Nutrition for Sport and Exercise Performance 13

Getting to know your unit

Assessment
You will be assessed externally through a written task.

This unit explores how nutrition affects sports performance how to apply nutritional principles to meet sport-specific nutritional requirements. You will focus on the concepts of nutrition and digestion and the components of a balanced diet, exploring the roles of macronutrients and micronutrients and the energy and nutrient demands of different sports. You will also learn how to optimise nutritional strategies.

This unit does not develop the breadth of knowledge and skills of a registered sports dietitian or nutritionist, but you will gain an appreciation of how diet affects sporting performance.

How you will be assessed

This unit will be assessed by a written task set and marked by Pearson. This task will assess your ability to interpret, modify and adapt a nutritional programme for a given scenario. There are 50 marks awarded for this task. The assessment will take place under supervised conditions and last for two hours.

You will be provided with a case study two weeks before the supervised assessment date. This case study presents an individual who needs guidance on nutrition in response to the personal and training needs affecting their performance. You should spend approximately eight hours over the course of the two weeks independently researching the case study and preparing notes.

You must be able to modify a programme for an individual in a way that demonstrates knowledge and understanding of nutrition and fluid intake relevant to requirements. You will need to show an understanding of the individual's health and well-being requirements and apply relevant nutritional principles and strategies, demonstrating the ability to conduct relevant research. You will also need to identify the impact of factors affecting digestion and absorption, and provide guidance and justification for your proposed adaptations to the nutritional programme.

The assessment outcomes for this task are as follows:

- **AO1** Demonstrate knowledge and understanding of nutritional principles, strategies and concepts
- **AO2** Apply knowledge and understanding of nutritional principles, strategies and concepts to sport and exercise performance in context
- **AO3** Analyse and evalute information and data relating to an individual's needs in order to determine modifications and guidance to improve sport and exercise performance
- **AO4** Be able to develop and adapt a nutritional programme in context and with appropriate justification

Getting started

Take a few minutes to think about the factors that might influence your food intake and choices. If you can think of ten factors, you are doing well, while 20 or more is excellent. Awareness of these factors will help you to formulate realistic and achievable dietary goals and plans when meeting the assessment requirements of this unit.

A Principles of nutrition and hydration

It is important to understand the basic principles of nutrition and the effects of nutrients on the body's ability to function during sport and exercise. **Foods** contain varying amounts of nutrients including carbohydrate, protein, fat, vitamins, minerals, fibre and water.

Any activity stimulates your body's need for fuel and fluid. Knowing the nutrients your body requires, along with the different functions of the nutrients, forms the basis for the science of **nutrition**.

The amount of each nutrient you need is referred to as your **nutritional requirement**. This differs depending on your age, sex, levels of activity and state of health. Some nutrients are more essential during different stages of life, such as calcium in childhood and iron during pregnancy.

▸ Why is it important to have a balanced and varied diet in order to stay healthy?

Key terms

Food – any substance derived from plants or animals containing a combination of carbohydrates, fats, proteins, vitamins, minerals, fibre and water.

Nutrition – the means by which your body takes in energy and nutrients from food to sustain growth and development, and to keep you alive and healthy.

Basic nutritional principles

Nutritional measurements and units

Energy is obtained from the foods you eat and is used to support your basal metabolic rate (the minimum amount of energy required to sustain your body's vital functions while you are awake – this is covered in more depth on page XXX), and all activity carried out at work and leisure. Energy is measured in **calories** or **joules**. As both these units are very small they are multiplied by 1000 and referred to as **kilocalories** (the UK system) or **kilojoules** (the metric or international system).

Key terms

Calorie (cal) – 1 calorie is the energy required to raise the temperature of 1 gram of water by 1°C.

Joule (J) – 1 joule of energy moves a mass of 1 gram at a velocity of 1 metre per second. Approximately 4.2 joules = 1 calorie.

Kilocalorie (kcal) – 1 kilocalorie is the energy required to raise the temperature of 1 litre of water by 1°C. It is equal to 1000 calories and is used to state the energy value of food. Kilocalories are often simply referred to as calories.

Kilojoule (kJ) – a unit of energy, equivalent to 1000 joules.

Recommended daily allowance (RDA)

Dietary standards have been used in the UK since the Second World War. The first set of standards focused on a **recommended daily allowance (RDA)**, which aimed to prevent nutritional deficiency by recommending an intake target per day for each nutrient. In the late 1980s, the government set up a panel of experts to review the RDAs of nutrients, and new **dietary reference values (DRVs)** were established. The phrase 'dietary reference value' is an umbrella term that can be applied to any of the following measures of nutrient intake values:

- estimated average requirements (EAR)
- safe intake (SI)
- reference intakes: reference nutrient intake (RNI) and lower reference nutrient intake (LRNI).

Estimated average requirements (EAR)

Estimated average requirements (EAR) are the most widely used value in assessing energy requirement. Many individuals require more than the EAR and many require less.

Safe intake (SI)

Safe intake (SI) is a term used to represent an intake that is thought to be adequate for most people's needs but not so high as to cause undesirable effects on health. It is used when there is insufficient scientific information to estimate the different requirements of different segments of the population.

Research

Find out more about DRVs by looking at the Department of Health's *Report on Health and Social Subjects 41: Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*, HMSO, 1991.

Based on your research develop a summary table of reference nutrient intake (RNI) requirements for males and females aged 15–18 years and 19–50 years.

Reference intakes (RIs)

On food labels the term reference intakes (or RIs) has replaced guideline daily amounts (GDAs), but the basic principle behind these two terms is the same. RIs are guidelines based on the approximate amount of energy and nutrients needed daily for a healthy, balanced **diet**. They are not intended as targets, as requirements are different for everyone, but they provide a useful indication of how much energy the average person needs.

Key term

Diet – a person's usual eating habits and food consumption.

Metabolism

Metabolism refers to the chemical processes that occur within the body in order to maintain life. Technically it consists of both **anabolism** (the build-up of substances), and **catabolism** (the breakdown of substances), but the term is typically used to refer to the breakdown of food and its transformation into energy.

Basal metabolic rate (BMR)

Basal metabolic rate (BMR) reflects the energy required to maintain body systems and to control body temperature at rest.

BMR is measured under strict conditions of rest in the morning, after an overnight fast in a temperature controlled environment free from distractions, medications and stress that would increase metabolic activity. Because measures of BMR require the need to sleep overnight in a laboratory, measures of **resting metabolic rate (RMR)** are often used instead, where the subject will have followed the same process but will have slept at home.

These terms are often used interchangeably when referring to energy expenditure, and measures of BMR and RMR usually differ by less than 10 per cent.

Prediction equations can be used to estimate basal metabolic rate. For example, the Harris–Benedict equation takes into account sex, weight, height and age.

Harris–Benedict equation

Males: BMR = 66.5 + (13.75 × weight, kg) + (5.0 × height, cm) – (6.76 × age, years)

Females: BMR = 655.1 + (9.56 × weight, kg) + (1.85 × height, cm) – (4.68 × age, years)

Worked example

An 18-year-old female athlete weighs 55 kg and is 175 cm tall.

655.1 + (9.56 × 55 kg) + (1.85 × 175 cm) – (4.68 × 18 years) = 1420 calories

To predict total daily energy requirements, a **physical activity level (PAL)** needs to be applied. The Harris–Benedict equation recommends the following PAL values to enable calculation of an individual's daily **total energy requirement (TER)**.

Physical activity levels (PALs)

Little to no exercise: TER = BMR × 1.2

Light exercise (1–3 days per week): TER = BMR × 1.375

Moderate exercise (3–5 days per week): TER = BMR × 1.55

Heavy exercise (6–7 days per week): TER = BMR × 1.725

Very heavy exercise (twice per day, extra heavy workouts): TER = BMR × 1.9

Worked example

Using the same example, the female athlete trains 6 days a week, so her TER = 1420 calories × 1.725 = 2449.5 calories

Theory into practice

Based on your current body weight and level of physical activity and training, estimate your total daily energy requirement. Do you think your energy requirements are constant, or do they vary from day to day? What practical considerations does this have for trying to estimate and meet your requirements?

Energy balance

You achieve 'energy balance' when the amount of energy you take in as food and drink (**energy intake**) equals the amount of energy you expend (**energy expenditure**): you will neither be losing nor gaining weight.

There are four major components of energy expenditure: resting metabolic rate (RMR), dietary thermogenesis (DT), physical activity (PA) and adaptive thermogenesis (AT).

Key term

Lean body mass – body weight minus body fat primarily composed of muscle, bone and other non-fat tissues.

- **Resting metabolic rate (RMR)** can account for 60–75 per cent of total energy output and represents the largest component of total daily energy expenditure. RMR is closely related to **lean body mass** and so is influenced by body composition: muscle tissue is much more active metabolically than fat tissue. Gains in muscle mass will result in increases in RMR. RMR is also influenced by your age, sex and genetic background.
- **Dietary thermogenesis (DT)** refers to the energy expended above RMR for digesting, absorbing, transporting and storing food. It is influenced by calorie intake and the composition of your diet, along with your individual nutritional status. High energy intakes and a regular eating pattern are thought to help maintain higher rates of DT, while skipping meals and restrictive dietary practices lead to a reduction in DT.
- **Physical activity (PA)** represents the most variable component of your total energy expenditure. This is the additional energy expended above RMR and DT, and will contribute more to total daily energy expenditure in active individuals. Exactly how much it contributes varies depending on:
  - how active your general lifestyle is
  - how often, how energetically and for how long you exercise
  - what type of activity it is.
- **Adaptive thermogenesis (AT)** is energy expenditure that occurs as a result of environmental or physiological stresses placed on your body, such as a change in temperature that may require you to respond by shivering, or stress that causes anxiety or fidgeting – both will increase your energy expenditure.

When energy intake exceeds expenditure, this is referred to as **positive energy balance** and weight is gained. If intake is less than requirements, the additional energy required will be drawn from your body's fat reserves and weight will be lost. This is referred to as **negative energy balance**.

PAUSE POINT

Do some research to find out the other equations for predicting BMR and TER. Which do you think is the best?

Hint Consider factors related to sex, size and body composition that might affect the ability to predict requirements accurately.

Extend What could you do to control some of the limitations of these equations?

Physical activity

The relative value of fuels for activity differs. Fat and carbohydrate are the main energy fuels for your exercising muscles. Exercising muscles prefer **glucose** as a fuel, particularly as the intensity of the activity being undertaken increases. Protein may be used during prolonged periods of exercise and towards the latter stages of endurance events like the marathon, particularly if fat and carbohydrate as sources of fuel within the working muscles have become limited.

Key term

Glucose – the main type of sugar in the blood; a major source of energy for the body's cells.

When you exercise, your muscles use energy at a rate that is directly proportional to the intensity of your activity and its duration. If this energy is not replaced as it is used up, your muscles will be unable to maintain their rate of work and the intensity of the activity will need to be reduced or stopped.

Calories expended in different activities

At rest, we use energy at a rate of about 1–1.2 calories per minute, which is equivalent to about 1400 to 1700 calories per day, the basal metabolism for the average individual. Any activity will increase the rate of energy expenditure. Walking or jogging requires about 1 kcal per kg of body weight per km covered, but those with a larger body mass burn more energy at the same speed. Distance covered, not speed, will have a greater influence on total energy expenditure.

Worked example

Two men are starting a health and fitness regime: one weighs 70 kg and the other weighs 100 kg.

- Both men start by walking slowly (3 km per hour) for 30 minutes. The man who weighs 70 kg will use up about 105 calories, but the man who weighs 100 kg will use about 150 calories.
- As their fitness improves, the intensity is increased to jogging. They cover 4 km in 30 minutes. The man who weighs 70 kg uses up around 280 calories, but the man who weighs 100 kg uses around 300 calories.

A trained athlete with a body mass of 70 kg who ran 10 km in 30 minutes would use about 700 calories in time.

Body weight and body mass index

Body weight (or, more precisely, 'body mass') is usually measured in kilograms. Body mass can be classified by using the **body mass index (BMI)**. BMI assumes that there is a healthy weight range for any given height (see Table 13.1). An individual's BMI can be calculated by dividing their weight, in kilograms, by the square of their height, in metres (kg/m^2).

Worked example

An adult who weighs 65 kg and whose height is 1.70 m will have a BMI of 22.5: BMI = 65 kg ÷ (1.70 m^2) = 22.5

Using Table 13.1, they would be classified within the normal weight range.

Table 13.1: BMI classifications based on World Health Organization's International Classification of Adult Underweight, Overweight and Obesity

BMI	Classification
Less than 18.50	Underweight
18.50–24.99	Normal weight
25.00–29.99	Overweight/pre-obese
30.00–34.99	Obese class I
35.00–39.99	Obese class II
40.00+	Obese class III

Body composition

Body composition refers to the proportions of lean body mass and body fat that make up total body weight.

- **Lean body mass** includes bone, muscle, water, connective and organ tissues.
- **Body fat** includes both essential and non-essential fat stores.

People actively engaged in fitness regimes are often concerned about their weight, whether for performance or health reasons. Some athletes wish to alter body composition, with exercise generally increasing lean body mass and decreasing body fat.

