1 Nutrient Basics

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Key messages

• Eating a wide variety of commonly available foods helps ensure that all the body's needs for nutrients are met.
• Carbohydrates, both sugars and starches, are digested or converted into glucose to provide the body's primary energy fuel.
• Protein-rich foods or combinations provide all the essential amino acids.
• Alcohol is an energy-dense nutrient that should only be consumed in moderation, if at all, and should be avoided before or immediately after exercise.
• Some dietary fat is needed to provide the essential fatty acids and the fat-soluble vitamins (A, D, E and K).
• Current public health guidelines on a healthy balanced diet, alongside appropriate reference intakes for energy and individual nutrients, are useful tools in assessing dietary adequacy.
• Determination of dietary intake, both qualitatively and quantitatively, forms a key component of nutritional status assessment in athletes and non-athletes.
• An awareness of the errors and limitations of dietary assessment and its interpretation is essential if they are to be used to form the basis of change.

1.1 Introduction

A healthy balanced diet is vital for good health both from the perspective of an elite athlete and for those who enjoy working out to keep fit. Training can be optimised to help athletes and exercisers to reach their goals by making informed dietary choices. The key to making the diet healthy and balanced is to ensure it provides adequate energy from the consumption of a wide variety of commonly available foods, to meet the carbohydrate, protein and fat requirements for both health and exercise. The food we eat provides the nutrients required by the body. However, no one food or food group can provide all the essential nutrients the body requires. Athletes and exercisers should eat a variety of foods to provide all the essential nutrients to support the preparation for, the participation in, and the recovery from sports and exercise.

The body’s energy supply is derived from the nutrients in the diet. Nutrients are found in differing amounts in foods and are broken down in the body to provide a certain quantity of energy, commonly expressed as kilocalories (kcal) per gram (g). The main energy-yielding nutrients in the diet are as follows.

• Carbohydrate: 3.75 kcal/g
• Protein: 4 kcal/g
• Alcohol: 7 kcal/g
• Fat: 9 kcal/g.

1.2 Carbohydrates

Dietary carbohydrate is provided by a wide variety of carbohydrate-rich food and drinks. However, all carbohydrates, both sugars and starches, are ultimately converted to and absorbed into the blood in the form of glucose, to provide the primary energy fuel. There is no universal system that can adequately describe the diverse metabolic, functional and nutritional features of the various carbohydrate foods. One of the simplest ways of classifying carbohydrate foods is by their structure (Figure 1.1). Basically, they can be divided into four main groups.
Monosaccharides are single molecules of sugar: glucose, fructose and galactose. Glucose is found in most carbohydrate foods including sugars and starches. All carbohydrates are eventually digested or converted into glucose. Fructose is also known as fruit sugar and is found in fruits, vegetables and honey, and is converted into glucose by the liver. Galactose is part of lactose, the sugar found in milk and milk products.

Disaccharides comprise two linked sugar molecules that are broken down into monosaccharides by digestion. The disaccharides include sucrose (glucose + fructose), lactose (glucose + galactose) and maltose (glucose + glucose). Sucrose (table sugar) normally comes from sugar beet and cane, but is also found naturally in all fruits and vegetables, and even most herbs and spices. Lactose is found in milk and milk products. Maltose is formed when starch is broken down.

Oligosaccharides typically contain three to ten linked sugar molecules, which are broken down into monosaccharides by digestion. Fructo-oligosaccharides are found in many vegetables, such as Jerusalem artichoke, chicory, leeks, onions and asparagus, and consist of short chains of fructose molecules. Galacto-oligosaccharides occur naturally in beans including soybeans and consist of short chains of galactose molecules. Some oligosaccharides can only be partially digested by humans and therefore may be fermented in the large intestine. The fructans, inulin and fructo-oligosaccharides, have been shown to stimulate growth of potentially beneficial bifido-bacteria.

Polysaccharides, also known as glycans, are simply hundreds of molecules of monosaccharides joined together. Polysaccharides differ in the nature of repeating monosaccharide units, number of units in the chain, and the degree of branching. By far the most abundant polysaccharides in the diet are starches, which are simply many glucose molecules joined together. When starch is digested, it is first broken down into maltose and then into glucose.

