FrieslandCampina

Institute
for dairy nutrition and health

# Sport & Nutrition

## What does science say about the role of nutrition in sports performance?



# About this publication

Sport and nutrition are very closely linked with each other: the type and amount of food and drinks consumed around exercise helps to ensure better preparation, greater endurance, better recovery and, consequently, improved performance. Therefore, paying attention to nutrition is crucial for top athletes. Recreational athletes are also increasingly seeking advice on nutrition. What is the role of nutrition for athletes and sportspeople? Is there a difference between strength, endurance and team sports? And what about the amount and type of food and drinks to support training and optimum recovery after exercise? This publication on sport and nutrition has been composed by FrieslandCampina Institute and is based on scientific agreement and official dietary recommendations.


**Do you have questions?**

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# Sport and nutrition

Many people actively participate in sport and exercise. They go to fitness centres, swim, play football or volleyball, go running or take part in boxing or a strength sport. They do this because they enjoy it and like the challenge, for health, to look good or for social reasons. The exercise intensity and goals can vary from purely recreational to achieving a good performance.

In order to maximize enjoyment of sport and/or to achieve a good performance, nutrition is important for fuel, muscle repair and protection. Not only in terms of the total amount of nutrients (such as protein and carbohydrate) from food (such as bread, milk, vegetables, fruit), but also the timing of the meals is important, in particular the distribution of meals over the day and the best time to eat before, during and after exercise. Another important consideration is fluid intake.

The optimum daily diet depends on the sporting goal and level of performance, the sporting discipline, day to day training programme and the food preferences of the sportsperson. The greater the challenge to the body, the more important nutrition becomes. (ACSM *et al.,* 2016; IAAF, 2013)



# In theory: what does an athlete need?

A number of questions need to be answered before nutritional advice can be given to an athlete. How much fuel (energy) does a sportsperson need? Which fuels are preferred? What about the proportion of carbohydrate, fat and protein? What roles do the vitamins and minerals play?

### Energy

Physical activity requires energy. Therefore, a sportsperson often needs more energy than a more sedentary person who sits most of the day. The daily energy requirement of a sportsperson depends on a number of factors, such as type of sport, goals, training and competition schedules, and other lifestyle and occupational activity. During the more active phases, energy requirements are higher than during less active periods, for example during rest days, holidays or when injured. In the case of more frequent exercise, a lower energy intake (< 1,800 – 2,000 kcal per day) may lead to weight loss and diminished functioning which can have a negative effect on training or sports performance. (ACSM *et al.,* 2016; IAAF, 2013)

The starting point is for the sportsperson to consume sufficient energy to train well, keep a stable weight and maintain the desired body composition in terms of the proportion of lean and fat mass and bone density. This differs for each sportsperson.

**TABLE 1** Energy: Calories per gram

| Per Gram | kcal |
|---|---|
| 1 gram fat provides | 9 kcal |
| 1 gram protein provides | 4 kcal |
| 1 gram carbohydrate provides | 4 kcal |
| 1 gram alcohol provides | 7 kcal |

Source: SACN Carbohydrates and Health report, 2015

### Estimating energy needs

In order to determine energy requirements the individual energy needs at rest (Resting Energy Expenditure or REE) and the level of physical activity should be assessed. The REE is dependent on weight, height and age. There are different methods to calculate the REE. The level of physical activity is represented by the PAL value, whereby PAL stands for 'physical activity level'. Active athletes have an average PAL value of 1.8 (EFSA, 2013).

**TABLE 2** PAL value for adults

| Lifestyle | PAL value |
|---|---|
| Inactive (mainly sitting) | 1.4 |
| Moderately active | 1.6 |
| Active | 1.8 |
| Very active | 2.0 |

Source: EFSA, 2013

The European Food Safety Authority (EFSA) defined Dietary Reference Values (DRVs) for energy in 2013 providing recommendations for average energy requirements for men and women and different age groups. The basis of the average energy requirement is the Resting Energy Expenditure (REE) calculated in accordance with the Henry equation (Henry, 2005). EFSA has calculated average energy requirements for each age group at four different activity levels (PAL values) shown in table 3 (EFSA, 2013).