Changes in body composition can be monitored by a range of methods including skinfold analysis, bioelectrical impedance analysis and hydrodensitometry (underwater weighing). All these methods are best used for measuring changes in body composition over time, rather than for judging a single measurement in isolation. To minimise potential errors when measuring changes in body composition over time, always use the same method; ensure the subject is assessed by the same person, and take repeat measurements at the same time of day.

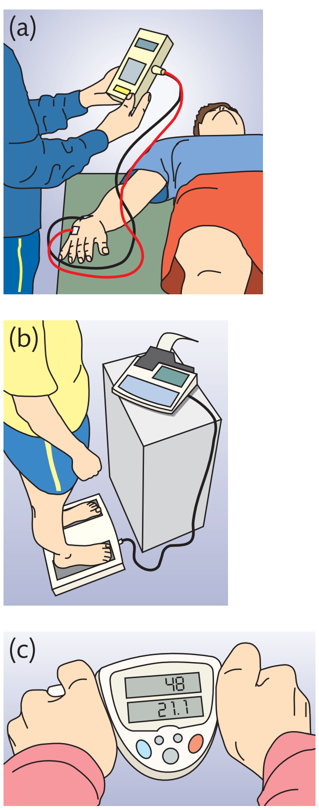

Figure 13.1: Bioelectrical impedance machines: (a) using electrodes, (b) foot-to-foot and (c) hand-to-hand

Bioelectrical impedance analysis (BIA)

Bioelectrical impedance analysis (BIA) is a standard technique for assessing body composition, particularly in the health and fitness sector. BIA machines (Figure 13.1) provide a quick, easy and non-invasive method of estimating percentage body fat. Some equipment uses electrodes attached to the hands and feet, other equipment requires the subject to stand on specially designed scales or to grip handles.

BIA machines measure resistance to the flow of an electrical current through the body, using the fact that different body tissues restrict (or impede) the flow of the current to different extents. Tissues that contain a large amount of water, such as lean tissue, provide a lower impedance than tissues such as bone and fat.

When using BIA techniques a number of assumptions are made, and equations applied, to obtain a body fat percentage figure. One potential drawback is that impedance measurements are related to the water content of tissues, so subjects must be fully hydrated and must abstain from exercise and substances that exert a diuretic effect – such as alcohol or caffeine – for at least 24 hours before the test. Invalid results may also be obtained for women immediately before or during menstruation, when the body's water content may be higher than normal.

Link

You can read more about measuring body composition in *Unit 4: Field- and Laboratory-based Fitness Testing*.

Research

Search online for 'body composition assessment'. Evaluate the range of body composition assessment products available in terms of affordability, ease of application and suitability for use with athletes. Be sure to consider skinfold assessment, air displacement plethysmography and dual-energy X-ray absorptiometry.

Macronutrients

Nutrients in food are categorised according to the relative amounts required by your body. Carbohydrate, fat and protein are termed **macronutrients**, as they are required in relatively large amounts on a daily basis. These nutrients are also the energy-providing nutrients of your diet.

Key term

Macronutrient – a nutrient required by your body in daily amounts greater than a few grams, e.g. carbohydrate, fat and protein.

Carbohydrates

Carbohydrates form your body's most readily available source of energy and can be accessed rapidly. One gram of carbohydrate provides approximately 4 kcal or 17 kJ of energy. Carbohydrate foods are divided into two basic types: simple and complex.

Simple carhohydrates

Simple carbohydrates are essentially sugars. They are formed from single and double sugar units and are easily digested and absorbed to provide a quick energy source.

The simplest carbohydrate unit is the **monosaccharide**, the most common of which is glucose. 'Saccharide' means sugar and 'mono' means one, so a monosaccharide is a single sugar unit. Glucose is used to produce adenosine triphosphate (ATP), the compound required for muscle contraction. Other monosaccharides include fructose, also called fruit sugar because it is found in fruits and vegetables, and galactose, found in milk.

Monosaccharides mostly occur combined in carbohydrates. Two monosaccharides together form a **disaccharide** or double sugar. The most common disaccharide is sucrose or table sugar. Others include lactose (found in milk) and maltose (found in cereals).

Complex carbohydrates

Longer chains of simple sugar units are called **polysaccharides** or complex carbohydrates. These allow large quantities of glucose to be stored as starch in the cells of plants or as glycogen in the muscles and liver of animals. All carbohydrate consumed ends up as glucose to provide energy.

Complex carbohydrates are an important source of energy since they are broken down slowly in your body to release energy over longer periods. They should form the largest percentage of your total carbohydrate intake. Unrefined sources such as wholemeal bread, wholegrain rice and pasta are preferable as they also contain a higher nutritional value by way of micronutrients and fibre.

Table 13.2: Sources of simple and complex carbohydrates in the diet

Simple	Complex
Sugar, syrup, jam, honey, marmalade, sugary fizzy drinks, boiled sweets, fudge, fruit juice, sports drinks, energy gels	Bread, bagels, crispbread, crackers, rice, pasta, polenta,noodles, couscous, potatoes, breakfast cereals, pulses, root vegetables

Recommended daily intake (RDA)

To support health and performance, it is recommended that around 50–60 per cent of your total daily calorie intake is derived from carbohydrates. Greater intakes may be required by athletes in regular intense training. For example, a marathon runner or a triathlete may need to get 65–70 per cent of their total daily energy from carbohydrates.

However, the average sedentary individual will require around 50 per cent of their total daily calorie intake to be supplied by carbohydrates, of which the majority should be from starchy complexsources. This would equate to around 250 grams per day for females and 300 grams per day for males. Table 13.3 estimates the carbohydrate requirements based on activity levels.

Table 13.3: Carbohydrate requirements based on daily activity levels

Level of daily activity	Carbohydrate per kilogram of body weight (g)
Sedentary	3–4
Less than 1 hour	4–5
1 hour	5–6
1–2 hours	6–7
2–3 hours	7–8
More than 3 hours	8–10

Whether eating for health or performance, the best approach to achieving an adequate carbohydrate intake is to eat at regular intervals and ensure all meals and snacks are centred around starchy carbohydrate foods, such as wholegrain breads, rice, pasta and potatoes. Athletes with high carbohydrate requirements may need to eat more frequent meals and snacks or consume more simple carbohydrates to achieve their requirements.

Glycaemic index (GI)

The glycaemic index (GI) is a rating that describes how quickly a food containing carbohydrate increases blood glucose after eating. Foods are ranked on a scale of 0–100, with glucose having a score of 100.

- Foods that have a **high GI** are broken down quickly in the body and cause a rapid rise in blood glucose. High GI foods, such as grapes, rice cakes and jelly beans may be useful in promoting optimal recovery after exercise as high GI foods will stimulate insulin release and a replenishment of muscle glycogen stores.
- Those with a **low GI** are broken down more slowly and cause a more gradual increase in blood glucose. It is thought that low GI foods help to control appetite and keep you feeling fuller for longer which can be useful when trying to reduce body mass. They also promote better blood glucose control and more stable energy levels.

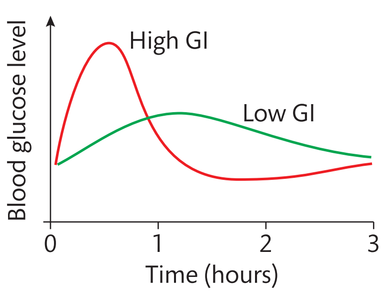

Figure 13.2: Blood glucose response to from and low GI foods

The GI of a food is determined by its composition in terms of its macronutrient and fibre content and how it is processed and cooked. Fat, fibre and protein content lower the GI of a food.

Research

Draw up a list of the common carbohydrate-rich foods you consume in your day-to-day diet. Carry out an internet search using the term 'glycaemic index' and use your research to categorise your food choices as high, moderate or low GI.

Theory into practice

Based on your current body weight and level of physical activity, estimate your carbohydrate requirements in grams per day. Do you think your requirements are constant, or do they vary from day to day? What practical strategies could you implement to ensure you achieve your carbohydrate requirements?

Fats

Fat is an essential nutrient. **Triglycerides** form the basic component of fats. Each triglyceride consists of a glycerol molecule with three fatty acids attached. When triglycerides are digested and absorbed by your body they break down into **glycerol** and **fatty acids**. Fats are obtained from animal and vegetable sources.

Fatty acids contain chains of carbon atoms to which hydrogen atoms attach. If all the carbons are associated with two hydrogens, the fat is **saturated**, but if one or more of the carbons is without hydrogen then the fat is **unsaturated**. Unsaturated fatty acids can be of two kinds: **monounsaturated** and **polyunsaturated**.

All fats in your diet are a mixture of these three fatty acid types. Fats that contain mostly saturated fatty acids are generally solid at room temperature, like butter, and are usually found in meat, eggs and dairy foods. The two exceptions are palm and coconut oil, which are plant sources. Fats composed mainly of unsaturated fatty acids are usually liquid at room temperature, like olive or sunflower oils.

Most dietary experts recommend cutting back on fat intake. This is sound advice for athletes as it allows them to consume a greater proportion of energy intake from carbohydrates to maintain glycogen stores, to support training and competition.

The primary function of fats is to provide a concentrated source of energy, forming your body's largest potential energy store. Even the leanest of individuals will have large amounts of energy stored as fat. Fat is more than twice as energy-dense as other macronutrients, yielding 9 kcal or 37 kJ per gram.

Fat protects and cushions your vital organs, provides structural material for cells and acts as an insulator to help maintain body temperature. Animal fats are a source of the fat-soluble vitamins A, D, E and K. Fat also adds flavour and texture to foods, which can lead to over-consumption.

Some sources of the different types of fat are shown in Table 13.4. It is generally recommended that we reduce our total fat intake and intake of foods which are high in saturated fat from non-dairy sources.

Table 13.4: Sources and types of fat in the diet

Saturated	Monounsaturated	Polyunsaturated
Full-fat dairy products, butter, hard margarine, lard, dripping, suet, fatty meat, meat pies, pâté, cream, cakes, biscuits, chocolate, coconut, coconut oil	Olive oil, olive oil spreads, rapeseed oil, corn oil, peanuts, peanut butter, peanut oil	Soft margarine, low-fat spreads labelled high in polyunsaturated fats, sunflower oil, safflower oil, soya oil, oily fish, nuts

Transunsatured fats or trans fatty acids are unsaturated fatty acids produced by the partial hydrogenation of vegetable oils. They are found in hardened vegetable oils, most margarines, commercial baked foods and most fried foods. An excess of these fats in the diet is thought to raise cholesterol levels.

Recommended daily intake

It is recommended that fat intake represents 30–35 per cent of total calorie intake: around 70 grams per day for females and 90 grams per day for males. Of this, only 6–10 per cent should be from saturated fats. Athletes involved in regular intense activity may need to further reduce their overall fat intake as a percentage to around 25–30 per cent of total energy consumed to achieve adequate carbohydrate intakes. However, in absolute terms this may equate to the same quantity of intake as that of the sedentary individual, as athletes will be eating more calories to meet their increased energy requirements.

Discussion

Government guidelines recommend 70 grams of fat per day for the average female and 90 grams per day for the average male. What nutritional strategies can be put in place to ensure recommended intakes are not exceeded?

Proteins

Proteins are essential to maintaining optimal health and physical performance. The smallest units of proteins are **amino acids**. You do not need to know the names and functions of the 20 individual amino acids, but the body needs all of them to be present simultaneously for protein synthesis to occur, to sustain optimal growth and functioning. Different protein foods contain different numbers and combinations of amino acids. The eight that your body is unable to make are called **essential amino acids (EAAs)** – they are a necessary part of your diet. The remaining amino acids are called **non-essential**, meaning your body is able to synthesise them if all the essential ones are present.

The chief role of protein in your body is to build and repair tissue. Protein may also be used as a secondary source of energy when carbohydrate and fat are limited, such as towards the end of prolonged endurance events or during severe energy restriction that may accompany dieting.

Proteins, like carbohydrates, have an energy value of approximately 4 kcal or 17 kJ per gram. Unlike carbohydrate and fat, excess protein cannot be stored in your body. If your protein intake exceeds requirements to support growth and repair, excess is used to provide energy immediately or converted to fat or carbohydrate and stored.

Protein foods are classified into two groups (see Table 13.5). The value of foods for meeting your body's protein needs is determined by their composition of amino acids.

- **High biological value** or **complete proteins** contain all of the EAAs. These are mainly of animal origin like eggs, meat, fish, milk and other dairy products, but also soya.
- **Low biological value** or **incomplete proteins** lack one or more of the EAAs. These come from plant sources such as cereals, bread, rice, pasta, pulses, nuts and seeds. Vegetarians and vegans must ensure that they eat a variety of these in careful combinations to ensure adequate intake of all EAAs; for example, beans and wheat complement each other well.

In the context of sports performance, does the typical UK diet contain adequate amounts of protein?

Table 13.5: Sources and types of protein foods in the diet

Complete/high biological value proteins	Incomplete/low biological value proteins
Meat, poultry, offal, fish, eggs, milk, cheese, yoghurt, soya	Cereals, bread, rice, pasta, noodles, pulses, peas, beans, lentils, nuts, seeds

Recommended daily intake

Active individuals have higher protein requirements in order to promote tissue growth and repair following training and competition. Overall, protein intake should represent between 12 and 15 per cent of your total daily energy intake.

