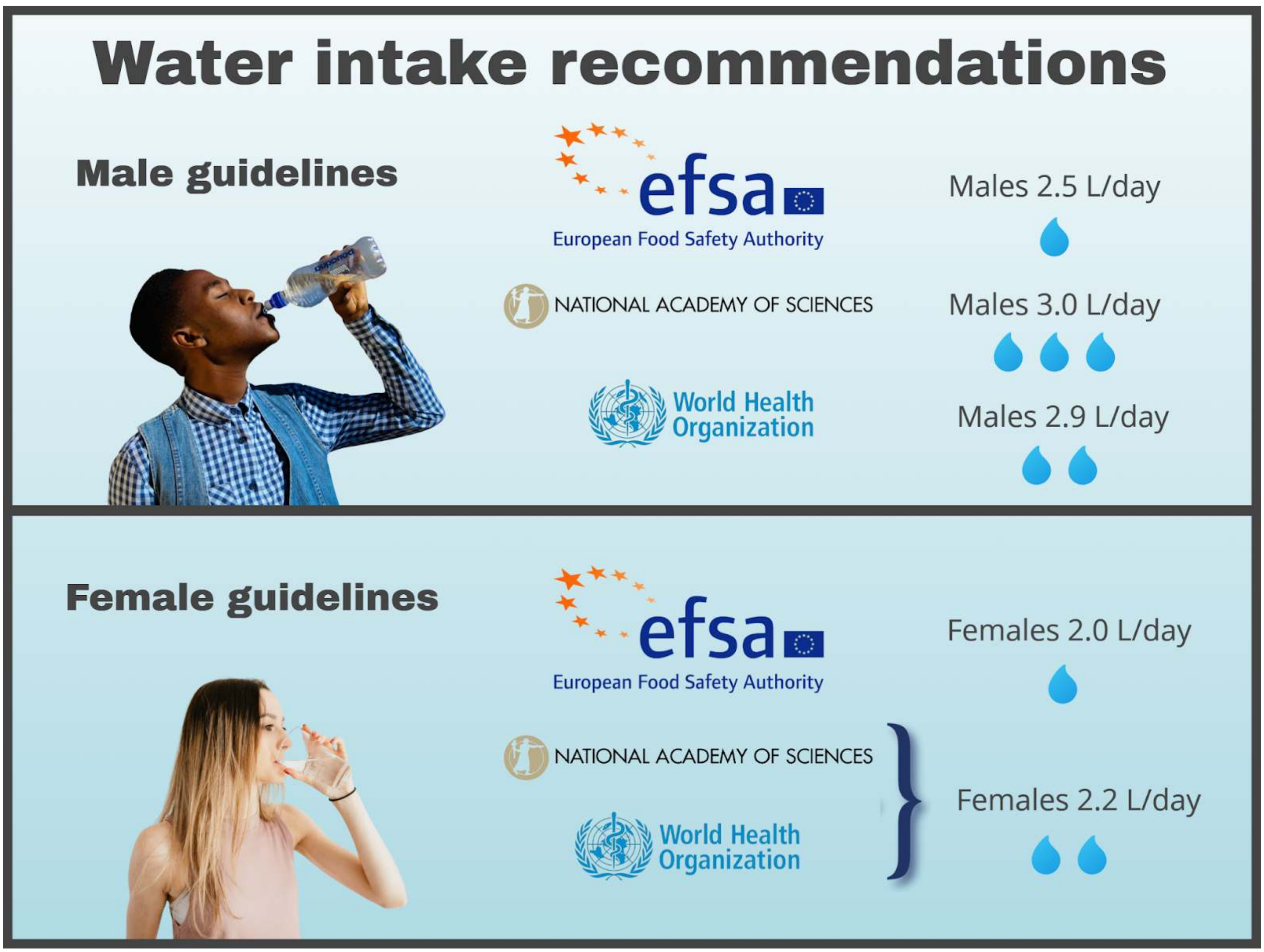
Water has so many different functions in relation to physiological processes. Some of these functions are:

- Water serves as a solvent for other compounds to be dissolved in and transported around the cells and the wider systemic circulation.
- Water is a major component of numerous bodily fluids, such as blood, sweat, saliva, tears, mucus secretions, and synovial fluid in between the joints.
- Water helps to regulate body temperature.
- Water is used as a medium to remove waste products through urine and sweat.
- Water helps in the process of digestion to transport food particles and to serve as a medium for digestive enzymes to mix with foods and chemically break them down.
- Water helps to maintain the narrow pH balance of the blood and the cells.
- Water is a significant component of the intracellular and extracellular fluid matrix that bathes and lubricates the tissues of the body, allowing for endless biochemical interactions to take place.

Water plays a vital role in helping a vast array of functions run smoothly within the internal ecosystem of the human body. However, the volume of water that is required to optimise health is dependent on many different factors such as body size, lean mass, activity levels, environmental conditions, dietary choices, and health conditions. As several of these factors are variable from day to day, while others are relatively fixed, or only changeable in the longer term, this makes it difficult to provide a one-size-fits-all guideline for appropriate water consumption. Past public advice to consume 6-8 glasses of water, or drink 2 litres of water per day, may easily be remembered, but they are non-specific and will fail to meet the individual needs of many across a population.

Fluid consumption

As a minimum guideline, it is wise to ensure the replacement of lost fluids from the body daily. Water is lost from the body in multiple ways, including through urination, defaecation, perspiration & sweat, and also as vapour through breathing. Urination is the most variable factor in our water losses. The kidneys are responsible for managing the amount of water that is removed through urination. The kidneys will adapt based on the needs of the body every hour throughout the day. If excess water is consumed then the kidney will filter more into the bladder for excretion and vice-versa if there is a lack of water consumed. Numerous studies over the years have tried to investigate the basic fluid needs of the general population. These fluid needs must take into account all sources of fluid such as water and beverages, water within the food that is consumed, and also water that results as a by-product of metabolic and energetic processes within the cells of the body.



Many international organisations have created general population water intake recommendations for males and females. The recommendations shown in the image are average water intake requirements that have factored out the water provided by food consumption and the typical metabolic processes. They are based upon an average 70kg male and 58kg female. These guidelines do not take into account additional exercise needs.

Active water losses

The amount of fluid lost in sweat and through breathing out water vapour will largely be dependent on the levels of daily physical activity performed. The more active an individual is, the more water losses will occur through these means. Therefore, it makes logical sense that active individuals will need to consume more fluids to replace the increased losses that occur during physical exercise. Exercise performance will be hindered if water losses reach 2% of body weight or higher (1.4kg of water lost for a 70kg individual). Males and females have approximately 2-4 million sweat glands spread across the surface of the skin. Average sweat rates during moderate to high-intensity exercise vary significantly based on the number of sweat glands per square centimetre. Individual variation can be as low as 35 active sweat glands per square centimetre, up to as high as 187 active glands, although the average has been measured at 81 active sweat glands per square centimetre. In a nutshell, more active sweat glands mean more water losses during exercise.

Average sweat rates during high-level exercise have been reported through scientific research to range from 0.5 L to 2.0 L/hour. This means that without water being replenished during exercise, performance reduction due to dehydration will usually become evident within 60-90 minutes of commencing exercise. The practical guidance to take from this information is that we should pay attention to individual sweat rates during exercise and those that exhibit higher sweat rates should be encouraged to consume higher amounts of hydrating fluids before, during and after exercise.

For physical exercise lasting up to 60 minutes follow these general hydration guidelines:

- Consume between 100-200 ml of water or hydrating fluids every 15 minutes during exercise performance to maintain hydration status and offset sweat-related water losses. This equates to 400-800 ml per hour.
- Drink water before any sensation of thirst is experienced, as thirst response is delayed in most people until significant sweat-related water losses have already occurred.
- Specific fluid needs will depend on sweat rate and individual body size.

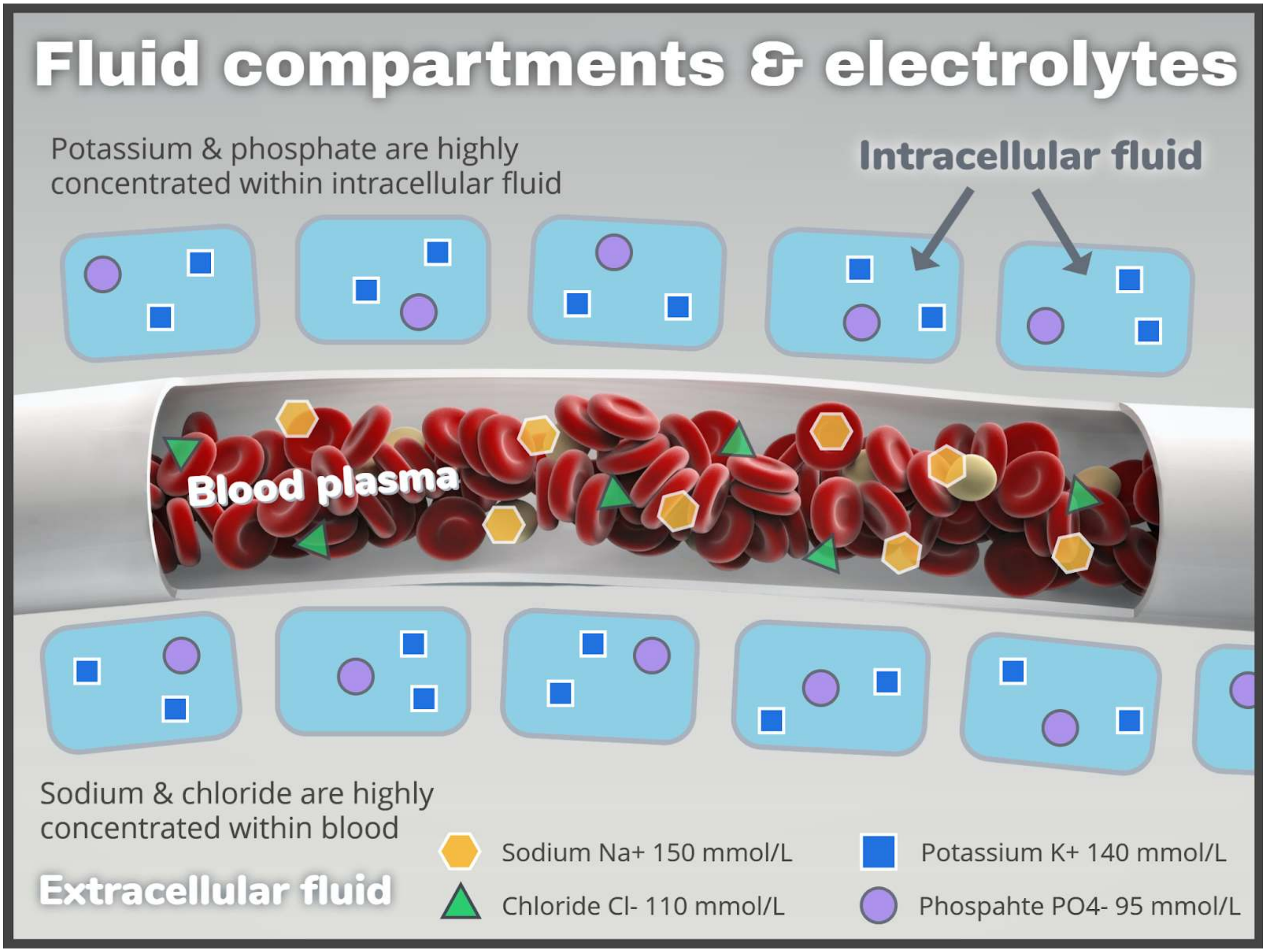
Hydration and electrolytes

Concerning prolonged exercise, above 60 minutes, simple consumption of water, though vitally important, does not immediately guarantee the hydration of thirsty cells within the body. Hydration, or fluid partitioning, is controlled very carefully between the bloodstream and the tissues of the body. Water is contained within two primary compartments of the body:

1. The intracellular fluid - the watery fluid that fills trillions of cells within the body - accounts for approximately 40% of total body weight.
2. The extracellular fluid - the fluid outside the cells of the body - accounts for approximately 20% of total body weight. There are 2 sub-categories:
    - The interstitial fluid - the fluid that fills the small gaps between cells - is approximately 16% of total body weight or 80% of the total amount of extracellular fluid.
    - The blood plasma - the watery fluid that carries red blood cells through the circulatory system - is approximately 4% of total body weight or 20% of the total amount of extracellular fluid.

Water moves between these major fluid compartments under the influence of electrolytes. The term 'electrolyte' is the name given to an inorganic element that has dissolved into a solution and become a charged ion, thus influencing the movement of water between fluid compartments. Four main electrolytes influence fluid movement; sodium, potassium, chloride and phosphate. The concentration of the electrolytes between the fluid compartments is carefully maintained to manage the balance of fluids as needed by the body. Changes in the electrolyte concentration within a compartment will influence the movement of water between compartments by the process of osmosis to help balance out the concentration of the solution in that given fluid compartment. In simple terms, it is the number of electrolytes dissolved in the fluid within the cells and within the blood plasma that determines the direction of water movement between the blood and the cells. Following consumption of a beverage and absorption through the digestive tract, effective cellular hydration requires the appropriate movement of water from the blood into the cells.

The diagram illustrates how the cells typically maintain the concentration of the four major electrolytes within the given fluid compartments; sodium and chloride are highly concentrated in the blood, whilst potassium and phosphate remain concentrated within the intracellular fluid.



Sports drinks

Sports drinks often provide greater benefits than water alone. They are usually composed of 3 main ingredients; water, a source of carbohydrate, and electrolytes, usually sodium and potassium. The electrolyte and carbohydrate content of a beverage will determine the impact it has on the movement of water between the intestine and the blood, and following absorption, the movement between the blood and the cells. This is referred to as the fluid's tonicity.

There are 3 types of beverages with different effects on the movement of water or solutes.

1. **Hypotonic drink:** the concentration of glucose/carbohydrate (≤40g/L) and electrolytes is lower than the blood which influences the movement of water to move rapidly from the digestive tract into the blood, and then from the blood into the cells. The net result is cellular hydration.

2. **Isotonic drink:** the concentration of glucose/carbohydrate (50-75g/L) and electrolytes is similar to the blood so the movement of water, glucose, and electrolytes out to the digestive tract and into the bloodstream occurs together and neither water nor solutes are preferentially favoured. The net result from the blood into the cells is some refuelling and some hydration to maintain cellular balance.

3. **Hypertonic drink:** the concentration of glucose/carbohydrate (≥80-120g/L) and electrolytes is higher than the blood which may delay gastric emptying and cause gastrointestinal upset during performance. The glucose and electrolytes are absorbed into the bloodstream increasing the relative concentration in the blood. This influences the movement of water to be drawn out from the cells. The net result is rapid refuelling of the cells but at the expense of cellular dehydration.

Whilst sports drinks provide a strong and highly profitable component of the soft drinks market, their use for exercise and with athletes needs to be carefully considered and may be best that they are only used sparingly. Consider the following recommendations from the International Society of Sports Nutrition (2013) on the subject of sports and energy drinks.

- Consuming sports and/or energy drinks 10-60 minutes before exercise can improve mental focus, alertness, anaerobic performance, and/or endurance performance.
- Carbohydrate feeding, using sports drinks, during exercise of about 45 minutes or longer can improve endurance capacity and performance.
- Athletes should consider the impact of ingesting high glycaemic load carbohydrates on metabolic health, blood glucose and insulin levels.
- Indiscriminate use of sports or energy drinks, especially if more than one serving per day is consumed, may lead to adverse events and harmful side effects.

Key learning points: Chapter 3 Micronutrients & hydration

Micronutrients

- Vitamins are important and beneficial nutritional compounds produced by plants, which are consumed directly by humans, or they are consumed by animals, which in turn are consumed by humans.
- Vitamins are composed of two distinct categories, fat-soluble and water-soluble compounds. The fat-soluble category contains vitamins A, D, E, & K. The water-soluble category contains the B vitamin group and vitamin C.
- Fat-soluble vitamins can be stored in adipose tissue and if eaten in excess may potentially become toxic. Water-soluble vitamins are regularly flushed out of the system and need to be consumed consistently to prevent deficiency.
- Minerals are the same substances that form the rocks and metals found in the earth. We must consume 15 minerals provided by the diet to sustain essential functions and contribute to health and wellbeing.
- Minerals are composed of two distinct categories, macrominerals, required in larger amounts, and trace minerals, required in very small amounts. The macromineral category contains potassium, chloride, sodium, calcium, phosphorus, magnesium, and sulphur. The trace mineral category contains iron, zinc, manganese, copper, iodine, selenium, molybdenum, and chromium.

Hydration

- Water must be consumed regularly to maintain the health of the body and tissues and offset the negative effects of dehydration which become symptomatic at only 2% dehydration.
- Recommended guidelines targeted to the general population indicate that average-sized males should consume 2-5-3.0 L/day of water, whilst average-sized females will require 2.0-2.2 L/day of water.
- Fluid losses that occur as a result of exercise and activity will increase the daily requirements for water/fluid consumption. Guidelines suggest that for general exercise individuals should consume between 100-200 ml of water or hydrating fluids every 15 minutes.
- Sports drinks are designed to provide water, carbohydrate, and electrolytes (dissolved minerals) to provide either hydration or rapid replenishment of fuel for exercise and to offset the fluid and salt losses that occur through sweating.

Chapter 4: Dietary strategies for endurance exercise

It is important to be able to define exactly what we mean by the term endurance exercise when discussing specific dietary recommendations that may be required to sustain physical activity for long periods. The direction and advice that will be provided within this section of the manual will relate directly to dietary adjustments that can be made to sustain activities involving large rhythmical movements utilising, in most cases, whole-body musculature for sustained periods above 60-minutes of continuous exercise and activity that elevates heart rate and breathing. Examples of such activities will include but are not limited to, running, cycling, swimming, rowing, hiking, climbing, cross-country skiing, nordic walking, canoeing, kayaking, paddleboarding, biathlon, triathlon, and even ultra-endurance activities such as a marathon or Ironman competition.

Due to the increased intensity of sustained exercise and activity the required volume of energy from the macronutrients in the diet will be altered and elevated compared to the general, more sedentary population advice for carbohydrates, fats, and proteins. The body's metabolism will be working at a faster rate during exercise and activity, so it stands to reason that enzymes and biochemical reactions are occurring at faster rates, and as such the micronutrient needs of the body will also be elevated in those who are highly active.

The primary purposes of nutritional advice tailored to endurance exercise are as follows:

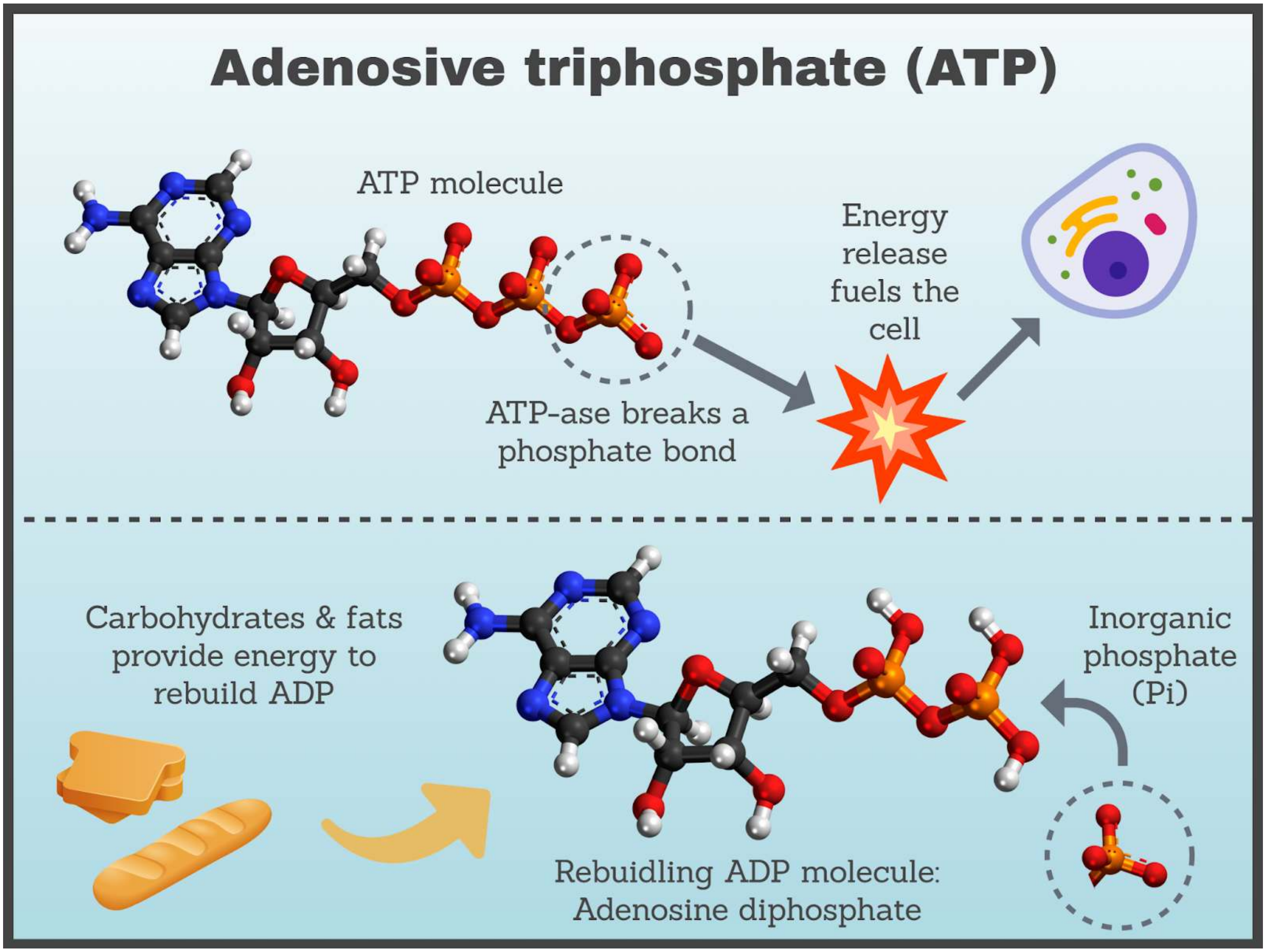
1. Provide sufficient calories from the most appropriate fuel source to sustain the increased energy demands of the exercise/activity.
2. Maintain a consistent supply of energy to avoid short-term energy dips or longer-term loss of energy during physical performance.
3. Restore spent energy and replenish depleted energy reserves within the body during recovery periods between exercise sessions.
4. Nourish the body to minimise exercise-related damage and inflammation that typically follows high-volume and high-intensity exercise.

Cellular fuel

The most basic fuel used in the human body is not glucose, it is a molecule called adenosine triphosphate (ATP). Humans are capable of converting all types of macronutrients, including proteins, fats, and carbohydrates, into a common cellular energy currency called ATP. All macronutrient-rich food that is eaten is used to transfer the stored energy within the food molecules to build and renew molecules of adenosine diphosphate (ADP), or spent ATP, back into usable energy currency once again ready to be metabolised for energy within the cells. ATP contains energy between its phosphate atoms that each form a bond. When a phosphate bond is broken by the enzyme ATPase, it releases energy that is used by the cell to power muscular contraction or other necessary functions. Sometimes the phosphate bonds are referred to as high-energy bonds, though this is somewhat misleading as they contain a similar amount of energy as other molecular bonds. A better description would be that they are capable of rapidly breaking their bonds to allow for energy release and also to quickly re-establish their bonds for energy restoration.

Several bioenergetic pathways service the restoration of spent ADP to become usable ATP once again. The two primary energy pathway categories are

1. Aerobic ATP production
   - Oxidative phosphorylation (fuelled primarily by carbohydrates)
   - Beta oxidation (fuelled by fatty acids)
2. Anaerobic ATP production
   - Glycolysis (lactate system fuelled only by carbohydrates)
   - Creatine phosphate (fuelled only by direct creatine phosphate availability)



Aerobic ATP production

Aerobic ATP production refers to the rebuilding of ADP molecules using basic macronutrients from our food supply in the presence of oxygen within the cell to create usable ATP molecules. This is the most common form of energy production in the cell providing for the vast majority of daily ATP requirements. Aerobic energy pathways, like our need to breathe, are active all of the time from birth through to death. The primary site of aerobic energy production is within a small organelle inside the cell called the mitochondria, which may be seen as the microscopic furnace of the cell. All oxygen-related energy production takes place inside the mitochondria and produces the vast majority of all daily ATP. Aerobically produced energy provides for all ATP utilised at rest and low levels of daily activity, as well as a considerable proportion of moderate-intensity exercise energy.

Aerobic ATP energy is predominantly produced using carbohydrates and fatty acids, though a small proportion (approximately 2-10%) of daily energy may be drawn from the breakdown of protein molecules, which are converted and fed into carbohydrate metabolism. In general terms, fatty acids provide for more aerobic energy at rest and lower activity levels, while carbohydrates provide more aerobic energy during moderate and higher exercise/activity levels.

Fatty acids pass along a chemical pathway known as beta-oxidation, which breaks the long chains down into smaller molecules, producing generous amounts of ATP along the way. The resulting compounds of beta-oxidation feed into the other aerobic mechanism called oxidative phosphorylation which then produces even more ATP. On average fatty acids produce 3-4 times more ATP per molecule than is achieved through the breakdown of glucose. Carbohydrates, like glucose, do not use beta-oxidation, they only feed into oxidative phosphorylation, but are still good at producing a substantial amount of ATP, but just not as much as fatty acids per molecule. Oxidative phosphorylation is a fast producing energy pathway, so glucose can generate ATP at faster rates than fatty acids. Beta-oxidation is a slower energy-producing pathway, hence why fatty acids are less involved in supporting moderate to high exercise intensity activities. The aerobic energy pathways typically sustain long-duration activity between 0-75% of maximal exercise intensity.

Anaerobic ATP production

Regardless of the intensity of exercise the human body always has the drive to breathe and access oxygen. Anaerobic ATP production refers to the chemical processes occurring within the cell, not whether the lungs are breathing oxygen or not. Anaerobic metabolism takes place outside of the mitochondria in the watery matrix of the cell known as the cytoplasm. The process of glycolysis involves the simple breakdown of glucose into two smaller sugar components known as pyruvate. This chemical breakdown releases a small amount of ATP. Glycolysis can produce ATP at a very fast rate enabling this energy-producing system to sustain exercise at very high levels between 65-95% of maximal intensity. The combination of a fast rate of production with a small amount of ATP produced per glucose molecule places significant limits on the availability of the original glucose fuel source in the muscle tissue. This means that glucose fed through glycolysis can only sustain high-intensity exercise for relatively short periods, usually from 30 seconds to a few minutes rather than minutes to hours.

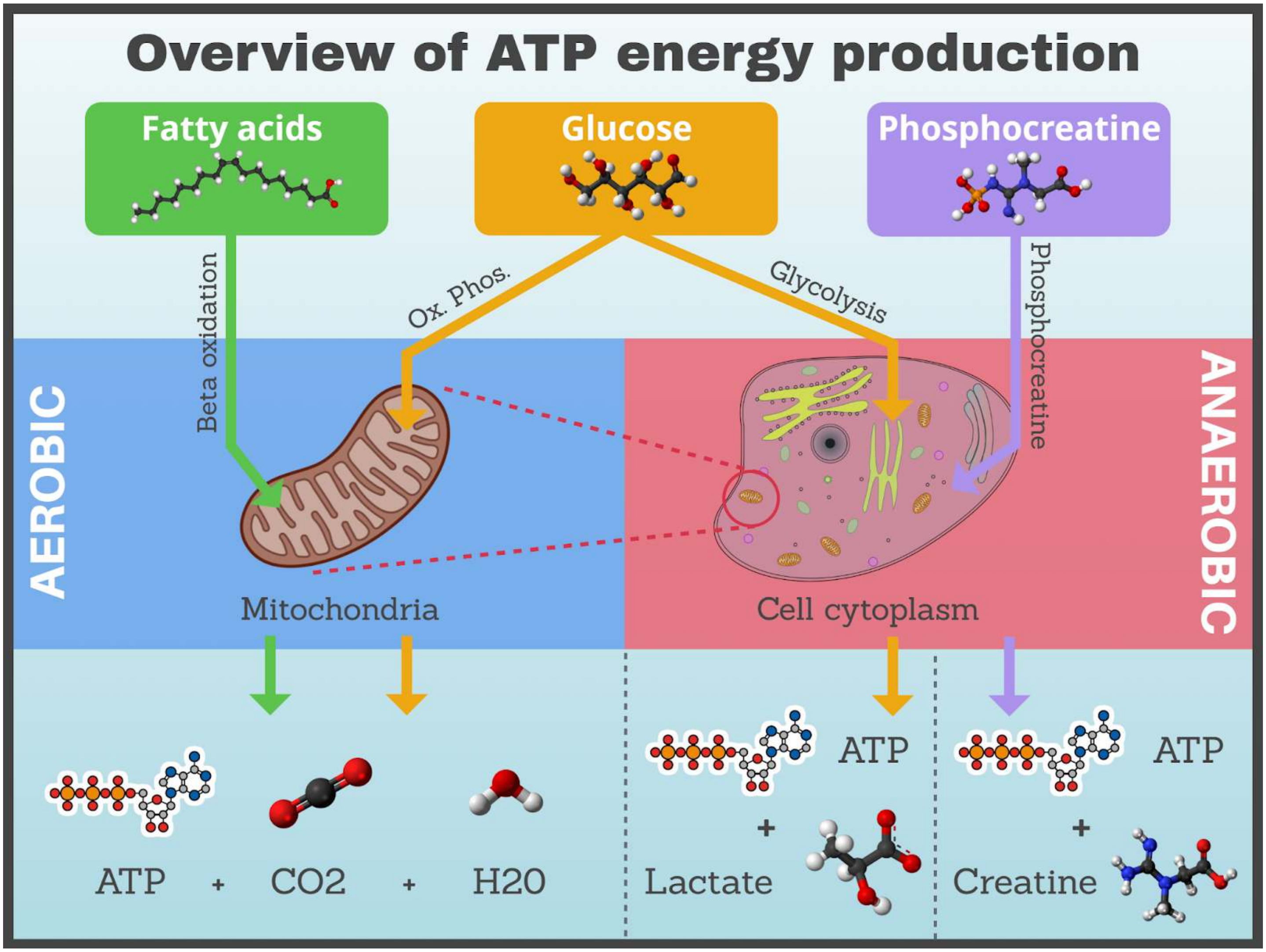
Part of the process of maintaining glycolysis production as long as possible is the creation of a by-product called lactate, more commonly known as lactic acid. As glycolysis continues, lactate levels begin to rise in the muscle tissue and in the blood which occurs simultaneously with an increase in hydrogen ions or acid levels within the tissues. This leads to a burning sensation in the muscles during high-intensity exercise. Whilst it may seem the burning sensation of lactate in the muscles is hindering potential exercise performance, the reality is without the production of lactate, glycolytic processes would cease much sooner, causing a rapid depletion of available energy and the slowing of exercise performance back down to aerobic levels where sufficient energy is still readily available to sustain aerobic level performance. When exercise intensity decreases and aerobic metabolism begins to predominate once again, the cells draw upon oxygen to diminish the lactate levels in the muscles by back-converting lactate to pyruvate for use in aerobic energy metabolism once again.

The final system of energy production is used only at the highest levels of energy demand, between 95-100% of maximal exercise intensity. The phosphocreatine (PC) system works as a single donor of inorganic phosphate that is simply passed from the creatine molecule to the spent ADP molecule. It is a very rapid one-to-one chemical swap, a single creatine phosphate can replenish a single ADP back to ATP. Therefore, the system only operates at maximum energy production as long as a supply of PC is available within the muscle tissue. Typically, PC can sustain maximum energy output between 6-15 seconds. If exercise continues once PC is spent, then performance will slow a little to draw energy from glycolysis and lactate will be produced and will build up within the tissues.

Contribution of aerobic/anaerobic ATP production during maximal effort relative to the duration of the exercise

Energy component	Duration in seconds			Duration in minutes					
	10	30	60	2	4	10	30	60	120
% aerobic	10	20	30	40	65	85	95	98	99
% anaerobic	90	80	70	60	35	15	5	2	1

The table strongly indicates that for continuous endurance exercise beyond 60 minutes, 98% of all energy utilised is drawn from aerobic energy metabolism. This suggests that the primary energy pathways fuelling this sustained level of continuous exercise will be beta-oxidation and oxidative phosphorylation. Therefore, the food that will sustain continuous endurance exercise will be rich in fats and carbohydrates. The percentage split of fats and carbohydrates to fuel an endurance exercise session will depend on several factors, including exercise intensity, exercise duration, fitness level, gender, and dietary preferences.