The major difference between sugars and starches is the size of the molecule. Traditionally, foods containing significant amounts of carbohydrates have been classified according to the major type of carbohydrate they contain, which led to the simplistic division of carbohydrate-containing foods into ‘simple’ (mainly consisting of sugars) and ‘complex’ (mainly consisting of starches). This over-simplification is misleading as the majority of naturally occurring foods contain a mixture of sugars and starches. Rapidly digestible starch (RDS), as the name suggests, is rapidly digested and absorbed in the small intestine; it is found in processed food and produces a large glycaemic response. In contrast, slowly digestible starch (SDS) is found in muesli, legumes and pasta and is completely but more slowly absorbed in the small intestine, therefore generating a smaller glycaemic response.

Considering that most carbohydrates ultimately end up as glucose to provide energy fuel, there are several other factors that may be more important to athletes and exercisers. These include how rapidly the carbohydrate is converted to glucose and its appeal and practicality, all of which are specific to the individual and the exercise situation.

Dietary fibre

Dietary fibre is a generic term for a group of carbohydrates derived from the edible parts of plants that are not broken down and absorbed by the small intestine. This definition includes non-starch polysaccharides (NSP), some oligosaccharides, lignin, resistant starch (RS) and sugar alcohols. NSP comprise a complex heterogeneous range of polysaccharides.
contributing the largest component of fibre, mainly found in plant tissues (90% from plant cell walls). NSP can be divided into cellulose (insoluble) and non-cellulose polysaccharides (mainly soluble). The soluble components tend to increase the viscosity of the gastrointestinal contents. ‘Resistant starch’ is a term that describes any polysaccharide of glucose that is resistant to digestion and hence passes to the large intestine intact. There are a variety of RS classifications: RS1 are physically inaccessible to digestion (e.g. whole grains); RS2 are resistant granules (e.g. in unripe bananas); and RS3 comprises retrograded amylase found in processed foods such as cooked and cooled potatoes and rice.

Dietary fibre content of food is quantified by various methods. Most UK food tables and databases have traditionally used the Englyst method, which is specifically a measure of NSP only. In 2000 the Food Standards Agency (FSA) legislated for the AOAC (Association of Analytical Communities: www.aoac.org) definition to be used, which includes NSP, RS and lignin. With this in mind, the UK estimated average requirement for fibre is derived from the Englyst method and hence would need to increase from 18 to 24 g/day if expressed as the AOAC definition.

### 1.3 Protein

Protein is the most abundant nitrogen-containing compound in the diet and the body. Throughout the day there is a continual process of protein turnover, with proteins being broken down and formed at the same time. The largest reservoir of protein is found in the muscles, but there is limited capacity to store new proteins. Therefore, protein intake in excess of requirements is either broken down to provide energy or stored as fat or carbohydrate.

Protein is needed for the growth and repair of tissues. During digestion, proteins are broken down into smaller units called amino acids. Amino acids are commonly described as the building blocks of protein. In chemistry, an amino acid is a molecule containing both amine and carboxyl functional groups. There are about 20 different naturally occurring amino acids, which can be combined to make a vast array of different proteins.

The terms ‘essential’ and ‘non-essential’ amino acids refer to whether the amino acid in question can be synthesised by the body at a rate sufficient to meet normal requirements for protein synthesis. There are eight essential (indispensable) amino acids for adults (isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine) that must be supplied in adequate amounts by the diet. Nutritionally, histidine and arginine are considered essential amino acids in human infants. After reaching several years of age, humans begin to synthesise histidine and arginine, and they thus become non-essential amino acids. The semi-essential (conditionally indispensable) amino acids can be made in the body, providing certain essential amino acids are present in the diet in sufficient amounts, for example cysteine requires methionine and tyrosine requires phenylalanine. Other amino acids, notably arginine and glutamine, are also regarded as ‘conditionally essential’ meaning that, during times of high utilisation, they may require repletion via the diet. For further information see Chapter 5 on protein and amino acids.

The majority of amino acids ingested by humans exist in a combined form as dietary proteins from both animal and vegetable sources. Not all proteins in the diet have the same nutritional value, since they contain different proportions of essential amino acids. The complete protein foods contain all the essential amino acids. In general, foods from animal sources contain substantial amounts of all the essential amino acids, but foods from other sources can be combined with each other to make complete protein foods. For example, the protein quality of plant products is improved when dairy products are added to a plant food and when plant-based foods, such as wheat and beans, are mixed together. Table 1.1 shows some examples of protein-rich foods or combinations that provide all the essential amino acids in sufficient amounts.