The misguided belief that additional protein will automatically help to build muscle has been perpetuated since the times of the ancient Greeks. Regular exercise does increase protein needs, but most people already eat enough protein. Athletes are likely to be eating more to meet increased calorie requirements, and therefore should already be eating enough to meet any theoretical increase in requirements.

Table 13.6: Daily protein requirements based on type of activity. Note nutrition experts do not generally recommend intake beyond 2 g per kg of body weight

Type of activity	Protein per kilogram of body weight (g)
Mainly sedentary	0.75–1.0
Mainly endurance	1.2–1.4
Mainly strength	1.2–1.7

Theory into practice

Based on your current body weight and level of physical activity, estimate your protein requirements in grams per day. Do you think you meet your protein requirements? Are there any factors related to your exercise or training regime that influence your protein requirements?

PAUSE POINT Reflect on your current ability to meet your targets for energy, carbohydrate and protein. Are there any barriers to you achieving these on a day-to-day basis?

Hint Consider whether any of the factors identified in this unit affect your ability to meet your daily targets.

Extend Identify any common themes that might be affecting the success of achieving your targets.

Micronutrients

Vitamins and minerals are referred to as micronutrients as they are required in much smaller amounts – some in minute quantities. Despite your relatively small requirements for these nutrients, many play a critical role in regulating chemical reactions in your body.

Vitamins

Vitamins are vital, non-caloric nutrients required in very small amounts. They perform specific metabolic functions and prevent particular deficiency diseases. Vitamins play essential roles in regulating many metabolic processes in your body, particularly those that release energy. They also support growth and the functions of the immune and nervous systems, and some are involved in producing hormones.

Most vitamins required to maintain health cannot be produced by your body and must be supplied by your diet. The exceptions are vitamin D, which your body is able to synthesise by the action of sunlight on the skin, and vitamin K, which can be produced by the bacteria of the large intestine.

Vitamins are obtained from a variety of plant and animal sources (see Table 13.7) and are broadly grouped depending on whether they are fat- or water-soluble.

- **Fat-soluble vitamins** are vitamins A, D, E and K. They have a number of common features. As the term suggests, they are found in the fatty or oily parts of foods. Once digested they are absorbed and transported in the lymph and ultimately reach the blood. As a result of their insolubility in water, they are not excreted in the urine and can accumulate in the liver and **adipose tissue**.
- **Water-soluble vitamins** consist of the B vitamins and vitamin C. Many of the B vitamins serve similar functions, facilitating the use of energy within your body. Excesses are excreted via the urine, so your body has only limited stores, necessitating regular intakes. It should be noted that many of these vitamins are destroyed by food processing and preparation.

Key term

Adipose tissue – loose connective tissue composed of adipocytes, specialised cells for the storage of fat. Its main role is to store energy in the form of fat, but it also cushions and insulates the body.

Different vitamins have specific functions and are required in different amounts. Individual requirements are determined by age, sex, state of health and levels of physical activity. The UK Department of Health has set dietary reference values (DRVs) for all nutrients for different groups of healthy people, and the reference nutrient intake (RNI) value should meet the needs of 97 per cent of the population (see Table 13.7). A balanced and varied diet with an adequate energy content should supply sufficient intake of all vitamins.

It is important to note that large amounts of some vitamins can be harmful to health. This is particularly true for the fat-soluble vitamins, as they can be stored in your body. The only situation in which large doses of any vitamin may be beneficial is when the body has a severe deficiency of a particular vitamin or is unable to absorb or metabolise vitamins efficiently, in which case supplementation may be medically advised.

Table 13.7: Vitamins – their sources, functions and deficiencies

Micronutrient and adult daily requirements (RNI)		**Good dietary sources**	**Functions**	**Deficiency**
A Retinol or beta carotene	Males 700 µg Females 600 µg Pregnancy +100 µg Lactation +350 µg	Retinol: liver, oily fish, eggs Beta-carotene: carrots, red peppers, tomatoes and green vegetables	Visual processes, connective tissue, immune response	Night blindness
B_1 Thiamine	0.4 mg/1000 kcal	Whole grains, meat, pulses, nuts, milk and yeast extract	Metabolism of fat, carbohydrate and alcohol	Neurological problems
B_2 Riboflavin	Males 1.3 mg Females 1.0 mg Pregnancy +0.3 mg Lactation +0.5 mg	Liver, dairy produce, meat, fortified cereal, eggs and yeast extract	Carbohydrate metabolism, vision, skin health and nervous system function	Poor growth
B_3 Niacin	6.6 mg/1000 kcal Lactation +2.3 mg	Meat, dairy produce and eggs	Carbohydrate and fat metabolism	Dermatitis, diarrhoea and confusion
B_6 Pyridoxine	15 µg	Meat, whole grains, pulses, nuts and fortified cereals	Protein metabolism and red blood cell formation	Deficiency is rare
B_{12} Cyanocobalamin	1.5 µg Lactation +0.5 µg	Meat, dairy produce, eggs, fortified cereals and yeast extract	Red blood cell formation and central nervous system function	Pernicious anaemia and neurological problems
Folic acid	200 µg Pregnancy +100 µg	Pulses, green leafy vegetables, wholegrain and fortified cereals	Regulates growth of cells, including red blood cells	Anaemia and diarrhoea
C Ascorbic acid	40 mg Pregnancy +10 mg Lactation +30 mg Smokers 80 mg	Green leafy vegetables, citrus and soft fruit, potatoes	Connective tissue formation, iron absorption and wound healing	Scurvy, bleeding gums, poor wound healing, weakness and fatigue
D Calciferols	No RNI set for adults	Dairy produce, oily fish, eggs and liver	Bone mineralisation and immune system function	Rickets in children, osteomalacia in adults
E Tocopherols	Males 8 mg Females 6 mg	Vegetable oils, nuts and seeds	Protects cells from free radical damage	Impaired coordination
K	No RNI set	Green leafy vegetables, vegetable oils, eggs, meat and dairy produce	Clotting of blood	Poor blood clotting

Minerals

Minerals are non-caloric nutrients that are essential to life, and like vitamins they are required in small or trace amounts. All minerals are essential to health and form important components of your body such as bone, connective tissue, enzymes and hormones. Some play essential roles in nerve function and muscle contraction; others regulate fluid balance in your body.

Levels of minerals are closely controlled by absorption and excretion to prevent excessive build-up. Some minerals compete with each other for absorption, especially iron, zinc and copper.

Table 13.8: Main minerals – their sources, functions and deficiencies

Micronutrient and adult daily requirements (RNI)		Good dietary sources	Functions	Deficiency
Sodium	1.6 g	Salt, cheese, meat, fish, tinned vegetables, salted nuts and savoury snacks	Neuromuscular transmission, fluid and acid-base balance	Hyponatremia (low sodium concentration in the blood)
Potassium	3.5 g	Meat, dairy produce, vegetables, cereals, nuts, fruit and fruit juices	Neuromuscular transmission, fluid and acid-base balance	Hypokalemia (low potassium concentration in the blood)
Calcium	Males 700 mg Females 700 mg Lactation +550 mg	Dairy produce, white bread, tinned fish with bones and pulses	Bone and tooth structure Nerve conduction and blood clotting	Stunted growth in children, osteoporosis in adults
Iron	Males 8.7 mg Female 14.8 mg Females aged 50+ 8.7 mg	Red meat and offal, eggs, dark green vegetables, breakfast cereals, pulses and dried fruit	Haemoglobin and myoglobin formation and a component of some enzymes	Anaemia and fatigue

Salt

Salt, or sodium chloride, is necessary to maintain fluid balance and to help muscle contraction and nerve transmission. Small amounts are required daily but most people exceed the required levels. Too much salt can raise blood pressure and increase the risk of heart disease. Adults should consume no more than 6 grams of salt per day.

Research

Investigate the signs and symptoms of hypokalemia and hyponatremia. Which groups of people are likely to suffer from these conditions?

PAUSE POINT How can you ensure that you achieve good dietary intakes of vitamins and minerals to avoid potential deficiencies?

Hint It might be helpful to review the 'Getting started' activity at the start of this unit.

Extend Undertaking your own research, can you identify any dangers of over-consumption of the vitamins and minerals listed in Tables 13.7 and 13.8?

Fibre

Fibre is a complex carbohydrate. It is the indigestible portion of food derived from plants. **Non-starch polysaccharide** (NSP) is the scientific term for dietary fibre. NSP forms the main component of plant cell walls, which is the principal component of dietary fibre. It resists digestion by the stomach and small intestine, providing bulk which aids the transit of food through your digestive system.

Key term

Non-starch polysaccharide – the scientific term for dietary fibre.

Fibre is obtained from wholegrain cereals, nuts, pulses, fruits and vegetables. It is thought to help in both preventing and treating certain diseases including cancer of the colon, diabetes, heart disease and irritable bowel syndrome. A high-fibre intake plus a high-fluid intake also helps to keep your bowel functioning efficiently. Adequate amounts may also play a role in weight control by helping to achieve the feeling of fullness.

There are two types of fibre: soluble and insoluble.

- **Soluble fibre** can be found in oats, rye, barley, peas, beans, lentils, fruits and vegetables. This is important in the control of blood glucose and cholesterol.
- **Insoluble fibre** is found in wholewheat bread, rice and pasta, wholegrain breakfast cereals, fruits and vegetables. It is thought to be important in the prevention of bowel disorders.

Adult daily requirements for fibre are 18 grams per day.

Athletes with high carbohydrate requirements will need to manage fibre intake because consuming large quantities of fibre-rich carbohydrate food can make the diet bulky and filling, with the potential to limit overall food and energy intake. It may also be necessary for some athletes to remove high fibre foods from their pre-competition meal if they suffer from gastrointestinal discomfort during competition.

Fluid intake

Water is one of the most important nutrients. You cannot survive more than a few days without it. Losses may be as high as a litre per hour during endurance-type exercise, even higher in hot or humid conditions.

During exercise, fluid requirements increase according to the type, duration and intensity of the exercise and the environmental conditions under which it is taking place. Understanding the relationship between hydration and sports performance is vital for achieving optimal performance in training and competition.

Maintaining hydration levels

Water is the main transport mechanism in your body, carrying nutrients, waste products and internal secretions. It also plays a vital role in **thermoregulation**, and aids the passage of food through your digestive system.

Key term

Thermoregulation – the ability to keep the body's temperature constant, even if the surrounding temperature is different.

Water makes up around 50–60 per cent of your total body weight. Actual amounts vary depending on age, sex and body composition. Muscle has a higher water content than fat tissue, so leaner individuals have a higher water content than fatter individuals of the same body mass.

To maintain water balance, a sedentary individual requires 2–2.5 litres of fluid per day. Around 10 per cent of your daily fluid requirements come from metabolic processes that release water within your body. The rest comes from your diet.

Water is lost from your body through a number of routes including urine, faeces, evaporation from the skin and expired breath. If water loss is high, your body becomes **dehydrated**. Fluid losses for athletes during training and competition are linked to the body's need to maintain temperature within very narrow limits. During exercise, body temperature rises and extra heat is lost through sweating. If fluid lost in sweat is not replaced, there is a risk of dehydration and performance may suffer.

Normal fluid requirements are in the region of 30–35 ml per kilogram of body weight per day, or 1 ml per calorie of energy requirement. Thirst is a poor indicator of dehydration, so drinking to just stay ahead of the sensation of thirst is recommended to ensure adequate fluid status.

Theory into practice

Using the equations 30–35 ml per kilogram of body weight per day, or 1 ml per calorie of energy requirement, calculate your daily fluid requirements. Do you think your fluid requirements are similar from day to day? What factors do you think might affect them?

Types of fluid

Water is considered an adequate fluid suitable for most exercise, but some sports drinks may be useful if exercising at higher intensities for longer durations. Most sports drinks provide three nutrients: carbohydrates to replace energy, water to replace fluid and **electrolytes** to replace minerals lost in sweat. The carbohydrate is usually glucose, fructose, sucrose or maltodextrins – all saccharides that are quickly absorbed. Sports drinks often contain a range of minerals and vitamins, but most often include the electrolytes sodium and potassium. The different types of sports drinks are outlined in Table 13.9.

Key term

Electrolytes – salts in the blood, for example, potassium and sodium.

Table 13.9: Types of sports drink

Type of fluid	Function
Isotonic	• Contain the same concentration of glucose to water as blood: 4–8 per cent or up to 8 grams per 100 ml of water • Usually contain sodium, making them more quickly absorbed into the bloodstream • Useful when exercise has been prolonged or during warmer weather • Can also be used before exercise
Hypertonic	• Contain over 8 per cent of carbohydrate and are absorbed more slowly • Provide a source of carbohydrate replenishment, but are not ideal for optimal rehydration and may need to be consumed with other fluids • Best used in the recovery stage after exercise
Hypotonic	• Have a lower concentration of carbohydrates and are more diluted than isotonic or hypertonic drinks • Contain less than 4 per cent carbohydrate (4 grams per 100 ml of water) and are generally easily absorbed and well tolerated • Although water is adequate for non-endurance training or when sweat losses are small, these drinks may encourage fluid replacement through enhanced taste

Carbonated drinks

Carbonated drinks can contribute towards achieving overall daily fluid intake, but it might not be best to consume them during or after exercise. The gas bubbles in carbonated drink expand the stomach, leading to the sensation of fullness resulting in the athlete consuming less fluid than required to achieve effective rehydration.