**Fatty acid metabolism through beta-oxidation provides a high energy yield with a slow rate of ATP production*

**Glucose metabolism through oxidative phosphorylation provides a moderate energy yield with a moderate rate of ATP production*

**Glucose metabolism through glycolysis provides a low energy yield with a high rate of ATP production*

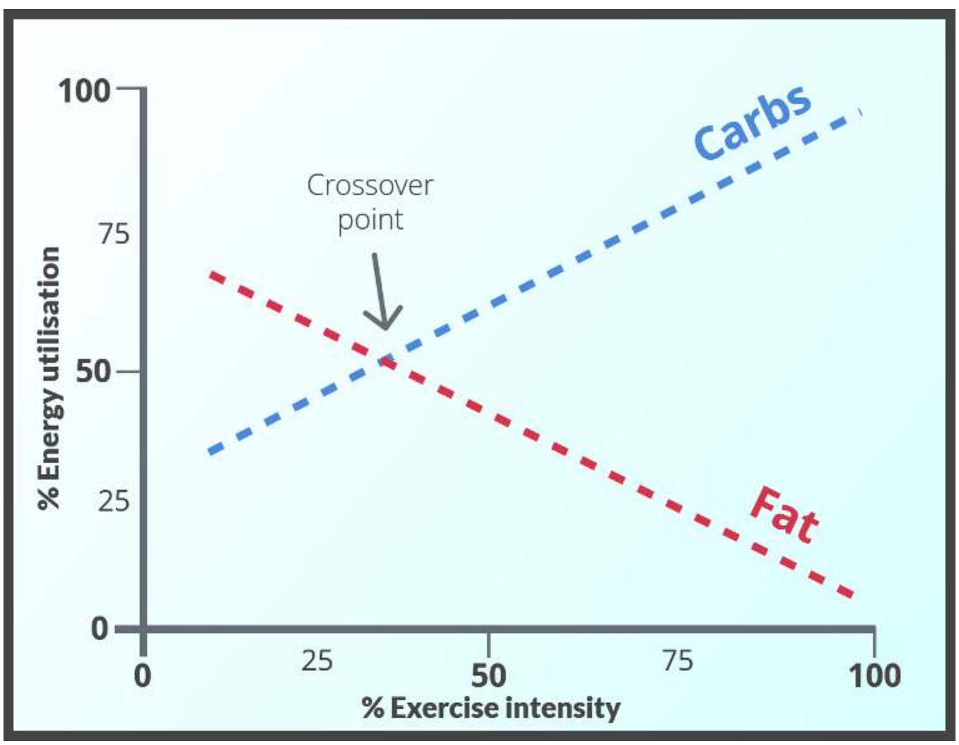
**Phosphocreatine metabolism through ATP-PC system provides a very low 1:1 energy yield with a very high rate of ATP production*

Endurance fuels

Carbohydrate and fat-rich foods provide a plentiful supply of calories in the human diet. The consumption of both of these energy-rich foods serves as the foundation for regular daily activity as well as the fuel needed for the steady restoration of ADP molecules during moderate to high-intensity activities. However, the balance of carbohydrate to fat consumption will vary based on individual needs and the intended objective.

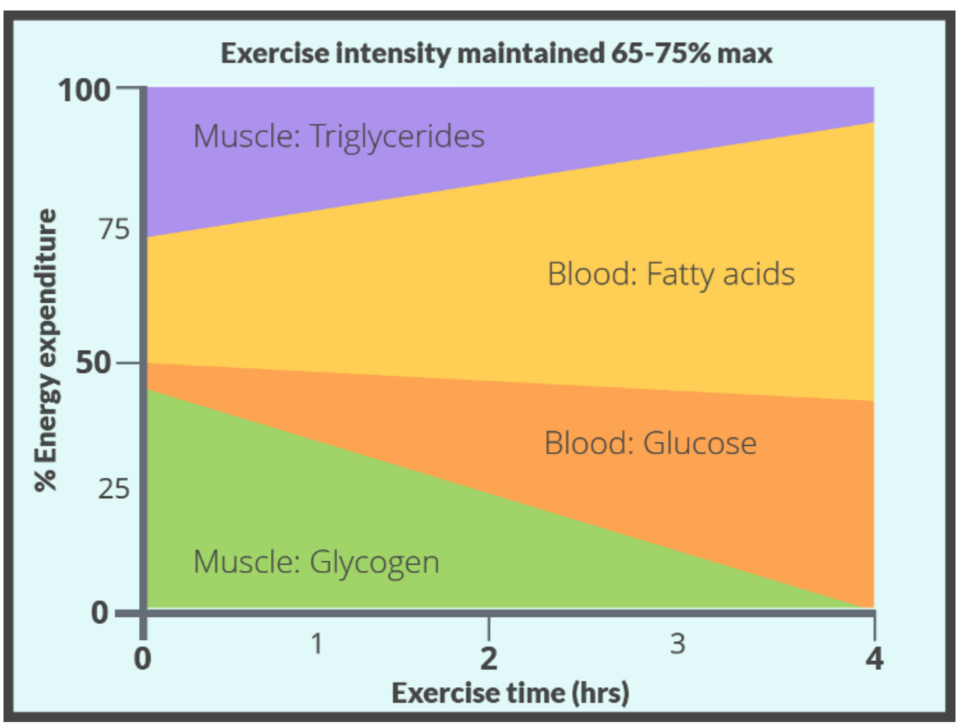
Exercise intensity

Science has clearly shown that at low-intensity activity levels, e.g. <30% of maximal effort, the dominant fuel source being utilised to produce ATP comes from the fats. At higher intensities of exercise e.g. >50-60% of maximal effort, carbohydrates are the dominant fuel source for the restoration of ATP. As the intensity of exercise increases, there is a shift in the metabolic fuels that are utilised in the muscle tissue from a fat dominant provision of fuel to a carbohydrate dominant provision of fuel. There is a point along the exercise intensity scale where the energy derived from carbohydrates exceeds that provided by fat. This specific work rate level has been named the 'crossover' point.



Exercise duration

During continuous, steady-state, low to moderate-intensity exercise, there is a gradual shift from carbohydrate dominant energy metabolism towards an increased reliance on fats as a primary fuel. This shift in preferred fuel towards fats is dependent upon the intensity of exercise remaining constant. Consuming rapidly absorbable carbohydrates, such as a sports drink, would quickly shift the predominance of fuel back towards carbohydrates due to the insulin increase that would occur in response to rising blood glucose. Fat and carbohydrates can be drawn from different locations to fuel exercise needs. Carbohydrates are drawn from existing blood glucose or stored muscle glycogen, whilst fats are drawn from existing blood plasma fatty acids or stored intramuscular triglycerides. As the duration of exercise lengthens, at the same steady-state and exercise intensity, the supply from each of these four locations varies in response to ever-changing metabolic parameters. Muscle glycogen and intramuscular triglycerides deplete as exercise duration increases and the whole system becomes more reliant on a continuous supply of blood glucose and free fatty acids being readily delivered through general circulation. These ongoing energy stores will come from the small stores in the liver, from adipose tissue, from protein breakdown (5-15% energy beyond 2 hours continuous exercise), or food consumption during the activity.

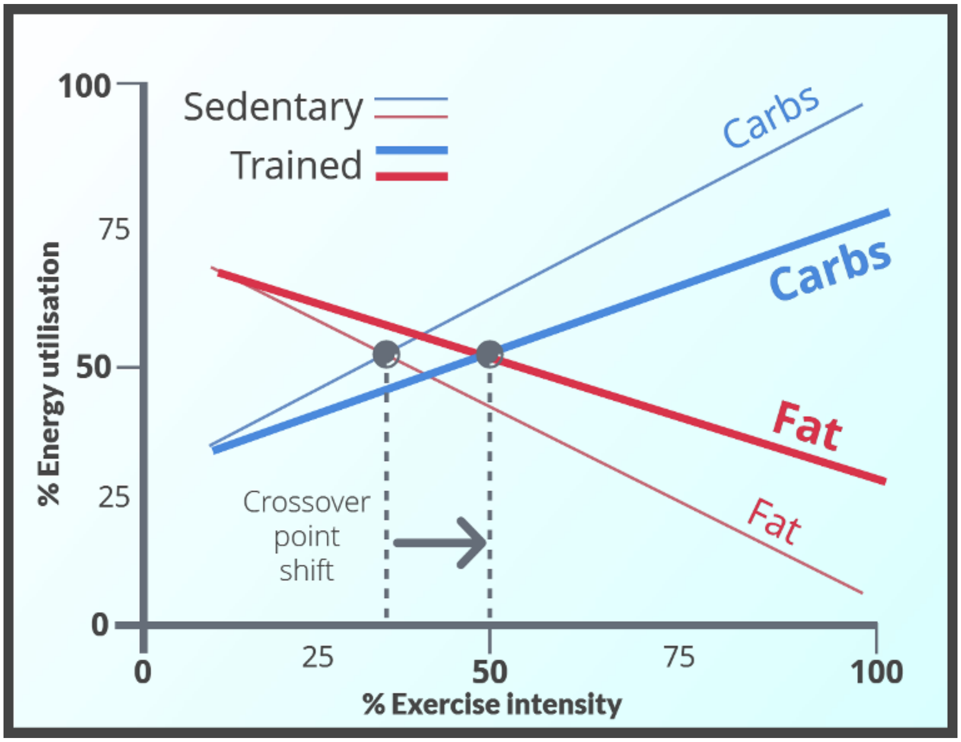


Fitness level

The physical adaptations that occur as a result of fitness training and exercise lead to both physical and metabolic changes in the physiology of the body. The physiological adaptations aid the body in being more efficient with its utilisation of fat and carbohydrate as the primary sources to rebuild spent ADP molecules. The physiological adaptations that occur as fitness level increases over a consistent training period are outlined in the table below.

Physical adaptations resulting from sustained endurance exercise	Metabolic adaptations resulting from sustained endurance exercise
• Increased lung capacity, oxygen intake, and carbon dioxide removal • Increased cardiovascular function • Improved blood flow • Increased red blood cell count • Increased myoglobin count • More effective oxygen delivery to the working muscles • Increased type 1 muscle fibres • Increased number of cellular mitochondria	• Increased muscle glycogen storage • Increased glycogen utilisation during exercise • Increased intramuscular triglyceride storage • Increased fatty acid utilisation during moderate-intensity exercise • Shift towards fatty acid metabolism at the same relative moderate-intensity workload • Increased lactate management and removal

Sedentary individuals will shift from predominantly oxidising fat towards burning predominantly carbohydrates at an earlier point in the exercise intensity scale. As fitness levels increase over time through a suitable training programme and the body becomes more efficient at managing oxygen availability, the metabolism is then capable of utilising fats to fuel exercise at relatively higher levels of exercise intensity. Whilst there will still be a point where carbohydrates become the dominant fuel, this crossover point shifts further up the exercise intensity scale in highly trained compared to sedentary individuals.

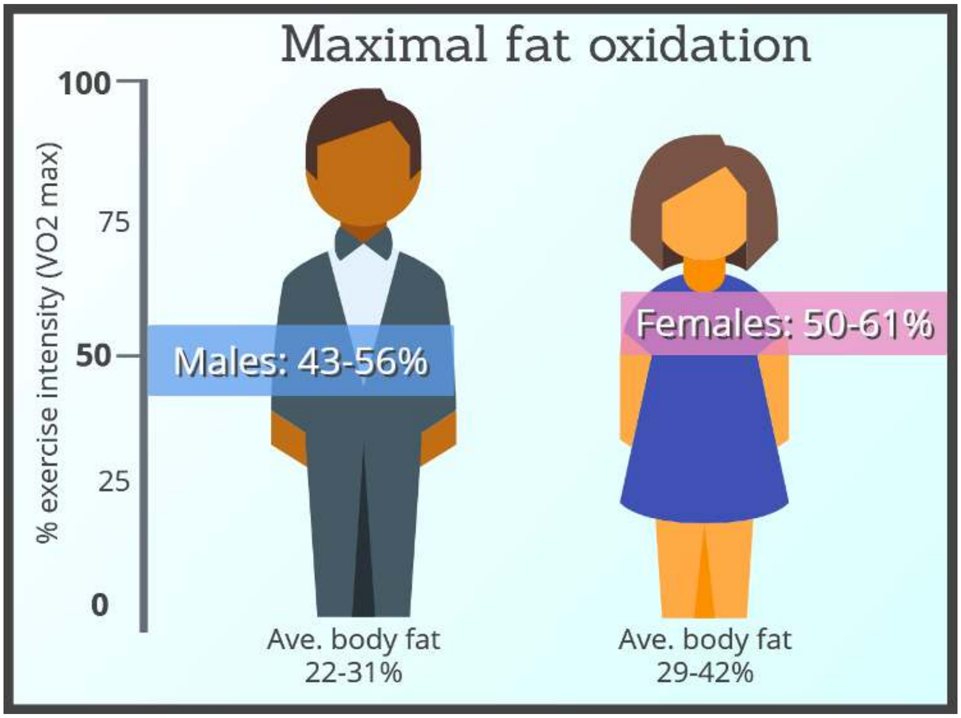


This metabolic shift up the exercise intensity scale is highly beneficial as it also delays the formation of lactic acid until higher exercise intensities. Lactic acid is the fatiguing by-product of high-intensity carbohydrate metabolism that often reduces physical performance due to the negative effects it has upon the muscle tissue. If carbohydrate metabolism is shifted up the exercise intensity scale due to increased fitness, this also means that lactate production does not occur until higher up the exercise intensity scale, ultimately allowing the exercise participant or athlete to compete at higher levels of physical performance with before the negative side effects of lactic acid begin to influence performance.

Gender differences

Scientific research has evidenced that males and females differ in the way in which they metabolise fuels to support endurance exercise. Numerous studies have shown that males oxidise higher amounts of carbohydrate and muscle glycogen during the same moderate-intensity endurance exercise as females. Conversely, research also shows that sedentary and moderately active females utilise a higher amount of free fatty acids during the same bout of moderate-intensity endurance exercise as males.

The crossover point of maximal fat oxidation in males typically occurs between 43-56% exercise intensity, whereas in females this same point has been found between 50-61% exercise intensity when carbohydrates become the dominant fuel. The take-home point is that females have approximately 5% higher maximal fat oxidation than males.



These differences in fuel utilisation seem to go hand in hand with the typical body composition differences between males and females. Males, on average, have higher lean body mass for storing muscle glycogen than females. Females, on average, have 8-10% higher body fat levels than males. Females have also been found to store a greater amount of intramuscular triglycerides than males. Therefore, it seems that different genders have developed to optimise the fuels that are more readily available to their respective physiology. It should be noted that in highly trained populations, the apparent difference in female free fatty acid utilisation diminishes to some degree. This is most likely due to the upregulation of metabolic endurance capacity which enables highly trained males to draw upon greater amounts of free fatty acids for fuel.

It is also evident from the available science that traditional high carbohydrate loading strategies used to super-compensate muscle glycogen stores appear to have less of an impact on improving female performance when compared to the typical increase in male performance.

This raises the question about potential differences in fueling males and females for endurance exercise, with males being more reliant on carbohydrates. Females may also benefit from a slightly higher dietary fat intake than males.

Dietary preferences

It is well known that the macronutrient composition of the diet can shift fuel oxidation rates either towards carbohydrate or fat utilisation. A high carbohydrate, low-fat diet will increase carbohydrate utilization through greater metabolic use of the increased availability of glucose in the blood and elevated glycogen stores. This increase in carbohydrate oxidation as a result of dietary carbohydrate 'loading' can occur within just 1-3 days. A high fat, lower carbohydrate diet has also been shown to impact the utilisation of fuels in favour of greater fat oxidation, but the upregulation of fatty acid oxidation seems to take longer, between 5-14 days to reach peak fat oxidation levels. A less desirable side effect of eating a high fat, low carbohydrate diet for 1-2 weeks is that glycogen stores will begin to deplete. Concerns have justifiably been raised regarding the impact on higher intensity performance when glycogen levels have become depleted.

The following table summarises the impact of different influencing factors on carbohydrate versus fatty acid oxidation.

Influencing factor	Metabolic shift in favour of fatty acid oxidation	Metabolic shift in favour of carbohydrate oxidation
Exercise intensity	Training at exercise intensities below 50% maximal effort	Training at exercise intensities above 60% maximal effort
Exercise duration	Longer training durations, above 2 - 2.5 hours of continuous exercise	Shorter training durations, below 1.5 - 2 hours of continuous exercise
Fitness level	Intermediate and advanced endurance-trained exercisers	Sedentary and recreational exercisers
Gender	Female (⇑ ~5%)	Male
Dietary preferences	High fat, low carb diets consumed over 5-14 days	High carb, low-fat diets consumed over 1-3 days

It should be remembered that all types of endurance training require both fat and carbohydrate to provide the total amount of needed energy, regardless of how many factors may or may not influence a metabolic shift one way or the other. An appropriate dietary solution to provide for the needs of endurance exercise must always include a certain amount of carbohydrate and dietary fat. In the vast majority of cases, avoiding the extreme ends of the high carbohydrate to high fat dietary spectrum will usually be necessary to find a macronutrient mix that works well for an active individual trying to optimise endurance performance.

High carbohydrate, low-fat recommendations

A high carbohydrate, low fat (HCLF) approach may be the most appropriate and beneficial strategy for success for some individuals. It is important to understand that several benefits come as a result of utilising this dietary approach.

1. Muscle and liver glycogen stores will be in plentiful supply before exercise and will be restored easily during the recovery period after training or performance.
2. Transportable and fast-acting carbohydrate foods and beverages are readily available when accelerated fuelling is required during or after physical exercise and performance.
3. Unprocessed, whole carbohydrate-rich foods carry numerous beneficial vitamins, minerals, phytonutrients, and fibre that contribute to the elevated metabolic and nutritional requirements to sustain endurance exercise and human health.

HCLF general guidelines

The first and most important factor in providing dietary guidelines for active individuals is to ensure that there is sufficient caloric intake to sustain the energy requirements of increased endurance exercise. The energy cost of exercise rises with the total amount of continuous exercise undertaken compounded against the level of intensity applied to a training session.

A typical training session under 60 minutes, performed 1-3 times per week will account for increased energy expenditure between 250-500 calories per training day. Undertaking moderate-intensity and volume training, between 1-3 hours, performed 4-6 days per week could increase training day exercise expenditure by 600-1000 calories. Whereas high volume, high-intensity endurance athletes training 3-6 hours per day, 5-6 days per week, could realistically increase their training day energy expenditure by 1000-2000 calories or more.

These additional energy expenditures indicate how energy needs may vary, but each client should be evaluated for their individual energy needs based on their body weight, gender, and level of exercise that will be fuelled regularly.

The following represents some more specific detail on how to meet the classic high carbohydrate guidelines for endurance athletes.

General fitness (30-60 mins per session over 1-3 days/week):

- Percentage intake: Consume 45 - 55% total calories from carbohydrate foods
  - Females total 2000 kcal/day: consume 900-1100 kcal carbohydrate/day
  - Males total 2500 kcal/day: consume 1125-1375 kcal carbohydrate/day
- Bodyweight calculation: 3-5g x weight in kg = total carbs g/day
  - 58kg female: 3-5g x 58 = 174-290g total carbs/day (696-1160 kcal)
  - 70kg male: 3-5g x 70 = 210-350g total carbs/day (840-1400 kcal)

Moderate to high intensity/volume fitness (1-3 hours per session, 4-6 days per week):

- Consume 50 - 65% total calories from carbohydrate foods
  - Females total 2800 kcal/day: consume 1400-1820 kcal carbohydrate/day
  - Males total 3400 kcal/day: consume 1700-2210 kcal carbohydrate/day
- Bodyweight calculation: 5-8g x weight in kg = total carbs g/day
  - 58kg female: 5-8g x 58 = 290-464g total carbs/day (1160-1856 kcal)
  - 70kg male: 5-8g x 70 = 350-560g total carbs/day (1400-2240 kcal)

High intensity/volume fitness (3-6 hours, 1-2 sessions per day, 5-6 days per week):

- Consume 60 - 75% total calories from carbohydrate foods
  - Females total 3100 kcal/day: consume 1860-2325 kcal carbohydrate/day
  - Males total 3800 kcal/day: consume 2280-2850 kcal carbohydrate/day
- Bodyweight calculation: 8-10g x weight in kg = total carbs g/day
  - 58kg female: 8-10g x 58 = 464-580g total carbs/day (1856-2320 kcal)
  - 70kg male: 8-10g x 70 = 560-700g total carbs/day (2240-2800 kcal)

HCLF guidelines: Performance day

For individuals who are performing in an athletic competition, there are a number of steps that can benefit preparation for an event, performance during an event, and recovery post-event. These guidelines provide current recommendations to follow, but it should be noted that all advice should be personalized to the needs of the individual athlete.

Preparation for the event/training

- A high carbohydrate main meal should be consumed 4-6 hours before an event/training to allow for digestion and assimilation of the carbohydrate content into muscle glycogen.
  - The meal should be composed of 1-2g/kg carbohydrates, 0.15-0.25g/kg protein, and should be low in fat (~20% fat).
  - Consume 300-500ml water to aid hydration and glycogen synthesis.

- Consume a light, easily digestible, 50g carbohydrate-rich snack with 5-10g protein between 30-60 minutes before exercise.

During the event/training

Endurance activities that extend beyond 90 minutes necessitate refuelling the body to maintain blood glucose and glycogen levels and maintain hydration status.

- Consume 30-60g of easily digestible carbohydrates per hour, contained within a 6-8% isotonic carbohydrate drink (200-400ml), with re-hydrating electrolytes every 15 minutes.

After the event/training

- After exercise is complete and heart rate has returned to rest, immediately consume a small 100-400kcal snack rich in carbohydrate (50-75%), moderate in protein (15-20%), and low in fat.
- Continue to rehydrate as required, gauging rehydration status by the colour of the urine, seeking light yellow or clear urine.
- Within 2-3 hours, to continue recovery, consume a meal with a ratio of 3:1 carbohydrates to protein, which is low in fat.
- Eat further meals over the next 24 hours that mimic the typical dietary eating pattern for the endurance athlete to sustain the recovery and refuelling process.

HCLF potential problems

A high-carbohydrate fuelling strategy may have potential problems. Common side effects may plague the athlete who follows these guidelines on a continuous basis to support their training and competing.

1. Bloating and digestive discomfort as a result of eating a high volume of starchy, high fibre foods as is found in most naturally sourced, complex carbohydrate food products.
2. The ongoing challenge of trying to provide sufficient carbohydrates for training and competitive events longer than 90 minutes. The choice between easily digestible foods or liquid sources of carbohydrate is a matter that must be evaluated in advance to determine the best options to meet each athlete's needs.
3. A high-carbohydrate diet to optimise muscle and liver glycogen stores will always mean that the athlete is carrying slightly more body weight due to increased water retention required for adequate storage of glycogen within the tissues.

High fat, low carbohydrate recommendations

Since the turn of the Millennium the scientific community has taken an increasing interest in the concept of using a high fat low carbohydrate (HFLC) dietary approach to fuel endurance and ultra-endurance exercise. Even at relatively lean body weight, the amount of adipose tissue stored on a human body is sufficient to support exercise for several days, not just a few hours. Therefore, the idea of drawing upon this large store of energy to fuel exercise and activity, whilst conserving the limited supply of muscle glycogen, is naturally a very intriguing concept. It is well-known that as exercise intensity increases, the percentage of energy provided by carbohydrates also increases, with the opposite occurring with regards to fatty acid oxidation.

Trained athletes have highly developed cardiorespiratory systems. The ability to provide oxygen to the working muscle has physiologically adapted to a substantially higher level, which can support the oxidation of fatty acids at considerably higher training intensities. This concept lends well to the idea of endurance and ultra-endurance exercise and physical performance where exercise intensity for such long durations leans towards moderate intensity to sustain continuous activity for so long. Both moderate intensity and long duration exercise provide favourable cellular conditions to rely upon fatty acids as the significant fuel source instead of carbohydrates.

Research has sought to determine whether fat-adapted athletes who had been consuming HFLC for at least 5-14 days had a performance advantage over those consuming the traditional high carbohydrate dietary approach. The benefits of HFLC in this scenario are

1. Fuel exercise with the largest stored source of energy instead of limited glycogen.
2. Minimal risk of bloating and digestive distress due to fewer starchy fibrous foods.
3. Performing at a slightly lower body weight due to reduced glycogen storage and thus less water retention to maintain glycogen stores.
4. Preserve the reduced glycogen storage for higher intense bursts of exercise e.g. sprint finish.

In summary, scientific research to date indicates that fat-adapted athletes exercising at moderate intensities (50-80% maximal intensity), similar to typical endurance and ultra-endurance training intensities, can perform to a virtually identical level as athletes following a high carbohydrate dietary protocol. Despite the similar performance numbers, some additional considerations do impact HFLC dieters.

Higher-level exercise and performance at >85% intensity in HFLC athletes does result in a decreased capacity below that of high carbohydrate fed athletes. This is not too much of a surprise as such higher intensities push metabolism even more dominantly towards carbohydrate fuelling and glycolysis. Being fat adapted cannot fuel glycolysis, which is completely carbohydrate dependent. One other observation is that fat-adapted athletes tend to report higher perceived exertion scores than carbohydrate fed athletes for the same relative workload, despite matching the same level of physical performance. Even with both of these additional considerations, HFLC is a very possible alternative option for trained individuals and athletes engaging in endurance exercise and physical performance. It may even provide a valuable benefit to athletes who experience digestive distress from consistently applying high-carbohydrate protocols, by offering some temporary or longer-term relief from uncomfortable symptoms that affect their wellbeing, daily mood, and possibly their performance.

HFLC general guidelines

Applying a high fat low carbohydrate (HFLC) dietary pattern can take some practice and may not come naturally to clients as they shift away from the widely accepted, mainstream higher carbohydrate dietary guidelines. It should be noted that HFLC still emphasizes good quality food with a plentiful supply of micronutrients and fibre. It is not a license to binge on meat and dairy, junk food, or an excessive amount of added fats/oils. HFLC meals can still provide a wide variety of different foods, flavours, and healthy plant produce. It should be noted that the term HFLC has the potential to cover a very wide range of macronutrient ratios. Whether referring to HFLC or HCLF, it is important to remember that the control or central reference point for macronutrient ratios is the standard dietary guidelines. Typical dietary guidelines set carbohydrates at 45-55% calories, protein at 10-15% calories, and fats at 25-30% calories. The necessary dietary adjustments for HFLC or HCLF are made regarding this central reference point.

The following table provides guidance on macronutrient ratios for males and females applying either HCLF or HFLC dietary strategies.

Macronutrient ratios

70kg Male: 2500 kcal/day

	Carbs	Protein	Fats
High carb LF:	55 - 75% 344-469g	9 - 12% 56-75g	15 - 25% 42-69g
Standard:	45 - 55% 280-344g	10 - 15% 70-84g	25 - 30% 69-84g
High fat LC:	15 - 30% 94-188g	15 - 20% 94-125g	40 - 60% 111-167g

58kg Female: 2000 kcal/day

	Carbs	Protein	Fats
High carb LF:	50 - 70% 250-350g	9 - 12% 45-60g	20 - 30% 44-67g
Standard:	45 - 55% 225-275g	10 - 15% 50-75g	25 - 30% 55-67g
High fat LC:	10 - 25% 50-125g	15 - 20% 75-100g	45 - 65% 100-144g

HFLC principles for performance

The scientific evidence supporting a HFLC dietary approach is not as robust and as well developed as the evidence in support of a high-carbohydrate approach. As discussed, there is promising scientific evidence suggesting that HFLC diets are a potential alternative for endurance exercise. The detailed specifics are not as clear cut as the traditional carbohydrate approach. Taking this into account, the guidelines included here will take the form of more generic HFLC principles supported by science, rather than exact protocols.

- Performance benefits for an HCLF diet have primarily been observed in trained athletes/individuals - there is not enough valid evidence to suggest the same benefits are available to less active and sedentary individuals with lower fitness levels.

- HFLC diets require 40-65% total fat calories and 15-30% total carbohydrate calories to stimulate a shift away from glucose driven aerobic energy production and to upregulate fatty acid-driven beta-oxidation pathways.
- Upregulation of fatty acid oxidation requires between 5-14 days to occur through the use of a carefully tracked HFLC diet.
- Fully fat-adapted athletes are capable of sustaining the energy demands of long-term endurance exercise intensities between 50-80% of maximal effort without loss of performance. Actual performance will depend upon fitness level and individual responsiveness to an HFLC diet.
- HFLC diets lead to reduced glycogen storage in muscle and liver. For 24 hours before an event or an important competitive performance, fat-adapted athletes may consume a higher carbohydrate diet (45-55% kcal) similar to the standard dietary guidelines to replenish depleted glycogen stores. This enables glycogen availability for high-intensity sprint performance without negating the full benefits of elevated fatty acid oxidation.
- HFLC adapted athletes can match physical performance compared to HCLF athletes, but they typically perceive exercise intensity slightly higher and may need support and encouragement to manage the increased psychological challenge.

Micronutrients for endurance exercise

Physical activity increases the metabolic demands upon the body. This means that energetic reactions must occur at a faster pace. The enzymes, cofactors and nutrients involved in energy production will be required and utilised at a faster pace too. The more frequent exercise takes place, the longer the training sessions last, and higher the endurance intensity performed, the greater will be the need for vitamins, minerals and phytochemicals to sustain metabolic health, optimal energy production, and physiological well being. The following tables (ISSN 2018) outline the most important micronutrients for endurance exercise and their scientifically-backed recommendations.

Micronutrient	Daily dose	Scientific research findings
Vitamin C	75-90 mg/day	In well-nourished athletes, vitamin C supplementation does not appear to improve physical performance. Some evidence indicates high dose vitamin C supplementation, following intense exercise, may decrease risk of upper respiratory tract infections.
Vitamin D	5 μg/day	Together with calcium may help prevent bone loss in athletes susceptible to osteoporosis, but vitamin D does not directly enhance exercise performance.
Vitamin E	15 mg/day	Numerous studies show supplementation can decrease exercise-induced oxidative stress. It may reduce red blood cell damage and improve oxygen delivery to the muscles, more particularly at higher altitudes.
Vitamin K	90-120 μg/day	High level supplementation in female athletes has been shown to increase bone growth/remodelling markers suggesting improved bone health.

Micronutrient	Daily dose	Scientific research findings
Calcium	1000 mg/day	Calcium supplementation may be beneficial in populations susceptible to weak bones or osteoporosis, but provides no ergogenic effect on exercise performance.
Phosphorus	700 mg/day	Well-controlled research studies report that sodium phosphate supplementation (4 g/d for 3 d) improves the aerobic energy system for endurance exercise. There is no ergogenic value of other forms of phosphate.
Zinc	8-11 mg/day	Studies indicate that high level zinc supplementation (25 mg/d) during training minimises exercise-induced changes in immune function.

Key learning points: Chapter 4 Dietary strategies for endurance exercise

Macronutrients are utilised to convert their energy to the universal energy currency in the body called adenosine triphosphate (ATP).

- Oxidative phosphorylation (glucose) and beta-oxidation (fatty acids) are both aerobic energy pathways that produce ATP within the mitochondria of the cells in the presence of oxygen.
- Glycolysis (glucose) and phosphocreatine are both anaerobic pathways that produce ATP at a high rate within the cytoplasm of the cell, and neither pathway requires oxygen to be present.
- Multiple factors determine the dominant fuel that is used by the cells to produce aerobic ATP, including

- Exercise intensity - low intensity (<46%) is fuelled primarily by fatty acids, whereas higher intensity (>55%0 is fuelled primarily by carbohydrates.
- Exercise duration level - longer duration (>90-120 minutes) shifts energy production towards more fatty acid reliance.
- Fitness level - increased fitness leads to a higher crossover point where the body shifts towards dominant carbohydrate oxidation.
- Gender differences - the female crossover point averages ~5% higher than males amongst the general public. The difference is less obvious in trained athletes.
- Dietary preferences - emphasising fat or carbohydrate within a diet will shift cellular oxidation in the direction of the more dominant dietary component.

Benefits of a High-carbohydrate low-fat approach include:

- Elevated muscle and liver glycogen stores are readily available for oxidation.
- Easily transportable fluid-based carbohydrates to utilise during a performance.
- Many natural carbohydrate foods come with other beneficial nutrients such as vitamins, minerals and fibre.

- It is important to understand and be aware of the various options for applying an HCLF diet, review these carefully within Chapter 4.
- Benefits of a high-fat low carbohydrate approach include

- Increased reliance upon our largest natural source of energy, ie. body fat.
- Decrease digestive discomfort that is sometimes brought on by elevated carbohydrate intake.
- Maintaining a slightly lower body weight due to a reduction in water-based glycogen storage.
- Fatty acid oxidation spares Ltd glycogen stores making them available for high-intensity bursts required to write physical performance.

It is important to understand and be aware of the various principles for applying an HFLC diet, review these carefully within Chapter 4.