**Vegetarian and vegan diets**

Protein combining is not necessary in a vegetarian diet where milk, cheese and eggs are eaten, because these foods provide adequate amounts of all the essential amino acids. Strict vegetarians, and in particular vegans who eat no dairy products or eggs, need to plan their diet carefully to ensure that their combination of plant foods provides them with all the essential amino acids. However, this mixing and
matching of plant foods to provide all the essential amino acids does not need to occur at the same meal but can take place over the course of the day.

### 1.4 Alcohol

Alcohol is an energy-dense nutrient that should only be consumed in moderation, if at all, and should be avoided before or immediately after exercise. The advice on sensible drinking exists to limit the health risks associated with excessive intakes of alcohol. In the long term, continued heavy drinking causes liver damage and other health problems. In the short term, excessive amounts of alcohol can be toxic to the individual as well as potentially dangerous to others, due to the resulting loss of coordination or self-control and behavioural changes.

Alcohol consumption may impede post-exercise recovery. Furthermore, many sports are associated with muscle damage and soft tissue injuries, either directly due to the exercise or from the tackling and collisions involved in contact sports. Although the evidence is limited, it would be advisable for athletes who suffer considerable muscle damage and soft tissue injuries to avoid alcohol in the immediate recovery phase, probably for 24 hours following the event.

Alcohol is not generally a banned substance in sport, with the exception of some sports such as fencing and shooting. It is likely that its consumption will interfere with judgement and skilled performance in sport, and in particular may increase the risk of injury. Therefore guidelines for sensible drinking should be followed at all times and especially in the period after training or competition.

In the UK, one unit of alcohol is measured as 10 ml or 8 g of pure alcohol. This equals one 25-ml single measure of whisky (ABV 40%), or one-third of a pint of beer (ABV 5–6%) or half a standard (175 ml) glass of red wine (ABV 12%). As the absolute volume (ABV) of alcohol varies between drinks, it is more accurate to calculate alcohol units using the following equation:

\[
\text{Strength (ABV)} \times \text{Volume (mL)} \div 1000 = \text{No. of units}
\]

For example, 1 pint (568 ml) of 5.2% strength beer = 

\[
5.2 \times 568 \div 1000 = 2.95 \text{ units.}
\]

Based on the evidence of associated health risks the recommended maximum levels of alcohol consumption were originally set at no more than 21 units per week for men and 14 units per week for women. However, following the growing evidence of the detrimental effects on health of heavy or ‘binge’ drinking, the sensible drinking guidelines were switched to daily maximum intakes. For example in the UK, these guidelines state that maximum daily intakes should not exceed 3–4 units for men and 2–3 units for women.

Alcohol is a high-energy nutrient, providing 7 kcal/g, and consequently its intake should be limited so that it does not displace other nutrients or result in unnecessary additional calories.

#### Table 1.1 Complete protein foods.

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy products</td>
<td>Milk, yoghurt</td>
</tr>
<tr>
<td>Eggs</td>
<td>Boiled, scrambled, omelette</td>
</tr>
<tr>
<td>Fish</td>
<td>Fresh, tinned or frozen, e.g. salmon, tuna</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>Beef, lamb, ham, sausages</td>
</tr>
<tr>
<td>Poultry</td>
<td>Chicken, turkey</td>
</tr>
<tr>
<td>Grains plus legumes</td>
<td>Bean curry or lentils with rice, peanut butter sandwich, bread with hummus, baked beans on toast</td>
</tr>
<tr>
<td>Grains plus nuts or seeds</td>
<td>Muesli mix with oats and nuts or seeds, e.g. hazelnuts or sunflower seeds, rice salad with nuts, e.g. walnuts, sesame seed spread (tahini) on bread</td>
</tr>
<tr>
<td>Legumes plus nuts or seeds</td>
<td>Mix of peanuts and nuts, e.g. cashews</td>
</tr>
<tr>
<td>Grains plus dairy products</td>
<td>Breakfast cereal and milk, rice pudding, pizza or pasta with cheese, cheese sandwich</td>
</tr>
<tr>
<td>Legumes plus dairy products</td>
<td>Bean curry in a yoghurt-based sauce, bean chilli with cheese</td>
</tr>
</tbody>
</table>

* Legumes include pulses (e.g. peas and beans) and peanuts.