Research

Investigate a range of commercial sports drinks and evaluate their potential use before, during and after exercise. What are the advantages and disadvantages of a high carbohydrate content in a sports drink?

Dehydration

Dehydration can reduce strength, power and aerobic capacity. Severe dehydration can cause heatstroke and may be fatal. A loss as small as 2 per cent of body mass can be enough to begin to affect your ability to perform muscular work. For a 75 kg male this would be equivalent to a fluid loss of only 1.5 litres from the body.

It is therefore important to minimise the risks of dehydration, and to note that thirst is a poor indicator of your body's hydration status. The warning signs for dehydration include:

- lack of energy and early fatigue during exercise
- feeling hot
- clammy or flushed skin
- not needing to go to the toilet
- nausea
- headache, disorientation and/or shortness of breath – signs of advanced dehydration.

Hypernatremia

Hypernatremia is associated with dehydration. It is a common electrolyte problem and is defined as a rise in serum sodium concentration above 145 mmol/L. It is generally caused by impaired thirst and/or restricted access to water.

Speed of rehydration

Fluid replacement can be accelerated by drinking still, cool drinks of reasonable volume. They should not be too concentrated, and they must be palatable to drink.

The more intense the activity, the more the absorption of fluid is slowed. Starting exercise well-hydrated and keeping a larger volume of fluid in the gut also facilitate rehydration, as does the inclusion of sodium in fluids.

Hyperhydration

Hyperhydration, also called **water intoxication**, usually occurs because the athlete is drinking too much water to try to avoid dehydration. Water intoxication can lead to **hyponatremia** (low sodium concentration in the blood), a potentially fatal disturbance in brain function that results when the normal balance of electrolytes in the body is pushed outside safe limits. Normal serum sodium levels are between 135–145 mmol/L.

Exercise-associated hyponatraemia is common in marathon runners, particularly slower runners who have plenty of time to take fluid on board during the event. Severe hyponatremia can result in seizures, coma and death. The warning signs for hyponatremia are similar to those for dehydration and include:

- nausea and vomiting
- headaches
- confusion
- lethargy
- restlessness and irritability
- muscle weakness and cramps.

Theory into practice

Devise your ideal sports drink and a five point plan to ensure adequate hydration. What practical strategies could be employed to monitor hydration status before, during and after exercise?

B Factors affecting digestion and absorption of nutrients and fluids

Before your body can make use of the energy and nutrients in food, the food has to be broken down to release them through the process of digestion.

Basic principles of digestion

The digestive system takes the food and fluid that you consume, extracts nutrients from it, and then jettisons any waste products. The functions are summarised in Table 13.10. The process is as follows.

1 Digestion starts in the mouth (the **buccal cavity**). Your teeth and jaws crush and grind food to mix it with saliva, which contains the enzyme amylase that begins the breakdown of starch.
2 After swallowing, food enters the **oesophagus**, the tube that connects your mouth to your stomach. The food bolus (a small round mass) is squeezed along the oesophagus by the process of **peristalsis** (a series of wave-like muscle contractions that push along the food). It takes around 3–6 seconds for food to travel from your mouth to your stomach.
3 Your stomach acts as a large mixing bowl, churning the food into a liquid called **chyme**. Lining your stomach are cells that produce and release gastric juices containing **enzymes** and hydrochloric acid, which help break down the food and kill any bacteria present in it. Food normally remains in your stomach for 1–4 hours, but fluid may pass through much more rapidly.

Key term

Enzymes – proteins that start or accelerate the digestive process.

4 From your stomach the chyme passes to your **duodenum** and then to your **small intestine**, a tube about 6 metres long. As the chyme enters your small intestine, it is mixed with more digestive juices, this time from the **pancreas**. Pancreatic juice contains **bile** made by the **liver** as well as **enzymes** to further assist the breakdown of carbohydrate, protein and fat. Bile is also alkaline (having a pH greater than 7) to neutralise the acid from the stomach. (Your **gall bladder** stores and concentrates bile until it is required for digestion, then it is released into your digestive tract to emulsify fats and neutralise the acids in partly digested food.)

5 Peristalsis continues to move the chyme through your digestive system to your **large intestine** (another long tube) and eventually the **rectum** and **anal canal**.

Key term

Bile – a greenish-brown fluid secreted by the liver and stored in the gall bladder that aids digestion.

Table 13.10: Functions of the digestive system

Function	Description
Breakdown of food	Digestion is a multi-stage process following the ingestion of raw materials (food). It involves mechanical and chemical elements in the process that leads to enzymes in the gut breaking down the larger chemical compounds in food into smaller compounds absorbed by your body.
Absorption of nutrients and fluid	The movement of digested food from your stomach and small intestine into your body tissues and blood. Absorption happens in the villi lining the small intestine. Each villus has a network of capillaries to quickly absorb nutrients. Amino acids (from proteins) and glucose (from carbohydrates) enter your bloodstream directly. Fatty acids and glycerol (from fats) are taken up by your lymphatic system.
Excretion of waste products	The removal of potentially poisonous end-products from metabolism, normally in urine and faeces. The main organs of excretion are the kidneys, through which urine is eliminated, and the large intestine, through which solid or semi-solid waste is expelled.

Absorption of nutrients and fluid

It is as the chyme moves through your small intestine that vitamins, minerals, amino acids, fatty acids and sugars are absorbed by your intestinal wall. Lining the wall of your small intestine are finger-like projections known as villi, which increase the surface area available for absorption. By the time the chyme reaches your large intestine, it is less fluid and has been reduced to mainly indigestible matter.

Your large intestine does not produce any digestive enzymes but continues to absorb water. Bacteria in your large intestine produce vitamin K. The residue (faeces) left behind is eliminated (excreted) from your body through your anus.

The digestive system is shown in Figure 13.3.

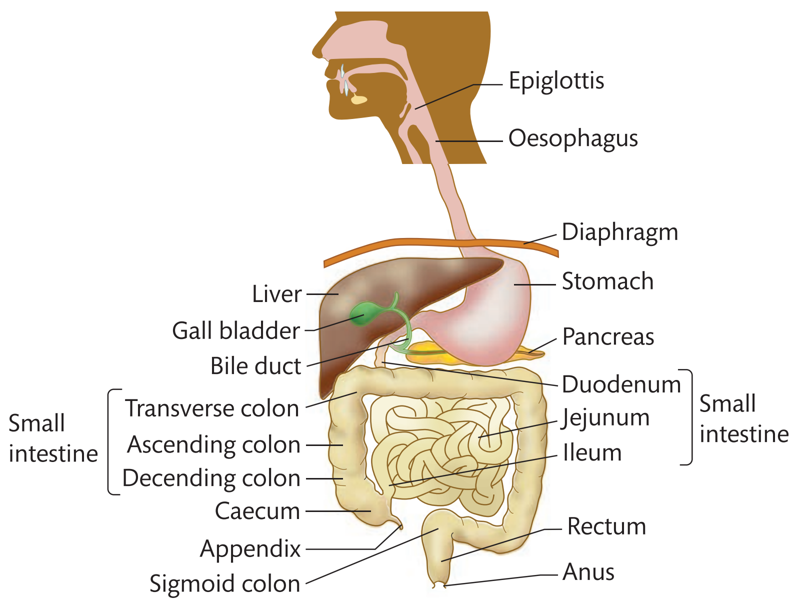

Figure 13.3: The digestive system

Timing of digestion and absorption

Gastrointestinal blood flow increases after meals, an experience known as **postprandial hyperemia**. The extent and the duration of hyperemia appears to depend on the composition of the meal. In general, fat and protein-rich meals are more powerful than carbohydrate-rich meals in stimulating hyperemia.

Digestion and absorption time varies for individuals. For healthy adults it is usually between 24–72 hours depending on what has been consumed. In general, after you have eaten it takes between 6–8 hours for food to pass through your stomach and small intestine.

Carbohydrates spend the least amount of time in the stomach and are digested quickest. Protein takes a bit longer, while fat takes the longest to fully digest. The precise time depends upon the food that you ate and the complexity of its structure. Digestion and absorption are slowed by a high fibre content.

Hormonal control of blood sugar and water balance

Blood sugar (glucose) levels

Key term

Secretion – the process of a substance being released from the interior of a cell to its exterior.

The body requires blood sugar to be kept within narrow limits (3.5–5.5 mmol/L). The hormones **insulin** and **glucagon** are responsible for this. Both are **secreted** by cells called the Islets of Langerhans within the pancreas. These regulate the use and storage of **glucose** by cells.

After eating a meal containing carbohydrate, starch and larger sugar units are broken down to glucose, absorbed in the small intestine and enter the bloodstream. This triggers a rise in blood glucose. The pancreas monitors blood glucose, and once it rises above normal levels it releases insulin into the bloodstream. Insulin causes glucose to move from the blood into the cells where it is used for energy, stored in the liver or muscle cells as glycogen, or converted and stored as fat.

When blood glucose drops below normal levels, between meals and during exercise, the pancreas secretes glucagon. The effect of glucagon release is to make the liver release glucose stored in its cells into the bloodstream to increase circulating blood glucose. Glucagon also facilitates the liver to make glucose from protein.

Water balance

The amount of water in the blood must be kept more or less constant to avoid cell damage. There needs to be a balance between:

- the amount of water gained from diet through food and drink and through water produced by **cellular respiration**
- the amount of water lost from the body in sweating, faeces, urine and expired breath.

This is achieved by **anti-diuretic hormone (ADH)**.

If you have not eaten or drunk for a while, or if you have been sweating a lot, the **hypothalamus** in the brain will detect a drop in the amount of water in the blood. The hypothalamus will relay a message to the **pituitary gland** to release ADH. The ADH will travel in the blood to the kidneys and cause the **tubules** to reabsorb more water into the blood. This leads to production of a smaller volume of more concentrated urine.

In other situations, the level of water in the blood may go up, for example, when it is cooler and the body is not losing as much water through sweat or because excess fluid has been consumed. Here the hypothalamus detects the change and sends a message to the pituitary gland slowing or stopping the release of ADH. Without ADH the kidneys will not save as much water and large volumes of dilute urine are produced until the level of water in the blood falls to normal levels.

Control of glycogen synthesis

Glycogen is a crucial source of glucose for fuelling activity. Around 80 per cent of glycogen is stored in your muscles while the rest is stored in your liver, with a small amount of circulating blood glucose. Excess carbohydrate which is not required to replenish glycogen stores is converted to fat and stored in your body's adipose tissue.

Carbohydrate can only be stored as glycogen in limited amounts – approximately 375–475 grams in the average adult, equivalent to approximately 1500–2000 kcal.

Day-to-day stores of glycogen are influenced by your dietary carbohydrate intake and levels of physical activity or training. Regular exercise can encourage your muscles to adapt to store more glycogen. This is an important training adaptation for elite athletes, particularly in endurance-type sports.

PAUSE POINT	Do you understand how cool downs can help improve an athlete's performance and avoid injury?
Hint	Intensity and duration of exercise influences the rate and amount of glycogen usage. Are there particular days in the week when you are more at risk of not recovering adequately?
Extend	Can you develop a five point plan to ensure you maintain adequate muscle glycogen levels to support optimal adaptation and recovery from training?

C Nutritional intake for health and well-being

Performance in and recovery from exercise are enhanced by optimal nutrition. For most sports, carbohydrate requirements are likely to contribute 55–65 per cent of total energy intake and protein 12–15 per cent, with the remainder coming from fat. Vitamin and mineral supplementation will not improve the performance of athletes whose diet is already adequate and varied.

To plan a diet for a sports activity, you need to consider the physiological demands of the activity, the phase of training and the individual's needs. These will help you to plan a **balanced diet** across the food groups.

Balanced diet for health and well-being

Foods are popularly classed as 'good' or 'bad' and 'healthy' or 'unhealthy', with **healthy eating** often viewed as a hardship or a chore. However, it is better to look at the overall balance of foods eaten as either healthy or unhealthy (see Figure 13.4).

Key terms

Balanced diet – a diet that provides the correct amounts of nutrients without excess or deficiency.

Healthy eating – the pursuit of a balanced diet to support health and reduce the risks of chronic disease. Healthy eating principles should form the solid foundations on which athletes can build more specific nutritional strategies to support training and competition.