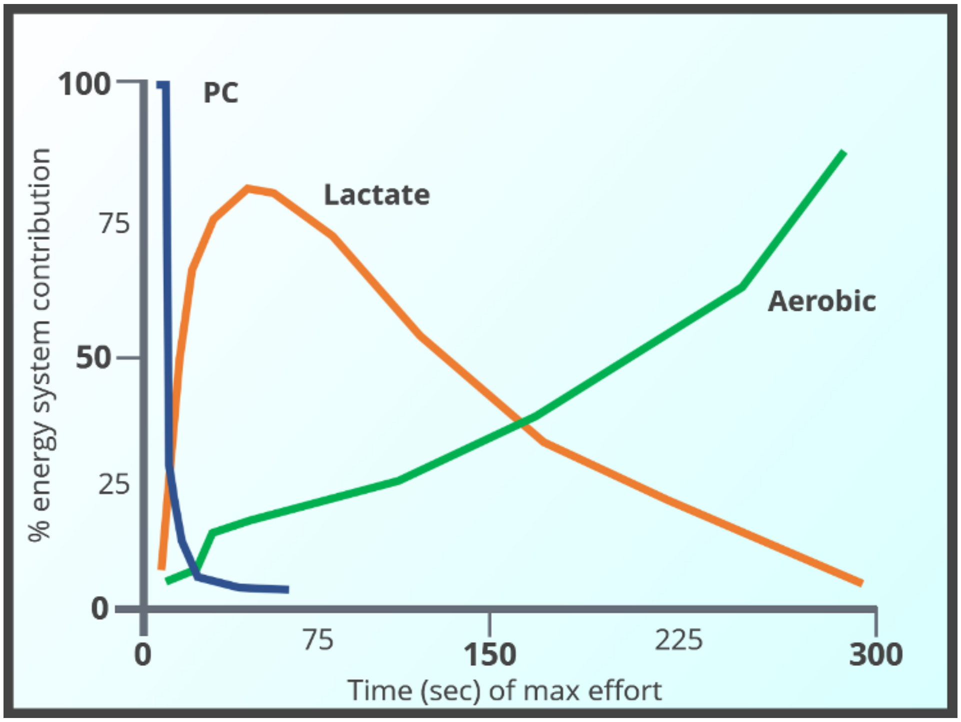
Chapter 5: Dietary strategies for high-intensity exercise

Before a discussion regarding the dietary strategies for high-intensity exercise can take place, it is important to first define the different types of higher intensity exercise and sporting performance that will likely inform a potential dietary strategy. A simple method is that high-intensity exercise can be broken down into two major categories:

1. Single bout high-intensity exercise e.g. a maximal sprint in athletics or a single maximal set of 8 repetitions during a barbell squat.
2. Repetitive bout high-intensity exercise e.g. many team sports such as soccer, hockey, rugby, and basketball, an interval training session, or applying a circuit training protocol to an exercise session.

A dietary strategy can be successfully determined by first looking at the energy systems profile of the exercise or sporting activity that needs to be fuelled. By identifying the aerobic or anaerobic demand it will help to inform the fuels that should be consumed. It may be an oversimplification to assume that all high-intensity exercise only Focuses on anaerobic energy production. It must be remembered that most high-intensity sporting activities are repetitive bursts of high activity followed by active or complete rest. Whether rest periods involve low-level activity or include complete stationery rest, the body will switch back to aerobic energy supply to recover the anaerobic substrates that have been burned during the high-intensity burst. Therefore, the aerobic energy system is very much involved in many high-intensity activities as the primary recovery support.

Within anaerobic performance, there are also differences based on the degree of lactate energy required or phosphocreatine energy required. The energy demands for a game of basketball or soccer are different to the energy demands of sports like baseball, cricket, or golf. Many sports have a continuous, moderately active component with large bursts of explosive energy interspersed throughout, whereas other sports have a start-stop nature with repetitive explosive demands followed by periods of complete rest. Understanding the intermittent energy demands and the different energy profiles of different sports or activities can help to plan an effective dietary strategy that is well matched to the expected energy usage of the desired activity or sport.



Sports or activities that require continuous ongoing activity with repetitive, medium duration, high-intensity bursts followed by reduced intensity, active recovery will dictate higher carbohydrate usage through glycolysis (lactate) and high aerobic systems. Carbohydrate-rich dietary strategies will be needed to underpin the staple diet and for refuelling during activity.

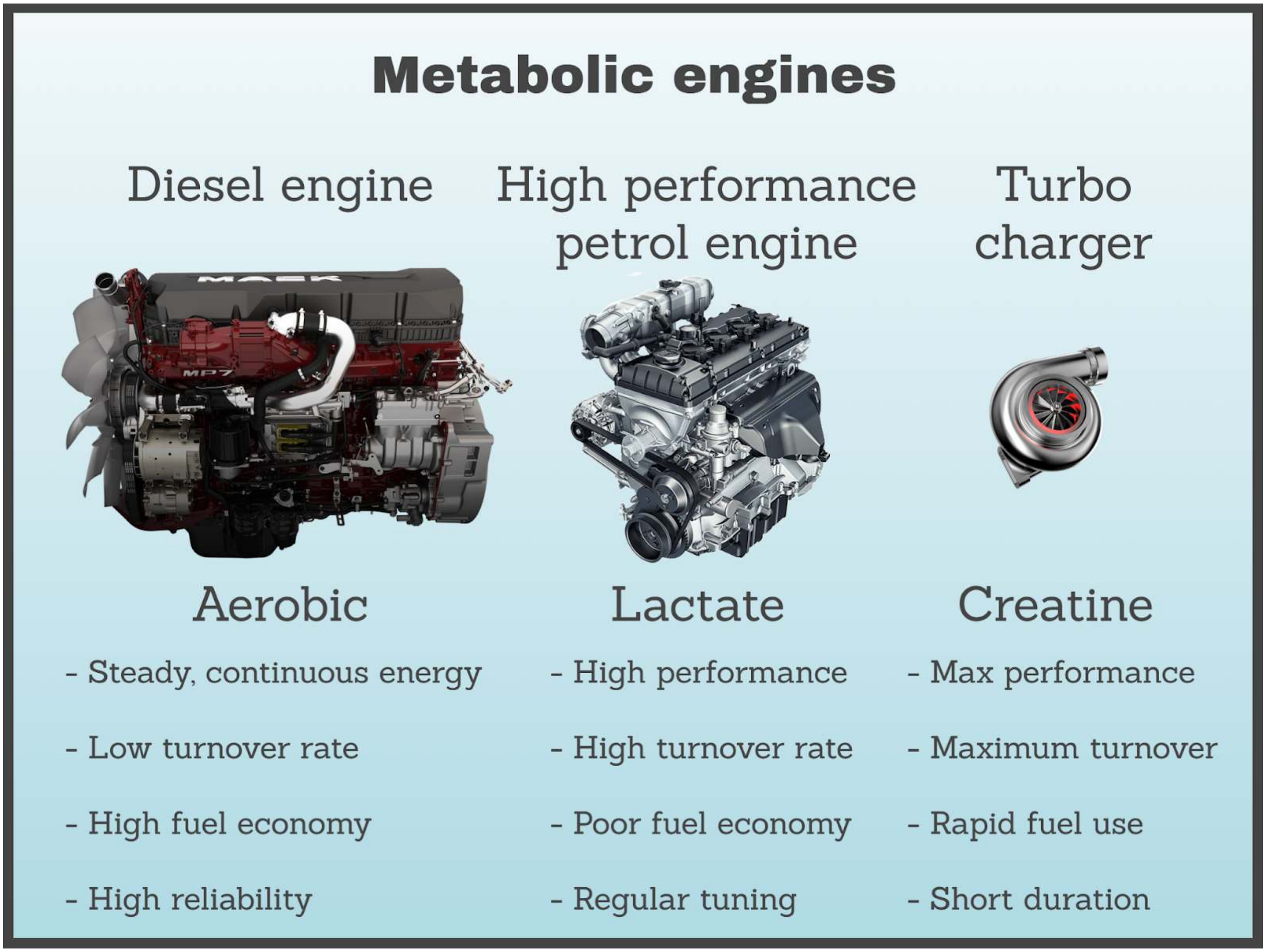
Sports or activities requiring repetitive, short explosive bursts separated by static rest in between, will rely on phosphocreatine to supply the working energy with the aerobic system providing recovery, and very little need for lactate energy production. Diets emphasising moderate carbohydrate and fat intake are effective for refuelling exercise of this nature.

The following table provides generalised guidance for the different energy demands of a range of different anaerobic-oriented sports/activities.

Sport/Activity	Activity type	% Phosphocreatine	% Lactate	% Aerobic
Olympic weightlifting	Explosive bursts & static rest	98%	0%	2%
Golf swing	Explosive bursts & low activity rest	95%	0%	5%
American Football	Explosive bursts & static rest	85%	10%	5%
Baseball	Explosive bursts & static rest	80%	15%	5%
Volleyball	Explosive bursts & static rest	80%	5%	15%
Tennis	High-intensity bouts & inactive rest	70%	20%	10%
Basketball	High-intensity bouts & active recovery	60%	20%	20%
Field hockey	High-intensity bouts & active recovery	50%	20%	30%
Soccer	High-intensity bouts & active recovery	50%	20%	30%

Metabolic effects of repetitive exercise

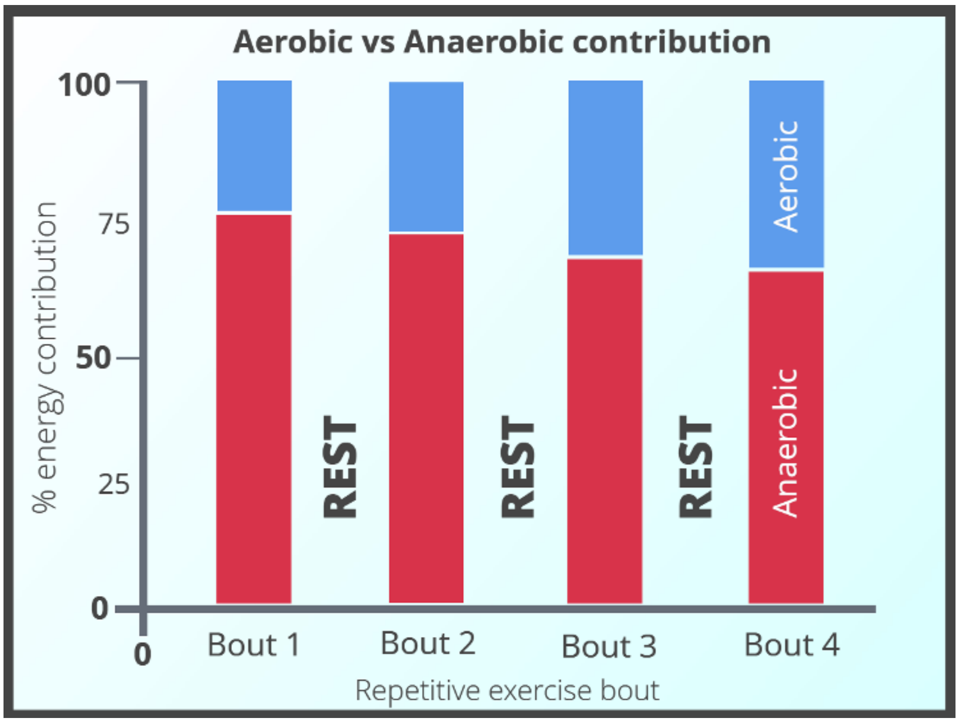
It is relatively easy to scientifically identify the energy systems involved in a single bout of intense exercise. This has enabled exercise science to identify that very short bursts of maximal intensity exercise (95-100%), between 6-15 seconds in length, are almost exclusively fueled by the phosphocreatine system. It is also well known that higher intensity bouts of exercise (70-95%) lasting from 30 seconds to 5 minutes in length are primarily fuelled by anaerobic glycolysis (lactate energy system). However, when these same high-intensity exercise workloads are repeated back-to-back with short rests in between, exercise scientists have found that the energy dynamics do not repeat like-for-like throughout the repetitive bouts.



There is a gradual shift in the energy profile for successive, repeated bouts of intense exercise. This is because the aerobic energy system is always active in the background and never stops producing ATP under aerobic conditions in the cells, no matter the specific energy profile of an intense burst of physical activity.

A maximal or high-intensity bout of exercise stimulates a rapid increase in heart rate and breathing, even though the cells are producing the majority of ATP without specifically using oxygen in that given moment. The rapid increase in heart rate and breathing quickly increases the oxygen supply into the body which continues for a period beyond the end of the bout of intense activity. This can be easily observed after a maximal burst by the sustained, rapid breathing rate that continues for 1-2 minutes into a static rest period.

This compensatory oxygenation response not only restores the oxygen needed to replenish spent ATP and alleviate lactate build-up, but it also increases blood and tissue oxygen saturation levels for a short period after the exercise burst. This can be seen as oxygen super-compensation. There exists a slightly elevated oxygen supply, above the resting norm within the muscle tissues, in readiness for a repeat bout of similar intensity activity.



This adaptation results in a greater energy contribution from the aerobic system in the 2nd bout and subsequent high-intensity bouts that follow. Oxygen super-compensation is true for repetitive maximal bouts and also for repetitive high-intensity (lactate) bouts of exercise/activity. As a result many high-intensity, repetitive sports or exercises derive more of their overall energy from the aerobic system than has been traditionally expected.

Dietary principles for high-intensity training

Whilst the dietary guidelines and recommendations for continuous endurance exercise are very well researched and established in the scientific literature, the dietary recommendations and guidelines around high-intensity exercise have not been given the same level of research and rigour.

Most often the dietary recommendations for high-intensity exercise simply default to the standard guidance given for general sports nutrition. There is rarely any clarification between the different types of high-intensity exercise and the potential variation in energy system needs.

The following principles will help to direct some adaptations and adjustments for consideration when providing dietary recommendations for those engaging in high-intensity exercise or sports.

- Determine the energy demands of the exercise/sport and allocate it to one of the 3 main categories:
    1. A single bout of high-intensity exercise or maximal physical performance.
    2. Repetitive, maximal short bursts of exercise/activity with static rest for recovery between bursts.
    3. Repetitive, high-intensity exercise/activity with low-moderate active recovery to alleviate lactate between bouts.
- Apply an appropriate set of dietary principles to the individual engaging in the high-intensity exercise/activity - track behaviour change, dietary response, and ongoing performance to adjust and adapt to meet the needs of the client.

Category A: Single bout of high-intensity exercise/activity

- Exercise duration will usually be <45 minutes and therefore dietary strategies need only focus on pre and post-exercise requirements. No refuelling is needed during exercise.
- Calculate and meet individual active and rest day caloric needs.
    - **General:** consume 6-10 g/kg carbohydrates per day, meet bodyweight-oriented daily protein requirements, and consume between 20-30% calories as dietary fats. Eat a varied diet to optimise micronutrient sufficiency.
    - **Rapid refuelling between events** with <8 hr recovery: consume 1.0-1.2 g/kg of carbohydrates using small snacks and fluids up to 4 hours after the first event, then return to general daily guidelines above.
    - **After:** return to the general dietary guidelines above to replenish glycogen and phosphocreatine stores as needed.
- Apply these principles before and after exercise performance.

Category B: Repetitive, maximal burst, static rest

- Exercise and/or competition lasting >45 minutes up to several hours will require a nutritional strategy before, during and after exercise performance.
- Static rest periods will result in lower heart rates (<50% max) throughout the overall performance, which will shift metabolic recovery towards great fatty acid oxidation and less carbohydrate oxidation - dietary guidelines should reflect this greater emphasis on fatty acid oxidation.
- Calculate and meet individual active and rest day caloric needs.
    - **General:** Consume 45% calories from carbohydrates with 35% dietary fat and include bodyweight-oriented daily protein requirements. Eat a varied diet to optimise micronutrient sufficiency.
    - **During:** If training or competition exceeds 90 minutes, replace depleted glycogen, water and electrolytes by consuming an isotonic drink (5-8% solution) at a rate of 30-60 g/hour spread across regular intervals. Alternatively, a hypotonic drink (2-4% solution) with electrolytes and an easily digestible, carbohydrate-rich food may be consumed during rest periods instead.
    - **After:** If future exercise or competition is beyond 24 hours, then return to the general dietary guidelines above to replenish glycogen and phosphocreatine stores as needed.

Category C: Repetitive, high intensity, active recovery

- Intense exercise and/or competition lasting 45-120 minutes will require a nutritional strategy before, during and after exercise performance.
- Active recovery periods will result in higher average heart rates (>50% max) throughout the overall performance, which will shift metabolic energy output towards more sustained carbohydrate oxidation and less fatty acid oxidation - dietary guidelines should reflect this greater emphasis on carbohydrate oxidation.
- Calculate and meet individual active and rest day caloric needs.
    - **General:** Consume 50-60% calories from carbohydrates with 25% dietary fat and include bodyweight-oriented daily protein requirements. Eat a varied diet to optimise micronutrient sufficiency.

- **During:** Replace depleted glycogen, water and electrolytes by consuming an isotonic drink (5-8% solution) when appropriate rest periods or gaps in activity permit. If there is a halftime or mid-exercise break, consume hydrating fluids and small, easily digestible carbohydrate snacks that do not cause digestive discomfort during exercise.
- **After:** Prioritise re-hydration needs. Consume a small 100-200 calorie carbohydrate snack <2 hours of cessation of exercise. If future exercise or competition is beyond 24 hours, then return to the general dietary guidelines above to replenish depleted glycogen and phosphocreatine stores as needed.

Key learning points: Chapter 5 Dietary strategies for high-intensity exercise

The energy demands of a sport or targeted exercise objective should be analysed before dietary guidelines are provided. Energy demands should be identified according to the 3 categories:

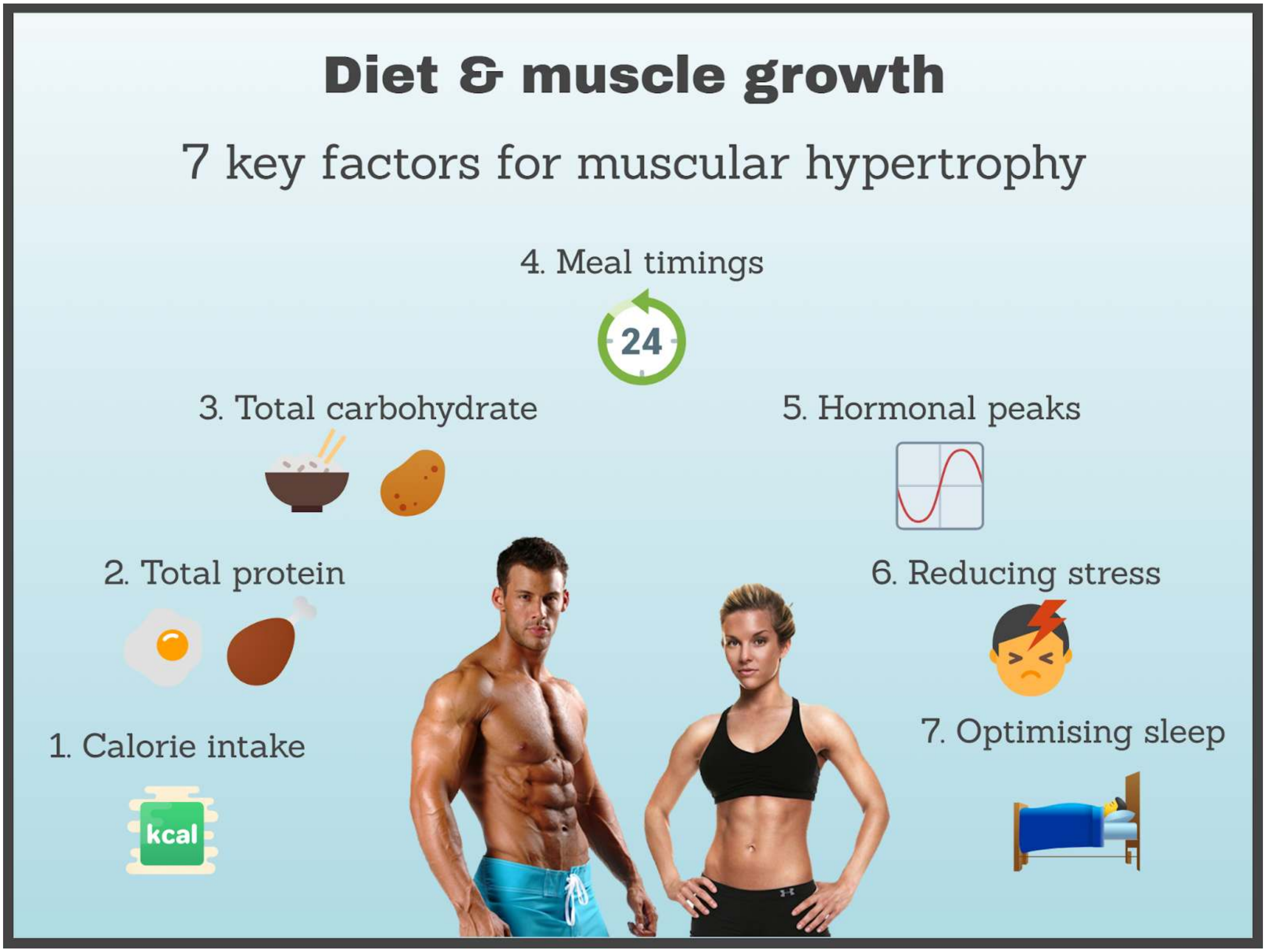
- Single bout of high-intensity activity
- Repetitive, maximal burst, with static rest
- Repetitive, high-intensity bouts, with active recovery

Dietary needs should be determined based upon the metabolic energy demands of the activity, the daily calorie requirements of the individual, and the overall duration of the activity.

- All forms of sport/activity will need appropriate and relevant dietary guidelines for before and after physical activity.
- Short duration activities do not need refuelling during the performance, only rehydration.
- Longer duration activities need a suitable plan for refuelling appropriately to fit with the work-to-rest nature of the activity.

Chapter 6: Dietary strategies for muscular hypertrophy

Muscular hypertrophy is an increase in the volume and cross-sectional area of a muscle. Beyond bodybuilding, which is purely focused on muscle size and appearance, many sports and activities can benefit from an increase in muscular hypertrophy due to the performance benefits that often accompany such a change, such as, increased strength, increased power, and greater total bodyweight. Muscular hypertrophy will occur when a stimulus for muscle growth harmonises with the provision of nutritional needs to optimise sustainable and ongoing levels of muscle protein synthesis (MPS). Naturally, a protein-rich diet will be important to the achievement of sustained MPS, but it is not the whole story, there are several other considerations to take into account.



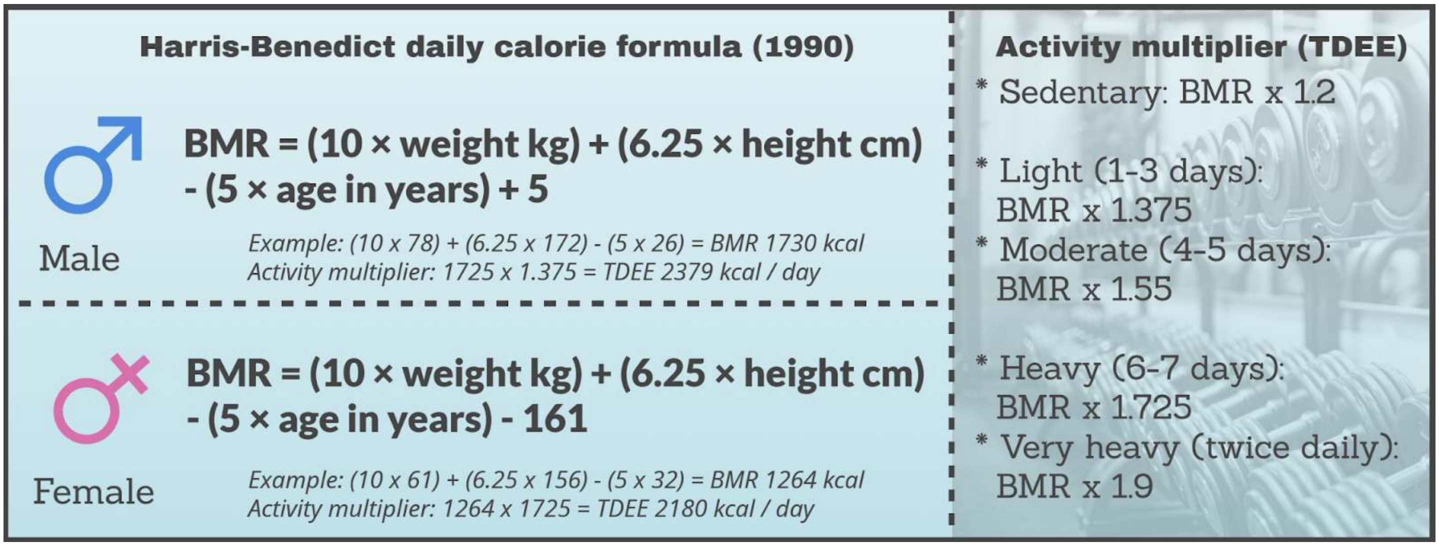
There are at least seven important considerations to account for when planning a dietary approach to support the development of muscular hypertrophy.

1. Calorie intake

Evidence suggests that an excess of dietary calories is necessary to optimise muscle protein synthesis (MPS), and therefore, muscular hypertrophy. The excess of calories should not become extreme or it will risk spilling over and causing body fat and adipose tissue to increase, which is rarely the intended goal. Therefore, it is necessary to calculate an individual's daily calorie requirements and carefully control the small excess of calories required to ensure there is sufficient spare to fuel the metabolic cost of muscular growth and repair. Current guidelines, in line with accepted science, indicate that appropriate dietary excess should be between 350-500 calories to provide sufficient support towards MPS. Care should be taken to ensure accuracy in achieving this calorie excess. To manage calorie excess accurately, basic daily calorie requirements need to be determined.

Calculating a good estimate of daily calorie needs first requires the determination of basal metabolic rate (BMR). This is defined as the minimum energy requirement of the body when activity, movement, and digestion are eliminated. BMR can only truly be measured after 12 hours of fasting, 24 hours without exercise, and under conditions of complete rest immediately following a full nights sleep before any other physical activity or movement is performed. Despite sounding similar, BMR should not be used interchangeably with resting metabolic rate (RMR) as it is a less rigid measure. RMR is the energy used by the body when at rest after 12 hours without any exercise or physical activity, but it does not require a fasted state, nor a full 8 hours sleep.

BMR can be estimated using the Harris-Benedict formula (1990) which has been shown to have an accuracy of +/-0.9% in lean subjects, decreasing to +/-9.1% in obese subjects and is considered the most reliable and accurate equation predictor of BMR. Once BMR is calculated then it can be factored against an activity multiplier based on exercise frequency and intensity to estimate total daily energy expenditure (TDEE). The following panel shows examples of male and female BMR and TDEE calculations. It will be beneficial to use an example of a fictitious client to help illustrate and apply these principles and tools. The example client, named Paula, is a 32-year-old, 61 kg, female physique competitor. Paula’s BMR and TDEE is shown below.



Once the correct maintenance TDEE has been calculated, then the additional excess calorie requirement of 350-500 kcal can be added to the TDEE value to ensure sufficient energy availability to invest into MPS and muscular hypertrophy over time. Returning to the example of Paula, the 61 kg female athlete indicated above, with the inclusion of a 350 calorie excess, her daily calorie needs to support a 6-day intense hypertrophy training programme would require 2530 kcal/day (TDEE 2180 + 350). Once calorie needs are established, then the next stage is to determine the breakdown of macronutrients that will comprise the calorie total, especially the protein and the carbohydrate requirements in line with recommendations.

2. Total protein

Following a resistance training session, in the absence of post-exercise food consumption, research shows that muscle protein balance remains negative and there is a loss of muscle tissue. This single point helps to highlight the importance of food consumption in conjunction with resistance training. Muscle growth and development can only occur under conditions of positive protein balance. In chapter 2, macronutrients, the importance of regular protein consumption for the body was clearly explained along with protein intake requirements for various activity levels. Dietary protein and resistance training have been scientifically studied for many years and there is a vast volume of research on the topic.

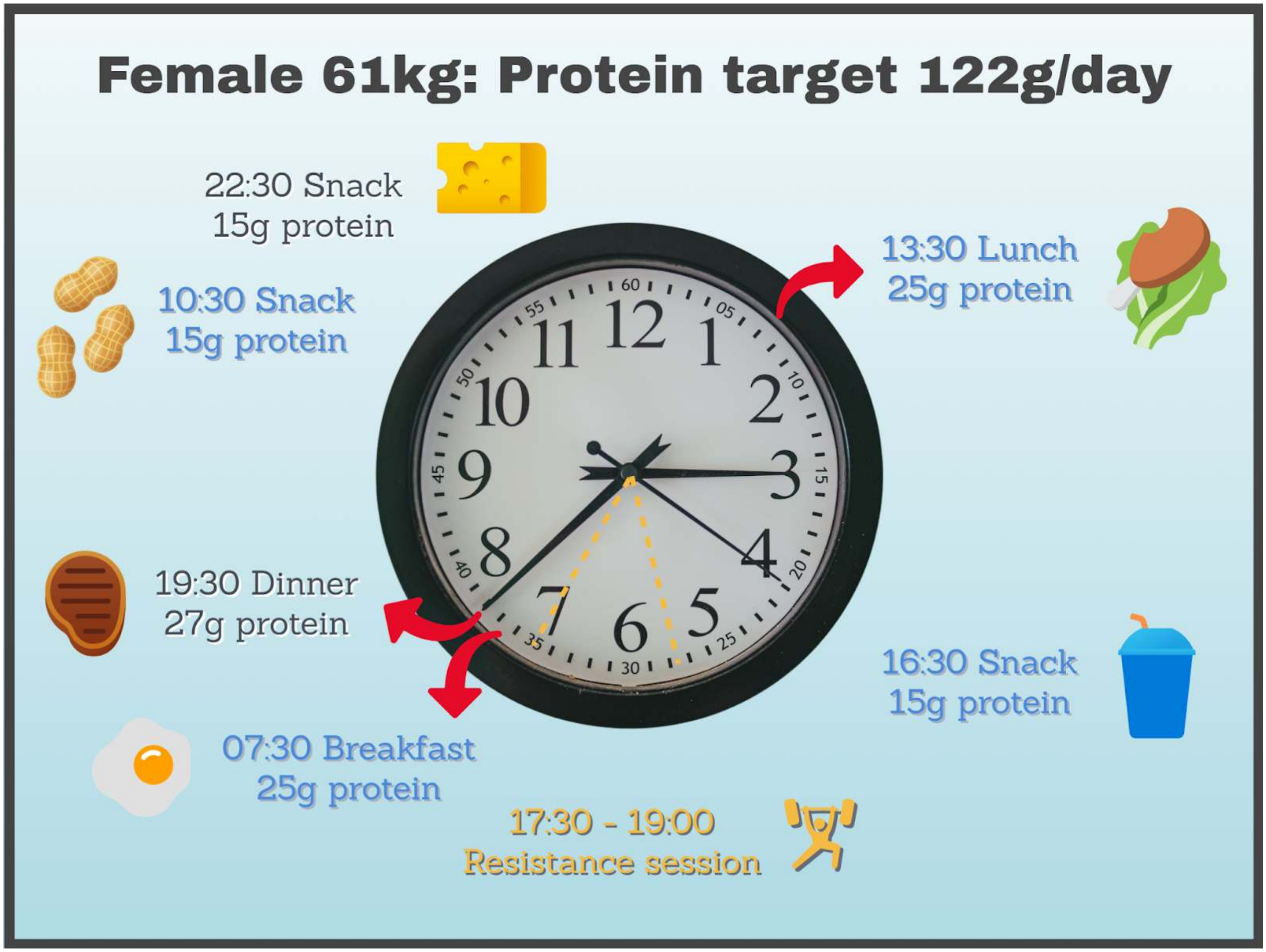
The following key points regarding dietary protein help to summarise the major findings of the scientific literature on the topic and therefore should be factored into individual dietary recommendations:

- Skeletal muscle is sensitised to the effects of dietary protein uptake and MPS for up to 24 hours after a bout of resistance training.
- General protein consumption for regular exercisers and athletes should be between 1.4-2.0 g/kg/day.
- Acute protein intake is recommended at 0.25g/kg body weight, or an absolute intake of 20-40g per dose.
- Spacing acute intakes between 3-4 hours apart across the day has been found to help promote MPS more effectively.
- Consumption of carbohydrates with protein after resistance training can help to restore muscle glycogen and may help mitigate cellular muscle damage.
- Including highly bioavailable protein-rich food sources that are rich in essential amino acids (between 6-15g EAA), especially leucine (1-3g), have been shown to help maximise rates of MPS.
- There is some evidence that pre and post-exercise protein feedings may provide a minimal contribution towards improved MPS.
- Total protein and sufficient total calorie consumption are by far the most important predictor of positive hypertrophic response to resistance training.
- In most healthy resistance-trained individuals or athletes, higher intakes are not necessary, but it is worth noting that long-term safety studies investigating higher intakes of protein between 2.5-3.3 g/kg/day found that increased consumption appears to exert no harmful effects on cholesterol markers, kidney or liver function.

It is important to be able to translate the guidelines into actionable daily objectives that can be achieved in a step by step manner. The guidelines will be applied by returning to the example of Paula, the female physique competitor to help illustrate how to plan in accordance with these recommendations.

Paula trains 6 days per week, so it is appropriate to apply the upper intake of 2.0 g/kg/day of dietary protein. This accounts for 122g protein (61kg x 2) or 488 kcal (19%) out of her daily calorie target of 2530.

Paula's relatively high 122g daily protein consumption can be spread across 3 meals and 3 snacks as follows:



Paula will eat a variety of different high-quality protein sources rich in EAA to help maximise MPS including eggs, cheese, lean beef, chicken, fish, pork, duck, pistachios, peanuts, almonds, pumpkin seeds, whey and casein protein powders.

3. **Total carbohydrate**

Carbohydrates play an important part in fuelling resistance training sessions, but the level of importance may not be as significant as it is for endurance athletes who often engage in long-duration glycogen depleting activities. However, there is value in including carbohydrates in the diet as a macronutrient to balance protein and fat consumption. This will typically be in the range of 45-60% of daily calories once protein (g/kg) and 20-30% dietary fat has been accounted for.

This level of carbohydrate is more than sufficient across a 24-hour period to maximise muscle glycogen stores and ensure the muscles have the fuel they need to invest in each planned resistance session.