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1.5 Fat

There are many different kinds of fats, but each is a variation on the same chemical structure. All fats consist of fatty acids (chains of carbon and hydrogen atoms, with a carboxylic acid group at one end) bonded to a backbone structure, often glycerol (a backbone of carbon, hydrogen and oxygen). The main components of dietary fats and lipids are fatty acids, which vary in length from one to more than 30 carbons. A fat’s constituent fatty acids may also differ in the number of hydrogen atoms that are bonded to the chain of carbon atoms. Each carbon atom is typically bonded to two hydrogen atoms. When a fatty acid has this typical arrangement, it is called a ‘saturated’ fatty acid because the carbon atoms are saturated with hydrogen, meaning they are bonded to as many hydrogen atoms as possible. In other fats, a carbon atom may have a double bond to a neighbouring carbon atom, which results in an ‘unsaturated’ fatty acid; more specifically, a fatty acid with one double bond is called a monounsaturated fatty acid (MUFA) whereas a fatty acid with more than one double bond is called a polyunsaturated fatty acid (PUFA).

Fatty acids are the densest source of dietary energy, providing 9 kcal/g, but lipids also have important structural roles in membranes. A typical dietary fat contains a mixture of both saturated and unsaturated (MUFA and PUFA) fatty acids. Different foods have varying proportions of fatty acids such that the fat in meat, dairy products and coconuts is predominantly saturated fatty acid; olive and rapeseed oils have a high proportion of MUFA; and sunflower and soya oils are mostly PUFA. Essential fatty acids are a subgroup of PUFA that the body cannot make and therefore need to be supplied in adequate amounts by the diet. Essential fatty acids can be divided into two classes: the omega-3 (ω-3) and omega-6 (ω-6) fatty acids (Table 1.2).

The type of fat that dominates the diet depends on the proportion of different fatty acids present in the choice of foods consumed. The amount of dietary fat required depends on several factors including age, body size and training levels.

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Table 1.2 Sources of essential fatty acids.

<table>
<thead>
<tr>
<th>Omega-3</th>
<th>Omega-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oily fish, e.g. salmon, mackerel, sardines, herring, pilchards, and tuna in oil</td>
<td>Seeds, e.g. sunflower and sesame</td>
</tr>
<tr>
<td>Linseeds and pumpkin seeds</td>
<td>Nuts</td>
</tr>
<tr>
<td>Oils, e.g. soyabean and rapeseed</td>
<td>Oils, e.g. sunflower, safflower, corn, groundnut, sesame, rapeseed and soya oils</td>
</tr>
<tr>
<td>Walnuts</td>
<td>Polyunsaturated margarine</td>
</tr>
</tbody>
</table>

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1.6 Assessing dietary intake

When improving or maintaining nutritional health it is vital to diagnose current nutritional status as this highlights individual needs and will help determine dietary and lifestyle modifications. Accurately and reliably determining the current dietary intake identifies inadequacies (or excesses) that can give rise to biochemical, physiological, clinical and performance-related changes. The progression of any deficiency (or excess) can be detected by various means of nutritional assessment as summarised in Figure 1.3.

As depicted in Figure 1.3, the earliest detection of any inadequacy can be made through the measurement of dietary intake. However, measurement of habitual dietary intake, by its very nature, is hard to undertake as diet patterns are rarely systematic and dietary information can be highly personal. As such, all methods of its measurement are a practical compromise to one degree or another. The two basic problems to overcome are (i) accurately determining current customary food intake and (ii) converting this information into absolute amounts of energy and nutrients. Table 1.3 summarises the features of some of the commonly used dietary assessment methods. However, for clarity these will now be discussed in more detail in the following sections by separating methods into quantitative and qualitative.

**Quantitative methods**

**Food records and food diaries**

These aim to provide a quantitative assessment of actual food intake prospectively over a period of commonly 3–10 consecutive days. The actual number of days should be realistic in terms of compliance and should usually include at least one non-working/non-training day to take into account differences in food consumption. On the simplest level, subjects record the description and timing of meals and this information is translated into nutrient composition assuming standard weights, portion sizes and composition. The validity of this method can be improved following clear instruction (verbal and written), and providing the individual with a clear form/diary on which to record the information. Developments in multimedia and communication technology (internet websites, hand-held computers, and mobile phone applications) have seen increasing use of user-friendly, menu-driven applications to help aid recording and sending of dietary intake data.

Providing the individual receives comprehensive instructions on its use, weighed food records can
overcome errors in estimation of portion sizes and weights. Use of food photography may also be useful, either by comparing foods eaten to photographs of standard food portions, or for the individual to photograph the food eaten (aided by the advent of digital camera technology). Nevertheless, on all levels, when using food records it is important that assessors be supportive, non-judgemental and emphasise the importance of accuracy, particularly if they are to receive valid feedback and advice. Whatever the sophistication of approach, rubbish in will inevitably lead to rubbish out, so it is vital that clear instruction and clarification of entries post recording is undertaken.