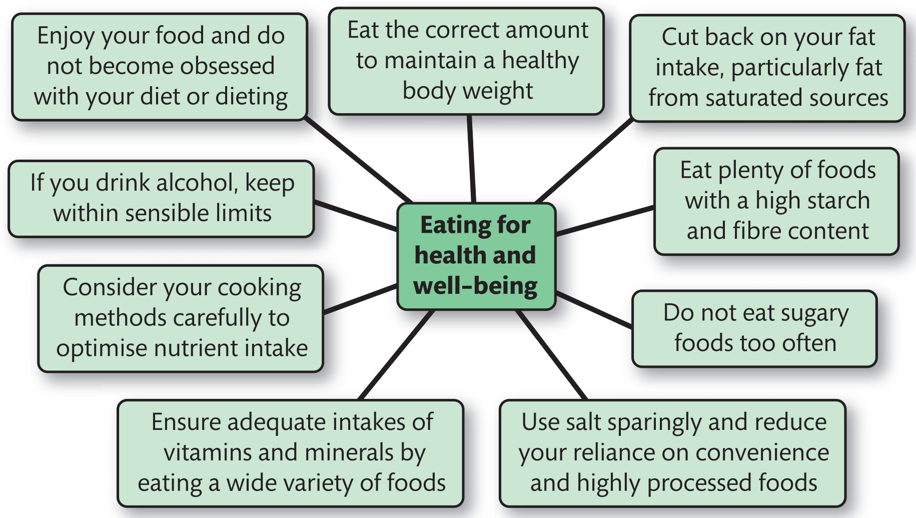

Figure 13.4: A simple guide to eating for health and well-being

The Eatwell Guide

The Eatwell Guide is produced by the UK government and represents the proportions of the main food groups that form a healthy, balanced diet (see Figure 13.5). It applies to most people in the UK, except children under the age of five. The key messages of the Eatwell Guide are that people should try to:

- eat at least 5 portions of a variety of fruit and vegetables every day
- base meals on starchy carbohydrates, choosing wholegrain options where possible
- have some dairy or dairy alternatives, choosing lower fat and lower sugar options
- eat some proteins (e.g. beans, pulses, fish, eggs, meat), including 2 portions of fish – 1 of which should be oily – each week
- choose unsaturated oils and spreads and eat them in small amounts
- drink 6 to 8 cups of fluid each day.

People with special dietary requirements or medical conditions should speak to a registered dietician about how to adapt the Eatwell Guide to meet their individual needs.

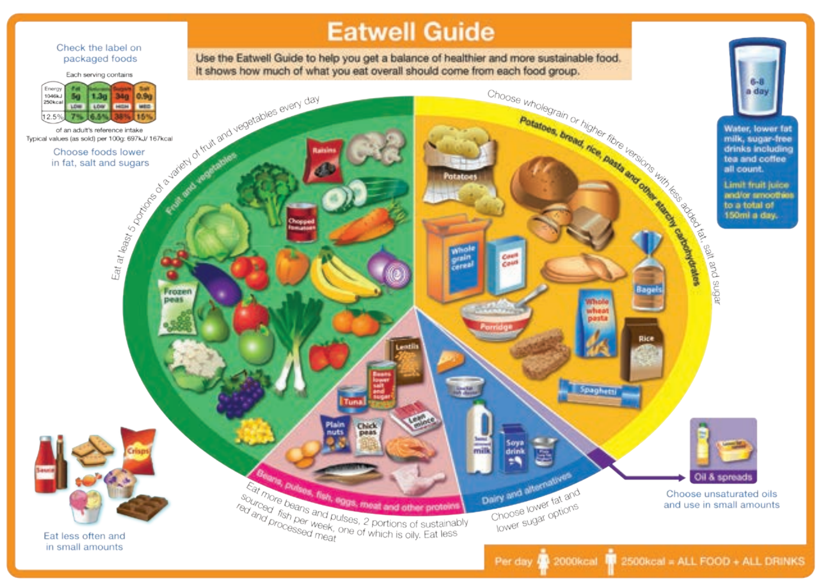

Figure 13.5: The Eatwell Guide (Source: Public Health England in association with the Welsh government, Food Standards Scotland and the Food Standards Agency in Northern Ireland. © Crown Copyright). Do you try to limit your intake of foods with a high fat or sugar content?

Table 13.11: Recommended daily amounts and nutrients supplied by each of the main food groups (Adapted from The Eatwell Guide © Crown copyright 2016. Re-used under the terms of the Open Government Licence v.3.0)

Food	How much	Tips
Fruit and vegetables		
All fruits and vegetables including fresh, frozen, canned, dried and juiced varieties; potatoes do not count as they are considered a starchy carbohydrate food	Aim for at least 5 portions of a variety of fruit and vegetables every day A portion of dried fruit is 30 g and only counts as one of your 5-a-day A portion of fruit juice or smoothie is 150 ml and only counts as one of your 5-a-day	Try to eat as many different types of fruit and vegetables as possible Avoid adding sauces or dressings that are high in fat, salt or sugar Limit fruit juice and smoothies to a combined total of 150 ml per day
Starchy carbohydrates		
Bread (soda bread, rye bread, pitta, flour tortilla, baguettes, chappatis, bagels), rice, potatoes, breakfast cereals, oats, pasta, noodles, maize, cornmeal, couscous, bulgar wheat, polenta, millet, spelt, wheat, pearl barley, yams and plantains	Eat plenty of starchy carbohydrates including potatoes, bread, rice and pasta Choose wholegrain varieties, or keep the skins on potatoes, for more fibre, vitamins and minerals	Base your meals around starchy carbohydrates Choose products that are lowest in fat, salt and sugar Avoid adding too much fat or sauces
Dairy and dairy alternatives		
Milk, cheese, yoghurt, fromage frais, quark, cream cheese, and non-dairy alternatives to these foods	Eat some dairy or dairy alternatives each day Choose lower fat options when possible	Try swapping to 1% fat milk as opposed to whole or semi-skimmed milk Try buying reduced fat cheese
Proteins		
Meat, poultry and game, white fish, oily fish, shellfish, nuts, eggs, beans and other pulses, vegetarian meat alternatives	Eat some protein every day Eat at least two portions of fish each week, one of which is oily Limit processed meats	Try not to add extra oil when cooking or serving these foods Choose lean cuts of meat
Oils and spreads		
Unsaturated oils including vegetable oil, rapeseed oil, olive oil and sunflower oil, soft spreads made from these oils	Use sparingly and less often as they are often high in fat	Choose lower fat spreads where possible Choose oils high in unsaturated fat and low in saturated fat
Foods to eat less often and in small amounts		
Cakes, biscuits, chocolate, sweets, puddings, pastries, ice cream, jam, honey, crisps, sauces, butter, cream, mayonnaise	These foods are not required as part of a healthy, balanced diet. If included, they should be consumed infrequently and in small amounts	Use lower fat spread instead of butter Swap cakes and biscuits for a slice of malt loaf or a teacake with low fat spread

Food preparation and nutritional composition

Some nutrient loss is a consequence of almost all food preparation processes. Exposure to heat, light or oxygen will alter the nutrients in food. The effect of food preparation on nutrients will vary depending on the characteristics of the food and the processes followed. Cooking methods that involve water, such as boiling, often reduce micronutrients as they get washed out, a process known as leaching. Steaming and microwaving will help to preserve micronutrient content. Processing, including preparation, can make food healthier, safer, tastier and extend its shelf-life.

To optimise nutrient availability, choose good quality foods, preferably natural or lightly processed as these are likely to have a higher nutritional value. Boiled, grilled and baked items are likely to be lower in fat than fried and roasted items. Cured foods, particularly cured meat or fish, will have undergone a range of different preservation and flavouring processes involving the addition of a combination of salt, sugar and either nitrate or nitrite. The curing processes may also involve smoking.

Research

Juicing and raw foods are now a popular means of trying to increase the nutrient content of the diet for the health conscious. Investigate the potential advantages and disadvantages of these two methods of food preparation.

Benefits of a balanced diet

Scientific research suggests that the benefits of a healthy balanced diet include increased energy and vitality, improved immune system function, maintenance of healthy body weight and reduced risk of chronic disease.

Deficiencies, excesses and imbalances in dietary intakes all produce potentially negative impacts on health which can lead to a range of dietary-related disorders. Disorders of deficiency include **osteoporosis** (lack of calcium) and **anaemia** (lack of iron), while disorders of excess include **obesity** (excess calories) and **coronary heart disease** (excess fat). Imbalances of dietary intake may occur during periods of high nutritional demand such as growth or pregnancy, or when physical or psychological difficulties impact on meeting adequate nutritional intake such as during old age.

The obesity epidemic is growing at a steady rate. Obesity increases the risk of various diseases, in particular, **cardiovascular disease** and **Type 2 diabetes mellitus**. Both are considered lifestyle diseases which can be prevented and managed by diet and activity.

Cancer

The role of diet in heart disease or diabetes is fairly clear, but it is not as clear-cut for cancer. Many foods and nutrients have been studied for cancer prevention, but finding specific links between a food or macronutrient and cancer is difficult. Foods contain an array of components, macronutrients, micronutrients and non-nutrients that may contribute to cancer prevention. But we also eat and drink a variety of foods, creating interactions between them that are challenging to study, and in some cases the way food is prepared can be an influencing factor.

However, there is some strong evidence for the role of fruits and vegetables. These are thought to protect against several cancers, including those of the mouth, pharynx, larynx, oesophagus, stomach, lung, pancreas and prostate. However, the extent of the protection and how it works requires further research.

Fibre also appears to have a protective role in some cancers. Fibre adds bulk to your stools and moves food more quickly through your digestive system. Protein is often studied as a risk factor for cancer. Most of these studies suggest that people who eat more red meat have a higher risk of developing colorectal cancer than those who eat less red meat, but avoiding processed meats appears to be even more important. Alcohol is also thought to increase the risk of several cancers.

Case study

Diet diary

Keep a record of everything you consume for at least 3 days, including one weekend day. Be as accurate and honest as possible, and do not modify your usual intake, otherwise you will not be evaluating your typical diet. Carry your record with you at all times and:

- list the type and quantity of food/drink consumed
- estimate the portion size using standard household measures, such as slices of bread, millilitres of fluid, or give the weight if known from packaging
- say when and where the food or drink was consumed – this will help you to assess external factors that affect your dietary intake
- state the methods of food preparation or cooking
- note any activity or exercise you took part in, including its duration and intensity.

Check your knowledge

1. Compare your record to the Eatwell Guide. Write a short report on your findings.
2. Is there room for improvement in your diet?
3. Does your diet meet the demands of your participation in sport and exercise?

Eating disorders

The phrase 'eating disorders' covers a wide spectrum of harmful eating behaviours used in an attempt to lose weight or achieve a lean appearance, including those listed in Table 13.12. People with an eating disorder often display a gross disruption of eating behaviour in which they deliberately and dangerously manipulate diet and body weight. Ritualistic eating is often combined with purging behaviours such as self-induced vomiting, laxative abuse and/or excessive exercise.

Anorexia nervosa and bulimia nervosa are psychiatric disorders because they are accompanied by other emotional disturbances. They are more common in women than men, and there is a higher incidence in those who participate in sport.

Table 13.12: Eating disorder descriptions

Eating disorder	Description
Anorexia nervosa	• Usually occurs in teenage years, but can start at any age. • A dangerous condition that can lead to serious ill health or even death. • Symptoms include fear of fatness, excessive worry about weight, under-eating, excessive weight loss, inability to stop losing weight even when below a healthy weight, excessive exercise, abuse of laxatives or other weigh-loss tablets, and an irregular or ceased menstrual cycle.
Bulimia nervosa	• May start in the mid-teens, but not usually present until the mid-20s, as most sufferers are likely to be of normal weight making the condition easier to hide. • Symptoms include worrying more and more about weight, binge eating, feeling guilty about weight and eating patterns while staying within a normal weight range, use and abuse of laxatives, self-induced vomiting and an irregular menstrual cycle.
Binge eating disorder	• Condition where the sufferer feels compelled to regularly over-eat. • Tends to develop in young adults, but often does not present until sufferers are in their 30s/40s. • Involves binge eating followed by dieting, but not vomiting. • Sufferers consume large quantities of food over short time periods, even when not hungry. • A distressing condition, but not as harmful as bulimia. • Sufferers are more likely to become overweight and suffer health complications from being overweight. • Men are equally as likely as women to suffer from this eating disorder.

PAUSE POINT Evidence suggests participants in appearance-orientated sports, where performance is evaluated by judges, may be more prone to eating disorders. Why do you think this might be?

Hint Use the internet to research high profile elite athletes who have suffered eating disorders.

Extend How could some of these concerns around weight control be avoided?

D Nutritional strategies for sports performance

Nutritional strategies

Athletes should pay careful attention to foods that can enhance, not hinder, their preparation for, participation in and recovery from training and competition. Most athletes obtain all the energy and nutrients they need by eating when they are hungry and choosing a balanced and varied diet.

Every sport requires sound nutritional strategies to support successful performance, but with different considerations to be taken into account. For example, with the intermittent nature of team sports, intensity of performance can alter at any time. These changes are irregular and can be random, and may draw significantly on the body's glycogen stores. Performance may be impaired towards the end of a match if glycogen stores are running low. In contrast, weight-loss methods and restrictive dietary practices are often used by athletes in weight category and aesthetic sports, with potential dangers to both health and performance.

Reflect

When developing nutritional strategies to support sport and exercise there should be no conflict between eating for health and eating for performance. For a sport of your choice, reflect on what matters to the athlete and how sound nutritional principles and practice could help to maintain health and improve performance.