Resistance training sessions are rarely glycogen depleting, though they may feel exhausting due to lactic acid build-up that is common in high repetition, high volume sessions. Typical hypertrophy focused training will target an exercise intensity of 70-85%, with moderate volume (6-9 sets per muscle). However, such training has only been found to decrease muscle glycogen by 36-39%. This is a long way from glycogen depletion and, therefore, carbohydrate refuelling during and immediately after a resistance session has been found to offer little performance or recovery benefit, especially when suitable pre-exercise nutrition practices are in place. The inclusion of carbohydrates during or immediately after a resistance session does not have an increased impact on muscle protein synthesis (MPS) when an optimal protein dose of 20-25 g has been consumed.

"...based on the available clinical data, there is no evidence that the addition of carbohydrates to a protein supplement will increase, acutely, muscle protein synthesis and, chronically, lean body mass, to a greater extent than protein alone..."

Figueiredo & Cameron Smith (2013)

Thus, the primary objective of consuming regular carbohydrates is to ensure muscles are well fuelled with glycogen to invest into each resistance training session. This can be accomplished without any need to adapt the standard activity guidelines specific to dietary carbohydrates.

If this is applied to our example athlete, then a daily total carbohydrate intake of 50-60% of calories spread across the day as part of her 3 major meals and smaller snacks will be perfectly sufficient. Paula's carbohydrate needs, based upon her total daily calorie requirements, are 1265 kcal (316 g) - 1518 kcal (380 g) per day. A macronutrient balancing 51% carbohydrate (323 g) requirement can be spread across the day and become part of the daily meals/snacks that are already planned for protein consumption.

The following example illustrates how the carbohydrate dietary requirement may be factored into a typical day along with protein needs. The total daily calorie target is 2530 kcal.

- 7:00 am - wake up
- 7:30 am - breakfast 25 g protein + 80g carbohydrate + 20 g fat
- 10:30 am - mid-morning snack 15 g protein + 25 g carbohydrate + 8 g fat
- 1:30 pm - lunch 25 g protein + 80 g carbohydrate + 20 g fat
- 4:30 pm - mid afternoon snack 15 g protein + 25 g carbohydrate + 8 g fat
- 5:30 - 7:00 pm - resistance training session
- 7:30 pm - dinner 27 g protein + 87 g carbohydrate + 20 g fat
- 10:30 pm - 1-hour pre-bedtime snack 15 g protein + 25 g carbohydrate + 8 g fat
- 11:30 pm - go to sleep

- Total protein: 122 g (19% calories)
- Total carbohydrate: 323 g (51% calories)
- Total fat intake: 84g (30% calories)
- Actual calorie intake: 2539 kcal

4. Meal timings

It is common within a hypertrophy dietary plan to find the inclusion of specific meals or food supplements timed around resistance training with the intention that this will elicit a training benefit and improve muscle protein synthesis (MPS). Numerous studies have taken an acute, short-term view of the impact of only protein, or protein & carbohydrate consumption immediately before or after a resistance training session. These studies have shown a positive impact on short-term MPS. This seems to justify the inclusion of such dietary measures. There is certainly no evidence that food or supplement inclusion at these times causes any negative impact. However, the vast majority of research that has taken a longer-term view on the impact of timing protein/carbohydrate consumption close to resistance training has failed to find a clear benefit in terms of strength gains, body composition changes, or lean muscle mass development. This is likely due to a much larger potential anabolic 'growth' window of time than previously thought. Unlike carbohydrates and glycogen restoration which is sensitised and can be replenished more rapidly in the hours following a training session, the same type of response does not appear to be relevant to protein. The bulk of evidence seems to point towards total protein intake across 24-hours as being the primary determinant of positive muscular hypertrophy and increased lean muscle mass over time.

Timing meals immediately around resistance training is not detrimental, even if there is no clear long-term hypertrophy benefit for this behaviour. If an individual feels it benefits their workout then there is no rationale to prevent it. Not eating certainly offers no benefit to muscular hypertrophy. If this dietary or supplemental practice is included, it may be best to include both protein & carbohydrate to benefit glucose/glycogen availability during the workout and to promote glycogen replacement after the session. However, the focus of the nutrition coach should be firmly on spreading the total daily protein requirement evenly (every 3-4 hours) across regular meals/snacks during the waking hours of the day. Regarding meal timings, this action has been found to have the greatest influence on long-term muscle gain.

5. Hormonal peaks

Consuming sufficient protein in the diet does not immediately result in muscular growth. The internal biological control systems will govern where proteins are distributed around the body and how they will be effectively utilised. There is a range of hormones that influence the resulting outcome of proteins and whether they will contribute to muscular growth and repair.

Testosterone has long been connected with increased muscular hypertrophy in response to regular resistance training, with the hormone significantly involved in regulating ergogenic, anabolic, and anti-catabolic processes. Blood levels of testosterone in men typically range from 8-29 nmol/L, but in women, they are much lower between 0.1-1.7 nmol/L. Immediately following a bout of intense resistance training, testosterone levels in men can increase threefold from resting levels ~13 nmol/L up to a peak of ~38 nmol/L within about 30 minutes. Peak testosterone is short-lived and returns to normal resting levels almost as quickly, but the influence of this acute hormonal release has been found to stimulate upregulation of androgen receptors on muscle cells for 1-2 days. This upregulation will likely promote longer anabolic effects which may be responsible for altering protein turnover, slowing muscle breakdown, elevating MPS and ultimately increasing muscle growth.

Individuals who exercise excessively and also have lack dietary zinc are more likely to experience low testosterone. Such individuals can benefit from zinc supplementation. Together with a decrease in exercise volume/intensity, this has been shown to help increase testosterone levels once again. Long-term supplementation with vitamin D has also been shown to help maintain healthy testosterone levels.

Moderate alcohol consumption appears to stimulate a small increase in testosterone levels. However, it should be noted that excessive alcohol consumption has a significant acute impact on decreasing testosterone levels.

Growth hormone is released in 6-8 bursts throughout a 24-hour day with the most significant burst occurring about 1-3 hours into a normal nighttime sleep opportunity, this burst accounting for nearly 75% of total daily growth hormone (GH). Outside of sleep, resistance exercise is the most potent physiological stimulant for GH release in both men and women. GH begins to rise 10-20 minutes into a training session, returning to normal levels about 1 hour after the training session has ended. Whole-body resistance training can increase GH levels 5 times above baseline, whereas applying isolation muscle exercises may only stimulate an increase between 2-2.5 times above base levels. Typical hypertrophy training methods (8-12 repetition sets, 1-2 minute rest) have been shown to increase GH levels more significantly than strength training methods (5 repetition sets, 4-5 minute rest). An increase in GH has a general influence on all types of protein regulation throughout the body, not just muscle proteins, and it is known that GH does not have a direct impact on MPS. The anabolic effects of GH are indirect. GH causes its effects via the stimulation and release of another hormone called insulin-like growth factor 1 (IGF-1). IGF-1 has a more direct impact on MPS and therefore muscle maintenance and growth.

Melatonin has a positive influence on raising growth hormone. Combined with the highest daily GH burst occurring within 1-3 hours of nighttime sleep, this provides a good justification for ensuring that sleep is placed as a high priority for those seeking muscular development. Alcohol consumption has been shown to have an acute depressing effect on GH levels.

Insulin-like growth factor 1 (IGF1) production is controlled primarily by the release of GH, but some other hormones (e.g. thyroid hormones) also play a part. High circulating IGF-1 is strongly associated with increased MPS, formation of protein myofibrils, fatty acid utilisation, and insulin sensitivity. During resistance exercise, IGF-1 levels rapidly increase about 45% above resting levels and then decline within about 30 minutes after the end of the session. Repeated bouts of resistance training over time result in regular bursts of GH and IGF-1 which in turn leads to increased muscle hypertrophy and strength development. In those who are deficient in zinc, supplementation seems to provide a small positive increase in IGF-1.

Oestrogen in females oestrogen has long been connected with regulating skeletal muscle. Circulating oestrogen levels are acutely increased following resistance training, although average baseline oestrogen remains the same over many months despite regular resistance training. Oestrogen has a positive impact on IGF-1 and together these lead to increases in MPS, reduced muscle damage, improved recovery and in the longer-term increased muscular hypertrophy in women. The influence of oestrogen on muscular growth is not as potent as testosterone in males, hence why females do not develop muscle mass as readily as men.

6. Reducing stress

Exercise is a physiological stressor that challenges the system and elicits a hormonal response. The hormones adrenaline and cortisol are released during exercise, including resistance training. Both of these hormones are catabolic and responsible for breaking down energy from carbohydrates, fats, and proteins to supply the energy demands of the natural fight-or-flight mechanism. Unfortunately, these hormones can have a knock-on effect on skeletal muscle tissue. The microscopic trauma and muscle damage that results due to resistance training is also so enhanced by the presence of these and other catabolic hormones. Whilst catabolic hormones are in circulation, the shift towards anabolism, growth and repair is being hampered. This is why it is important to physically provide time for rest and recuperation following a resistance training session. Physical rest, including sleep, along with post-exercise food consumption, are necessary components of the growth and repair process to allow the body to move into an anabolic state.

Physical stress alone is not the only antagonist to muscular growth. Increased psychological and/or perceived stress can negatively impact muscle hypertrophy goals. This is an area where research is somewhat limited, but the studies that have been published confirm that chronic mental stress hinders physical growth and performance gains.

A 2008 research study assessed participant psychological stress, then had all participants undergo a 12-week resistance training programme. The results were measured through changes in barbell squat and bench press performance, as well as gains in arm and thigh circumference. In all categories, the high-stress group made less progress than the low-stress group. The low-stress group made 2.7-2.9% more gains in both bench press and squat performance respectively. There was a 2.6% greater level of improvement in arm circumference and a 1.2% greater improvement in thigh circumference in the lower stress group.

Another study in 2014 looked specifically at recovery from a range of resistance and cardiovascular training tasks while measured against existing participant psychological stress levels. Participants were tracked in their ability to recover as defined by muscle soreness, energy levels and fatigue scores. The lower stress group recovered faster, within 48 hours compared to the higher stress group, which took as long as 96 hours in some cases.

"In all analyses, higher stress was associated with worse recovery."

(Stults-Kolehmainen et al, 2014).

7. Optimising sleep

In studies involving full sleep deprivation it has been found that remaining awake all night and the following day reduces MPS by an average of 18%, whilst also reducing testosterone levels by 24% and increasing the catabolic stress hormone, cortisol. Partial sleep restriction of only 4 hours per night over 5 days has also been found to lower MPS by 19%, a statistically significant level. The short duration of the study limited the ability to see any notable reduction in muscle mass, but suggests that individuals who consistently sleep for short durations (<7 hours per night), may limit their physiological capacity to grow and develop muscle tissue. Therefore, to help maintain GH, testosterone and cortisol levels in their appropriate 24-hour rhythms, it is essential to manage sleep duration and quality accordingly. Maintaining a manageable and regular sleep schedule that allows for 7-9 hours uninterrupted per night is desirable. Minimising light and disruptive noise in the bedroom, together with ensuring a comfortable bed and sleeping environment all go a long way towards assisting with good sleep.

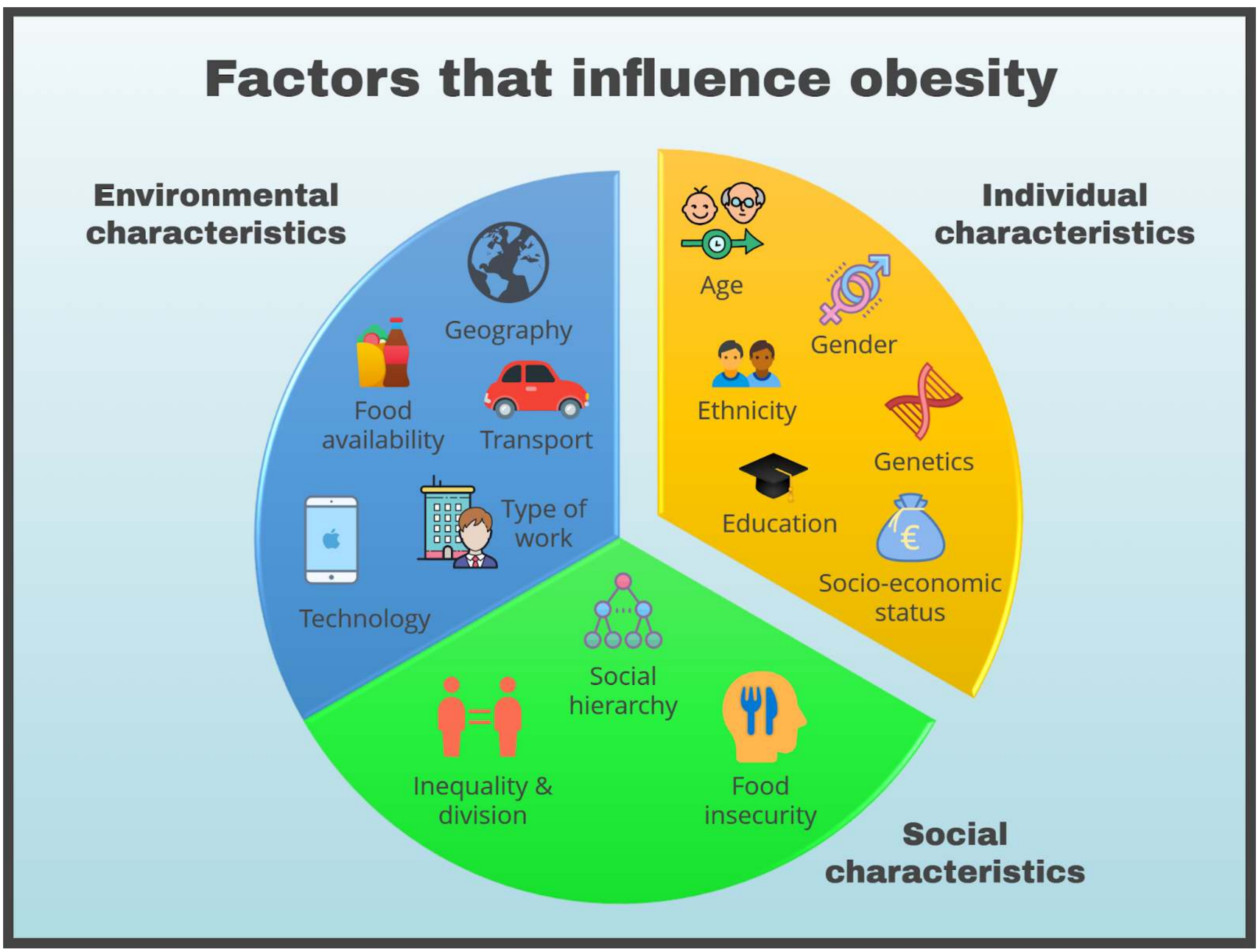
From a dietary perspective, adequate magnesium is the primary nutrient connected with good sleep patterns. Supplementation is most beneficial for sleep in those who have low dietary intake. Supplemental lavender, or even aromatherapy, has also been shown to help those who struggle to sleep effectively.

Key learning points: Chapter 6 Dietary strategies for muscular hypertrophy

- Muscular hypertrophy is reliant upon a regular, modest excess of daily calories (350-500 kcal/day) to ensure that there is an energy surplus to invest into muscle tissue growth and development. Calculate an individual's calorie needs using the Harris-Benedict BMR and TDEE formulas.
- Consuming sufficient total daily protein (typically between 1.4-2.0 g/kg/day) is essential to ensure that there is a steady supply of proteins and amino acids to feed into muscle protein synthesis.
- Single meals/snacks of protein-rich foods do not need to exceed a dose of 20-40g maximum as there is no increase in the rate of muscle protein synthesis with dietary intake above this acute level of consumption.
- The primary benefit of including carbohydrate foods is to ensure adequate fuel to invest in resistance training. Consuming carbohydrates simultaneously with protein does not provide any additional benefit in terms of the rate of protein synthesis or the total amount of protein uptake into muscle cells.
- There is no inherent hypertrophic benefit of timing protein intake alone or combined protein & carbohydrate consumption immediately before, during or after resistance training. There is no harm in this practice, however, the evidence shows that total 24-hour protein consumption is the primary driver of muscular hypertrophy.
- Testosterone, growth hormone, insulin-like growth factor 1, and oestrogen in females are the primary hormones responsible for stimulating the growth and repair of muscle tissue following resistance training and during the recovery period.
- Optimal sleep supports growth hormone production, physical and mental recovery, and sustaining anabolic processes while reducing catabolic effects in the body.

Chapter 7: Dietary strategies for body fat reduction

There are likely many different circumstances in which an individual may require a reduction in body fat, from morbid obesity which threatens someone's health to minor reductions in body fat to help an athlete reach a desirable weight category for competition. Too often the assumption is that regardless of the individual, the method or strategy applied to achieve body fat reduction will be the same. This is an overly simplistic view that relies purely upon the laws of thermodynamics and calorie balance. Successfully achieving a reduction in body fat will usually require an individualised approach that will help to optimise a range of new behaviours that the individual can sustain and adhere to at least long enough to reach the intended target. It is important to understand and appreciate that there is a wide range of factors that influence weight gain and obesity that extend far beyond basic caloric imbalance.



It would be unrealistic to expect a nutrition coach to be able to control and manage all possible factors that may contribute to eating behaviours and the food environment. Lasting weight management will usually require a consistent effort that is maintained over a significant duration of time and, therefore, it does require a certain mindset to be willing to accept the challenge associated with identifying and changing habits and behaviours that have likely led to body fat gain in the first place. This behavioural perspective has led some experts to believe that body fat reduction is primarily a psychological problem where individuals simply need to take control of their habits and behaviours. Behaviour change is certainly an important component but it's not the only component. The strategic actions that are taken to alter dietary consumption, physical activity levels, daily lifestyle habits, the social environment, and family or professional support systems will all play a vital part in finding a way through the maze that is personalised weight management and body fat reduction.

Calories in versus calories out

Perhaps the most fundamental principle that underpins weight management are those that are drawn from the laws of thermodynamics. The first law of thermodynamics simply states that:

'...energy can be neither created nor destroyed, but only transformed.'

The human body is constantly transforming energy in the form of kilocalories by metabolising food within the cells to produce heat and energy. In physics, this first law of thermodynamics strictly refers to heat or energy contained within a closed system. This physical principle does not directly take into account the losses that are common in a biological system, like the human body. The remnants of energy contained in faeces and urine, for example, show that not all food energy consumed is directly absorbed into the system. A scientist called Wilbur Atwater determined around the turn of the 20th century that the total combustible energy available in foods was not the same as the energy available to the body following digestion, absorption, and excretion.

The following table defines these important energetic factors determined a century ago related to the 3 primary macronutrients.

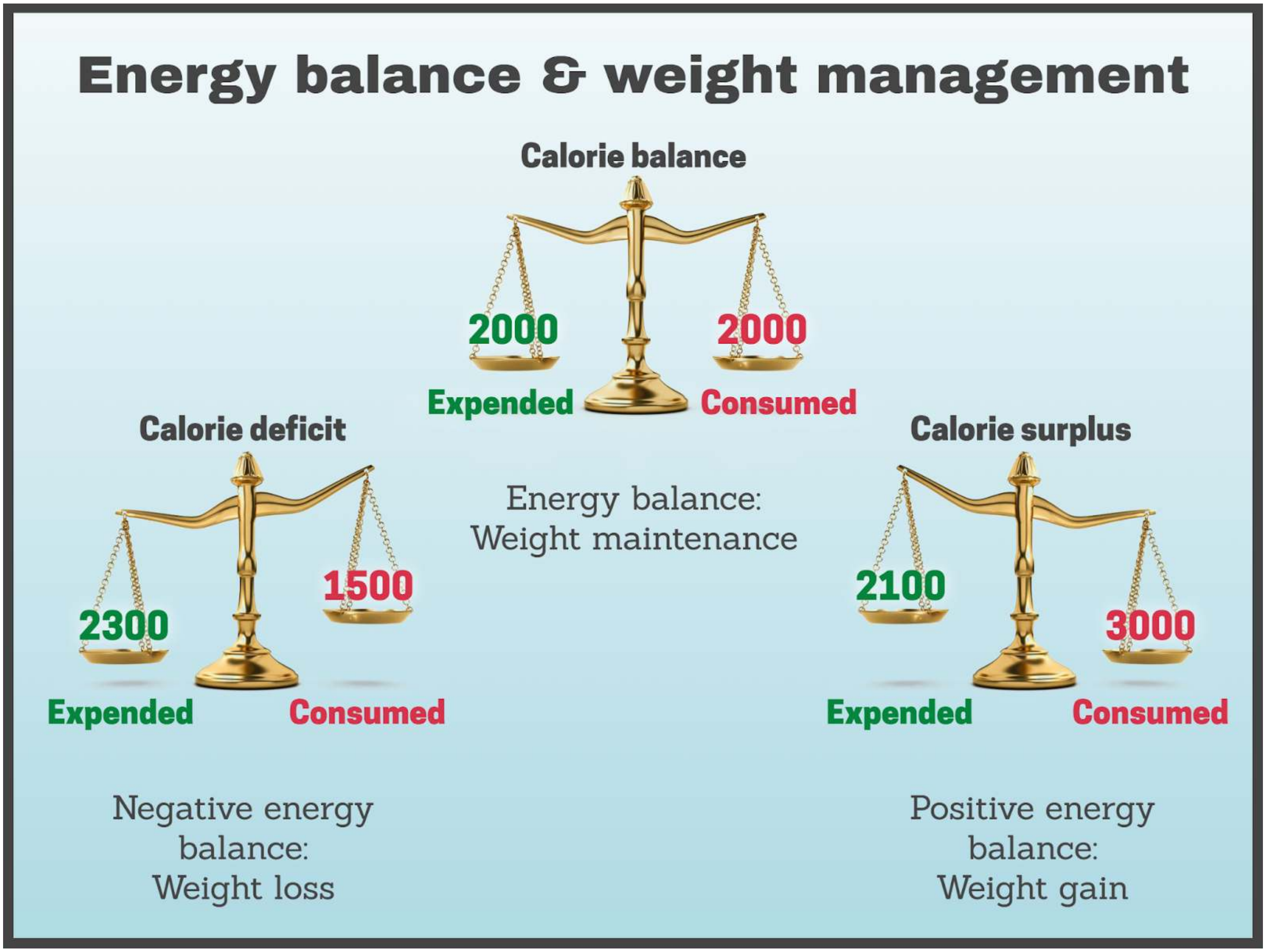
Macronutrient	Energy of combustion	% energy available for absorption	Energy available
Protein	5.65 kcal/g	92%	4.0 kcal
Fat	9.40 kcal/g	95%	8.9 kcal
Carbohydrate	4.10 kcal/g	97%	4.0 kcal

The work of Atwater showed that these factors were not exact, but were average values that were intended to help determine the caloric contribution for a typical mixed diet. However, when measuring a single food, the margin of error within the Atwater factors becomes apparent as a result of the natural energy variability of food. Further research on the Atwater factors has found on average that they tend to overestimate the available energy of mixed diets by an average of 6.7% (ranging between 1.2-18.1%). If the Atwater factors that are used to determine the basic calories per gram of foods are not exact, when these are applied to dietary records for many foods eaten across days and weeks we must accept that there will certainly be a small degree of error in the calculation of total caloric intake.

Despite these minor errors in the general Atwater factors, the primary position held by most experts is that weight management is a matter of balancing daily dietary consumption against daily energy expenditure. This is often applied using a simple mathematical equation based upon the first law of thermodynamics.

$$\Delta \text{ Energy} = \text{Energy in} - \text{Energy out}$$

The implications of this basic mathematical formula are further explained in the image below. Matching calorie intake with expenditure brings balance and no change in body weight. If food consumption is less than daily expenditure then weight loss will result if this state remains over a consistent period. Whereas if food consumption regularly exceeds daily energy spent then weight gain, most likely in the form of additional body fat, will be the result.



These well-known energy balance principles are used as the basis of countless weight management programmes whether the goal is body fat reduction or muscle building. However, the task of tracking daily calories with a high degree of accuracy is not simple. For example, an additional factor that affects overall energy balance is known as the thermic effect of food (TEF). TEF refers to the increase in metabolic rate that occurs after consuming food. It requires energy invested into digestion to harness the energy contained within a meal. Each macronutrient requires a different energy cost to break down and digest in relation to the energy provided.

- Fats use 0-3% i.e. 200 kcal fats consumed requires 0-6 kcal to digest and absorb.
- Carbohydrates use 5-10% i.e. 100 kcal carbohydrates consumed requires 5-10 kcal to digest and absorb.
- Protein use 20-30% i.e. 100 kcal protein requires 20-30 kcal to digest and absorb.

TEF is often considered an important factor for weight loss and is used to justify higher protein consumption so that more energy is spent through digestion. Research is yet to justify this hypothesis as summarized in the following statement:

'Although differences in ***TEF*** *are evident after the consumption of lower- compared with higher-protein meals, the actual energy differential is modest, highly variable, and difficult to quantify, and hence, probably has* ***minimal impact on weight loss and weight maintenance****.'*

(Leidy et al, 2015)

Tracking calorie consumption is an important tool that has been made considerably easier by modern digital applications that are freely available online and via Smartphone applications. Modern calorie tracking software programmes will usually require the user to input data about themselves, including gender, height, age, and activity levels to determine basal metabolic rate (BMR) and total daily energy expenditure (TDEE) as a baseline for calorie deficit to be determined. A daily calorie target will usually be prominently displayed to aid the user to see their daily consumption filling their allowable energy quota each day.

Simply logging daily food intake as accurately as possible provides an end of day report that outlines actual energy consumption against the intended daily target. Digital food tracking applications certainly make the process of tracking much more convenient, but they do not guarantee 100% accuracy. A small amount of excess energy consumed consistently over days, weeks, and months can lead to weight gain and stored body fat. Therefore, it is possible that if too much emphasis is placed on the mathematical calculation of calorie intake and deficit, then the weaknesses and inherent limitations of calorie tracking software still has the potential to lead to failure in goal achievement.

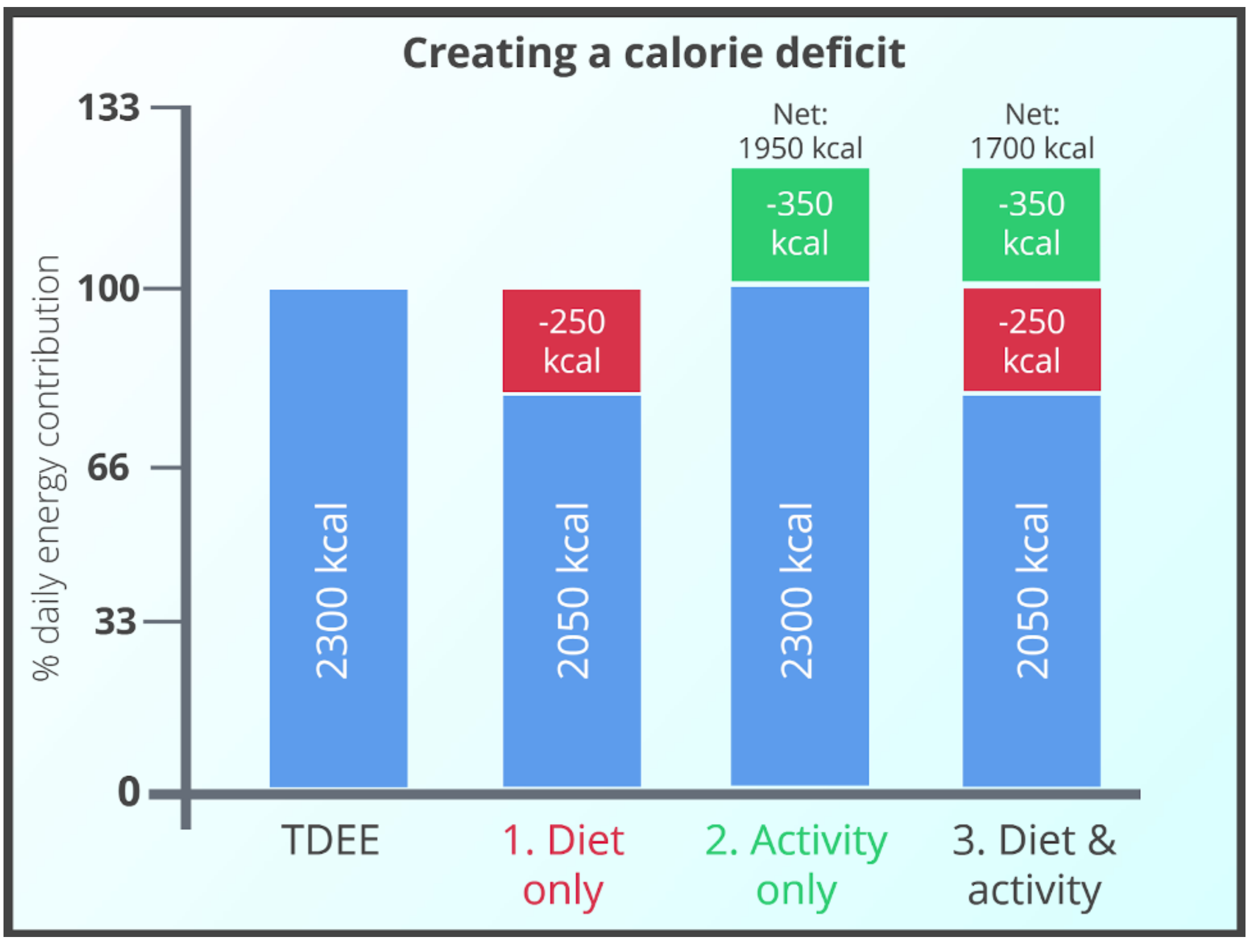
Consider the following 4 limitations of calorie trackers.

1. Food tracking software is dependent on the accuracy of the food records at the heart of the very software programme. These records are also reliant on the general Atwater factors which we have already established have a small 6.7% margin of error.
2. The software food records are dependent on the accuracy of the food label information declared for each food. In the USA and across the EU there is a generous 20% tolerance allowed for natural variation in the declared caloric total provided on the label.
3. The system is subject to the accuracy of the input provided and the user correctly identifying the specific food from the thousands of items within the software directory, sometimes with many very similar items within the same food category. Some applications have a barcode scanning feature to ensure the food is identified correctly. This is only relevant for food products that come with packaging and it does not guarantee the accuracy of fresh food information that has no packaging or barcode.
4. Tracking also requires that accurate portion sizes are determined and entered into the system when logging dietary consumption information. It is likely most users will simply estimate the portion and serving sizes rather than check exact sizes or weights.

Tracking calorie consumption is certainly a helpful tool, despite the challenge of ensuring the accuracy of the data. It provides increased awareness and accountability for the individual user and also for the nutrition coach who is guiding the client to improve their eating behaviours. It would be wise to be open and honest with client's about the potential for inaccuracy when using diet tracking applications. It is also necessary to highlight their benefits to the overall process of behaviour change. Increased awareness and accountability of daily food consumption are powerful tools and motivators in managing dietary change and developing new, beneficial habits that will help move an individual closer to their desired goals.

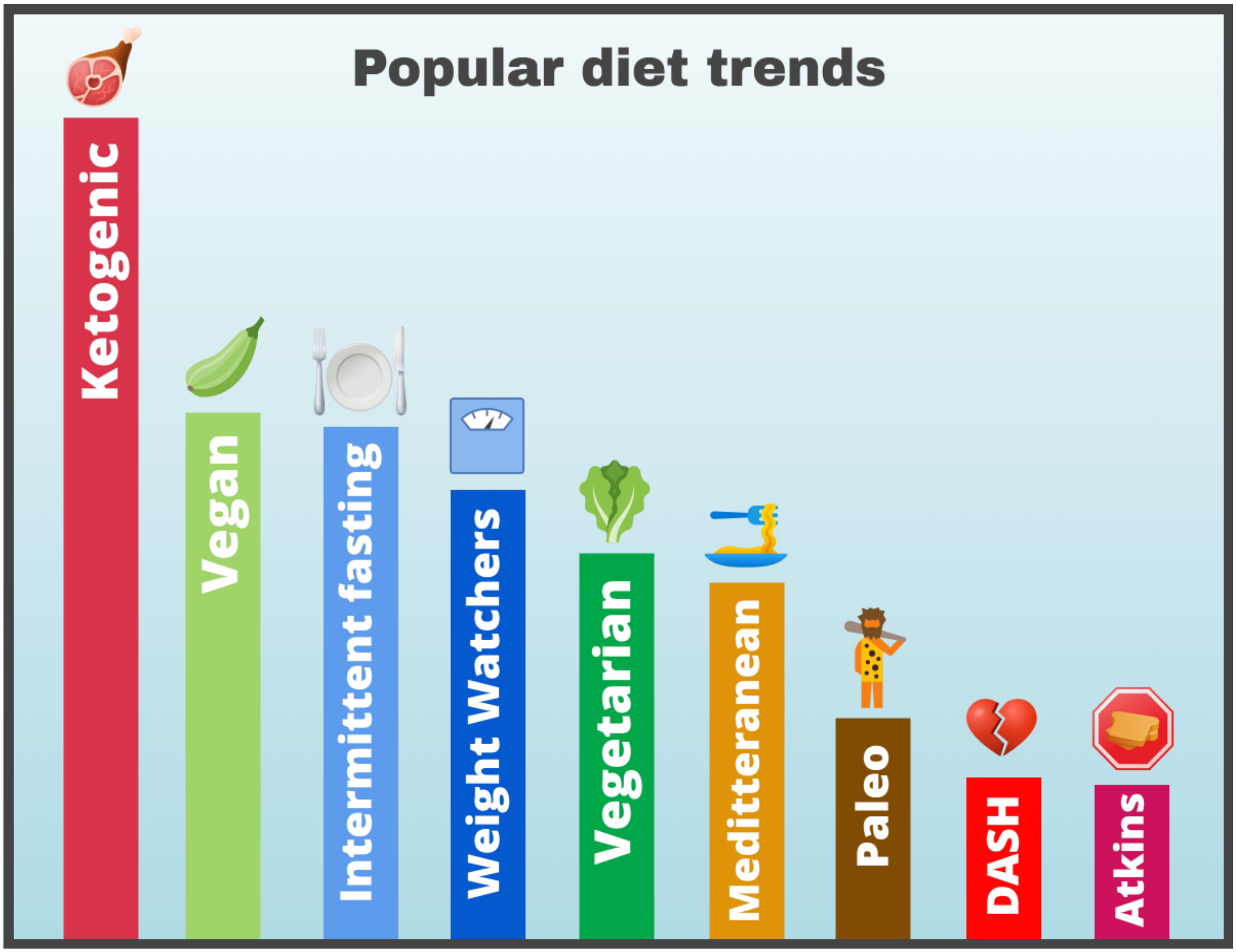
Regardless of the challenges of accurately tracking calorie intake, successfully creating a sufficient calorie deficit is still a requirement in the weight management battle. There are three primary ways in which a calorie deficit can be created once an accurate estimate of total daily energy expenditure has been determined:

1. Apply a sufficient reduction in calorie intake, without any change in activity levels.
2. Apply an increase in physical activity or exercise without dietary calorie reduction.
3. Apply a combination of dietary calorie reduction combined with increased physical activity.