**TABLE 3** Average energy requirements (AR) for adults

| Age (years) | REE (kcal/day) | AR at PAL = 1.4 (kcal/day) | AR at PAL = 1.6 (kcal/day) | AR at PAL = 1.8 (kcal/day) | AR at PAL = 2.0 (kcal/day) |
|---|---|---|---|---|---|
| Men | | | | | |
| 18 - 29 | 1674 | 2338 | 2672 | 3006 | 3340 |
| 30 - 39 | 1621 | 2264 | 2588 | 2911 | 3235 |
| 40 - 49 | 1599 | 2234 | 2553 | 2873 | 3192 |
| 50 - 59 | 1578 | 2204 | 2519 | 2834 | 3149 |
| 60 - 69 | 1440 | 2017 | 2305 | 2593 | 2882 |
| 70 - 79 | 1416 | 1984 | 2267 | 2550 | 2834 |
| Women | | | | | |
| 18 - 29 | 1346 | 1878 | 2147 | 2415 | 2683 |
| 30 - 39 | 1296 | 1813 | 2072 | 2331 | 2590 |
| 40 - 49 | 1285 | 1798 | 2055 | 2312 | 2569 |
| 50 - 59 | 1274 | 1783 | 2037 | 2292 | 2547 |
| 60 - 69 | 1164 | 1628 | 1861 | 2093 | 2326 |
| 70 - 79 | 1154 | 1614 | 1844 | 2075 | 2305 |

Source: EFSA, 2013





### Carbohydrate

Carbohydrates consist of one or more sugar molecules, for example glucose. Glucose is an important fuel for the body, in particular for the brain and nervous system, as well as for muscle. Glucose is stored in the muscles and liver in the form of glycogen. This supply is limited and has to be replenished on a daily basis and after exercise. The body can produce glucose from protein, but it is mainly obtained through carbohydrate from food. Dietary advice for athletes can be based on general nutritional guidelines in which 50% of the total energy intake (en%) consists of carbohydrates (SACN Carbohydrates and Health report, 2015). For an adult woman with an energy intake of 2,000 kcal this would amount to 250 grams carbohydrate per day (50% of 2,000 kcal = 1000 kcal = 250 grams carbohydrate). More specific nutritional recommendations for athletes provide guidance for carbohydrate intake in terms of grams per kilogram body weight. A daily intake of 5-7 grams carbohydrate per kilogram body weight is advised for people undertaking sports in a moderately intensive way (1 hour of exercise per day) and 6-10 grams of carbohydrates per kilogram body weight for intensively active athletes (1 to 3 hours of exercise per day) and up to 8-12 grams of carbohydrates per kilogram body weight for extremely active athletes (more than 4-5 hours per day). This is based on athletes for whom optimum availability of carbohydrate is important for the training intensity and performance (in particular elite athletes). People who seriously participate in sports but may not always train at such a high intensity can lower this quantity (ACSM *et al.*, 2016). With respect to diets with a low energy intake (< 1,800- 2,000 kcal per day), the optimum ratio of energy intake between the macronutrients should be determined on an individual basis in accordance with exercise goals (ACSM *et al.*, 2016).

### Energy sources during exercise

In the case of short duration exercise (3-5 minutes) the energy source is predominantly adenosine triphosphate (ATP) and creatine phosphate present in the muscles. In addition, glycogen stored in muscles can be used as an energy substrate without oxygen and is called anaerobic metabolism.

Aerobic metabolism (which requires oxygen) of glycogen from liver and muscles supplies the body with energy for longer duration exercise. During physical activity lasting 1 to 4 hours at 70% of the maximum oxygen uptake around 50-60% of the energy is released from carbohydrate. The rest comes from metabolism of fat.

During metabolism of carbohydrates in the muscle cells more energy is released per time unit than from metabolism of fats (ACSM *et al.*, 2016). Therefore carbohydrates are referred to as a 'fast' fuel and fats a 'slow' fuel. During low intensity exercise, energy is supplied by both carbohydrates and fats, whereas during more intense exercise a higher proportion of energy is supplied by carbohydrates. Training can improve the capacity to oxidise fat during exercise, which allows for a greater use of fat as an energy source. The advantage of this is that the supply of muscle glycogen will be depleted less quickly and the exercise can continue for a longer duration (ACSM *et al.*, 2016; IAAF, 2013; Loon van, 2013).