The labour-intensive nature of recording food intake can give rise to errors, either in accuracy of recording or in eating behaviour. Highly composite meals are likely either to be avoided or misreported. Likewise, foods eaten outside the home, or takeaways may be vaguely reported and snacks and beverages may be omitted due to memory failure or conscious omission. Overall, misreporting of intake is a common trait as psychology has a major influence on validity, for example under (or over)-reporting may be used to prevent scrutiny or judgement by the assessor or simply to lessen the labour of recording. Under-reporting of intake is commonly seen in obese individuals, whereas over-reporting, although less common, tends to be seen in the non-obese, particularly those who want to gain weight. Dietary surveys in athletes using food records demonstrate a typically higher energy intake compared with the estimated average requirement (Figure 1.4). Nevertheless, under-reporting can still be prevalent in athletes for the same aforementioned reasons. Determining misreporting of intake can be achieved using an independent measure of status (e.g. urinary nitrogen), although this is rarely used in practice. Comparing reported energy intake with estimated energy expenditure may be used to assess validity (i.e. under- or over-reporting), assuming the individual is in energy balance during the measurement period (i.e. 3–10 days). However, quantifying energy expenditure accurately in active individuals poses its own difficulties.

Translating food intake into nutrient intake
Even following minimal behavioural change and maximising the accuracy of portion size estimation, a further source of error when quantifying intake is made when translating food intake into nutrient composition. Nutrient intake is typically ‘quantified’

<table>
<thead>
<tr>
<th>Method</th>
<th>Uses and limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food records</td>
<td>Record of all food and drink consumed over a period of time (3–10 days), usually recorded by the respondent. Food portion sizes can be estimated or quantified with use of weighing scales. Information converted to nutrient intakes using food composition database.</td>
</tr>
<tr>
<td>Diet history/interview</td>
<td>Interview method. Gauge if habitual dietary habits. Portion sizes estimated possibly with use of photographs/food models. May also be incorporated with food record and/or FFQ.</td>
</tr>
<tr>
<td>Food frequency questionnaire (FFQ)</td>
<td>Questionnaire comprising comprehensive list of food items coupled with frequency of intake. Can be self-administered. Can include information on usual food portion sizes.</td>
</tr>
</tbody>
</table>
from information on the described food and amount eaten, utilising a food composition database of analysed foods. It is important that the limitations of food composition data are understood and taken into consideration when assessing the nutrient composition of the diet. Specifically, the sources of variation in the use of a food composition database can be divided into two main areas: (i) investigator error as a result of the incorrect coding of foods (i.e. matching of foods consumed with foods listed in the foods composition tables); and (ii) error due to the limitations in the food composition data itself.

Incorrect coding of foods is likely if the description of the reported food is unclear in terms of food variety, preparation and cooking method. Further complications arise from the absence of a reported food in the composition database, hence the reliance on a best match alternative which may differ in nutrient composition. Both of these sources of error can be reduced by clear instruction of the subject as well as suitable training of the assessor.

As well as limitations in the number of foods in the database, errors can arise due to the samples of food used in its construction, which may vary according to season, soil, harvesting, brand, processing additives, fortification, preservatives and cooking methods. In addition, the development of computer composition software may also be a source of error as there may be discrepancies between dietary analysis software packages.


**Qualitative methods**

**Diet history/interview**

The purpose of this retrospective technique is to gain insight into current habitual/usual dietary intake and meal patterns, typically representing intake over the previous month. The diet history technique has the advantage of obtaining information on habitual intake, with a relatively low burden on the participant, and typically high compliance. The validity of the information obtained is dependent on the memory and honesty of the participant. Psychology also comes into play as to many people disclosing their diet is highly personal and may lead to omissions (consciously or subconsciously). The validity and reliability of this technique is questionable in some populations (e.g. children, the elderly, the obese, and those with eating disorders) and is also less reliable in those individuals with erratic eating patterns (e.g. some athletes). In any situation, the quality and validity of information gained is dependent on the interviewer’s skill and training.

Information on typical portion sizes can also be gained through the use of food portion photographic...
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atlases or plastic food models. Although the main use of the information gained through the diet history is an overall picture of diet quality, if undertaken correctly it can be used to suggest dietary sources of nutrients and highlight potential inadequacies or excesses that can be addressed. The information obtained cannot be compared directly against reference intakes for specific nutrients (e.g. Dietary Reference Values or Dietary Reference Intakes), but habitual eating patterns can be compared with qualitative healthy eating guidelines. More importantly, the diet history also provides insight into the individual’s lifestyle alongside eating patterns, which will help suggest changes that are both practicable and attainable.