Popular diets

The term 'diet' is defined as the food and drink regularly consumed. In reality, everyone is on a diet of some type when viewed through this broad definition. However, weight loss has been strongly associated with the concept of dieting for decades. Within the perspective of weight loss, a diet is a regimen of eating and drinking sparingly so as to reduce body weight or body fat mass. There are many reasons why an individual may seek to adhere to a specific diet, such as weight loss, improved health, disease management, muscle gain, or nutritional sufficiency. There has been an explosion of different dietary methods over the last 50 years. With so many diets available, it is difficult to know which to follow. Despite all the different diet names, brands, and businesses, most diets conform to a general type.



Archetypal dietary systems

There is a broad range of dietary systems that have been implemented over the years to help manage excess body fat. In this context, an archetypal diet is simply an original version of a dietary system that has been imitated over time, generally due to new trends. Rather than review the numerous individual diets and all the various names that they have been given, it may be best to recognize them as merely small variations of existing systems. It will be beneficial to review the fundamental principles behind the 6 different diet archetypes to understand the underlying methodology and their potential for success. Most body fat reduction diets fall within or close to these 6 dietary patterns.

Dietary system	Intended goal	Method	Evidence for/against
Low energy diets (LED)	Induce rapid weight loss (1.0-2.5 kg/week) and attempt to preserve lean mass in overweight and obese subjects	Consume between 800-1200 kcal/day whilst engaging in a resistance training programme	• Resistance training helps preserve metabolic rate during LEDs. • Should only be used in short-term (8-12 weeks) to limit risk of sustained low micronutrient intake.
Low-fat diets (LFD)	To impose caloric restriction by targeting the most energy-dense food source, dietary fat (9 kcal/g)	Defined as a dietary intake of 20-35% of calories from fat Supported by a large evidence base and tends to be more widely accepted	• LFD have not been found to provide any greater level of weight reduction in the long-term than a similar level of energy restriction. • By default, an LFD becomes a high carbohydrate diet by contributing 45-65% of calories.

Dietary system	Purpose	Method	Considerations
3. Low carbohydrate diets (LCD)	To impose caloric restriction through carbohydrate reduction, drawing upon the proposed metabolic advantage of reduced insulin levels, combined with the increased appetite regulation imposed by higher protein diets	No official definition exists, but research includes the following options: <40% kcal/day from carbohydrates <200 g/day from carbohydrates Between 50-150 g/day from carbohydrates	• Research of moderate (30-45%) LCDs has yielded mixed results in comparison to LFDs with no clear advantage. • Strict LCDs (<20%), compared to control diets, show short and long-term advantages in both weight loss and cardiovascular risk. • The weight-loss advantage of LCDs is small, averaging (0.57-1.46kg) greater weight loss in obese subjects.

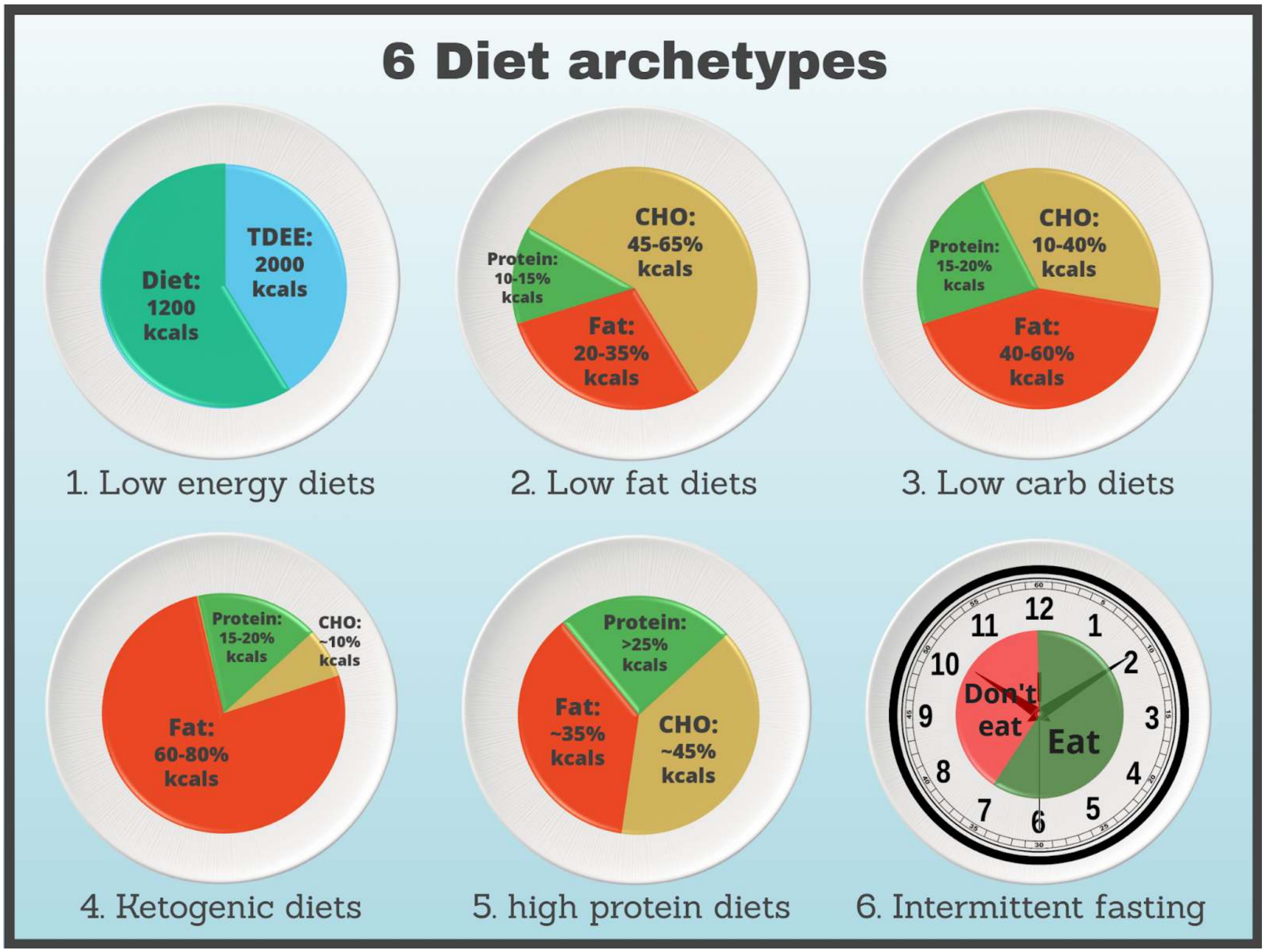
Dietary system	Purpose	Method	Considerations
Ketogenic diets (KD)	Reduce daily carbohydrate intake to a level where the body shifts energy metabolism over to very short-chain fats called ketones gradually over 7 days	Maintain carbohydrate intake below 50g or ~10% total calories Maintain a moderate protein consumption (1.2-1.5 g/kg/day) The balance of daily calories are derived from fat (~60-80%)	• Ketosis is a relatively normal state, common during fasting, and should not be confused with ketoacidosis, a pathological condition. • Many of the benefits attributed to KD may be as a result of increased protein intake, which increases satiety, resulting in self-selected lower calorie consumption (between 294-441 kcal/day). • Controlled studies matching protein and total calories between KDs and control diets found no metabolic weight loss advantage. • Rise in fat oxidation rates on a KD plateau within 1 week and ketone levels remain stable thereafter. • Higher fat oxidation rates do not guarantee net body fat losses, as KDs also increase fat storage.
High protein diets (HPD)	Increase daily protein consumption to benefit from higher satiety levels and thus manage lower energy intake more easily with less hunger and fewer intense food cravings	Maintain protein intake >25% total daily calories Protein intake ≥1.8 g/kg/day Balance of daily calories split as needed between carbohydrate and dietary fat	• High protein diets repeatedly out-perform low protein intake (0.8 g/kg) for sustaining lean mass with fat reduction. • Protein intake ≥1.8 g/kg spread evenly across 4-6 meals throughout the day provides greater body fat reduction effects than conventional low-calorie diets. • Protein has the highest digestive energy cost but is also the most satiating nutrient by far. • Excess protein consumption may be lost through increased non-exercise activity, greater protein oxidation during exercise, or faecal excretion.

Dietary system	Purpose	Method	Considerations
Intermittent fasting diets (IFD)	Fasting is abstinence from food consumption, which significantly reduces calorie consumption	There are 3 main types of IFD: Alternate-day fasting (AFD) - a 24-hour fasting period followed by a 24-hour feeding period which does not compensate for the fasting period. Whole-day fasting (WDF) - applies 1 or 2 days of complete fasting within any week with maintenance feeding on the regular days which does not compensate for the fasting days. Time-restricted feeding (TRF) - provides a fasting period and a feeding period within a set 24-hour day e.g. 16-20 hours fasting & 8-4 hours feeding.	• ADF has a strong evidence base for reduction in fat mass and retention in lean mass when the alternate feeding days allowed the participants to eat as much as necessary to address hunger and energy levels. • WDF has been consistently effective for weight loss, but there is minimal or no difference compared to daily feeding low calorie-controlled diets over the longer term. • TRF induces reductions in body weight, but the more extreme 20-hour fast and 4-hour free eating feeding window may result in some negative side effects e.g. decreased testosterone. • IFD diets appear to cause a hunger-suppressing effect, potentially as a result of the increased ketones during the fasting periods which may help manage the overall reduction in caloric intake. • Meta-analysis on IFD shows that when matched for total caloric intake there is no additional weight reduction benefit when compared to other calorie-restricted diets.

This chart of the 6 diet archetypes summarises a wide variety and range of scientific evidence on the subject of body fat reduction and dietary approaches for weight loss. The following quote offers an authoritative review regarding this collection of diet-related evidence:

'Each [dietary] method has its strengths and weaknesses. No single approach is ideal for all circumstances. Rather, the practitioner...must employ the most practical option for the...needs of the individuals at hand...The various diet archetypes are wide-ranging in total energy and macronutrient distribution. Each type carries varying degrees of supporting data...Common threads run through the diets in terms of mechanism of action for weight loss and weight gain.'

(ISSN, Aragon et al. 2017)



The nutrition coach must get to know the client and their dietary habits, preferences and behaviours to help them identify which of the 6 archetypal diets is the best fit for them.

Satiety and cravings

One of the big challenges for any individual who is seeking to manage their calorie intake in an attempt to reduce body fat is the ongoing battle with hunger and cravings. There is a fundamental biological drive to eat food that is built around habitual routines and eating behaviours. Scientists have identified a vast array of different biological mechanisms involved in stimulating hunger and providing a sense of satisfaction after eating a meal.

'The biological regulation of appetite…is very complex, engaging a number of tissues, organs, hormones, and neural circuits throughout the body in a feedback loop between the brain and peripheral tissues.'

(MacLean et al. 2017)

When actively striving to reduce caloric intake the natural biological processes in the body are activated to try and restore habitual eating patterns and guarantee continued energy provision and nutritional sufficiency at a familiar level. Understanding what steps can be taken to manage hunger and cravings more effectively can serve as significant support in controlling calorie intakes. It is not necessary to expend significant amounts of daily willpower (a limited psychological resource) to resist ongoing cravings and the relentless drone of hunger pangs. Drawing upon a range of scientific findings regarding different types of food and their impact on appetite and satiety can serve to strengthen applied strategies to maintain a reduced calorie intake without battling against internal biology.

There is strong evidence that satiety is stimulated by total energy intake and increased distension of the stomach. However, physiological satiety has multiple mechanisms. Several appetite hormones and regulatory peptides are also involved in the control of hunger and a sense of satisfaction following food intake. Different foods and meal combinations will affect the different satiety factors at varying levels.

Satiety factor	Location	Satiety	Mechanism
Gut distension	Stomach receptors measure pressure and stretch of the stomach lining.	↑ satiety	Gastric nerves communicate to the brain the degree of stretch on the gut in response to the volume of food consumed. Stimulates satiety independently of nutrient content.
Insulin	Released from the pancreas into the bloodstream	↑ satiety	Insulin receptors in the hypothalamus respond by increasing feelings of satiety.
Leptin	Released from the adipose tissue	↑ satiety	As adipose tissue increases the rate of fat storage, the rate of leptin release into circulation increases, causing the hypothalamus to increase feelings of satiety. Works together with CKK.
Ghrelin	Released from the stomach	↑ hunger	Stomach releases ghrelin at habitual eating times and initiates the physiological need for food intake. Ghrelin rapidly declines in response to food consumption.

Satiety factor	Location	Satiety	Mechanism
Cholecystokinin (CKK)	Released from the duodenum and jejunum of the small intestine	↑ satiety	In response to food entering the duodenum, CKK slows gastric emptying, while also causing the pancreas and gallbladder to release enzymes and bile for digestion. Works together with Leptin.
Glucagon-like peptide 1 (GLP-1)	Release in the small intestine in response to the presence of food	↑ satiety	In response to food entering the small intestine, GLP-1 slows gastric emptying, modulates gastric acid secretion, and enhances the release of insulin into circulation.
Oxyntomodulin (OXM)	Release in the small intestine in response to the presence of food	↑ satiety	In response to food entering the small intestine, OXM slows gastric emptying and reduces the levels of the hunger hormone, ghrelin.
Peptide YY	Released from the small and large intestine in response to the presence of food.	↑ satiety	In response to food entering the small intestine, PYY is released into circulation proportionally to the amount of total energy consumed, peaking within 1-2 hours and remaining elevated for up to 6 hours after consumption. PYY slows gastric emptying and intestinal transit.

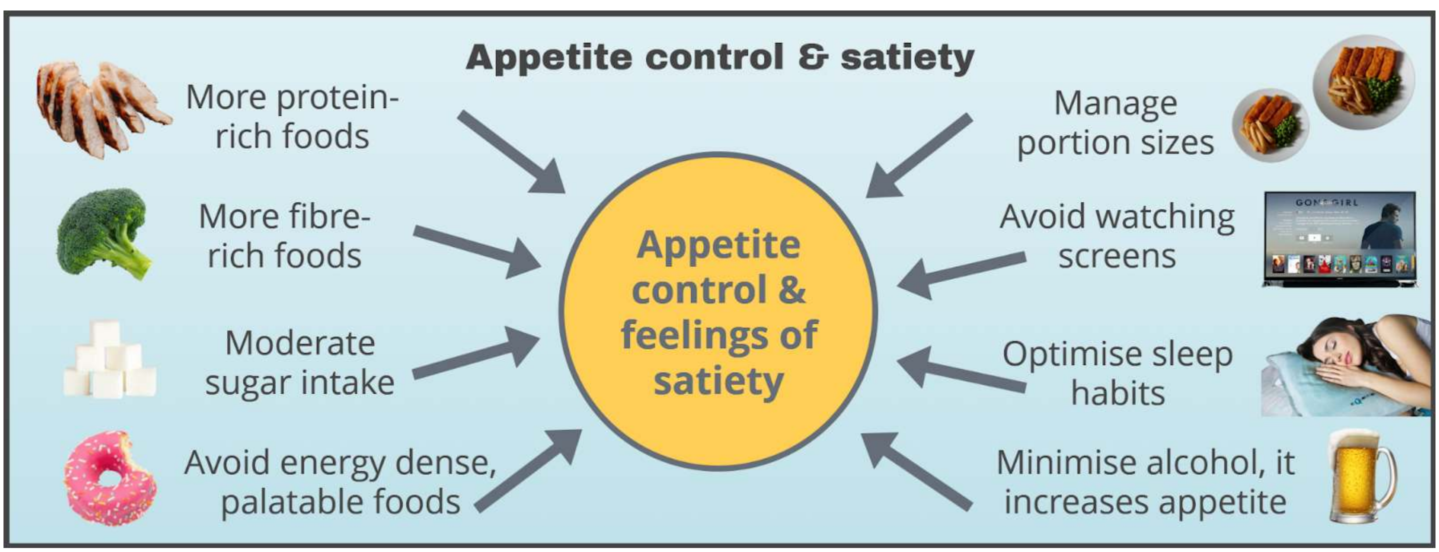
Dietary patterns and satiety

Many factors can negatively or positively impact feelings of satiety, from the composition of the food that is eaten to the patterns and behaviours surrounding food intake. Successfully managing appetite and supporting higher levels of satiety is a truly effective tool for the nutrition coach. It is easier to control daily calorie intake when appetite is not spiking at regular intervals throughout the day. The following bulleted list provides a summary of what science has discovered surrounding food intake and satiety.

- Protein-rich foods provide significantly higher and longer-lasting levels of satiety than carbohydrates and fats when matched for calorie consumption. It appears a sufficient protein intake is required to benefit from the higher satiety effects, with expert suggestions of an acute 50g intake, or a sustained daily intake of 25% of calories as recommended in a typical high-protein diet (HPD).
- Dietary fibre-rich foods provide a consistently higher and longer-lasting impact of satiety than low fibre foods. Foods rich in soluble fibre account for this increased effect more than foods containing mostly insoluble fibre.
- Whilst it has been postulated that low glycaemic index (GI) and low glycaemic load (GL) foods may provide greater satiety, the scientific evidence to support this claim does not hold up when the differences in dietary fibre are taken into account. As many low GI and low GL foods are rich in fibre, fibre itself is likely responsible for observations around greater satiety.
- Simple sugars have been shown to have a complex effect on satiety, with different responses and results in the research. In general, they appear to generate a moderate increase in satiety, but the effects are relatively short-lived and hunger seems to return relatively quickly.
- Out of all the macronutrients, isolated dietary fats have the lowest impact on satiety. However, they do have an effect, slowing gastric emptying, and reducing ghrelin. It should be noted that fats rarely occur in isolation in nature, and are often combined with sources of protein.
- Even though alcohol provides 7 calories per gram, it has a clear stimulatory effect on appetite, increasing hunger and food consumption.
- Evidence indicates that overall energy density (energy per weight of food) and palatability (being agreeable to the taste) may have a more important role in appetite and weight than individual macronutrient effects. Low energy density foods appear to have a higher, longer-lasting impact on satiety than energy-dense, palatable foods which result in high calorie intake and lower feelings of satiety.

There is also a range of external factors that are worth considering when seeking to optimise satiety effects in the management of body fat and weight loss.

- Access to a greater variety of food options at a meal appears to reduce feelings of satiety and increase energy intake. This is because repeated consumption of the same food reduces palatability as the same tasting food becomes less enjoyable the more is eaten. When a wider variety of tastes and flavours are available, this maintains food appeal for longer.
- Observational studies show that most people will consume more food and total energy when larger portion sizes are on offer. Despite the increase in food consumption, there does not appear to be a direct increase in satiety levels as a result. This suggests that controlling portion sizes may be a valuable way to control calorie intake, without negatively altering satiety.
- Lack of sleep has been shown to negatively impact satiety hormones by increasing ghrelin and decreasing leptin the day after partial sleep loss. This has been shown to result in increased intake of energy-dense, highly palatable foods the following day with greater overall calorie consumption.
- Watching television or other screen-based entertainment at the same time as eating has been shown to lower individual responsiveness to satiety signals. The distraction of screen time seems to draw attention away from internal biological signals and leads to greater food consumption.
- Eating during social gatherings seems to relax individual perception of appropriate levels of satiety. Research shows that people usually eat up to 44% more food during a social group meal, and may seek to feel a higher level of satisfaction before eating cessation.

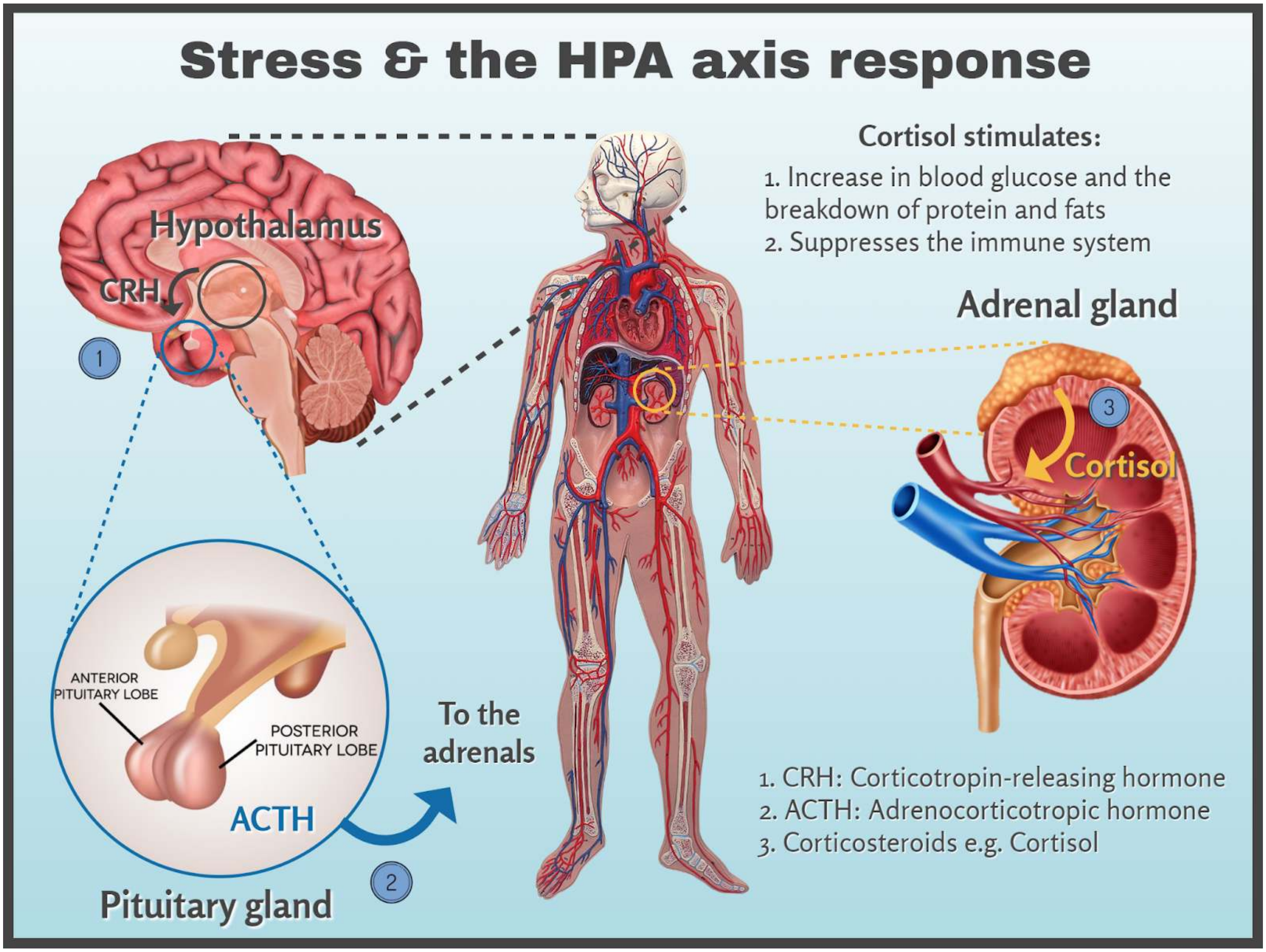


Stress and weight management

Stress has been defined as; *'a negative* [mental or] *emotional experience accompanied by biochemical, physiological and behavioural changes.'* Significant chronic stress will affect the majority of the population to differing degrees at different times throughout life. Stress can be caused by personal worries, social anxieties, peer pressure, professional strains and deadlines, educational performance, legal problems, relationship problems, family burdens, abuse, death and grieving for a loved one, financial pressures, concerns over personal or family safety, physical injury, health problems, poor eating behaviours, lack of sleep, poor physical fitness, and many other similar or related factors.

The burden of mental and emotional stress has very real physiological consequences within the body. A mental or emotional perceived stressor initiates a hormonal cascade via the hypothalamic-pituitary-adrenal axis (HPA). A small area in the midbrain called the hypothalamus produces corticotropin-releasing hormone (CRH) which stimulates the nearby anterior pituitary gland. This causes the pituitary to release adrenocorticotropic hormone (ACTH) into the circulation which quickly reaches the adrenal glands on top of the kidneys. The adrenals, in turn, release corticosteroids, the majority of which is a hormone called cortisol. Cortisol ensures the body has a ready supply of energy to deal with the perceived stressor.

It is apparent that under acute stress, the HPA driven hormonal response initiates the breakdown of glycogen and fats (and also proteins) ready for use to power the energy requirements of the body throughout stressful circumstances. Despite the apparent fat-burning stimulus of cortisol, numerous scientific studies have found that under sustained, chronic perceived stress there are strong associations with increased body weight, specifically increased abdominal and visceral fat. This observation is further strengthened by research that shows high-level stress is linked to increased calorie consumption despite no apparent increase in hunger. These additional calories tended to come from energy-dense, highly palatable foods which may be a learned mechanism to help blunt the stress response. Scientific observations have also found that those under high levels of sustained stress are significantly less likely to undertake regular physical activity, therefore the additional calorie intake is less likely to be compensated for through exercise.



'Observations from a number of randomized weight-loss trials indeed confirm that a high stress level and low state of mood hinder a successful weight loss outcome and increase the risk of dropout. Hence, stress poses an important barrier for weight loss efforts and improved health.'

(Geiker et al. 2017)

Stress, therefore, not only increases the chances of gaining weight, especially around the waistline, but it also significantly increases the likelihood of failure in the successful application of weight management strategies, especially those that include a physical activity component.

On a more positive note, there is research that indicates an increase in B vitamins, calcium and magnesium has been shown to have a beneficial effect on cortisol and the effects of stress. Most studies used supplemental nutrients, but there is nothing to suggest strengthening whole food dietary intake of these nutrients would not provide the same stress modulating benefits. Where chronic stress has led to decreased mood, omega 3 fatty acids, especially EPA has been found to provide health benefits that aid in a decrease of circulating cortisol within a few weeks. It may also be wise to apply a range of beneficial stress management techniques to help reduce the physiological stress response and support rest and recovery processes that allow the body the chance to rejuvenate. Scientifically proven stress management activities include:

- Deep breathing techniques e.g. box breathing - slowly breathe in for a count of 5, hold for 5, breathe out slowly for 5, hold for 5, then repeat through 5 cycles.
- Guided imagery or visualisation techniques to help focus on relaxing places, people, pets or experiences in the mind to help alter the physiological state towards calm.
- Mindfulness meditation involves sitting comfortably, focusing on steady deep breathing, whilst repeatedly bringing the mind's attention to the present moment without drifting into concerns about the past or the future.
- Yoga or Tai Chi combine breathing, posture and flowing movements to help reset the mind and relax the body.
- Relaxing body massage can provide needed attention to tight and knotted muscles to reduce feelings of tension and caring human contact that helps to relax both the mind and the body.

Sleep and weight management

Adults who sleep <6 hours per night are statistically 7 times more likely to have a body mass index (BMI) in the overweight category by the time they are only 27 years old. This is just one of many research statistics that show a strong association between reduced sleep duration and problems of weight gain and body fat storage. At this stage the science supporting this connection is indisputable.

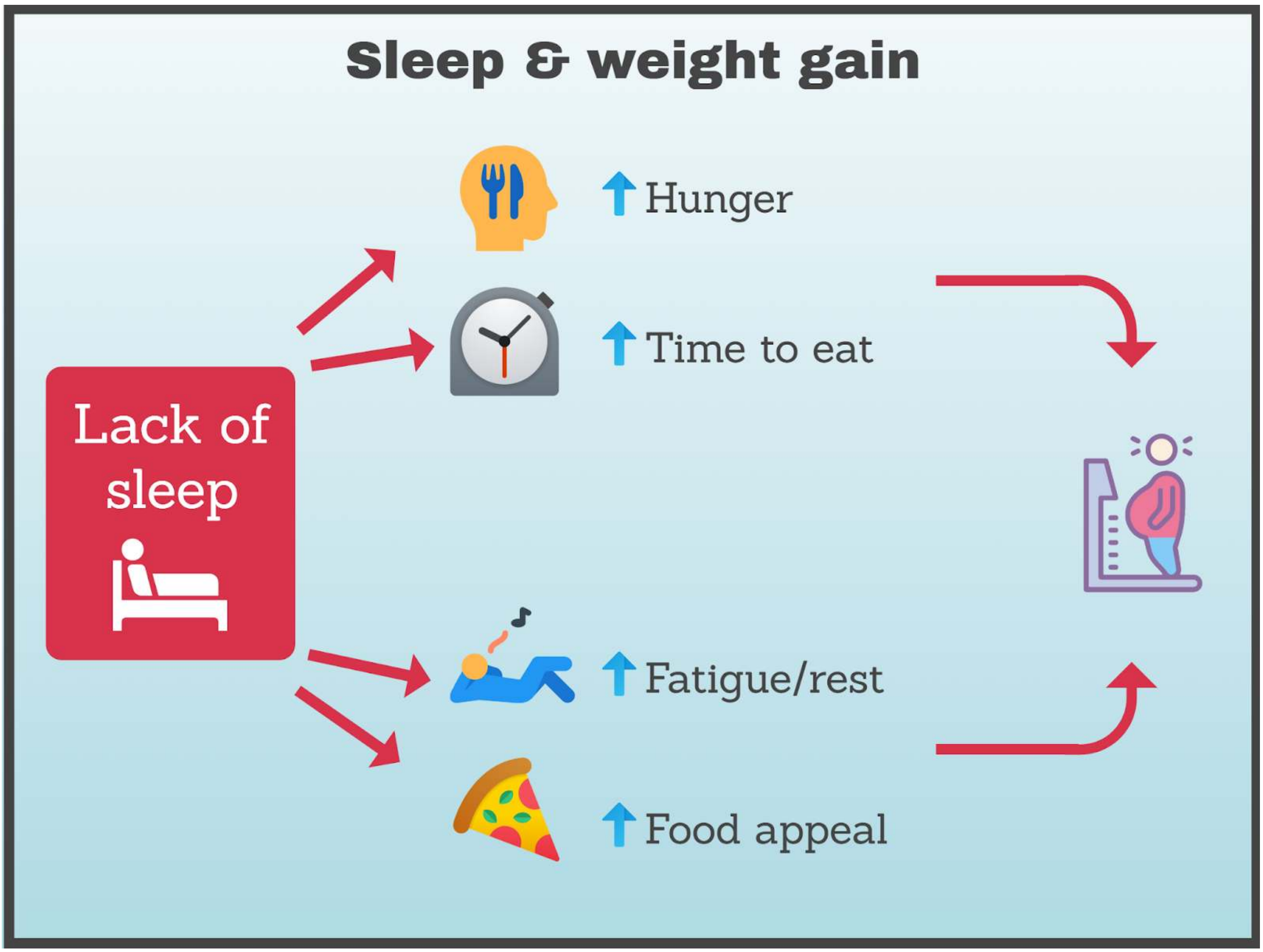
The following range of facts supports this position:

- 7 cm larger waistlines between <5 hours sleep and >8 hours sleep.
    - *'The main result of this population-based study is the independent inverse relationship between objectively measured sleep duration…and central obesity in women.' (Theorell-Haglöw et al. 2010)*
- *'Across 22 studies utilising data collected from 56,259 participants… results yielded a small but significant negative relation between sleep duration and waist circumference in which shorter sleep durations are associated with an increase in central adiposity.' (Sperry et al. 2015)*
- 'Epidemiologic studies consistently demonstrate that habitual short sleep duration is a risk factor for obesity…studies show that adults who report sleeping ≤5–6 h/day have more adiposity, larger waist circumferences, gain more weight over time and are more likely to have obesity.' (Grandner & Spaeth, 2019)

There appear to be several physiological changes that occur in individuals who experience regular partial sleep loss. Two primary observations are to do with the appetite and satiety hormones, leptin and ghrelin. Leptin is released from the adipose tissue under conditions of net increase in fat storage, signalling to the brain a state of positive energy balance and therefore reducing signals of hunger and increasing feelings of satiety. Ghrelin is released from the stomach, especially during habitual eating times, to stimulate sensations of hunger and encourage food consumption. Research has shown that individuals who underwent only two nights of sleep restriction (4 hours per night) experienced ghrelin levels increasing by 28% and leptin levels decreasing by 18%. This resulted in increased hunger, reduced satiety, and increased energy consumption. The typical increase in calorie consumption following a period of sleep restriction averages between 300-500 calories per day, even though the increased energy needed to sustain the body during the additional period of wakefulness has only been estimated to be between 100-150 calories per day. The type of calories consumed tended to come from energy-dense, highly palatable foods such as sweet and salty snacks. There is some logic to the changes in these biological drivers as the body needs to sustain the higher metabolic cost of remaining awake instead of being asleep. However, with additional consumption of calories approximately 2-3 times greater than the estimated metabolic cost of partial sleep loss, it appears that broader changes are occurring in the body than simple adjustment of appetite-regulating hormones.