Carbohydrate loading

The aim of carbohydrate loading is to increase the muscles' capacity to store glycogen above their normal level. This may be useful to athletes competing in endurance events that last longer than 90 minutes, such as marathon running, triathlon and endurance swimming. When your muscle cells run out of glycogen, fatigue sets in. High pre-race glycogen stores help to delay fatigue and improve performance during the latter stages of a race.

The amount of glycogen available for storage in the muscles is related to the amount of carbohydrate consumed and the level and intensity of activity undertaken. For most sports, a diet consisting of between 5–10 grams of carbohydrate per kilogram of body weight will maintain liver and muscle glycogen stores.

Guidelines for carbohydrate loading suggest that athletes maintain their normal carbohydrate intake for the first three days, but increase it in the last three days before competition (see Table 13.13). This technique offers elevated muscle glycogen levels, with the possibility to increase stores by as much as 20–40 per cent.

Carbohydrate loading will not increase your endurance unless you are a highly conditioned athlete: additional carbohydrate will not result in extra muscle glycogen stores unless the enzymes within the muscles are primed by regular hard training. Instead, the extra carbohydrate is likely to be stored as fat.

Table 13.13: A guide to carbohydrate loading

Days before race	Training	Diet
7	Intense 90 mins	Usual 50–60% carbohydrate diet
6 & 5	Moderate 40 mins	Usual 50–60% carbohydrate diet
4	Moderate 30 mins	Usual 50–60% carbohydrate diet
3	Moderate 20 mins	70% carbohydrate diet
2	Light 20 mins	70% carbohydrate diet
1	Rest	70% carbohydrate diet
Race day		Well-tested pre-race meal

Theory into practice

Devise a suitable carbohydrate loading strategy for a runner undertaking their first marathon. Be sure to include practical meal and snack suggestions.

Increased protein intake

Many athletes believe they need to eat large amounts of protein to build muscle and increase strength, but this is often not necessary. Some of these foods are high in animal fats, considered bad for long-term health. They may also leave no appetite for carbohydrate foods to provide sufficient energy stores to support training. In most cases, eating a normal, varied diet and meeting energy (calorie) requirements should provide enough protein.

When active individuals do require more protein per kilogram of body weight in order to promote tissue growth and repair, the International Olympic Committee's consensus on sports nutrition recommend an intake of 1.2–1.7 grams per kilogram of body weight per day. The lower end of this range should cover the requirements of most endurance athletes, with the upper end meeting the needs of those engaging in more strength and power activities.

Weight loss

For some sports, low body weight may be crucial, sometimes below an athlete's natural weight. These include weight-category sports, such as boxing, weight lifting, rowing and some martial arts, and weight-controlled sports such as distance running, gymnastics, figure skating and diving. These sports present challenges in maintaining a nutritionally adequate diet while reducing or maintaining weight. Inappropriate weight-loss practices include:

- fasting or skipping meals
- laxative abuse
- bingeing and purging
- intentional dehydration via sweatsuits or saunas.

Most athletes who talk about achieving weight loss usually mean fat loss, as losses in muscle mass may result in unfavourable changes in their power-to-weight ratio. A sensible goal is to reduce body fat by about 0.5–1.0 kg per week (a loss of 3500–7000 calories). It is preferable to make these calorie savings by reducing the intake of dietary fat while maintaining carbohydrate and protein intakes. Some athletes on restricted energy budgets may require the guidance of a registered sports nutritionist to achieve weight loss targets while maintaining a healthy diet.

Theory into practice

Produce a short leaflet for athletes in a weight-controlled or category sport that focuses on maintaining health and performance while attempting weight loss?

Weight gain

Weight can be gained by increasing the amount of fat or the amount of lean body mass. Both will register as increases in weight on the scales, but the results will be very different for body composition. Gains in fat weight are relatively easy to achieve, but gains in lean body mass can only be achieved by adapting to a progressive strength training programme, supported by an adequate diet.

When athletes talk about weight gain, they usually mean muscle gain. Strength training provides the stimulus for muscles to grow, while adequate nutrition allows them to grow at an optimal rate. Rates of weight/muscle gain depend on genetics and body type.

To gain strength and size, it is necessary to achieve a slightly positive energy balance – approximately an extra 500 calories per day – and a protein intake of about 1.4–1.7 grams per kilogram of body mass. A high-protein diet, or supplementing with amino acids (common practice for many athletes wishing to gain muscle bulk and size) will not automatically lead to great increases in muscle size or strength. Achieving an adequate energy intake is more important.

In a very few instances the athlete may wish to gain fat weight, such as in contact sports where additional body fat may provide extra protection.

Case study

Building up

Will is 24 years old and works as a security operative at a local nightclub. He has been training regularly for the last two years by attending the gym six times a week and is considering becoming a competitive body builder. He consumes large quantities of high biological value protein foods at regular intervals throughout the day at mealtimes and for snacks, along with 500 mls of a whey protein supplement each day.

Since starting training Will has made some improvements in his bulk and strength, but a significant amount of the weight gain appears to be round his midriff, and he often complains of tiredness and low energy levels. He would like to achieve greater gains in strength and more overall gains in muscle bulk.

Check your knowledge

1. What nutritional advice would you give Will to help him achieve his goals?
2. Is there any additional information on his diet and exercise habits that would be helpful to know in order to formulate appropriate advice?

Application of nutritional strategies for different sports events

The sections on weight loss and weight gain have hinted that different activities require different dietary plans or strategies to optimise performance.

Endurance events

Endurance activities significantly challenge an athlete's energy and fluid stores. The longer and more intense the aerobic training or competition, the more depleted these stores become.

Endurance athletes should aim to maximise glycogen stores. Increasing carbohydrate intake during the two or three days before competition is a useful strategy. Carbohydrate supplements (energy drinks, bars or gels) may be a useful dietary addition.

Endurance athletes should start exercise fully hydrated. The longer the duration of the activity, the more important it is to consume fluids during it. Sports drinks can provide carbohydrate as well as replacing fluids.

Strength and power events

In strength, power and sprint sports, nutritional strategies support the development of lean body mass (muscle) as well as meeting energy demands. Although carbohydrate requirements are not as great as for endurance events, they are still important. Combining carbohydrate with protein post-exercise promotes an **anabolic** environment and increases protein synthesis that helps promote muscle development. However, excessive protein intake should be avoided.

Key term

Anabolism – the constructive metabolism of the body – the building of tissue.

Sprinters may find it helpful to take on both carbohydrates and protein after exercise

Sports requiring strength and endurance

Many sports require high levels of both strength and endurance. For example, high levels of muscular strength and endurance are required for rugby as well as weight-category sports such as judo. Nutritional demands will be dictated by the nature of the individual sport and participant requirements, but key nutrients in all cases are carbohydrate and fluid.

Weight-category or weight-ccontrolled events

Leanness or a specific weight may be considered important for optimal performance, placing greater emphasis on what the athlete eats. It is important to remember that the fewer calories consumed, the fewer nutrients consumed. Calcium and iron intakes are reported to be particularly low in studies investigating the diet of female participants in these sports.

Healthy eating and Eatwell Guide principles apply to the planning of dietary intakes for these sports, but greater emphasis may be placed on a low-fat diet. However, this should not be at the expense of essential nutrients such as carbohydrate, protein, vitamins and minerals. Adequate fluid intake and hydration are also essential to maintain concentration for the technical demands of these sports.

Case study

Macronutrient energy distribution

Maxwell has recently taken up the triathlon. His usual diet consists of a macronutrient energy distribution of 40 per cent carbohydrate, 40 per cent fat and 20 per cent protein. He is about to enter his first major competition.

Check your knowledge

1. What effect could this macronutrient distribution have on his performance?
2. What practical advice could you offer to improve his diet?
3. What could Maxwell do in his preparation for the competition to help to delay fatigue?

PAUSE POINT What factors are likely to impact the nutritional requirements of team sports?

Hint Consider the physiological demands of team sports and the energy systems involved.

Extend Using a team sport of your choice, develop nutrition guidelines you would apply to meet the nutritional needs of players during in-season training and competition.

Supplements to support nutritional strategies

Discussion

The sports world is flooded with pills, powders, bars and drinks that promise to provide a competitive edge within the rules. Should you invest in these products or in sports science support, such as nutritional advice, sports psychology and training techniques?

Athletes are always looking for something to give them a competitive advantage. The financial cost of dietary manipulation and nutritional supplementation is often high. Misinformation often supports questionable practices, some of which can be harmful. The supplement market is worth millions but the manufacture, processing, labelling and marketing of these products is poorly regulated with variable quality control. The products available all make convincing claims including better recovery, increased strength and size, loss of body fat and enhanced immune function.

Supplements can essentially be broken down into two main categories.

1. **Nutrient or dietary supplements** help the athlete meet their overall nutritional needs, by providing a practical alternative to food or by helping to meet higher than average requirements for nutrients, particularly carbohydrate and protein.
2. **Nutritional ergogenic aids** generally aim to enhance performance through effects on energy, body composition and alertness.

Key term

Ergogenic aids – ergogenic refers to the application of a nutritional, physical, mechanical, psychological or pharmacological procedure or aid to improve physical work capacity or athletic performance. Ergogenic aids are assumed to enhance performance above and beyond what would normally be expected, for example caffeine and creatine.

Nutrient or dietary supplements

Nutrient supplements include:

- sports drinks, gels and bars
- liquid meal and protein supplements
- carbohydrate loaders and powders
- multivitamin and mineral supplements.

Some athletes find these products help them to meet their nutritional goals during particularly demanding periods of training and competition. For example, sports drinks are a convenient way to meet the high energy demands of training or competition.

Athletes must know how and when to use them to get maximum benefit towards supporting nutrition goals. If used in the correct way (time and amount), supplements can assist athletes to train and compete at their best. However, poor regulation of the supplement industry means marketing hype often overstates unproven benefits.

Supplements should be safe, effective and legal. Poor practice can lead to problems. Athletes must balance the potential benefits against risks, particularly of anti-doping rule violations: a significant number of supplements on the market contain doping agents that will cause an athlete to fail a drugs test.

Supplements will not compensate for consistently poor food choices, but may provide a short-term solution for a nutrient deficiency until a dietary solution can be implemented, particularly if the athlete is travelling and living away from home.

Athletes often follow hearsay about supplement use, and can take them in larger doses than is sensible. Supplement use requires assessment and advice by a registered sports nutritionist and/or medical practitioner. Supplements should not be used by young athletes (those under 18 years of age), unless medically indicated and monitored.

Discussion

Athletes need a training diet that can be adapted to situations such as injury or specific competition requirements. Discuss how nutrient supplements can help athletes meet macronutrient intake goals for training and competition.

Common supplements

Caffeine

The most common source of caffeine in our diet is coffee, but cola drinks, energy drinks, and specialised sports foods and supplements also contribute.

Caffeine was removed from the World Anti-Doping Agency (WADA) prohibited list in 2004. This change was made despite the acknowledgment that caffeine enhances performance even in small doses (similar to everyday consumption); however, monitoring caffeine use via urinary caffeine concentrations was not reliable.

On consumption, caffeine is rapidly absorbed and transported to body tissues and organs. Its effects can vary between individuals with both positive and negative influences, including:

- the mobilisation of fat from adipose tissue and muscle cells
- changes in muscle contractility
- alterations to the central nervous system influencing perception of effort or fatigue
- stimulation of adrenaline
- effects on the heart, such as increased blood pressure and heart rate.

Recent research suggests that caffeine's major effect is to reduce the actual or perceived fatigue which occurs with prolonged activity. It enhances alertness and increases the time that an individual can sustain their optimal output or pace.

Athletes wanting to use caffeine to enhance performance should develop supplementation strategies that use the lowest effective dose. The effects of acute intake follow a U-shaped curve: although low to moderate doses produce positive effects and a sense of well-being, the effects of higher doses can include:

- increases in heart rate
- impairments or alterations of fine motor control and skilled performance
- anxiety or over-arousal.

Theory into practice

You have been approached by the strength and conditioning coach of a local rugby club. The club is concerned about the increased use of caffeine-rich energy drinks and supplements by players. Consider how you might develop a caffeine-use strategy for implementation by the club.

Creatine

Creatine is a naturally-occurring compound found in the brain and skeletal muscle due to dietary intake and endogenous synthesis from amino acids. Muscle creatine content varies between individuals, mostly likely due to age, gender and fibre type. Vegetarians not consuming a dietary source of creatine are reliant on the body's synthesis of creatine and have lower muscle creatine concentrations than meat-eaters.

Creatine supplements can be used in different ways, including acute loading (taking a high dose of creatine over a short period of time, usually 5 to 7 days) or chronic use (taking a low dose every day for a longer period of time, e.g. 28 days). They may help:

- athletes undertaking resistance training to build lean body mass
- during sprint training sessions where athletes are required to repeat short explosive maximal efforts with brief recovery intervals
- in sports with intermittent work patterns, such as basketball, soccer and tennis.

Research

Investigate the range of creatine supplements available on the market and different protocols for use. What advice would you give a 17-year-old basketball player considering creatine supplementation?

There appears to be considerable variability in response to creatine supplementation but it is advised that supplementation is limited to experienced and well-developed athletes. Those with the lowest initial levels, such as vegetarians, may show the highest response, while those with resting creatine content near the muscle threshold may show no or little enhancement. Creatine uptake into the muscle may be boosted by simultaneous intake of a carbohydrate-rich meal or snack.