Food frequency questionnaires

This method attempts to retrospectively assess intake of specific or all common foods over a period of 1–6 months through a self-completed questionnaire. A typical food frequency questionnaire (FFQ) will comprise two components: a list of food items and a set of frequency response categories. In order to assess total intake of all nutrients the FFQ must contain a list of all the commonly eaten foods and hence would typically be many pages in length and time-consuming to complete. Some FFQs focus only on specific foods, groups of foods, or food sources of a specific nutrient, and may therefore be shorter in length. The basic FFQ can be modified to incorporate an estimate of portion size; for simplicity this is often simplified into small, medium or large, provided there is some description of these portions (e.g. photograph or household measure). Almost all commonly used FFQs have been previously validated against either food records or with biological markers; however, the method used to validate may itself have some inherent errors.

The FFQ has the advantages that it can be self-administered, is quick and non-invasive, requires little respondent effort and has a relatively high response rate. It can also be administered by non-professional personnel, either in person or remotely. As a result, the FFQ is often the tool of choice when assessing large groups or populations. The FFQ has been used to place individuals into percentiles of intake but cannot be used to quantitatively assess individual intake, only a representation of dietary composition. Seasonal variation in habitual intake also governs representation of the dietary data obtained from FFQ, particularly in temperate climate countries.

1.7 Dietary and healthy eating guidelines

Ascertaining adequacy of dietary intake requires an appreciation of individual requirements, some of which will be elevated in those participating in significant amounts of sport or exercise. The specific requirements for energy and nutrients in athletes will be covered in more detail in other chapters of this book. In broad terms, an appreciation of individual dietary adequacy may be gained through comparison with dietary guidelines and reference intake values based on a comparable general population. These comparators may be in the form of qualitative guidelines on overall diet composition in terms of foods and food groups, or more quantitative reference intakes associated with health for specific nutrients.

Qualitative dietary guidelines

These are developed mainly as a public health tool whereby foods are categorised into food groups and the guideline diet is then presented as suggested relative proportions of these food groups. The number and definition of food groups can vary depending on the country of origin, and typically reflects the common cultural diet in that country. In addition, the means of presenting the suggested proportions of these food groups may also vary between countries, again to better represent the eating culture. In the UK, the FSA depicts a healthy diet based on five food groups whose relative proportions are shown as segments on a plate, promoted as the ‘eatwell plate’ (Figure 1.5a). This plate model, manifested previously in the UK as the ‘balance of good health’, was chosen as a reflection of the traditional British diet (colloquially, ‘meat and two veg’). In the US, the United States Department of Agriculture (USDA) Center for Nutrition Policy and Promotion endorses the My Pyramid Food Guidance System (Figure 1.5b), an update on the widely recognised food pyramid model used previously, presenting the diet as comprising six food groups. In addition to these two widely used examples of healthy eating guidelines, the FAO/WHO have devised food-based dietary
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The appropriate food-based dietary guidelines from a comparable population may be used for individuals, subsequent to dietary assessment, as they can help identify food groups in excess or inadequacy and hence suggest changes for improving overall diet quality. In addition, provided overall energy intake is appropriate, adherence to these guidelines will more likely lead to adequate relative intakes of macronutrients and micronutrients.

Quantitative reference intakes
There are a set of reference values of daily intake for specific nutrients for a healthy population and these
can be used as a benchmark to assess nutritional adequacy of an individual’s assessed intake. The requirement for any nutrient can be defined as the lowest continuing intake that will maintain a defined level of nutrition for an individual within a given group or population. This criterion may differ for individuals at different life stages, for example during pregnancy, lactation, childhood/adolescence and older age.

In order to prevent confusion, it is important to be clear on the terminology with regard to recommended values of nutrient intakes. Historically, recommended intakes have been expressed as Recommended Daily Amounts in the UK and as Recommended Daily Allowances in the US, confusingly both expressed as RDAs despite slight differences in definition and actual published reference values. In the UK, since 1991 the RDAs have been superseded by Dietary Reference Values (DRVs). In the US, development of the Dietary Reference Intakes (DRIs) has expanded on the previously defined RDAs as well as the Canadian Recommended Nutrient Intakes. For the majority of nutrients, both the UK DRVs and the US DRIs are based on a healthy reference population (free from consequences of deficiency or excess), whose reported intake follows a normal distribution. The reference values for a particular nutrient relate to the level of intake that is equal to or greater than that achieved by a set proportion of the healthy reference population. Figure 1.6 shows these intakes relative to a normally distributed intake for healthy individuals in a life stage or gender group.