Sleep loss is associated with changes in brain activity within the prefrontal cortex and thalamus, both regions known to be associated with willpower and exerting self-control. The brain appears to become even more active at the sight of tempting foods, more than would be observed following sufficient sleep.

This suggests that sleep restriction may reduce willpower and capacity to resist the tempting lure of highly palatable foods that are enjoyable to eat. Combined with our modern environment where energy-dense foods are readily available and this becomes a recipe for weight gain. Altered hunger hormones that increase appetite, increased food appeal, additional opportunity to eat within a 24-hour day, greater fatigue due to lack of sleep, and reduced motivation for physical activity, all contribute to the increased likelihood of weight gain. It is also worth noting that a higher prevalence of sleep problems are reported in those who are overweight or obese. This may create a downward spiral where poor sleep contributes to excess calorie intake and more sedentary behaviour, whilst increased weight gain further exacerbates sleep problems and reduces sleep duration.



There is a range of strategies that can be applied to reduce the likelihood of short duration, quality sleep. The application of such strategies, well focused on primarily lifestyle adjustment will have a knock-on effect on weight management related behaviours.

'...sleep plays an important role in weight-loss across many age groups and types of weight loss programs...sleep extension interventions prove to be a promising new behavioural approach to weight management and metabolic health.' (Grandner & Spaeth, 2019)

1. Establish an achievable, consistent sleep schedule (±30 minutes) that can be maintained across both working and non-working days, weekdays and weekends. The body has fundamental, internal biological clocks that govern daily functions (circadian rhythms), including the sleep-wake cycle. A regular schedule helps to entrain this cycle to time biological sleep onset with a consistently scheduled bedtime.
2. Caffeine is a potent sleep antagonist due to the effects it has on sleep pressure. The longer an individual remains awake the greater the level of sleep pressure that builds in the background. Caffeine reduces the biochemistry involved in creating sleep pressure. Therefore, caffeine consumption later in the day may limit the ability to initiate sleep. Caffeine can remain in the system for many hours after consumption. As a general rule, caffeine should not be consumed within 6-8 hours of the regularly scheduled bedtime.
3. The immediate sleep environment is also a factor that impacts the duration and quality of sleep. Maximising darkness during sleeping hours is an important external cue that allows for sleep to occur. Gradually reducing daylight and artificial light in the hour prior to scheduled bedtime, and ensuring maximum darkness within the bedroom will assist in sustaining better quality sleep.
4. Managing the noise that occurs throughout the night is also beneficial to sleep dynamics. It tends to be noise differential that is disruptive to sleep rather than continuous noise. Sudden noises, bleeps, bumps, or knocks tend to be more disruptive than a consistent level of background noise. Where possible minimise sudden disruptive sounds even if they are relatively small. Where it is not possible to remove all sudden sounds during the night, the use of a consistent white noise (sound of a fan, wind blowing, stream flowing, rainfall etc.) to mask any background sounds can also be a beneficial strategy to reduce sleep disruption.

Key learning points: Chapter 7 Dietary strategies for body fat reduction

- A broad range of environmental, social, and individual characteristics affect the risk of overweight and obesity.
- Controlling calorie intake and creating a calorie deficit are essential steps in the successful management of body weight and body fat reduction.
- Six archetypal diets identify and map out the basic systems for the vast majority of dietary strategies utilised in the process of body weight management and weight loss:

- low-energy diets
- low fat diets
- low-carbohydrate diets
- ketogenic diets
- high protein diets
- intermittent fasting diets

- The human body has a highly complex physiological process for controlling feelings of hunger and appetite, involving various hormones, gut peptides, and neurological processes to manage the right amount of daily food consumption.
- Reducing calorie intake to manage excess body weight will almost certainly create an increase in appetite and hunger. A range of strategies can be applied to help control feelings of hunger and satiety more effectively:

- Increasing protein & fibre intake
- Reducing high energy-density foods and sugar
- Reducing the range of different food types during a single mealtime
- Managing portion sizes per meal/snack
- Avoiding food consumption in front of TV screens or computers
- Minimise alcohol consumption
- Improve sleep duration and quality

- Increased levels of chronic stress are strongly associated with increased food consumption, especially energy-dense, highly palatable foods being consumed immediately following a significant stressor.
- Short sleep duration is strongly associated with increased body mass and body fat storage. Partial sleep loss alters hunger and appetite hormones, increases food appeal for energy-dense, highly palatable foods, lengthens the wakeful time within a day providing more opportunity to eat, and it increases fatigue, which in turn reduces the motivation to engage in physical activity.

Chapter 8: Dietary analysis

Alexander Graham Bell is reported to have said, *'Before anything else, preparation is the key to success.'* Bearing this sentiment in mind it is important to prepare the necessary evidence, dietary needs, and behavioural change options before coaching a client in the strategies for goal achievement. This preparation starts with gathering necessary information from the client to review and analyse in detail so that a plan of action is well informed and suitably matched to the needs of the individual. It can be tempting to provide a client with a prefabricated diet plan and simply request they follow this 'proven' strategy for success. This type of one-size-fits-all approach immediately makes the strategy less effective as it is not carefully tailored to the individual needs of the client. It is the preparation, planning, and sculpting of a personalised dietary strategy to support the needs of an individual client that justifies the fee charged. This attention to detail and high-level service creates the value that a client is willing to pay for, and then they will naturally become a willing advocate for your nutrition services amongst their friends and connections.

Gathering information

There are numerous different ways in which nutrition coaches can gather information from a client about their eating habits and dietary behaviours. Each of the different methods has value and can contribute to a better understanding of the client and their current and past history with regards to diet and nutrition. It is advisable to determine which methods are most appropriate to the type of nutritional service that is being provided. A basic, high volume dietary service that is targeted to a broad group or population will likely only need to gather basic levels of information to match individuals with previously planned and prefabricated nutritional protocols that suit their general objectives. A personalised, low-volume dietary service that is targeted to serve single clients at a time will require a much deeper level of information gathering to create a bespoke plan that is specifically matched to the needs and behaviours of the individual.

Information gathering options may include:

- Dietary history and habits questionnaire
- Dietary preferences questionnaire
- 24-hour dietary recall questionnaire
- Written food diary
- Diet and nutrition tracking software application

Dietary history and habits questionnaire

There is no set format for a dietary history questionnaire, but it should ask a series of beneficial questions on topics that will provide valuable information to understand how, what, when, and why a client chose to eat in a particular way in the past. Topics that may be addressed in such a questionnaire may include:

1. Primary reasons for trying to adjust or control dietary intake
2. Set diet plans that have been followed in the past
3. Dietary successes and/or failures
4. Food frequency questions regarding typical intake over the previous 3, 6 or 12 months
    - e.g. How many portions of fruit do you typically consume per day?
    - e.g. How often do you typically consume oily fish per week?
    - e.g. How many alcoholic drinks do you typically consume per week? When?
5. Favourite meals and snacks that have stood the test of time

Dietary preferences questionnaire

A dietary preferences questionnaire is primarily focused on determining which foods across a wide range of different food categories a client prefers to consume and which foods they do not prefer. It usually asks a client to rate the foods listed in one of two ways; the number of times they consume a specific food within a given timeframe (e.g. daily, weekly, monthly), or the degree to which they enjoy or dislike a food (e.g. like, no preference, dislike). Some examples of dietary preferences questions are

1. How often do you eat white potatoes?

1. ☐ Daily
2. Every other day
3. Twice per week
4. Once power week
5. Less than once per week
6. ☐ Never

2. How often do you drink pure bottled or tap water as a beverage? (Not mixed in other drinks of any kind)

1. More than 8 times per day
2. 5-8 times per day
3. 2-4 times per day
4. 1-2 times per day
5. I don’t usually drink pure water

3. Rate your preference for eating red meat.

1. Delicious
2. Like
3. No preference
4. Not keen
5. Dislike

4. Rate your preference for eating whole grain bread.

1. Delicious
2. Like
3. No preference
4. Not keen
5. Dislike

24-hour dietary recall

A dietary recall questionnaire can be utilised in a face-to-face interview or it can be provided to the client in advance for them to complete before a consultation. This is a relatively simple document that encourages the client to remember and record the food that was eaten across a 24-hour period. It is most common to record food consumption in respect to the day prior to consultation or completion of the questionnaire.

The type of questions that could typically be included are:

1. List the foods and approximate quantities eaten at breakfast (or other relevant meals).
2. Indicate the time of food consumption for each meal and snack.
3. Identify the source of the foods consumed e.g. homemade, supermarket, restaurant, a friend, vending machine etc.
4. Did you consume all of the food/meal? If not, please estimate how much remained of the original serving?

Written food diary

A written food diary uses a daily or weekly food record template to enable clients to record by hand the foods that they consume throughout a specific period. Food should ideally be recorded in the diary at the earliest convenience following food consumption, therefore the paper record needs to be carried with the client at all times throughout the day. Utilising a paper record and remembering to carry it over several days whilst the food diary is being completed is a common barrier to successful completion. This often results in the diary being completed by memory recall at the end of the day, which increases the chances of error. It is possible to use a basic digital form that is completed on a smartphone during the day. This may reduce the likelihood of forgetting the food diary record, but it still requires the client to remember to type in relevant details into the digital diary. Ensuring that a client completes a food day with sufficient detail also takes a little training and explanation otherwise the completed record is often lacking in detail which may hamper efforts to provide an accurate food analysis.

For many years the handwritten or digitally typed food diary has been the primary information-gathering tool of nutritionists and nutrition coaches alike. As a result, there are many different styles and formats for a food diary and it would be easy enough to locate freely available templates on the internet for immediate use. However, there is some value in a nutrition coach taking the time to develop a bespoke food diary template so that the information provided by the client maps to their thought processes and preferences for the presentation of daily dietary data. A food diary needs to be practical and easy for the client to utilise too.

The following example food reaction diary may help provide ideas for style and layout.

Positive reactions (green) / Negative reactions (orange)

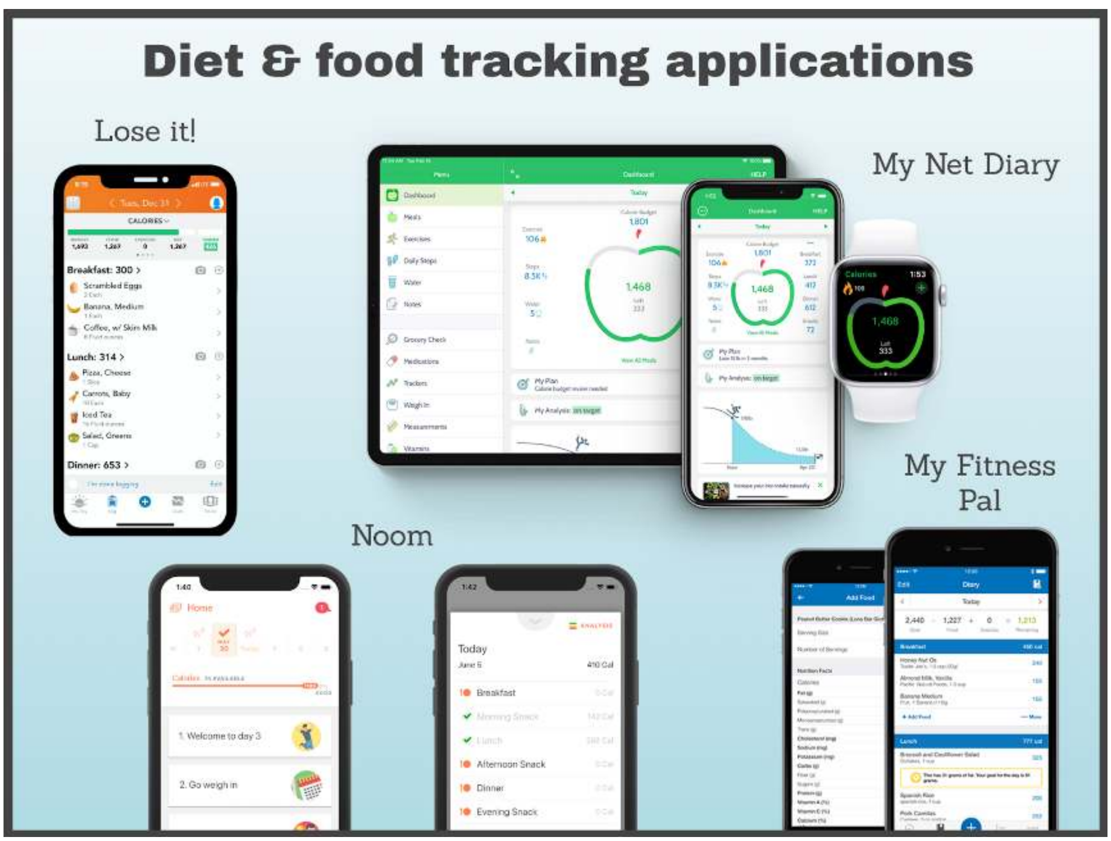
Food & Beverage Reaction Diary

Week	Breakfast 6 – 10am			Mid-morning Snack	Lunch 12 – 3pm			Mid-afternoon snack	Dinner 6 - 9pm			Evening snack
Day/date	Food:				Food:				Food:			
Record food type, quality, quantity, or portion size	Beverages:				Beverages:				Beverages:			
Rate 1 hour after meal	Hunger	Energy	Mood	Reason for eating	Hunger	Energy	Mood	Reason for eating	Hunger	Energy	Mood	Reason for eating
	Full	Renewed	Uplifted		Full	Renewed	Uplifted		Full	Renewed	Uplifted	
Circle a single suitable response in each column	Satisfied	Energetic	Positive		Satisfied	Energetic	Positive		Satisfied	Energetic	Positive	
	Cravings	Alert, but weary	Irritable		Cravings	Alert, but weary	Irritable		Cravings	Alert, but weary	Irritable	
	Hungry	Low, tired	Apathetic		Hungry	Low, tired	Apathetic		Hungry	Low, tired	Apathetic	

Insert: Breakfast meal photograph	Insert: Lunch meal photograph	Insert: Lunch meal photograph

Diet and nutrition tracking software

As technology has advanced a wide range of software and digital applications have been developed to make the task of tracking nutrition intake and analysing the resulting data considerably easier for both client and nutrition coach. Initially, nutrition software packages were large, complex programmes that needed to be uploaded to a computer. Once the food diary had been completed then all client information and food diary data were inputted by the nutrition coach. This was a labour-intensive task that did provide detailed and valuable information, but as it was so time-consuming that the costs were passed down to the client making this an expensive service. Modern digital applications allow the nutrition coach and their client to be connected via the internet. Many applications can be downloaded onto a smartphone or tablet and therefore become portable and accessible to the client wherever they travel. Clients can input their food and diet data into the application on a meal-by-meal and day-by-day basis. The applications are usually linked to a vast database of food analysis information that helps to track calories, macronutrients, micronutrients, fluid consumption and more. Completed food diaries are rapidly and easily analysed by the application and the reports can be shared between client and expert with ease. The advancement of technology has made detailed nutritional analysis a very affordable process and within the financial grasps of the large majority of clients today.



Review and analysis

Effective nutritional advice stems from having the right information to base actions and decisions upon. Once client information has been gathered it is important to review and analyse the information carefully to determine the current dietary and nutritional position of the client. It is this analysis process that will inform appropriate diet and behaviour change going forwards. There is a wide range of factors that may be reviewed from within a client food diary or from information contained within a questionnaire. The more detailed the information provided by the client, the more analysis can be done with stronger conclusions as a result. A discussion of several important nutrition factors that should be reviewed in the vast majority of client cases will follow.

Calorie content

In line with the diet hierarchy, most client cases should begin by determining the calorie content of their typical eating patterns. If the client has provided a written food diary or has utilised a nutrition tracking application, then there will be sufficient information to determine total caloric intake. It is most helpful when several days of diet diary have been completed. Ideally, this should cover both regular working days and days off work to determine differences in dietary patterns when the client's daily routine changes. The total calorie intake for each day should be calculated, then the average calorie intake across all recorded days can be determined by adding all calorie totals together and dividing by the number of days of a completed diet record. The average calorie intake should then be compared to the clients calculated total daily energy expenditure (TDEE). This will help to determine if the client's eating habits place them in a calorie surplus, calorie maintenance, or calorie deficit. It is also wise to look at the range of calorie intake across the days to see if there are patterns of consistency in consumption or if there are significant differences from day-to-day. The example in the table helps to illustrate why this is important.

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Average
Daily calories	2584	2165	2486	2033	2678 (High)	1843 (Low)	2536	2332 kcal
Exercise day	✓	×	✓	×	✓	×	×	
TDEE	2135 kcal		Surplus		~~Maintenance~~		~~Deficit~~	

The example shows that on average the client is consuming 197 calories more than is required on a daily basis. However, there are still some factors that vary from day to day. Even a moderate exercise session is likely to burn 300-400 calories, therefore on the 3 days of exercise, the average energy consumption plus the exercise likely reaches maintenance calories instead of surplus. In general, the client eats less on non-exercise days, reaching either calorie maintenance or a small deficit. The weekend appears to be the exception with a low and a high-calorie intake and no exercise completed, however, the average energy consumption over the 2 weekend days is 2190 calories, which is close to the TDEE target. The range of calorie intake is significant with the highest and lowest intakes showing a difference of 835 calories, possibly suggesting that on Saturday the client has missed one of their regular meals.

Once a thorough review of daily energy consumption has been performed, the results can be factored against the intended client objective going forwards, whether that goal is weight loss and body fat reduction, muscle growth, or weight maintenance. Goal setting and effective strategy development will be discussed in the next chapter.

Protein intake

It is reasonably common to find individuals who do not consume sufficient amounts of protein. As a result, protein should be high on the agenda during a nutritional analysis. Protein has an important role to play with regards to exercise performance, muscle growth and recovery, and of course, positively influencing satiety and hunger. Total protein intake should be determined for each day of a dietary record and the average intake calculated. The percentage of protein consumed can be calculated by factoring in the protein calories against the total calories for the day. The average protein intake should be compared against the client's required protein consumption based upon their activity levels and their body weight protein target. It is also important to look at the pattern of protein intake across the week to determine if there is a significant variation or a consistent amount of protein consumed per day. This information will help to provide a suitable basis for setting goals and targets that are appropriate to the individual.

The example in the table will help illustrate the importance of this information. For this example, the client is 78 kg body weight.

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Average
Daily calories	2584	2165	2486	2033	2678 (High)	1843 (Low)	2536	**2332 kcal**
Daily protein (kcal)	300 (12%)	232 (11%)	328 (13%)	252 (12%)	376 (14%)	208 (11%)	312 (12%)	**287 kcal (12%)**
Daily protein (g)	75	58	82	63	94	52	78	**72 g**
Protein per meal (g) *B-L-D	10-16-38	8-20-27	12-22-36	7-17-30	15-26-42	18-34	11-22-35	**12-18-35**
Exercise day	✓	×	✓	×	✓	×	×	
Protein target	109 g/day		~~Surplus~~		~~Maintenance~~		Deficit	

*B-L-D = Breakfast, Lunch, & Dinner

The example client is consistently eating a protein consumption that is lower than the required daily protein target based upon their body weight. As the client is already exercising 3 times a week, they were given a protein consumption target of 1.4 g/kg/day. On average the client consumes 37 g less protein than their daily required target. Even on the day in which they consume the greatest amount of protein they still fall short of their daily target by 15 grams. This level of protein shortfall of one third under target is fairly typical of the general population and indicates the need to manage protein consumption more carefully as part of the goals and strategies for this client. There is higher protein consumption on exercise days and Sundays, but this may be a consequence of higher calorie intake on these specific days rather than a concerted effort to eat more protein on exercise days. Protein consumption as a percentage of total calories ranges between 11-14% intake, averaging 12%. This is fairly typical of general population intake and variation in protein consumption appears to rise and fall in line with daily calorie consumption. The client's daily protein consumption patterns across breakfast, lunch, and dinner are also typical with the most protein (~35 g) consumed at dinner at the end of the day, and the least at breakfast (~12 g).

Other factors concerning protein that may become part of the analysis include:

- Identify when protein is consumed across the meals of each day. Ideally, it is best to spread protein evenly across all meals and snacks, but this is uncommon, and most protein tends to be consumed at one or two major meals during the day.
- Identify the type and quality of protein consumed. Identifying animal and/or plant sources of protein and the resulting bioavailability, seeking higher value, lean protein sources. Where plant-based protein sources are consumed, check for adequate complementary plant protein sources to raise the overall dietary value.
- Review whether a wide variety of protein sources are consumed across the food diary or if there are limited dominant protein sources consumed multiple times.

Fat intake

Dietary fat is often regulated amongst the general public because there is such a prevalent message about low-fat consumption through both government and national guidelines as well as the marketing messages spread throughout supermarkets and food stores. As dietary fat is a calorie-dense macronutrient, commonly, those who are mindful of their total calorie consumption will be utilising fat restriction as one of their tools to limit calorie intake.

Total dietary fat consumption should be calculated for each day of the dietary record with the average intake determined for the whole food diary period. The daily calories of fat consumed can be factored against the total calorie intake for each day to determine the percentage of total calories provided by dietary fat. Digital software applications will usually perform all these calculations as part of the basic daily report. Once the average dietary fat % consumption for the food diary is determined it can then be compared against the target intake as a key nutrition reference point.

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Average
Daily calories	2584	2165	2486	2033	2678 (High)	1843 (Low)	2536	**2332 kcal**
Daily fat (kcal)	1034 (40%)	693 (32%)	845 (34%)	610 (30%)	1018 (38%)	645 (35%)	989 (39%)	**833kcal (36%)**
Daily fat (g)	115	77	94	68	113	72	110	**93 g**
Exercise day	✓	×	✓	×	✓	×	×	
Fat target	466-816 kcal (20-35% kcal)		Surplus		~~Maintenance~~		~~Deficit~~	

The example client's dietary fat consumption varies across the week by 424 calories per day averaging 833 calories per day, which accounts for an average of 36% of their daily calories. This is a small surplus above the upper end of the desirable range for fat consumption. Bearing in mind that this client is also eating in calorie surplus across the week, then the daily fat intake, when compared against the preferred target in relation to the calculated client TDEE (427-747 kcal), shows a much larger daily surplus of dietary fat, with 4 days consumption exceeding the upper range. The change in daily fat intake appears to generally rise and fall in line with overall daily calorie intake, but not in a parallel manner. The variation in percentage intake is as great as 10% variation between the highest (40%) and the lowest (30%) consumption days.

Other factors that are worth investigating when evaluating dietary fat intake are:

- The sources of dietary fat in the diet, considering the mix of saturated, monounsaturated, and polyunsaturated fats contained within the food consumed or added as oils during the cooking process. Software applications will determine this balance easily as the system will calculate the figures automatically. High saturated fat (>10% kcal) in the diet is associated with an elevated risk of heart disease and an unfavourable cholesterol balance.
- The amount of omega-3 and omega-6 fatty acids consumed in the diet is also worth identifying, especially to help determine the ratio between these two types of fats. A high ratio of omega-6 to omega-3 fatty acids is strongly associated with elevated heart disease risk and increased inflammatory processes in the body.

Carbohydrate and fibre intake

Unless a client is specifically on a high carbohydrate diet for sports performance or on a low-carbohydrate/ketogenic diet for weight management, it is unlikely that they are carefully tracking their carbohydrate consumption. Carbohydrates are often the macronutrient that simply makes up the balance of calories once proteins and fats have been consumed. Staple foods and starches often form the bulk of meals, but as there are few limits placed on carbohydrates, they may not be a high dietary priority as an energy food despite strong promotion in public health guidelines and food marketing. Bearing this in mind it is important to ensure that carbohydrate consumption is not pushing calorie intake above the desirable upper level.

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Average
Daily calories	2584	2165	2486	2033	2678 (High)	1843 (Low)	2536	**2332 kcal**
Daily carbs (kcal)	980 (42%)	1240 (53%)	1313 (53%)	1171 (58%)	1284 (48%)	990 (54%)	1235 (47%)	**1173kcal (50%)**
Daily carbs (g)	245	310	328	293	321	248	309	**293 g**
Carbs per meal (g) *B-L-D	50-64-98	83-52-140	78-64-160	58-105-96	69-83-148	85-126	50-157-90	**68-88-123**
Fibre (g)	21	16	24	16	22	14	28	**20 g**
Exercise day	✓ 6 pm	×	✓ 6 pm	×	✓ 6 pm	×	×	
General Carbs target	1049-1282 kcal (45-55% kcal)		~~Surplus~~		Maintenance		~~Deficit~~	
Specific Carbs target	234-390 g (936-1560 kcal)		~~Surplus~~		Maintenance		~~Deficit~~	
Fibre target	>25 g/day		~~Surplus~~		~~Maintenance~~		Deficit	

*B-L-D = Breakfast, Lunch, & Dinner

If a client needs to consume carbohydrates to manage sporting performance and exercise then the appropriate amount needs to be calculated in relation to their body weight. Daily carbohydrate intake and calories can then be compared against the target carbohydrate needs. Beyond this specific exercise-fueling need, carbohydrate consumption may be evaluated in relation to the timing of carbohydrate foods around exercise, work, and physical activity. This example client, 78 kg in weight, is exercising 3 times per week and qualifies for the 'general fitness' carbohydrate recommendation of 3-5 g/kg/day.

The analysis table shows that the client consumes an average carbohydrate intake within the guidelines for both the general population recommendations and the more specific carbohydrate target for exercise when factored against the client's body weight. One area of concern is the lack of fibre within the client's diet as they consistently fall short of the minimum 25 g of fibre per day, only exceeding that amount on a single day in the diet diary. This is likely indicative of consuming too much refined, processed carbohydrate foods with not enough emphasis on unrefined starchy carbohydrates and a plentiful supply of fruit and vegetables. In regards to the timing of meals around exercise, the example client exercises immediately after work at 6 pm on 3 days each week. On exercise days lunch provides an average 75 g carbohydrate approximately 5 hours before the exercise session. This is moderate consumption, but it is too far away from the intended exercise session. Following exercise, the client consumes 135 g of carbohydrate, which is a high amount and will significantly contribute to the recovery of glycogen stores in the muscle. This suggests that the timing of carbohydrates before exercise could be improved.

Other factors that are worth investigating when evaluating dietary carbohydrate intake are:

- The number of foods consumed that fall into the refined, processed carbohydrate category compared to the number of foods that fall into the unrefined, unprocessed carbohydrate category.
- The amount of added sugars contained within the diet in comparison to the desired range of 5-10% of calories per day.

Macronutrient ratios

Specific targets for macronutrient ratios may be set when an individual is seeking to follow a specific dietary archetype as previously discussed in an earlier chapter. Beyond protein intake for increased satiety, the overall balance between the three macronutrient categories is not a significant factor that will greatly influence weight gain or weight loss, but it is a factor that is influential for several sport or exercise performance targets. Therefore, this is a secondary consideration once individual analysis of calories and each macronutrient have been completed. It is common to find that the macronutrient ratio is elevated to become the primary consideration or objective for guiding dietary consumption. In most cases, the ratio of macronutrients is a lower priority because it has a lesser influence on performance outcomes.

In reference to the example client, it is easy to review the macronutrient ratio that has been calculated from the average weekly calorie consumption for each of the three macronutrient categories. This provides a macronutrient ratio of 12% protein, 36% fat, and 50% carbohydrate (1:3:4). This is a very typical macronutrient ratio that closely reflects the typical government guidelines and the accepted ratios for a low-fat diet. Although it should be noted that the percentage of fat is just above the upper 35% range according to accepted guidelines.

Micronutrient intake

It is important that any diet provides the body with all the essential micronutrients needed to sustain health and well-being. It is near impossible to determine micronutrient data from questionnaires alone, but it is possible through the use of a detailed food diary or a nutrition tracking application. Be warned that not all nutrition tracking applications provide a full spectrum of micronutrient data. This is an essential requirement for nutrition coaches in our modern age. Therefore, ensure to utilise diet tracking software that provides complete micronutrient analysis.

The process of analysis is relatively simple once the actual amounts of each macronutrient are known. For each given micronutrient, simply calculate the total average daily amount consumed across all days of the food diary record, then compare them with the recommended intake value. For additional clarity, it helps to calculate the percentage of micronutrient consumption that has been achieved.

It may be helpful to break the full spectrum of micronutrient values down into low (<50%), medium (50-99%), and sufficient (≥100%) intakes compared to the daily requirements. This helps to provide a clear picture of where the nutritional shortfalls are and to inform appropriate dietary strategies to resolve this going forwards. The example table will illustrate how to do this effectively across a partial selection of micronutrients.

Female client	Vitamin A	Vitamin C	Vitamin K	Calcium	Potassium	Iron
Daily requirement	700 - 900 µg/day	75 - 110 mg/day	70 - 120 µg/day	900 - 1200 mg/day	3500 - 4700 mg/day	8 - 18 mg/day
Average daily intake	642 µg	53 mg	27 µg	1084 mg	3961 mg	8 mg
% daily requirement	92%	71%	39%	120%	113%	100%

Food reactions

Food reaction records can be very informative but are a lower priority than the previous analysis options that have been discussed, primarily because it takes time and lots of data to be certain of patterns and trends. Measuring food reactions is not typically a feature found in most nutrition or diet tracking applications. A well-designed written food diary will likely include a food reaction section where clients can respond to how they feel approximately 1 hour after consuming a specific food or meal. Whilst food reactions are a secondary analysis tool, they can be useful to guide a client towards the type of foods that their metabolism is better conditioned to manage. Some individuals feel and operate better on a high carbohydrate, low protein/fat diet, some do well on a moderate carbohydrate, moderate protein/fat diet, whilst other clients may function better on a high protein/fat, low carbohydrate diet. Looking for patterns in food reaction can be beneficial to revealing such variations in metabolic preference. Food reaction records can also indicate if there are certain foods that a client does not respond well to due to low-grade food sensitivities or potential food intolerance. When food is consumed that stimulates a low-level immune response (often below conscious awareness) this may result in lower energy, low-level digestive issues, and possibly altered mood.

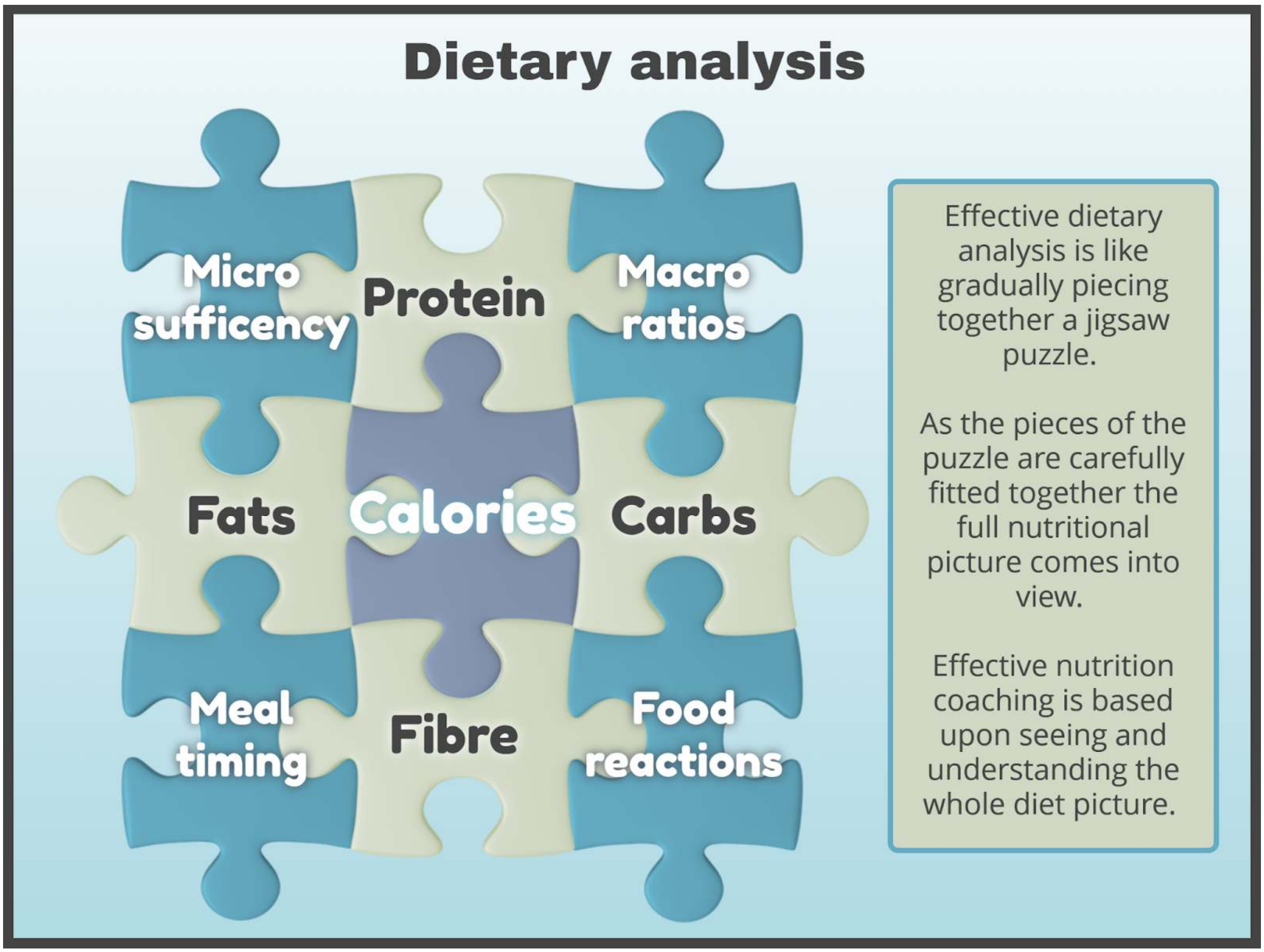
To analyse food reaction records across a whole food diary, simply total the number of positive versus negative reactions related to each type of meal (breakfast, lunch, & dinner). This relates the food reaction to the time of day as well as to the dietary components consumed so that 24-hour circadian rhythm does not influence the reactions to different meals. Once again observation skills are needed to observe different dietary patterns concerning food reaction scores. For example, if breakfast consistently results in negative scores, while dinner consistently results in positive scores, then it may be worth making a more detailed comparison of the different food content and macronutrient ratios of the two meals. This detailed review may help to unearth some worthwhile data or observations that might suggest needed dietary change. It may take several weeks and a little trial and error to collect enough food diary data to be confident in the food reactions data trends sufficient to recommend appropriate dietary change.