The long-term consequences of creatine use are still considered to be unknown. There have been few reports of adverse outcomes over its 25-year history of use, but there are anecdotal accounts of an increased risk of muscle cramps, strains and tears, and weight gain of up to 1 kg is often associated with supplementation. Some users also experience gastrointestinal discomfort or an increase in headaches.

Energy gels

Energy gels provide an easy-to-consume and quickly digestible source of carbohydrate – around 20–25 grams per pouch. They have a greater carbohydrate concentration than sports drinks. Individual products vary in flavour, consistency, type and amounts of carbohydrate and the addition of other ingredients such as electrolytes and caffeine. Good oral hygiene should be practised around their use, such as rountine tooth brushing and regular dental checks.

Energy gels should be consumed with water or other dilute fluids. This fluid intake will reduce the overall carbohydrate concentration, reducing the risk of gastrointestinal disturbance and helping to meet the general hydration needs of the activity.

Energy gels can help tour cyclists such as Geraint Thomas

These products are a costly alternative to common food and fluid options and are best used for specific conditions for which they are appropriate, rather than as an everyday snack. They are particularly useful as a compact source of fuel for endurance athletes during exercise lasting more than 90 minutes, such as cycling, triathlon and marathon running. To assess tolerance, athletes should practise using gels during training sessions if they intend to use them in competition.

Protein shakes and powders

Protein supplements can be classified according to their nutrient profile as providing:

- protein only
- a combination of protein and carbohydrate
- a supplement containing additional ergogenic ingredients such as creatine, specific amino acids, proposed fat burners or vitamins and minerals.

The decision to use any protein supplement should be based on a range of issues relevant to the individual athlete, particularly their training load and goals, daily energy requirements, usual diet, post-exercise appetite and budget. Before considering supplementation, atheletes should consult a registered sports nutritionist to establish if protein supplementation is necessary.

Protein shakes and powders are typically based on whey, casein and soy protein. Whey protein is rapidly digested and rich in branch chain amino acids, particularly leucine. Soy protein is also rapidly digestible and often used in mixed protein supplements and protein bars. In contrast, casein clots in the acidic environment of the stomach, resulting in slower digestion.

The timing of protein intake may be a more important factor than the total amount consumed. Each time protein is consumed a small spike in muscle synthesis occurs, with 20–25 grams of high biological value protein producing the maximal response. Eating quantities in excess of this offers no added benefit to muscle protein synthesis. Spreading protein consumption across the day and including it in meals and snacks will produce multiple spikes in muscle protein synthesis. In addition, eating protein in the hour following exercise can help to prolong the protein synthesis response, promoting muscle gains and minimising muscle breakdown.

Theory into practice

Draw up a list of meals and snacks providing 20–25 grams of high biological value protein that would provide athletes with enough protein throughout the day to support muscle protein synthesis.

Beetroot juice

Beetroot juice is a relatively new nutritional supplement. Beetroot is rich in nitrate. Following ingestion, nitrate is converted to nitrite and stored and circulated in the blood. In conditions of low oxygen availability, such as during exercise, nitrite can be converted into nitric oxide, known to play a number of roles in vascular and metabolic control.

From a health perspective, dietary nitrate supplementation increases plasma nitrite concentration and reduces resting blood pressure. From an exercise perspective, nitrate supplementation reduces the oxygen cost of submaximal exercise and can, in some situations, enhance exercise tolerance and performance. It also appears to represent a promising new approach for enhancing physiological responses to exercise, such as muscle efficiency and oxygenation.

The precise conditions in which nitrate may be ergogenic have yet to be fully established. The effectiveness of nitrate use might depend on factors such as:

- age and overall diet, health and fitness status
- the nature, intensity and duration of the exercise
- the dose and duration of the nitrate supplementation.

It appears that inactive and recreationally active individuals show greater performance improvements than elite athletes. Potential side effects include mild gut discomfort in some athletes and pink coloured urine and stools, both of which are harmless.

Diuretics

Diuretics increase urine production and, because some athletes use them to flush out residue from steroids, they are banned by WADA. They are also used to shed water as a temporary weight loss measure in sports with weight categories such as boxing and mixed martial arts. Naturally-occurring diuretics include alcohol and caffeine. These substances would not be recommended for use within safe and effective nutritional strategies.

Vitamin and mineral supplements

Vitamin and mineral ideficiencies will impair health and performance. However, there is no evidence that supplementing with these nutrients will enhance performance except where a pre-existing deficiency exists. Those at risk of deficiency include athletes who regularly restrict energy intake or lack sufficient variety in their diet.

Supplementation may be justified where known food intolerances exist which limit the types of food that can be eaten. It can also be justified when there is a prolonged and unavoidable reduction in energy intake or nutrient density of dietary intake; this might be because of an extended period of travel or a sustained period of energy restriction to support weight loss or maintenance.

Vitamin and mineral supplements are often seen as a substitute for poor intakes of fruits and vegetables. However, these supplements do not contain the array of phytochemicals found in fruits and vegetables that promote health benefits. Also, it has been shown that, in respect of the adaptive response to exercise training, large doses of antioxidant vitamin supplements (vitamins A, C and E) may be counterproductive because they disturb the balance of the body's antioxidant system.

Branch chain amino acids

Branch chain amino acids (BCAAs) have been widely used within body building but in recent years have become increasingly popular among the general athletic population. The BCAAs leucine, isoleucine and valine are essential amino acids that cannot be synthesised by the body and must be obtained from dietary sources. BCAAs have the unique characteristic that they can be metabolised in skeletal muscle, while other essential amino acids are metabolised via the liver.

It is suggested that they benefit performance in a number of ways including as a stimulant for muscle protein synthesis, by:

- preventing muscle protein breakdown
- reducing markers of exercise-induced muscle damage.

There is also a suggestion that BCAAs may impede the transport of tryptophan to the brain, reducing the synthesis of serotonin thereby lessening perception of fatigue.

Athletes with weight management concerns who are on tight energy budgets may benefit from supplementation with BCAAs. Research investigating the effects of supplementation has used a wide range of dosing strategies, but to get maximal benefits for muscle protein synthesis and recovery, a dose of BCAAs that provides around 2–3 grams of leucine is advised. However, BCAA supplementation should always be considered on an individual basis and guidance should be sought from a registered sports nutritionist.

Points to consider with supplement use

When evaluating the safety and efficacy of supplements of any kind, consider the following questions.

- Is it a banned substance?
- What are the perceived benefits?
- What does the weight of scientific evidence suggest?
- Is the research from a genuine, independent source?
- Does the research apply to the targeted sport?
- Are there any contraindications for use?
- Are there any side effects?

As the term suggests, even supplements that are proven to have performance benefits should be just that: supplements, not replacements for a sensible, well-planned, balanced and varied diet. Indiscriminate use of supplements is unwise.

Before deciding to use any supplement it is worth undertaking a cost–benefit analysis in terms of the potential performance benefits weighed against the costs, not only financial but also potential adverse effects on health and performance and the likelihood of contamination with banned or other undesirable substances. (Animal excrement and glass are just two undesirable elements that have been found in supplements due to unscrupulous production processes.)

The World Anti-Doping Code holds the athlete entirely responsible for any prohibited substance found in their system. Athletes are strongly advised to be cautious and vigilant about the use of any supplement and to optimise diet, lifestyle and training before turning to supplements.

Generally products manufactured within the food and pharmaceutical industries are safer because standards are more rigorous. You should have reasonable confidence in vitamin and mineral supplements produced by a pharmaceutical company and sports drinks and bars produced by a reputable food manufacturer.

It is wise to seek evidence-based reasons for using a supplement that can be supported by a substantial amount of independent scientific evidence. The evidence ought to be very compelling to outweigh any potential risks.

Research

Visit the WADA website and find out about the World Anti-Doping Code and its education programmes on the dangers and consequences of doping. Why should athletes be cautioned against the indiscriminate use of dietary supplements? What is the prohibited list and why is it important for athletes to be aware of this? How regularly is this list updated?

Nutritional intake during different phases of training and event

When developing sound eating habits and nutritional strategies to support training and competition, you should consider the overall issues shown in Table 13.14.

Table 13.14: Issues to consider when developing sound eating habits and nutritional strategies

The types of food eaten to support training and competition	The timing of meals and snacks around training and competition
Ensuring a balanced diet is achieved in respect of all nutrients	The problems of travelling to training and competition venues
Encouraging an adequate calcium and iron intake, particularly for females	Promoting long-term health and reducing the risk of chronic disease
Maintaining a sufficient fluid intake	Minimising the risk of injury and illness

The nutritional requirements for different sports and individuals will vary according to:

- the type of sport and training methods undertaken
- the intensity, duration and frequency of training or competition
- the training status and fitness level of the individual.

The Eatwell Guide principles should still be used to plan meals (see page xx). They should form the foundation on which to develop more specific performance nutrition strategies (see Figure 13.6).

Athletes should eat sufficient carbohydrate and **start refuelling** as soon as possible after training, when muscle's capacity to refuel is at its greatest. This may not coincide with traditional mealtimes. Eating may need to be fitted in around the training process, with smaller, more frequent meals and snacks being necessary. Snacks and fluids should be carried in the kit bag at all times.

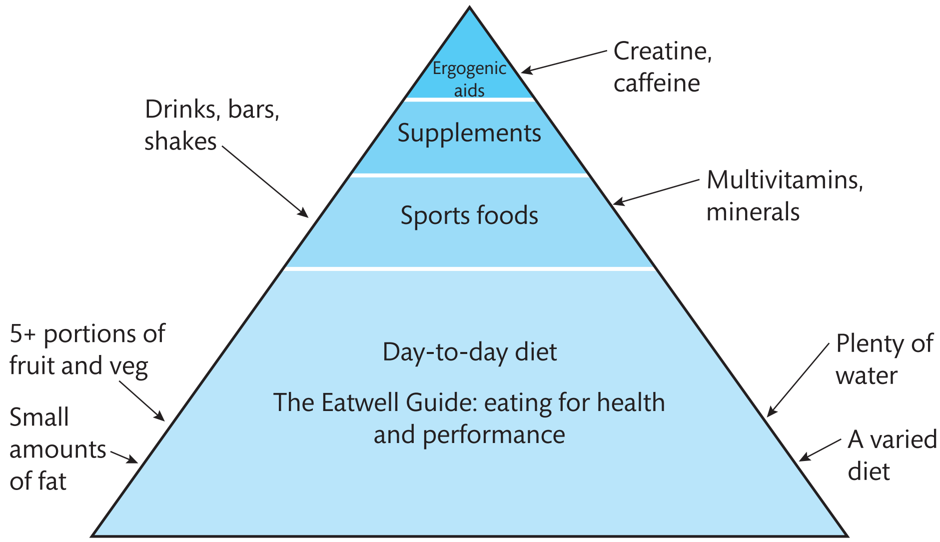

Figure 13.6: Value of sports nutrition strategies

A **high fluid intake** should be encouraged – see Table 13.15. In many sports, drinking alcohol after a match is traditional, especially at non-elite levels, but it is important to rehydrate with other fluids before drinking alcohol. Where an injury has been sustained, alcohol consumption may delay recovery and should be avoided for at least 48 hours.

Table 13.15: Fluid replacement strategies for exercise

Before	During	After
300–500 ml 10–15 minutes before activity	150–200 ml every 15–20 minutes	Based on body mass lost; replace losses 150%

Timing of food intake

Pre-event

Competition is not a time to experiment with new foods, so pre-event meals should be made of familiar foods and provide adequate fluids. A pre-competition meal should aim to top up muscle and liver glycogen stores, so it should be rich in carbohydrate but low in fat and fibre and should contain a moderate amount of protein.

Larger meals take longer to digest and nervousness can result in delayed digestion. Solid foods can usually be consumed with comfort up to two hours before an event, but liquid meals or carbohydrate drinks can be consumed up to 30–60 minutes before. Athletes in events lasting longer than 90 minutes should, where possible, taper training in the week leading up to the event, include a rest day, and consume more carbohydrate and fluid than normal.

Athletes should begin the event fully hydrated and drink plenty of water both during and after activity. Training should be used to practise fluid-replacement strategies. Drinking 300–500 ml of fluid 10–15 minutes before exercise is recommended.

During event

During training and competition, fluid loss is a major consideration. During intense training or competition, isotonic sports drinks may be consumed. This may be beneficial especially if training or competition lasts longer than 60 minutes. Drinking 150–200 ml every 15–20 minutes during exercise is recommended.

During endurance or ultra-endurance events lasting longer than four hours, solid foods may be required. In these instances, energy bars or gels might be useful as a more concentrated source of carbohydrate.

Theory into practice

Regular sports performers should be encouraged to practise their fluid and fuelling regimes in training to ensure that they do not run into any unexpected problems during competition, such as gastrointestinal distress. What practical advice can you give an athlete about this?

Case study

Nutrition and competition

Jon is 16 years old and is competing in a national squash tournament next weekend. He has improved his performance significantly this season and really wants to do well at this event. His goal is to gain selection for an international competition in Asia. He has noticed in previous tournaments that as he progresses through the rounds he becomes more fatigued and struggles to make shots.