For both DRVs (UK) and DRIs (US) the Estimated Average Requirement (EAR) refers to the mean intake of a nutrient within the healthy population, which relates to a 50% risk of inadequacy (i.e. only 50% of a healthy population will have a higher intake). Assuming the healthy population is normally distributed, an intake two standard deviations (2SD) higher than the EAR relates to a risk of inadequacy of only 2–3%. In the UK, this level of intake is defined as the Reference Nutrient Intake (RNI), whereas in the US this is defined as the Recommended Dietary Allowance (RDA). In the US, where an RDA cannot be determined for a nutrient, then an Adequate Intake (AI) is used as an alternative, based on the available evidence. In the UK, DRVs additionally quantify a Lower Reference Nutrient Intake (LRNI) as an intake that is two standard deviations (2SD) lower than the EAR, corresponding to a risk of inadequacy of 97–98%. Unlike DRVs, the DRIs used in the US also express values for a tolerable
Upper Limit (UL) for some nutrients where excess intake may exhibit adverse effects. More recently in the UK the Scientific Advisory Committee on Nutrition have produced a draft report suggesting that the EAR for energy should be increased from the current DRV in both men and women to a level of 2104–2176 kcal/day for women and 2630–2726 kcal/day for men over 19 years of age (assessed on a median physical activity level of 1.63), an increase of 100–200 kcal/day.

For easy reference, Table 1.4 presents the current published reference intakes for energy and macronutrients from both the UK and US. Nevertheless, use of reference intakes to determine nutritional adequacy needs to be undertaken with caution. Firstly, the reference intakes will only provide a relative likelihood of adequacy based on a comparable healthy population and hence may not reflect individual requirements. For example, increased requirements for energy and some nutrients are likely in individuals who have a greater than average level of activity or participate significantly in sports and exercise. In all cases use of reference intakes to determine adequacy is wholly dependent on a robust, representative and quantitative measure of current dietary intake. This, in itself, may be difficult to obtain to a high degree of accuracy due to inherent sources of error in methods to assess dietary intake.

### 1.8 Food labelling

Food labels provide valuable information about food products and, where required, provide nutritional information that can be used to make informed decisions with respect to meeting the requirements of exercise and ensuring general health. In the UK the Food Labelling Regulations (1996) make it a requirement that all manufactured foods contain certain information, but at present there is no legal requirement to provide nutrition information unless a nutrition claim is made about the product. Some common claims made on food labels are described in Table 1.5.

A nutrition claim is defined as a statement, suggestion or implication, made in any labelling, presentation or advertising of a food, that the food has particular nutritional properties. The FSA has developed guidelines for the use of certain nutrition claims in food labelling and advertising and some claims are...
specifically legislated under the Food Labelling Regulations (schedule 6). These are for foods with specific nutritional uses, for reduced and low energy foods, for protein formulations (e.g. for reduced and low energy foods, protein, vitamins and minerals, and those with specific nutritional uses).

If present, nutrition information panels give valuable information on energy and nutrient values. Nutrition information is usually given in calories or grams for nutrient per recommended serving and per 100g. The value per 100g is the most useful for comparing foods of similar type, or when analysing total nutrient intake. Food labels in the UK are based on provisions set out by the European Commission on nutritional labelling whereby when a nutrition claim is made the nutrient label must conform to the following conditions:

- Group 1 nutrients which must be listed include energy value, protein, carbohydrate and fat.
- Where a nutrition claim is made for sugars, saturates, fibre or sodium, these Group 2 nutrients are to be listed, i.e. sugars, saturated fat, fibre and sodium.
- Where a relevant claim is made, labels must also list starch, polyols, monounsaturates, polyunsaturates, cholesterol, minerals or vitamins (present in significant amounts as defined in the regulations).

In addition to these regulations, voluntary guidelines introduced by the Institute of Grocery Distributors, a trade organisation representing UK and international food and grocery-related businesses, suggest use of the following.

- Guideline daily amounts for energy, fat and saturates.
- Per serving information for energy and fat outside the main nutritional label (e.g. on front of package).