Meal and snack timings

Last but not least is a review of the typical times of day in which a client normally eats their meals and consumes their snacks. Once again this is a matter of seeking to observe patterns and trends in the times that food is consumed. Commonly, these times may be more fixed during working days compared to days off work. It is commonplace to find that individuals only eat 2 meals per day and fill the remaining time with snacks, especially on working days. This is often because work is the priority and food is simply the fuel to keep things ticking along. However, there can be a wide level of variation in regards to the timing of food eating habits. The following table shows a range of some common variations in eating patterns related to meal timings.

	Breakfast	Snack	Lunch	Snack	Dinner	Snack
Type 1: Clockwork	07:30	10:30	13:00	15:30	18:30	21:00
Type 2: Late start	10:30	N/A	13:30	16:00	19:30	N/A
Type 3: Late eater	N/A	11:30	14:30	17:00	20:30	22:30
Type 4: Fuel only	11:00	N/A	N/A	13:30	19:00	N/A
Type 5: Meals only	08:30	N/A	12:30	N/A	18:00	N/A

Meal timings should be reviewed in light of the many of the previously discussed dietary priorities. If total calorie intake is too high and the client eats 3 meals and 3 snacks a day, then it may be wise to discuss removing 1 or 2 of the snack times to help reduce calorie intake. If the client eats a 'fuel only' type of diet, eats only 2 meals, and does not consume enough daily protein, then it may be wise to introduce a lunch to help increase the protein intake across the day. If a client eats a meals only pattern but arrives at the gym fatigued at 5 pm, then it may be worth introducing an afternoon snack to help maintain better energy into the workout session. It is these types of considerations that matter when reviewing meal timings, rather than meeting a fixed or arbitrary time on the clock for each meal or snack. Food intake has to be adaptable to work in the context of the client's lifestyle and circumstances, whilst still contributing to good health and wellbeing.

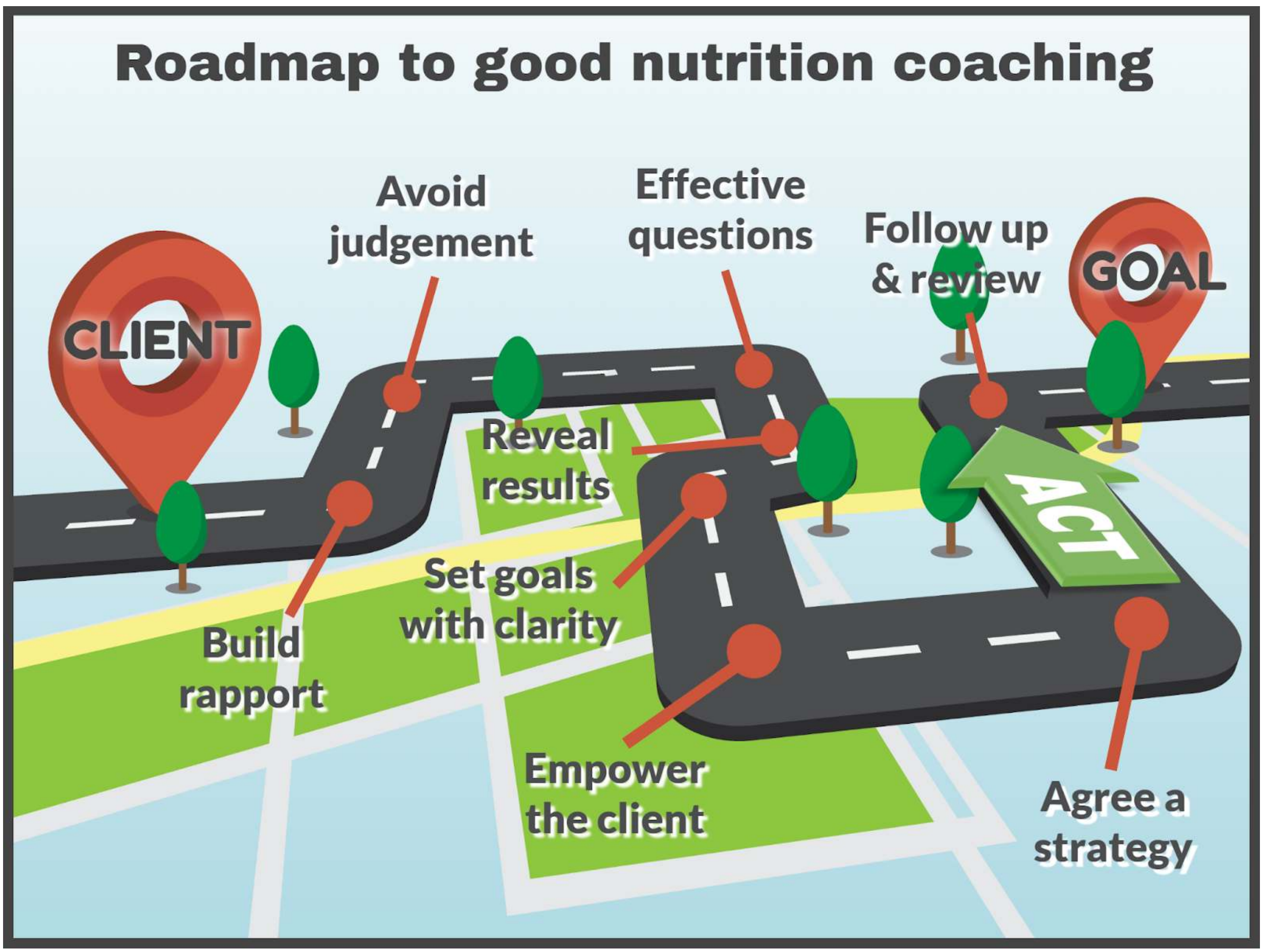


Key learning points: Chapter 8 Dietary analysis

- Gathering dietary information can be done using several different options:
    - Dietary history and habits questionnaire
    - Dietary preferences questionnaire
    - 24-hour dietary recall questionnaire
    - Written food diary
    - Diet and nutrition tracking software
- Once collected, dietary information needs to be analysed and interpreted. The following key points will help to guide the process of reviewing and interpreting dietary information. This list is set in dietary priority order:
    - Calorie intake - the average daily calorie intake can be determined and compared against the client's calculated total daily energy expenditure (TDEE).
    - Protein intake - the average daily protein consumption can be determined and compared against the client's calculated protein needs based on their current bodyweight.
    - Fat intake - the average daily total fat consumption can be determined and the percentage fat intake calculated and compared against the maximum 30% of calories guidelines. Where possible the average daily saturated fat consumption can be determined and compared to the maximum 10% of calories guideline.
    - Carbohydrate intake - the average daily total carbohydrate consumption can be determined and compared against the specific carbohydrate to bodyweight needs based upon their current level of physical activity.
    - Fibre intake - the average daily total fibre intake can be determined and compared against the recommended minimum intake of 25g/day.
    - Micronutrient intake - where data is available, the average intake for each micronutrient can be determined and compared against the optimal daily intake requirements previously referenced in the micronutrient chapter.
- Food reactions - when using a food diary that includes post-meal food reactions scores, this can be used to identify dietary patterns in relation to the different foods being consumed and the prevalence of positive or negative responses recorded in the diary.
- Meal and snack timings - identify patterns to inform behaviour change.

Chapter 9: Nutrition coaching

Understanding a sufficient level of scientific information on the subject of nutrition is, of course, very important to be able to provide appropriate dietary analysis and understand the steps that should be made to help a client move forward towards their goals and objectives. However, it is also important to be able to adequately coach the client and help them to move forward in their behaviours and habits towards the intended goals and objectives. These are two distinct components of being a nutrition coach and it is important to master both parts; the nutrition science and the nutrition coach. The previous chapters of this text have primarily covered nutrition science, understanding all of the different elements that make up effective nutrition to support health and wellbeing. This chapter will review the skills needed to be an effective nutrition coach that will help and support a client as they make the changes towards effective dietary habits and behaviours.



There are 8 important steps to providing appropriate nutrition coaching in a manner that will help clients feel they are working with a professional who is understanding and will support them as they gradually move towards their dietary goals. These 8 steps can be viewed as the turning points on a roadmap that leads towards successful goal achievement.

Build rapport

Rapport has been defined as, *'a relationship characterized by agreement, mutual understanding, or empathy that makes communication possible or easy.'*

An integral part of having rapport with a client is gaining their trust and being able to communicate in a manner that brings mutual understanding between both parties. Communication is built upon both verbal and non-verbal information that is shared between people. Developing rapport with a client hinges upon these 3 factors; agreement, mutual understanding, and empathy.

Building relationships of trust

To provide an effective nutrition coaching service it is essential that the client's trust their nutrition coach. Formal certifications and professional reputation will provide a starting point in establishing trust, but the bulk of trust will mostly be founded on the direct interactions between client and coach. Building trust is a long-term process that is strengthened by each positive step that shows the client you are invested in their welfare and have their best interests in mind.

Gaining trust with a new client begins with simple actions, such as the coach sharing some relevant information about themselves, their background, what inspired them to become a nutrition coach, and why they enjoy supporting clients to achieve their goals. Asking appropriate questions about the client to get to know them, understand their circumstances, and what inspired them to seek out a nutrition professional, will help to invite the sharing of similar introductory details and begin to set in place important foundational information to build a professional relationship upon. It is important during this early sharing of information to actively seek common ground to express empathy, and to identify experiences between each other that create a familiar bond of understanding.

To gain trust a coach must have integrity and be honest and true to their word. When a coach commits to doing something for a client, there should be no question as to whether it will be completed or not. Therefore, decisions should be carefully considered, agreed upon with a client, and then the plan of action acted upon in a positive and time-sensitive manner. A coach must also demonstrate trust in the client and their ability to move forward with the agreed plan of action. Expressing trust in the client helps to increase the value of their commitment to the change required. It is important that a client feels that their needs are central to the success of the professional relationship and that no part of the process is focused on the coach promoting themselves or their business.

It is not helpful to the building of trust for a coach to maintain an air of superiority, implying that their dietary habits and practices are impeccable. To relate to and understand the client, being open and honest about personal dietary challenges of the past and present can help to establish a sense of humanity and normality. Even if the nutrition coach never intends to put themselves on a pedestal, it is common for clients to do so as they see the coach as an expert who has the answers and who has mastered the process. It is more helpful for the client to see the coach as someone who has been where they are and that they can serve as a guide to help them move from their current dietary location to a new desired dietary location. This helps to build authenticity and often is more inspiring than the impression of near dietary perfection that may seem unattainable to a new client.

Communication is an important part of strengthening trust as well.

Communication skills

Communication is the *'ability to express ideas effectively both verbally and in writing, in individual and group situations, adjusting language, terminology and non-verbal communication in a manner appropriate to the recipients, resulting in understanding and/or action.'*

In most cases, communication between a nutrition coach and their client will be either verbal, non-verbal, or written. Verbal communication is a very important skill to develop. Just because a coach can speak and does speak every day, does not guarantee that their language, volume, speaking pace, tone of voice, variation in pitch, terminology and phrases, or their typical thought processes are well-matched with a client.

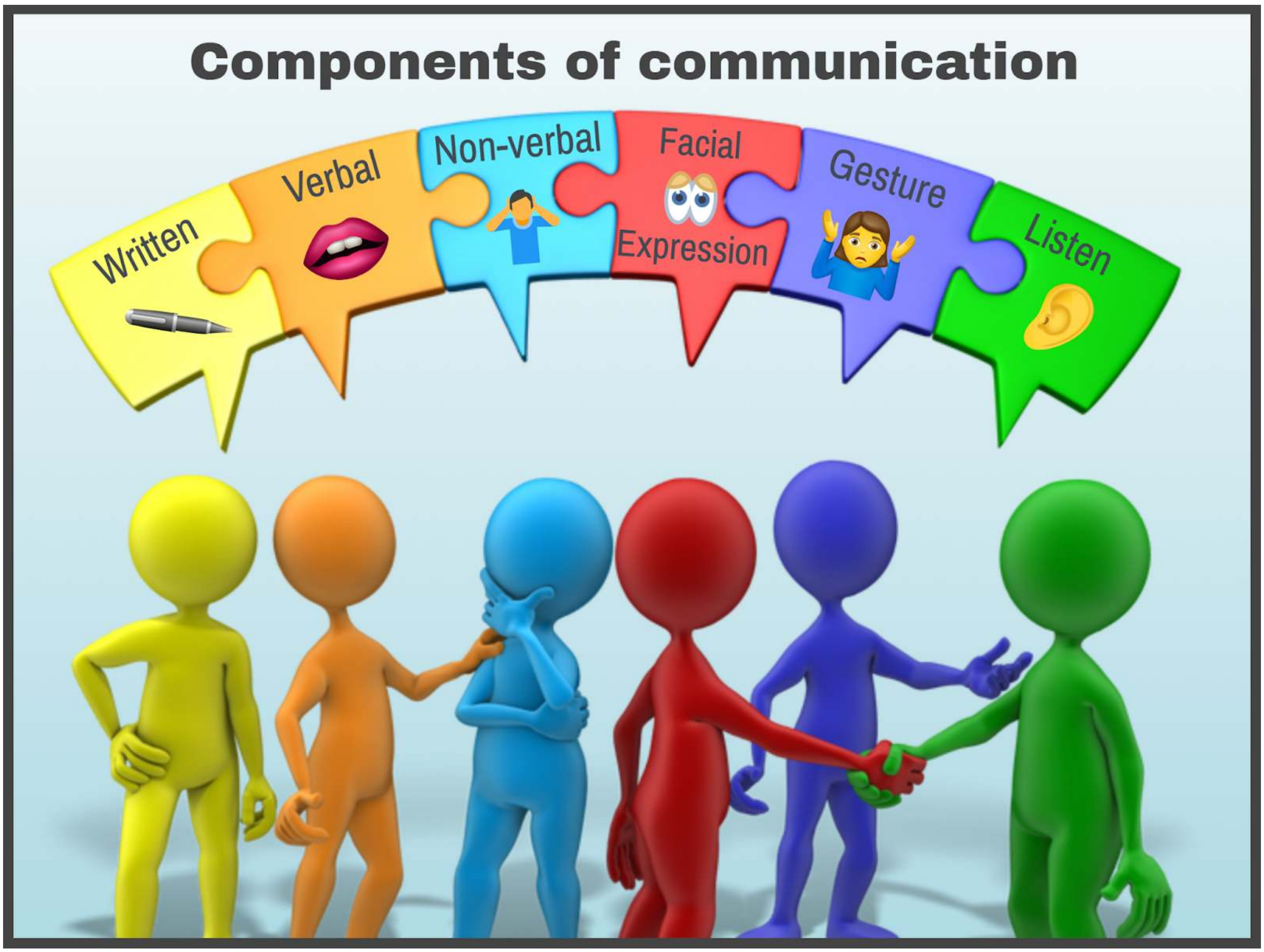
Good communicators quickly recognise how a person or group communicates and then adapts their style to be more closely matched to the style of the other person or party. This adaptable nature makes them better communicators as their primary motivation is to be better understood and to better understand the other person.

Closely tied in with good verbal communication is the important skill of listening to understand another person's verbal and non-verbal communication. Being able to ignore distractions, listen and observe with full focus to a client to understand them is an important part of communication and essential for building trust. A client must feel that their communication is understood and the key to this is listening. Listening is more than simply hearing, listening is understanding, relating, interacting with relevant counter communication, using body language to show interest, asking questions for clarification, and re-stating to express understanding.

It is increasingly common to interact with clients in written form over email, digital messaging, software applications, and written diet reports. Therefore, being able to write clearly and professionally is also very important. The colloquial language typically used among friends is not appropriate for the professional environment. It is important to write in full sentences, with paragraphs, using good grammar and appropriate, clean language when communicating in written form to clients. There is a range of software applications that can be installed on a computer to help identify written errors in both language and grammar that will suggest improvements to the user. This can help provide support to a coach to improve written communication with clients in a more professional manner. A full discussion on effective verbal and written communication is outside the scope of this text, but needless to say, it is an important part of becoming an effective nutrition coach.

Non-verbal communication most often refers to facial expressions and body language, including conscious gestures, and subconscious body positioning. We observe body language in almost every daily communication, so it is something humankind is used to observing, even if it is not always at a conscious level. Body language may be very obvious like using the hands to gesture during talking to help emphasize certain words and enhance communication points to another person or group. Facial expressions are another commonly used way of expressing and communicating. The human face is capable of producing many hundreds of different facial expressions and these expressions may help provide increased understanding to the words that are said. In many cases, a facial expression may still communicate meaning even when no verbal words are offered.

Body language can also be much more subtle and may be expressed subconsciously through body positioning or small movements. For example, a more commonly known subconscious movement may be seeing an individual rub their lower neck or touch their ear as a sign of feeling awkward, anxious or stressed. A nutrition coach can learn to be more observant and seek to understand what a client is communicating by keeping more conscious attention on their physical body language. Ultimately better communication through verbal, non-verbal and written means will help to enhance the sense of trust and rapport between nutrition professionals and their clients.



Avoid judgement

During the regular communication that a nutrition coach will have with a client, it is highly likely that the client will discuss personal and sensitive information with the coach. Appropriate diet and lifestyle information must be received in good faith and without judgement from the coach. A client may live an entirely different lifestyle to a nutrition coach and have different priorities and habits. In some cases, significant differences may cause surprise, disappointment, frustration, or some other emotional response from the coach. If a client sees a negative reaction from a coach in response to the details they confide in you, this may be seen as unwelcome judgement towards them and their way of living. This can diminish trust and lead to tension between client and coach. It is important to be as accepting as possible of the information shared and to recognise the client is focused on changing their behaviour and striving to establish more beneficial habits. Being non-judgemental does not mean remaining neutral. It is important to listen to and understand the client, their lifestyle and circumstances to help facilitate a series of changes towards more health-promoting actions. This will require professional consideration of existing actions and behaviours and the ability to recognise opportunities for positive change. A good nutrition coach is always supportive of the client, even if they are not always supportive of specific undesirable actions and behaviours. Past and existing actions and behaviours do not define the client, they simply provide a roadmap for how the client got to their current position which resulted in seeking out the help of a nutrition coach.

Ask questions

An important part of gathering information to inform new or ongoing actions and behaviour change is to ask questions. The right questions applied in the right way can be a powerful tool in a consultation or client review. There are 4 primary question types.

1. Closed questions

Closed questions usually prompt a very short answer, such as 'Yes' or 'No' or they may be answered with a simple fact or snippet of information. They are called closed questions because they close down the conversation and do not naturally engage communicating participants to express greater detail or provide further information.

- Do you always eat a roast dinner on Sunday?
- What is the name of your favourite soft drink?

Closed questions are beneficial for gathering simple facts or checking a person's understanding. They can also help conclude a topic of discussion before moving to a different subject.

2. Open questions

Open questions encourage longer answers with more detail and often begin with what, how and why. An open question directly requests that an individual express further knowledge on a subject, or to share their thoughts, opinions or feelings on a matter.

- What are your typical daily meal times?
- How do you feel after you eat that late at night?
- Why did you choose that product for your post-workout shake?

The primary role of open questions is to open the conversation up and encourage the other participant to communicate more information than they may have done up to that point. Whilst they are useful for generating discussion, too many successive open and closed questions, due to their direct style, can feel a little like the individual is being subjected to an interrogation. It is important to break questions up with restatements, expressions of interest, statements of understanding, and other questioning techniques.

3. Indirect questions

Indirect questions are a method of easing a recipient into the question so that it feels less formal or intrusive. They tend to feel more conversational and, because they are less blunt, they feel more polite. Contrasting examples with direct questions will help to illustrate the indirect questioning style.

- What is your body weight? *(direct)*
- To help calculate your basal metabolic rate, please let me know your current body weight? *(indirect)*

- How late was your evening snack? *(direct)*
- That's interesting. To help me understand the impact on your sleep, can you tell me what time you ate your evening snack? *(indirect)*

Indirect questions serve as a great method of breaking up the direct nature of closed and open questions and helping the consultation feel more like a discussion.

4. Leading questions

Leading questions are designed to draw an individual's thinking and response towards an idea or concept by adding a predesigned element or concept into the question.

- Why do you think doughnuts are not healthy for the body? *(includes an assumption that the client does think doughnuts are unhealthy).*
- Which of the 2 snack time options best allows you to include a 15 g portion of protein? *(leads the client to weigh up the 2 options rather than say neither are suitable).*

Whilst it is best to allow a client to answer questions freely and openly, there is still a place for carefully crafted, leading questions that help nudge them towards a more desirable answer.

Using appropriate questions can be an important tool for getting to know a client and for gathering information during an initial client consultation before a client completes a food diary or records their diet using a digital application. Questioning may also be beneficial after a food record has been made to get clarity on some of the entries or information provided. Questioning also serves as a valuable tool during a food diary feedback session or in the future during periodic progress review meetings. Obtaining correct and detailed information is vital for planning suitable goals and strategies to direct each client.

Reveal results

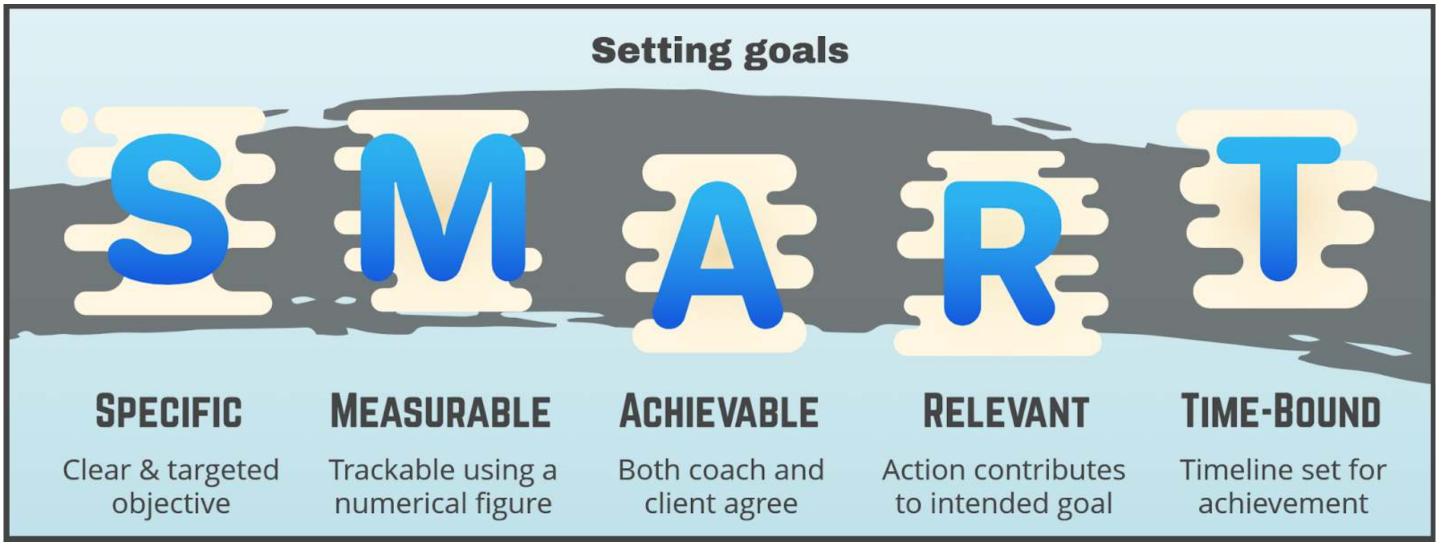
Following the completion and analysis of a client food diary or the provision of a detailed nutrition tracking report from a digital application it is usually appropriate to schedule time to discuss the information contained in the record with the client. Providing professional feedback to the client on their dietary patterns takes planning, skill, and plenty of carefully devised communication. It is common for clients to feel somewhat defensive or exposed when a nutrition professional reviews their diet diary. Eating habits reveal more than just nutritional sufficiency. Eating is one of the primary things we do daily to care for ourselves and our bodies. Most people believe that they are good at looking after themselves and when someone has the opportunity to look in detail at this personal process, it can leave them feeling exposed and vulnerable. Some may even fear the judgement or negative feedback that may result as their ‘bad’ eating habits become exposed. Therefore, reviewing a food diary with a client is a discussion that needs to be managed sensitively in a spirit of open honesty, without negative judgement of the individual for who they are or how they live and eat.

The following steps will help to manage this important discussion appropriately.

- Write a clear, honest, and understandable report regarding the dietary findings in the food record. Review the major findings plainly and simply, matching the level of the discussion with the client's level of understanding. Aim to be factual about the information without using any judgmental terminology, phrases or body language.
- Be observant of the client during the discussion of the dietary report. If their facial expressions or body language show signs of concern, embarrassment or other negative responses, then take the time to ask their thoughts and feelings. Listen and be understanding. Equally, if you observe positive body language, invite them to share why they responded in such a manner.
- Praise the client for good results and reinforce positive dietary behaviours and habits that are already in place. Leverage existing positive dietary habits where possible to instil new habits and behaviours that will lead towards agreed dietary objectives.
- Create in advance a list of 3-6 priority focus items, drawn from the dietary analysis, to discuss in further detail with the client. These need not necessarily be the 3-6 biggest problems, just matters that need attention and may likely form the intended dietary goals going forward. It may be wise to have a mix of larger and smaller issues to allow for some easier to achieve actions as well as some that will require more diligence to achieve.
- Discuss the priority focus items in detail with the client sharing your rationale and the evidence in the diary for their inclusion in the priority list. Ask the client for their views and perspective for each item on the list to gauge their response. Determine which items carried positive and negative client responses and weigh these up for their potential dietary impact and the likelihood of client adherence to each required change.
- If the dietary record report creates further relevant questions, ask the questions with care to obtain clarity and understanding, especially if the answers will likely impact the 3-6 priority areas of focus.

Set goals with clarity

The use of the SMART acronym is commonly used across the business and personal development fields. Each letter in the acronym specifically directs to an important component that helps with effective goal setting.



However, only 3 of the letters within the acronym directly correlate with things that should be written down when developing a new goal. The letter S for specific, the letter M for measurable, and the letter T for time-bound, all relate directly to essential elements of writing and recording a significant goal. The letters A for achievable, and R for relevant, are important to consider and review once a goal has been recorded, but they do not directly form part of the written goal.

To understand the process better, an explanation of the letter S, the letter M, and the letter T in some more detail is necessary to understand how each relates effectively to goal setting.

Specific

The creation of large, long-term outcome objectives is common, but in nutrition coaching, it is often more practical and successful to focus on and record smaller goals that will contribute over time to a large outcome goal. Initially, it is crucial to identify a component or contributing factor that will play an important part in the achievement of the larger outcome goal. For example, consuming nuts and seeds regularly is a contributing factor to overall protein intake, which in turn can positively influence muscle development. Setting a goal based on increasing the consumption of nuts and seeds would be focused on the process that may, in time, lead to the larger outcome goal of increasing muscle size.

The identified goal component must relate directly to realistic behaviour change that the client can act upon regularly. Any ambiguity or lack of clarity around a targeted component will make the resulting recorded goal also feel uncertain and vague. This may negatively impact the achievement of the intended goal. Effective goals must be stated briefly, specifically, and be tied to a numerical tracker.

Measurable

The specific goal component that is identified must have the capacity to be measured and tracked via a numerical figure. Therefore, care must be taken to select components or factors that lend to being represented by a number. For example, using a before and after photograph of a client will record via an image any change that may occur in body size or appearance. However, it is hard to quantify exactly how much change has occurred via a photo and so this may be less effective as a measurement. It is noted that when visible change has occurred, a photo may be quite motivational for the client. However, if circumferential measurements of the client's limbs and torso were chosen as the tracking tool, this would result in specific numbers that can be recorded at the start. At a later point in time, the same locations on the body could be measured once again and any change that has occurred can be quantified. This is very effective in demonstrating the degree to which change has happened. Being able to measure a goal and the degree to which that change has occurred is an essential part of creating accountability and proving to the client that the goal has or has not been achieved. Without a measurable component, goal setting is simply unproductive. Simply put, goals must absolutely be measurable!

Time-bound

A time frame must be set for the achievement of a goal. Without setting a specific timeline the coach or client may not feel the urgency of action that is required with regards to their behaviours and habits. The time that is set needs to be sufficient to allow the required level of change to be possible. Too little time to reach the goal will likely cause the client to give up with little hope of achievement, while too much time may cause the client to put off changing their behaviour to a later date because it is too easily achieved. The time component for a goal should be possible, but should also create a sense of urgency to begin the change now. The client will be a valuable resource in determining suitable time frames as they will have the best understanding of how they can incorporate the needed actions into their own life.

Example dietary goals

Before we progress on with the discussion of the letters A and R, it would be wise to provide an illustration of effective goal setting using the letters discussed so far. The table below shows two examples of how to write nutrition-related goals using the letters S, M, and T from the SMART acronym. Each goal shows a less effective way to record a goal, in the left column, and then compares it to a more effective recorded goal, in the right column.

GOAL 1	Less effective goal	More effective goal
Specific	Eat more fruit	Increase fruit intake by 4 portions from 5-6 portions/week up to 9-10 portions/week
Measurable	Recall fruit intake at the end of the week	Record daily fruit consumption using a digital dietary tracking application
Time-bound	Over the next few weeks	Achieve the goal consistently for at least 2 consecutive weeks within the next calendar month
GOAL 2	**Less effective goal**	**More effective goal**
Specific	Eat less sugary chocolate	Reduce sugar-rich chocolate consumption from 5 x 80 g per week to only 2 x 40 g consumption per week
Measurable	Memory recall report over email	Track daily chocolate consumption using a habit tracker app e.g. Strides
Time-bound	Immediately	Improvement to be observed during week 1, with full compliance during week 2.

The poorly recorded goals in the left column above are too vague, rely on inaccurate measurement and reporting methods, and allow either too much time leeway to create any urgency, or expect immediate compliance without any room to move at all. The goals in the right column have been carefully written to meet the requirements of the acronym letters S, M and T, in such a manner that the client and trainer cannot misunderstand the required change in behaviour. Goals must be recorded with sufficient detail, with numerical measurement values, and a realistic timeframe included to remove any client doubt or uncertainty. Once goals are written in this way the goal can then be reviewed in respect of the letters A and R.

Relevant

Both the coach and the client must agree that the behaviour change that has been outlined under the 'Specific' part of the goal applies to the larger goal it is intended to contribute towards. If the client cannot see the purpose for why this change will help towards the larger goal, then the level of relevance may be brought into question, and the goal may need to be revised. Alternatively, the coach may need to educate the client as to why this specific behaviour change will contribute to the achievement of the larger goal.

Achievable

There are many different considerations as to whether a goal will be achievable. Often a coach may believe that the goal is achievable because to them it appears to be a simple enough behaviour to follow, but it is even more important that the client also believes that the goal is achievable. This will have much to do with what specific behaviour change is required and whether the timeline is realistic. The client must first believe and agree that they can make the intended changes in their behaviour as laid out under the ´Specific' part of the goal. Secondly, the client must believe and agree that the timeline set for the achievement of the goal is also possible. If both coach and client agree then this is likely a realistic, achievable goal if the intended actions are followed carefully. If one party does not agree, then the reasons for disagreement should be discussed so that the goal may be revised to meet the achievable requirement.