Check your knowledge

1. Suggest a suitable pre-competition meal plan for Jon and give him some advice on suitable snacks and supplements he could use to keep himself fuelled and hydrated during the tournament.
2. Suggest ways in which you might monitor or evaluate Jon's nutritional preparation for the competition and the impact of your advice on his performance.
3. Are there any additional factors to consider if Jon achieves his goal?

Post-event

Good nutrition can make its greatest contribution in aiding recovery after training or an event. It is important to refuel as soon as possible after each workout or competition. The longer refuelling is delayed, the longer it will take to fully refuel. Athletes may find it easier to have small, frequent meals and snacks at regular intervals to help to maximise glycogen synthesis.

To refuel efficiently, a high carbohydrate diet is required. Post-exercise, carbohydrates that are easy to eat and digest are preferred. Athletes are advised to consume a high-carbohydrate (at least 50 grams) low-fat snack as soon as possible after training or competition, preferably within the first half-hour, when the muscles' capacity to refuel is greatest. They should eat their next meal, which should be rich in carbohydrate, within two hours.

After exercise, rehydration should start immediately. Drinks containing carbohydrates will also help with energy and glycogen replacement. These may be particularly useful if the activity has been intense and led to a suppression of appetite and a reluctance to eat solid foods.

Weight and urine-colour checks are a useful and simple way of monitoring fluid status during and after training and competition.

- A weight reduction of 1 kg is equivalent to 1 litre of fluid loss.
- Frequent trips to the toilet to pass plentiful quantities of pale-coloured urine are an indicator of good hydration, whereas scant quantities of dark-coloured urine indicate poor hydration.

These simple checks before and after exercise can be useful in determining fluid requirements post-training or during competition. As a guide, after-exercise fluid losses, based on mass loss, should be replaced 1.5 times within the first two hours of recovery.

Reflect

Consider what you have learned about pre-event, during event and post-event nutrition. How might the same principles be applied over a season of competition: pre-season, mid-season and post-season?

Assessment practice

Alex is a triathlete who is looking to make better food choices to optimise training and recovery. Her profile is shown below.

Alex has been competing since the age of 14 and is currently ranked in the top five nationally in her age group. She is a university student living at home with her parents and siblings.

- Her meals are prepared mainly by herself or her mother.
- She has no current medical history but had a bout of illness three months ago where she lost 3 kgs in weight.
- She would like to increase her variety and quality of food choices and reduce her cravings for sweet foods.
- She has no food allergies or intolerances.

Alex has an important race coming up in six weeks time and is aware that the course is going to be particularly challenging and wants to make her race day preparation as good as it can be. The food record below represents what she typically eats.

Typical food record		
Day 1 (Friday)	8.45 a.m.	1 medium bowl of porridge with 180 ml skimmed milk
	9.30 a.m.	• 1 standard tub fat-free yoghurt • 500 ml blackcurrant squash
	11.45 a.m.	• 500 ml water
	12.00 p.m.	• Beef and mustard sandwich: 1 medium wholemeal bread roll, 2 slices of beef, thin spread of mustard • 1 small packet salt and vinegar crisps • 1 apple and 1 orange • 250 ml blackcurrant squash
	5.00 p.m.	• 1 small roast chicken breast • 1 tbsp each of roasted courgette, carrots, parsnips, onion • Large serving basmati rice • 500 ml blackcurrant squash
	6.00 p.m.	330 ml can of ordinary lemonade
	8.30 p.m.	• Small bowl of leftover rice and roasted vegetables • 500 ml blackcurrant squash
	9.30 p.m.	• 1 medium bowl of honey nut cornflakes with 200 ml skimmed milk • 2 fun size chocolate bars
	Extra fluids	Approx. 1.5 l isotonic sports drink during training

Day 2 (Saturday)	8.45 a.m.	• 1 medium bowl of porridge made with 180 ml skimmed milk • 250 ml fresh orange juice • 1 standard tub fat-free yoghurt
	11.30 a.m.	500 ml electrolyte drink
	12.00 p.m.	• Beef and mustard sandwich: 1 medium wholemeal bread roll, 2 slices of beef, thin spread of mustard • 1 small pot rice pudding • 1 pear and 1 apple • 250 ml blackcurrant squash
	3.00 p.m.	• 1 small bowl multi-grain cereal with 160 ml skimmed milk • 1 × 150 g bag of jelly sweets
	6.30 p.m.	• Beef stir fry: 150 g beef, half a small jar of black bean sauce, 75 g pre-sliced stir fry vegetables • 2 scoops of mango sorbet • 500 ml blackcurrant squash
	8.30 p.m.	1 standard tub fat-free yoghurt
	Extra fluids	500 ml water during strength and conditioning session
Day 3 (Sunday)	8.30 a.m.	• 1 medium bowl of porridge made with 180 ml skimmed milk • 1 medium banana • A handful of jelly sweets
	12.00 p.m.	• 3 medium slices of toast with 1 tsp jam and 40 g cheddar cheese • 1 pear and 1 apple • 250 ml blackcurrant squash
	3.00 p.m.	330 ml can of lemonade
	6.00 p.m.	• Large supermarket salad bowl: pasta, rice, sweetcorn, beetroot, cherry tomatoes • 2 scoops of mango sorbet
	8.00 p.m.	2 fun size chocolate bars
	9.30 p.m.	• 1 medium bowl of multi-grain cereal with 200 ml skimmed milk • 250 ml blackcurrant squash
	Extrta fluids	Approx. 1.5 l isotonic sports drink during training

1 Interpret Alex's current nutritional intake in relation to health and well-being. Is there any additional information that might help you to make suggestions to improve Alex's nutritional strategies?

2 Modify Alex's current nutritional strategies for the requirements of training and competing in triathlon.

3 What is your recommeded guidance for Alex based on her phase of training?

4 What guidance and nutritional strategies would you recommend for Alex's race day preparation?

Plan

- Do I understand that I am being asked to interpret an athlete's current nutritional intake and develop nutrition strategies based on their current phase of training to optimise health and performance?
- Do I need to undertake further research before I get going?

Do

- How am I going to present the information? How can I ensure this is clear and logical?
- How can I make sure I justify my proposed modifications and recommendations?

Review

- Have I proposed nutritional recommendations that are specific to the individual and their sporting event?
- Have I considered the impact of factors affecting digestion and absorption on my proposed modifications and recommendations?

Getting ready for assessment

This section has been written to help you do your best when you take the assessment test. Read through it carefully and ask your tutor if there is anything you are still not sure about.

Sample answers

For your set task you will be provided with some background information on a client which requires you to interpret current nutritional intake, demands of the athlete's sport and phase of training and recommend strategies to optimise health and performance.

Look at the sample scearios which follow and our tips on how to answer them well.

Example 1

Billy is a junior national squad cross country athlete. He is a student and prefers to follow a vegetarian diet. Recently he has been feeling increasingly fatigued after finishing his training sessions and wonders if this is linked to his eating habits.

From chatting with Billy you establish he has a very irregular meal pattern with frequent long gaps between his meals. He knows he should try to manage his hydration better but often forgets to think about his fluid needs around his training programme. He is concerned as he has a big race coming up in five days' time where he would like to achieve selection for an international race in Berlin the following weekend.

Based on what you know about Billy, recommend nutritional guidance based on his phase of training and upcoming event.

Answer

There are three likely nutritional causes for Billy's increased fatigue: (1) inadequate carbohydrate intake and poor refuelling strategies following training, (2) dehydration as a result of a poor fluid intake or (3) iron deficiency as a result of being vegetarian. The iron deficiency is the least likely and can only be medically determined and so it would be more appropriate to concentrate on his carbohydrate and fluid intakes.

Before considering recommendations and modifications, try to interpret the impact of current dietary habits to show you understand their implications for health and performance. This shows you have considered the athlete's profile carefully.

Billy's most important concern is his upcoming race. Billy should try to eat regular carbohydrate-rich meals and snacks throughout the day. He can use the Eatwell Guide principles to plan his meals. He should aim to eat sufficient carbohydrate and start refuelling as soon as possible after training, when his muscle capacity to refuel is at its greatest. A sample day's meal plan might include:

- breakfast: a bowl of porridge made with semi-skimmed milk topped with some dried or fresh fruit with a slice of toast and jam and a small glass of fruit juice
- lunch: a jacket potato with baked beans, a yoghurt and an apple
- evening: bean and pasta bake with a green salad and a rice pudding pot
- bedtime: a bowl of cereal with semi-skimmed milk.

He should ensure that he does not leave long gaps between his meals. To help with this, Billy should develop a kit bag snack pack of durable snack items (such as cereal bars, dried fruit, milkshakes and Jaffa cakes) to carry around with him, so he can start to refuel as soon as possible after training. Billy should also make sure he carries fluids at all times, or at least a waterbottle that he can fill up when necessary. He should try to just stay ahead of thirst, as thirst is a sign that he is already dehydrated. He can also monitor his urine colour and volume as a sign of his daily hydration status.
The following guide to fluid management before, during and after exercise might help him to manage his hydration status.

Before	During	After
300–500 ml 10–15 minutes before activity	150–200 ml every 15–20 minutes	Based on body mass lost; replace losses 150%

On race day, Billy should ensure that his pre-race meal contains fluid to support hydration and is low in fat and fibre to facilitate gastric emptying and prevent gastrointestinal distress. It should also be high in carbohydrate to maximise control of blood glucose and moderate in protein content so it does not take too long to digest but helps him feel satiated. Most importantly, it should be made up of familiar foods he tolerates well. He should carbohydrate-load the night before with a pasta- or rice-based meal and make sure he is well hydrated before going to bed.

This answer does recommend nutritional guidance based on his phase of training and upcoming event. To achieve a higher mark it would have been useful to have considered the role of sports foods and supplements in helping Billy to meet his needs.

Example 2

Rhianna is a journalist; she weighs 52 kg and is 1.60 m tall. She trains 3–4 times a week with varying methods including circuits, runs, track and plyometrics sessions. She is training for her first 10 km run and aiming to improve her running, overall fitness and strength.

Rhianna's diet and activity record is detailed below:

Day 1:

- *Breakfast: two slices of white toast with butter*
- *Lunch: jacket potato with cheese and beans*
- *Mid-afternoon snack: banana*
- *Evening circuit session*
- *Dinner: pasta with tuna and pasta sauce, medium size portion*
- *Drinks: four teas with semi-skimmed milk, litre of water, large glass of orange juice*

Day 2:

- *Breakfast: raisin Danish*
- *Mid-morning: 3-mile run on the treadmill*
- *Lunch: salmon and cream cheese sandwich, apple*
- *Dinner: jacket potato, salad, tuna burger*
- *Drinks: one cappuccino, three teas with semi-skimmed milk, litre of water, large glass of orange juice*

Day 3:

- *Breakfast: small bowl of frosted flakes, semi-skimmed milk, one slice of toast with butter and marmalade*
- *Lunch: toasted ciabatta with mozzarella, sun-dried tomato and pesto*
- *Mid-afternoon snack: flapjack*
- *Evening track session (15 × 60-metre sprints)*
- *Dinner: baked beans on two slices of white toast*
- *Drinks: three teas with semi-skimmed milk, litre of water, large glass of orange juice*

Interpret Rhianna's current nutritional intake in relation to health and well-being. Then suggest modifications in relation to her sport-specific demands.

Answer

Looking at Rhianna's current intake she tries to follow a high carbohydrate diet with most of her meals based around carbohydrate-rich foods, such as bread, cereals, potatoes and pasta, but she could swap the raisin Danish for a bowl of cereal. In this way, she will have less fat and include a better source of vitamins and minerals, particularly calcium, with the addition of milk. Calcium intakes could be enhanced with the inclusion of nutritious desserts such as yoghurt or rice pudding, which would also provide useful carbohydrate. The glass of orange juice each day will be helping Rhianna to meet her vitamin C requirements, but overall she should aim to include a greater variety of fruits and vegetables in her diet. She has a reasonably high fluid intake and does try to include a litre of water each day. Higher intakes may be required to cover her training sessions. An increased frequency and duration of training will result in greater fluid requirements, so to minimise the effects of fluid losses while training she should always aim to start sessions fully hydrated and drink during and after.

While higher intakes are likely to be required to cover her training, it would be helpful in interpreting Rhianna's current intake to calculate actual requirements using one of the equations provided and then give more prescriptive advice on what to drink and how much, and when.

To ensure that her energy stores are maintained it is best to increase the percentage of her daily calories consumed from carbohydrate to around 60 per cent and drop fat to 25 per cent. She should aim for a carbohydrate intake equivalent to 5–6 g for every kilogram of body weight providing around 250–300 g per day. A protein intake in the region of 1.2–1.4 g per kilogram of body weight should be adequate to meet her requirements giving 59–69 g per day, with a fat intake of no more than 70 g per day. To achieve her carbohydrate requirements she should aim to base all her meals around starchy carbohydrate foods, with at least two good quality protein portions around 75–100 g and at least three servings from the dairy food group each day.

The answer does suggest modifications to Rhianna's diet in relation to the demands of her sport but for a higher mark it could go into more detail about her current nutritional intake for health and well-being and provide detail on factors affecting digestion and absorption of nutrients