Guideline Daily Amounts (GDAs) are based on UK DRVs and current public health targets (e.g. for sodium) and are often expressed as a single value based on a woman (or man) with an energy requirement of 2000 kcal/day. Separate GDAs may also be presented for adult men and for children. It is important to note that GDAs do not replace DRVs, particularly for micronutrients, and are designed merely to be a guide to the consumer.

In the UK, the FSA has recommended a system of ‘traffic light’ food labelling which provides at a glance information about the fat, saturated fat, sugars and salt content of food. Red indicates a high content, amber a medium, and green a low content. The criteria for each level are shown in Table 1.6. Some companies and supermarkets have decided to use this system, and labelling usually includes the amount of each nutrient per portion with the label. Nevertheless, some companies and retailers have not accepted this system and instead opt for a system proposed by the Food and Drink Federation based

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<th>Table 1.5 Common claims used on food labels and their definitions and/or legal requirements.</th>
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<tr>
<td><strong>Bio</strong></td>
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<td><strong>Free from</strong></td>
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<td><strong>Fresh, pure, natural</strong></td>
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| **Gluten-free** | Those made from ingredients that are naturally free of gluten or from wheat, which has gluten extracted.  
Note that it is not possible to remove all gluten from wheat so these products may still contain trace amounts of gluten. The law specifies that all foods for babies less than 6 months old must indicate if they contain gluten. New laws are to be enforced from 2012 to control the phrases used on packaging stating suitable for people with gluten intolerance. |
| **Light, lite** | Not defined by law. Is often used to imply different qualities, e.g. texture, colour, or less salt, fat, or calories than similar foods. |
| **Low fat, fat-free** | The law requires these claims must not be misleading but it does not state when they can be used or specify a level of fat (except for spreadable fats). |
| **May contain nut or seed traces** | Useful for allergy sufferers. |
| **No added sugar, unsweetened** | Simply means sugar or sweetener has not been added, not necessarily low in sugar. |
| **Organic** | Originates from growers, processors and importers registered and approved by organic certification bodies. |
| **Reduced/low salt or sodium** | The law does not state how much less salt or sodium these products should contain although the FSA recommend this be 25% less than a standard product. |
on GDAs. This system avoids the use of colour coding but provides the energy, sugars, fats, saturated fat and salt content per serving both as an amount and as a percentage of the GDA.

However, adding to the confusion is that no single labelling system has been accepted by all companies and retailers, and some companies and retailers even use a combination of two systems on the same packaging.

1.9 Perspectives on the future

The nutrient basics presented in this chapter represent understanding that has been established for some considerable time. Nevertheless, it is important to have an appreciation of the basic concepts of nutrition in order to understand how they are altered when applied to an exercise situation. Research continues to explore the interplay between nutrition and exercise, and many focus on particular nutrients or specific nutritional interventions in a very controlled experimental way, which may not translate to free living situations. In addition, the literature often assumes a level of nutrition knowledge which, if absent in the reader, can lead to misunderstanding of particular findings.

It is very important to be aware of overall nutritional adequacy and dietary requirements when extrapolating any specific knowledge into dietary advice. As described in this chapter there are a variety of ways in which dietary adequacy can be estimated, although all these methods are fundamentally flawed in some way. It is unlikely that methodological limitations in dietary assessment will be fully resolved in the future, despite advances in technology, so an appreciation of these limitations will remain vital for their correct use and interpretation.

Currently in the UK and US there are government-led nation-specific healthy eating guidelines, which as a foundation are as applicable to the athlete or exerciser as they are for the general population. The specific energy and nutrient requirements for athletes and exercisers, when training or competing, are discussed in more detail in other chapters in this book. It is possible that the format of these guidelines may change in the future, although it is likely the fundamental message may remain similar. When considering reference intake values for nutrients, it is important to consider that these are likely to be updated periodically. Specifically, the current UK DRV’s have been in place since 1991 and hence are due a revised version. However, the current US DRIs, although published in 2005, are reviewed every 5 years. It is less clear how the quality, quantity and clarity of nutritional information on food labels will change in the future as this would require agreement between retailers, manufacturers, governments, legislators and other stakeholders.

Further reading


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<tr>
<th>Table 1.6 UK Food Standards Agency ‘traffic light’ food labelling system (values expressed as per 100g of food unless specified).</th>
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<tr>
<td></td>
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<tr>
<td>Fat</td>
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<td>Saturated fat</td>
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<td>Sugars</td>
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<td>Salt</td>
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**Websites**

http://www.nhs.uk/Livewell/GoodFood/Documents/eatwellplate.pdf

http://www.mypyramid.gov/

http://www.aoac.org