Empower the client

It is easy to assume that the role of the nutrition coach is to determine all the answers, set the dietary goals, and create the correct strategies for the client to apply. Whilst the nutrition coach is the expert, this is still a less effective method of helping a client achieve the results they seek. A more effective method is for the nutrition coach to utilise the client as a partner in the goal and strategy development process. After all, the client knows themselves, their ability, and life circumstances far better than the nutrition coach. If the client is involved in developing their own goals and in determining how those goals will transform into daily action points, then they will be much more invested in the achievement of those goals. This is empowering to the client as it allows them to be involved in the decision-making process to help determine their future results.

It is important that the nutrition coach still guides and directs the discussion about the intended goals and strategies. As the expert, the coach will be aware of the key topics to be discussed, the priorities that need to be addressed, and throughout the discussion, they may provide insights to the client for developing an effective strategy.

The following example of a conversation will help to illustrate how a coach may facilitate the development of an effective goal together with the client.

Coach: "During the dietary analysis I calculated your total fluid intake. This resulted in an average daily intake of 1.3 L of total fluids per day. This total includes water and all other beverages consumed each day. When we compare this to your ideal calculated fluid requirements, at 2.5 L per day, there is a shortfall of 1.2 L that we need to address. What are your thoughts on this information?"

Client: "To be honest I'm not very good at remembering to drink more water. I do enjoy my daily coffee, but I get so busy with work that I forget to drink regularly. So, I'm not surprised by this result."

Coach: "Without trying to be too serious, it is important to get sufficient daily fluids. Your hydration status each day will have a bearing on your physical and mental functioning. So, being dehydrated will reduce your productivity at work, even if you are not aware of this. In particular, on days you attend the gym it's important that you arrive well hydrated as you will lose a lot of water during exercise and that can lead to reduced physical performance."

Client: "I completely understand. What you're saying makes a lot of sense and I can agree that this is something I really should address. I don't imagine it will be too difficult. I just need to make it a better habit in my daily life."

Coach: "It is great to hear you are quite positive about resolving this going forwards. Let's start by setting a SMART goal, then we can discuss a strategy to implement the change. Firstly, I just mentioned the shortfall of 1.2 L per day. Do you think that you can increase your fluid intake by that much each day? It is basically doubling your current intake."

Client: "Mmmm? When you say it like that it does sound like a lot. I am not sure I would remember to drink that much more."

Coach: "I can appreciate your hesitancy. What do you think would be a manageable goal for you to increase your fluid consumption then?"

Client: "What is half of 1.3L? 600-700 ml? Let's go for just over half, how about 750 ml more?

Coach: "I like your thinking, yes, that should be manageable. That will work. It may be tricky to remember to drink more water in your busy office environment, so would you mind if I recommend you start using a simple water tracking app on your phone? It will remind you with alerts to drink water at intervals you set within the app. It will also show you your daily total consumption as you log each intake. I know you always have your phone handy!"

Client: "Haha! Yes, my phone is always on me. I did not know there was an app that tracks water intake. Sounds just like my sort of thing. It would be great to have regular reminders. I think without that I would forget. Perfect!."

Coach: "I thought you'd appreciate the tracker app. Finally, we need to set a time frame for the goal. I would suggest that we give you the first week as a practice week to get used to using the app and in managing your increased water intake. How do you feel about tracking this closely during each day of the second week with the intention of reaching your target of 750 ml more fluid per day during your 5 working days? Then in the 3rd week, you can aim to achieve this for all 7 days, including your weekend days?"

Client: "Yes, a week to get used to things seems fair. I am sure I can get this up to speed by the second week, that sounds very fair. Though I imagine I may be less focused on it over the weekend…but I suppose the app will still remind me. Go on, let's plan all 7 days for week 3."

Coach: "Great! So, just to re-state the goal; You will increase your daily fluid consumption, mainly with water, by a further 750 ml, to consume 2050 ml of water/fluids per day. This will be achieved on all working days during week 2, then all 7 days of the week by week 3. How does that goal sound to you?"

Client: "Yes, that sounds good to me. I feel confident with the app that I can achieve that"

This example illustrates how the coach discusses this goal with the client at each step along the way. By including the client the goal was adjusted and adapted to a reduced level that seemed more appropriate from the clients perspective. The coach may well have thought that an increase in 1.3 L per day would have been easy to achieve. However, the client, knowing their personal circumstances at work, felt that it was unrealistic to double their fluid consumption. The coach was adaptable and they agreed to a reduced interim goal for the client to work towards. A good coach understands that the ultimate goal does not have to be achieved in one single step. Breaking goals down into smaller, more manageable chunks is a useful method to move a client from their current position, focusing them in the right direction, towards the achievement of the larger objective. The client will also feel much more invested in this goal as they helped to set the parameters of the goal, and agreed on the tracking method which was well matched to his personal preferences. The chances of the client adhering to this goal is much higher because of the coaching discussion around setting the goal. It would have been quicker for the coach to simply state the goal at the start, without any discussion, but the parameters may have been too high, the client may not have liked the reporting method and they would have felt forced upon to make this change. Adherence to such a process is much likely to be less, which may result in the goal not being reached. Despite the increased time taken to determine the correct goal, this time invested with the client is worthwhile and achieves a much more successful coaching result.

Agree on a strategy

A strategy is different to a goal. A strategy has similarities to navigating with a map. There may be several possible routes to get to the intended destination. The goal is to reach the target location by a certain time, but the strategy is planning and executing the best range of options required to reach that point. In the following image, option 3 seems to be the best route with the joint shortest distance and with only 3 changes of direction, it is also the simplest route. However, it also travels along the main roads through the city and may have the worst traffic and slowest average speed. Therefore, routes 1 and 2 may be more attractive options when travelling through a busy city centre. This helps to illustrate that a strategy is a process of carefully weighing up the options against the existing circumstances and then implementing a series of choices or behaviours to reach a goal.

The creation of an effective strategy requires an understanding of the client and their current circumstances and lifestyle in relation to a specific goal that has been agreed upon. It will also require an understanding of a client's willingness to change to determine the most favourable course of action that will help achieve the intended objective. For example, if the intended goal is to lose 3% body fat within a time frame of 3 months, there are a wide range of possibilities and actions that may be considered to help move the client towards that goal. Successful strategies could be built around any one or a combination of the following factors:

- energy deficit through reduced caloric intake
- managing food cravings and appetite only
- exercise frequency and increased caloric expenditure
- stress management and improved sleep

There are two primary types of strategies that can be applied to a specific goal.

Progressive strategy

A progressive strategy focuses on changing behaviour or habits through a step by step, slow and gradual process. It breaks a goal down into a series of smaller behaviours that will accumulate towards the achievement of the desired goal. The number of steps required will depend upon the agreed time component and the difficulty of achieving the intended goal. Progressive strategies are best applied when it is expected that a goal will take a longer period to achieve e.g. 5-12 weeks or longer. Progressive strategies help a client focus on small actions to help create habits out of simpler behaviours within any given day or week. As the client masters the initial change, the behaviour that is required of them is then incrementally progressed in difficulty. This process is repeated until the desired larger goal is achieved.

By way of example, if an omnivorous client needed to increase their protein intake from 65 to 120 grams per day and had agreed to an 8-week behaviour change process then a progressive strategy would work well in this situation. The following table outlines how the strategy may work by breaking the larger goal down into 4 phases of change across the 8-weeks. Note the progressive nature of this example and how the client is coached towards the goal achievement through carefully managed actions that build upon one another. It can be valuable to work on the development of the different phases of a progressive strategy together with the client. It helps them take ownership of the strategy and feel that they are directly managing their dietary change process with the support of an expert coach. Setting goals in this manner helps to reduce the chances of a client feeling overwhelmed when considering the intended outcome, as it directs their focus to the gradual changing process.

Progressive phase	Actions required for each phase of the strategy
Phase 1	Add 10 g protein into the mid-morning and 10 g into the evening snacks - this will achieve 85 g per day. Choose from a list of preferred protein-rich foods e.g. cheddar cheese, salami, boiled eggs, almonds, pistachios, peanuts, pumpkin or sunflower seeds.
Phase 2	Maintain actions in phase 1. Add a 15 g source of protein at breakfast. - this will achieve 100 g per day. Choose from the preferred list of breakfast foods e.g. bacon, scrambled eggs, low-fat Greek yoghurt, breakfast ham, almonds, chia seeds, or peanut butter.
Phase 3	Maintain actions in phases 1 & 2. Increase the portion size of protein at lunch from 15 g to 25 g each day, a 40% increase in size. This change will achieve 110 g per day. Maintain the variety of protein foods that already exist, but include more protein per serving.
Final phase	Maintain actions in phases 1 & 2. Introduce a 20 g protein shake as a mid-afternoon snack or pre-workout meal on your 3 training days - on these days the protein portion size at lunch can remain at 15 g. On non-training days, consume a 10 g protein bar as a mid-afternoon snack. These 2 actions combined with the previous 3 phase changes will amount to daily consumption of 120 g per day.

Optional strategy

Optional strategies can be applied when the length of time to achieve a goal is relatively short (<4 weeks) or when the coach is undecided on what the best option is for the client. By offering a series of simple options to a client, they are then allowed to choose which of the strategies provided would best fit their needs. A client will know their own life and capabilities best and are thus well placed to determine a favourable course of action. Allowing the client to choose from a range of possible options helps to empower the client and aids in them taking ownership and accountability of the chosen short-term strategy.

Earlier in the chapter, when discussing goal setting, an example of a client who needed to increase daily fluid intake was used. The time frame for goal achievement was 3 weeks. And as such an optional strategy is likely the best choice for planning the actions for achieving the goal. By way of reminder, the intended goal was:

To increase daily fluid consumption, mainly with water, by a further 750 ml, to consume 2050 ml of water/fluids per day. This will be achieved on all working days during week 2, then all 7 days of the week by week 3.

The client already consumes 1.3 L of fluids per day by drinking 3 x 200 ml coffees, and 2 x large 400 ml glasses of water with lunch and dinner. The table provides a potential list of optional strategies that will help the client put the intended goal of an additional 750 ml intake into action.

Select a single option	Actions required for optional strategy
Option 1	Maintain your existing fluid consumption. Consume 3 additional 250 ml glasses of water at the following times during the working day: • 1 x 250 ml glass of water within 30 minutes of arriving at work in the morning. • 1 x 250 ml glass of water within the last 1 hour of work hours. • 1 x 250 ml glass of water 90 minutes before bedtime.
Option 2	Maintain your existing fluid consumption. Purchase a 1-litre water bottle. Mark a 250 ml line on the bottle. Fill the bottle full at the beginning of the working day. Keep the bottle nearby during the day. Set the water habit app to alert you once an hour for 7 hours during the working day. Consume 100 ml of water every hour for 6 hours. Upon the final alert consume the remaining 150 ml so that the waterline in the bottle has now dropped to the 250 ml line.
Option 3	Maintain your existing fluid consumption. Consume a 250 ml glass of water immediately upon waking. Increase your lunch and dinner water consumption from 400 ml to 500 ml. Keep a large 300 ml glass of water on your desk at work, sip the contents gradually throughout the working day.
Option 4	Maintain your existing fluid consumption. Determine your own strategy to consume an additional 750 ml of water per day.

Providing the client with this list of options helps to empower the client in the decision-making process so that they have control over the method and how it may impact their daily life. This creates client buy-in and helps them to take ownership of the process ahead of them that will lead to goal achievement. Providing the client with the option to determine their own strategy is also valuable. Even if they do not choose one of the strategies devised by the nutrition coach, each of these options may give the client ideas about how they can apply a strategy that better suits their daily life. It still achieves the intention to involve the client, create buy-in and increase client motivation to achieve the intended goal.

Follow up & review

After creating clear goals and devising effective strategies it is important to create performance accountability and to set a time and date when the goal achievement or the progress towards goal achievement will be reviewed.

'Accountability is the glue that ties commitment to the result' - Bob Proctor

It is common to find clients full of motivation and enthusiasm following an effective discussion about personal goals and strategies to achieve them. If managed well these discussions will help to inspire clients to reach for something better. However, many things in daily life can interfere with that initial enthusiasm and direct a client off course. A properly planned process of follow up and review will help the client to maintain motivation and provide needed accountability for their daily actions. When a client knows that you will check on their progress, it increases the urgency to act and accomplish the intended goals. A sense of urgency is important with respect to putting a strategy into action. Regular, proactive follow up with a client also shows that you are genuinely interested in their success and are seeking to support them through the process from start to finish.

Follow up

The number of times follow up is required with a client will depend on how challenging the goal is to achieve and how long the time frame is for goal achievement. Goals that are more difficult and challenging for the client to achieve will require more regular follow-up and review. The longer the time between the initial goal-setting process and the intended accomplishment of the goal, the more follow up will be required to keep the client on track.

A minimum amount of follow up to support a client effectively would be as follows:

- An initial follow up within 2-7 days of the initial goals and strategy meeting. This is used to thank the client for their involvement in the goal-setting meeting, to reinforce the intended actions and strategies, and to find out how the client has performed over the initial few days. It may also be a time to resolve any early problems or snags in the process.

- A follow up at the mid-way point between goal setting and intended goal achievement. This follow up is a good time to request a client progress update and to offer help and encouragement to the client to stay on course. It can also be a time to adjust or adapt the client's efforts if they have strayed off course and need re-focusing.
- A final follow up during the final days/week before the planned review meeting. This follow up is a key time to motivate and encourage the client to achieve the goal or to get as close to goal achievement as possible. This can also serve as a reminder for the client to track their behaviour or results to provide the data needed to inform the review meeting.

As discussed already, more challenging goals and longer periods set to reach goal achievement will likely need a more robust and regular follow up process than the basic 3-step follow up. A nutrition coach may start by asking the client their expectations and needs with regards to follow up support. A coach needs good judgement, and awareness of their time availability, and reference to the product/service price paid by the client when determining a bespoke follow-up process of support.

Review

Once the time has passed for the achievement of a goal, it is appropriate to review the progress made by the client in a more formal setting. This can be done through a goal review meeting which is like a more in-depth follow-up. The relevant information and data must be available to the nutrition coach before the appointed meeting. This may require the client to provide a new food diary or nutrition record from a digital application. If other forms of tracking are used to oversee the behavioural change process then the information collected by this tracking method should be provided to the nutrition coach in advance of the meeting.

The nutrition coach should ideally have completed a preliminary progress review report to serve as the basis of the discussion during the goal review meeting. The progress report does not need to be lengthy but should be accurate and as clear as possible. The intention is to illustrate to the client the progress that has been made through the agreed actions that were taken based on the goals and strategies previously set. The following general outcomes from a progress meeting are likely.

The client has completely achieved or even exceeded the goal. This is the ideal result that both the client and nutrition coach wanted and the client should be warmly congratulated on their efforts and the achievement. Even when a goal has been successfully achieved it is still important to gain feedback about the process and how the client found the application of the strategic actions. Obtaining feedback may prove useful and inform the actions applied in future goals and strategies, with the same client or other clients seeking the same results.

The client has made more than 50% progress but did not achieve the intended outcome. This is not an ideal result, but significant progress has been made. The client should be praised for their efforts and the nutrition coach should still demonstrate in the report the contrasting changes between now and the start that have been achieved by the client. The client may be disappointed for not reaching the goal, but the process of looking back to where they started can still serve a purpose and help the client see more clearly the progress that has been made. The key is to find the balance somewhere between overly praising lack of achievement and wallowing in the disappointment of not reaching the intended goal. The intention is to use the review as a springboard to re-commit the client to continue on their journey towards the intended goals. The nutrition coach will then discuss revised goals and strategies to refocus the client on the desired goals. Gaining client feedback is very important in this process to weed out less effective actions from the previous attempts and to develop improved actions that may be more successful in the forthcoming period. Revised goals and adapted strategies should then be created based upon client feedback and further open and honest discussion.

The client has not progressed enough towards the intended goals. Ideally, a nutrition coach will already have been trying to manage a client, through prior follow up processes, who has struggled to apply the needed changes in diet and behaviour to reach the intended goals. This type of review will engage the client in an open and honest discussion to determine why the client did not apply the actions, or why the actions applied did not work for the client. This is still a valuable process that can help the coach to understand the client better and may help to inform the ongoing work to be done between client and nutrition coach in future. The coach should be working to enthuse the client to try again and to adapt the goals and strategies to mitigate any weaknesses in the previous process that have been revealed as a result of the review feedback and discussion. Revised goals and adapted strategies should then be created based upon client feedback and any further open and honest discussion.

Nutrition coaching is a skill that takes time to develop and master. High technical knowledge about nutrition may not necessarily translate to being good at supporting a client through a series of dietary and behavioural changes. When nutrition knowledge comes together in harmony with a skilled, client-focused coach, the results can literally be life-changing for the client.

Every nutrition professional should be seeking to become a skilled, client-focused coach. Achieving success as a nutrition professional will dependent upon it!

Key learning points: Chapter 9 Nutrition coaching

- Effective nutrition coaching requires trust between coach and client. Building rapport is a key component of trust.
- Good communication is an important aspect of coaching and includes:
  - Written e.g. email, website, messaging, reports etc.
  - Verbal e.g. in-person, phone, voicemail etc.
  - Non-verbal e.g. facial expressions, gestures, body language etc.
  - Listening e.g. understanding, re-stating, interacting etc.
- Asking appropriate and well-structured questions can significantly improve and help facilitate an effective nutrition coaching session. Question types include:
  - Closed questions - good for confirming facts and to check understanding.
  - Open questions - encourage longer answers with more detail.
  - Indirect questions - soften the questions for a more conversational feel.
  - Leading questions - help to limit the range of answers or nudge a client towards a more desirable response.
- A thorough nutrition analysis report should form the basis for future actions, goals, and personalized strategies.
- Goal setting is a vital skill that takes practise to develop. Goal setting should not dictate actions to the client but should involve the client in the creation and decision-making process in regards to their personalised goals.
- The SMART acronym is a beneficial tool for setting effective goals.
- A strategy is the process of determining the route or actions that will most likely deliver a client to the achievement of their personalized goals. There are 2 main types of strategy:
  - Progressive strategies - a series of steps or phases that gradually lead a client towards the achievement of a goal. Suitable for goal timelines between 5-12 weeks.
  - Optional strategies - a range of choices that the client can choose from, each of which will help to achieve the intended goal. Suitable for goal timelines shorter than 4 weeks.

Chapter 10: Supplements

The development of fitness and participation in sport naturally leads to the subject of how to improve physical and sporting performance. The application of specific exercises and targeted physical activity will bring about a performance improvement. Concerning diet, a common consideration is whether a performance improvement can be gained through the consumption of specific foods, food extracts, or supplements. Performance-enhancing foods or supplements are broadly known as ergogenic aids. An internet search for sports performance supplements will bring a vast list of results with numerous claims about foods and supplements that can boost exercise and sporting performance. The sports nutrition and supplements business is vast with an estimated global market worth $13.9 billion in 2018 and projections that it could more than double by 2025. Wherever there is money to be made, there are plenty of people and businesses trying to cash in on the market. Unfortunately, this means that there are many products on the market that carry claims of improved results and performance gains, but simply do not have sufficient independent, high-quality scientific research to support such claims. Fitness and nutrition coaches need to be wary of the sports supplement market and should maintain a healthy scepticism regarding supplement claims.

Before a review of a range of legal and scientifically validated performance-enhancing foods and supplements, it is important to establish the professional allowances and the scope of practice of a certified nutrition coach. A nutrition coach must remain within their designated scope of practice or risk causing potential harm to a client. If a client does suffer directly as a result of consuming supplements prescribed by their coach, it will place the coach in a precarious position regarding legal action against them, for which, if they have business insurance, they will not likely be covered because they coached a client outside of their allowable scope of professional practice. Whilst this is a potentially extreme situation and may not be very likely to occur when taking supplements that can be legally sold, it has to be acknowledged that it is still possible. It only takes a single moment, operating outside of professional boundaries, to undo years of hard work building a successful coaching business and reputation. It is strongly advised to stay within recommended professional limitations.

Professional scope of practice: Nutrition coach

CANNOT DO	CAN DO
Prescribe diets or supplements to treat diagnosed medical and/or clinical conditions.	Analyse dietary consumption patterns and provide professional nutrition coaching.
Prescribe diets or supplements to treat symptoms of medical and clinical conditions.	Guide clients regarding food shopping, recipe ideas, cooking, & other practical tips to improve everyday dietary practice.
Diagnose medical conditions or health-related disorders, no matter how small.	Inform clients about supplements and their proven purposes.

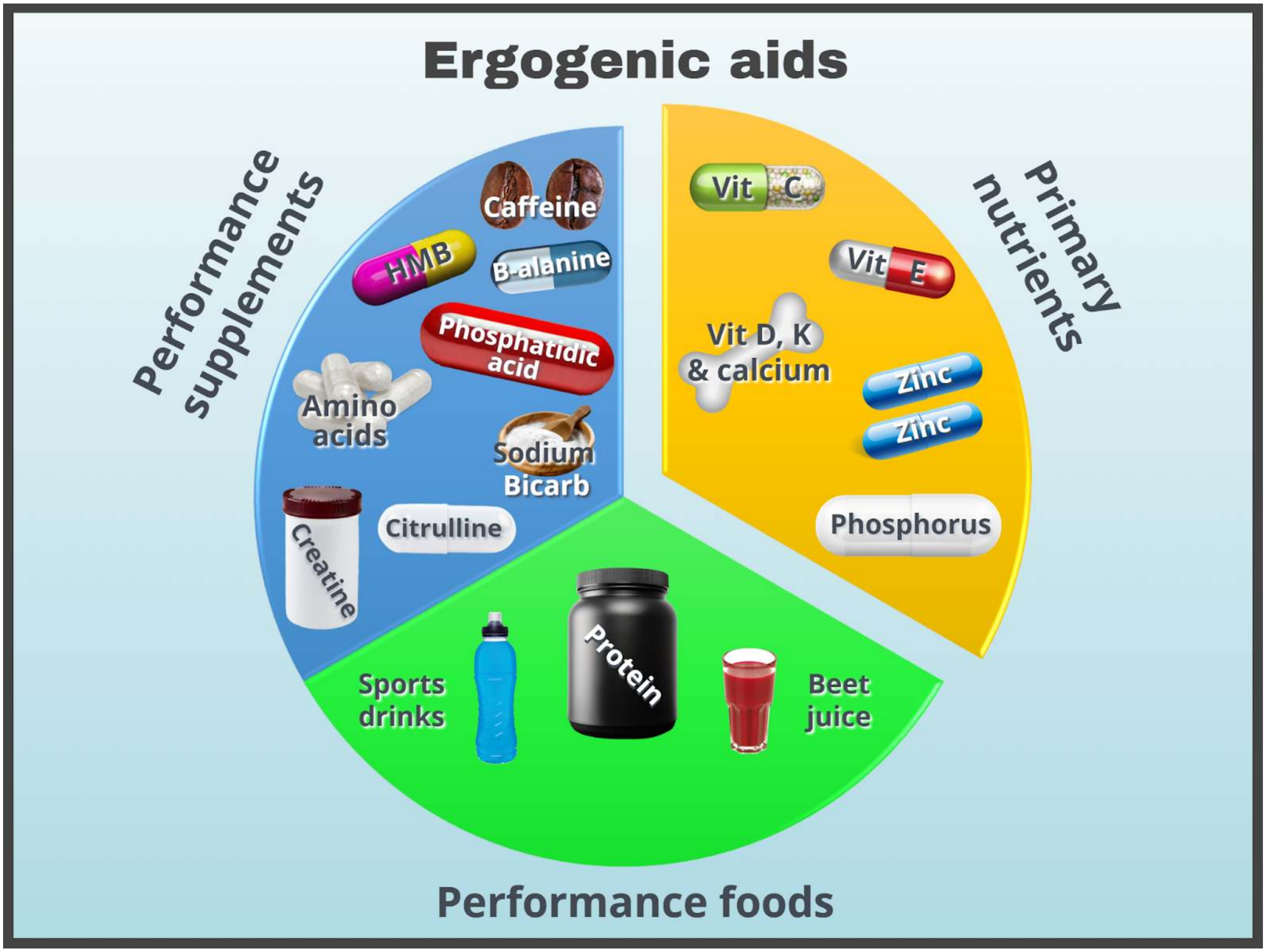
**This relates to a certified nutrition coach/advisor without a relevant nutrition degree or specific supplement certificate*

A nutrition coach is certainly able to inform a client regarding the availability of a specific food, nutrient, or supplement and to educate them regarding the benefits and risks associated with using these products. They must not prescribe supplements or outline a recommended intake at any time. Generating accurate, educated awareness regarding a supplement is acceptable, but the decision to use a supplement or not is a matter for the client to determine. It is important to acknowledge that supplements and ergogenic aids alone will not outperform a well managed, sufficient dietary intake. To be able to physically perform at a high level, sufficient calories, macro and micronutrients, and plenty of fluids are essential. The use of specific nutrients or supplements may help to enhance, but should not substitute for an adequate diet. As the name suggests, they are designed to conveniently supplement the diet, not replace the diet.

This chapter is not intended to be a complete resource for everything there is to know about supplements and exercise performance. However, it will provide a beneficial level of understanding regarding a range of scientifically validated foods, nutrients, and supplements and their potential for enhancing fitness and physical performance.

Ergogenic aids

An ergogenic aid can be broadly defined as a method, technique, or a substance that is specifically utilised for the purpose of enhancing performance. This review will look specifically at food and nutritional aids.



There are 3 main categories of ergogenic aids.

1. Primary nutrients - vitamins & minerals that support health and wellbeing and may promote an indirect benefit for physical performance.
2. Performance foods - specific foods that impart a clear performance-enhancing benefit.
3. Performance supplements - specific individual compounds that provide a direct or indirect performance-enhancing effect.

Primary nutrients

The primary vitamins and minerals that the body needs to support healthy physiological function rarely provide any additional ergogenic benefit when the regular daily diet consistently delivers the optimal required doses of each nutrient. Many health benefits are certainly available for individuals who are deficient in their micronutrient intake. Micronutrient sufficiency as a whole is a powerful tool to support the body through all kinds of exercise-related stressors. In terms of specific benefits, there is some scientific evidence to show that certain micronutrients help to support physiological processes that are indirectly related to exercise performance.

Micronutrient	Potential benefit	Strength of the evidence	Size of the effect
Vitamin C	Small reduction in the effects of muscle damage after exercise. Some evidence of decreased upper respiratory tract infections when taken regularly.	Moderate evidence	Minor effect
Vitamin E	Small reduction in the effects of oxidative muscle damage related to exercise.	Moderate evidence	Minor effect
Vitamin D, K & calcium	Improvements in bone strength and bone mineral density.	Moderate evidence	Moderate effect
Phosphorus Sodium phosphate	May improve oxygen transport and possibly benefit aerobic performance. It may also serve as a buffer to lactic acid accumulation.	Moderate evidence	Minor effect
Zinc	High zinc supplementation may reduce exercise-induced immune suppression.	Poor evidence	Minor effect

Performance foods

The overall impact of the diet on physical performance is a necessary consideration. Seemingly basic foods have the potential to negatively impact performance. For example, feeling bloated after eating too much pasta, too close to exercise, may result in a below-par competitive performance. Whereas other foods, such as proteins and amino acids, may have a minimal immediate effect on how an individual feels in terms of energy and performance, but at a cellular level they are positively influencing the development of the muscular tissues and structures that can enhance performance in the long-term. There are a small number of foods that have consistently been found in the scientific literature to deliver a beneficial effect on physical performance.

Performance food	Potential benefit	Strength of the evidence	Size of the effect
Whey protein shakes/bars	Whey protein appears to increase muscle protein synthesis more than other protein sources in the short term. In the long-term whey increases lean mass gains, combined with resistance training to a similar degree as other protein sources.	Moderate evidence	Moderate effect
Sports drinks	Carbohydrates in the diet and quick release carbohydrates (glucose) in sports drinks promote increased performance by prolonging exercise duration and reducing fatigue.	Strong evidence	Moderate effect
Beet juice **Nitrate**	Nitric oxide is a potent vasodilator of blood vessels. The high nitrate levels in beet juice have an ergogenic effect, primarily in higher intensity anaerobic exercise by reducing the oxygen cost of exercise. Nitrate also appears to improve aerobic performance, though to a lesser degree than anaerobic performance, Nitrate may help reduce the rating of perceived exertion for the same relative intensity of exercise, though there is mixed evidence for this.	Moderate evidence	Moderate effect

Performance supplements

Performance supplements can be defined as consumable concentrated compounds that do not fall into the categories of primary nutrients or performance foods but have been found to provide a positive ergogenic effect. There is a small range of performance supplements that have been found to deliver performance-enhancing effects in the scientific literature. The following table outlines these scientifically validated supplements, their possible effects, the strength of the evidence, and the size of the effect.

Performance supplement	Potential benefit	Strength of the evidence	Size of the effect
Caffeine	A potent stimulant that reduces fatigue and increases alertness. Caffeine benefits high-intensity anaerobic performance by increasing power output. A smaller increase in aerobic performance has been observed, possibly due to the increase in adrenaline and cortisol that results from consumption. There is some possible evidence that caffeine may reduce participant rating of perceived exertion scores and potentially increase training volume capacity.	Moderate evidence	Moderate effect
Creatine monohydrate	Creatine is a rapid rebuilder of muscular ATP energy. There is strong evidence that creatine increases muscle creatine content, helping to significantly increase power output and reduce short-term fatigue. There is strong evidence that creatine leads to small increases in lean mass when combined with resistance training. Creatine does increase water retention which accounts for the majority of increased body weight. Creatine may help to increase anaerobic performance, but the effect is relatively small.	Strong evidence	Major effect

Performance supplement	Potential benefit	Strength of the evidence	Size of the effect
Beta-alanine	Beta-alanine is an amino acid that binds to histidine to form a molecule known as carnosine. Carnosine is a lactic acid buffer that is beneficial during high-intensity exercise. Strong scientific evidence demonstrates a definite, but small (2.5%) ergogenic effect on increasing high intensity, muscular endurance capacity. It may also have a small effect on reducing fatigue.	Strong evidence	Minor effect
Sodium bicarbonate	Sodium bicarbonate acts as a buffering accent against rising acidity in the muscle (lactic acid) and the blood (carbonic acid). There is strong evidence that intense, anaerobic exercise gets a small, but reliable ergogenic benefit from consuming sodium bicarbonate. There are smaller possible effects on aerobic exercise and reducing blood pH.	Strong evidence	Minor effect
Hydroxy-methyl-butyrate (HMB)	HMB is an anti-catabolic metabolite of the amino acid leucine that has been reliably shown in the scientific literature to reduce acute muscle protein breakdown. However, long-term studies that researched the potential for increases in lean mass have provided limited convincing evidence.	Moderate evidence	Moderate effect

Performance supplement	Potential benefit	Strength of the evidence	Size of the effect
Essential amino acids (EAA)	EAAs represent the protein components that have the highest biological value in regard to muscle protein synthesis. Strong evidence illustrates that consuming the full complement of EAAs creates the greatest increase in protein synthesis when compared to just BCAAs or leucine. It should be noted that protein synthesis is higher when EAAs are consumed as part of a whole food protein source in comparison to a pure EAA supplement form.	Strong evidence	Moderate effect
Branched-chain amino acids (BCAA)	The BCAAs are 3 specific amino acids, leucine, isoleucine, and valine, that are purported to compose ⅓ of human muscle tissue. Evidence shows that BCAAs do increase muscle protein synthesis, but not as much as a high biological value wholefood protein source, whey protein, or a full complement of EAAs. BCAAs may have a small increased effect on fat oxidation.	Moderate evidence	Minor effect

Performance supplement	Potential benefit	Strength of the evidence	Size of the effect
Citrulline	Citrulline is used by the body to produce arginine and then nitric oxide, the potent blood vessel vasodilator. There is moderate evidence that oral citrulline ingestion generates a moderate increase in both arginine and nitric oxide. Citrulline may contribute to small decreases in fatigue and muscle soreness after exercise while providing small increases in training volume capacity.	Moderate evidence	Minor effect
Phosphatidic acid (PA)	PA supplementation may increase anabolic signalling in skeletal muscle and enhance small gains in lean muscle mass when combined with resistance training.	Poor evidence	Moderate effect

Lack of evidence

Many supplements are currently targeted towards the sports and fitness market that do not have sufficient, good quality scientific evidence to support their ergogenic claims. In some cases, the scientific evidence even falsifies the performance-enhancing claims. This list represents some of the more commonly used supplements that fall into this unproven category. Until such times as there is scientific evidence to support the claims of performance benefit, it would be wise to discourage the use of these supplements and nutrients when being specifically used for an ergogenic purpose. There may be other benefits for consuming the supplements listed below, but this will be for a purpose other than enhanced physical performance.

Proposed ergogenic supplements with a lack of evidence to prove efficacy	
Alpha-ketoglutarate	Taurine
Arginine	Quercetin
Boron	Glycerol
Chromium	Arachidonic acid
Conjugated linoleic acids (CLA)	Carnitine
D-Aspartic acid	Isoflavones
Gamma oryzanol	Ornithine-alpha-ketoglutarate
Glutamine	Vanadyl sulfate
Ribose	Medium-chain triglycerides (MCTs)

Conclusion

You have reached the end of this course text. We applaud you for all your hard work and efforts to learn the necessary content and develop the skills to become a Fitness Nutrition Coach. In order to achieve the certification, please ensure you complete any supporting learning materials and prepare yourself to sit the final assessment. Upon successfully passing the final assessment you will be awarded the Fitness Nutrition Coach credential. We look forward to celebrating this course achievement with you.

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