### Carbohydrate loading

For endurance athletes and sports teams who sustain moderate to high activity levels over a longer time (>40 minutes), it may be useful to optimize the muscle glycogen supply before performing strenuous exercise (for example, a race or a match) to ensure optimal performance. This can be done by increasing the quantity of carbohydrate consumed for 2-3 days prior to the event. In order to avoid excessive energy intake, the increase in energy from carbohydrate can be offset by a reduction in fat intake. It is often advised to combine carbohydrate loading with a less heavy training schedule to spare glycogen stores (Loon van, 2013).

**TABLE 4** Guidelines for carbohydrate intake before exertion to optimize muscle glycogen supply

| Situation | Quantity of carbohydrates | Moment of intake |
|---|---|---|
| Normal carbohydrate intake in preparation for activity <90 minutes | 7-12 g/kg body weight per 24 hours | Daily |
| Carbohydrate loading in preparation for activity >90 minutes | 10-12 g/kg body weight per 24 hours | Every day in the 36-48 hours preceding activity |
| Carbohydrate intake just before activity of >60 minutes | 1-4 g/kg body weight | 1-4 hours before activity |
| <8 hour recovery between two full demanding sessions | 1-1.2 g/kg body weight/per hour | First 4 hours after activity, then the normal required intake |

Source: AIS, 2015; ACSM *et al.*, 2016

### Carbohydrate during and after exercise

Carbohydrate intake during exercise can help spare muscle glycogen and allow exercise to continue for a longer period of time and/or at a higher intensity. Research studies have determined the quantity and type of carbohydrate which can be taken during exercise for optimum performance (see table 5). For shorter-duration exercise (up to 30-75 minutes) evidence suggests there is no need for replenishment of carbohydrate. A mouth rinse with small quantities of carbohydrate may be helpful. In the case of exercise lasting 1-2 hours, a carbohydrate intake of 30 grams per hour is recommended and for exercise lasting 2-3 hours the recommendation is increased to 60 grams per hour. This can be one type of sugar (e.g. glucose) or a mixture (e.g. glucose and fructose, i.e. beet or cane sugar). For ultra-endurance exercise of a certain intensity level, the quantity is even higher and it is recommended to use a mix of carbohydrates. This is because different sugar molecules use different transporters in the intestine and so the aim is to maximize absorption of each type of carbohydrate. However, to avoid intestinal problems it is important to practice a nutritional strategy in training to get used to higher carbohydrate intakes (Jeukendrup, 2017). Advice on carbohydrate intake depends on body weight and training status of the sportsperson (Jeukendrup, 2014; ACSM *et al.*, 2016). After exercise performance, carbohydrates are important for the replenishment of glycogen stores. When sufficient rest can be taken between exercise sessions, a normal diet will replenish the glycogen stores within 24 hours. However, when fast recovery is required or when the glycogen supply is to be optimized, additional carbohydrates in both solid and liquid forms are preferable immediately after exercise and during the following 2–4 hours after exercise. The required quantity of carbohydrate depends on the duration, intensity and frequency of training and body mass. After a longer endurance training session the body needs more carbohydrates to replenish muscle stores than after a strength training session. To optimize glycogen replenishment, 1.2 gram carbohydrate/kg/hour is advised post-exercise.

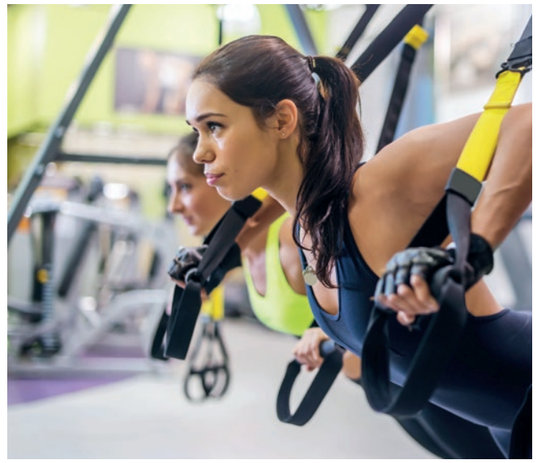
**TABLE 5** Guidelines for carbohydrate intake during exercise

| Level of exertion | Quantity of carbohydrate | Type of carbohydrate |
|---|---|---|
| 30 - 75 min. | very few or use a mouth rinse | Most types |
| 1 - 2 hours | 30 g/hour | Most types |
| 2 - 3 hours | 60 g/hour | Most types |
| > 3 hours | 90 g/hour | Glucose and fructose |

Source: Jeukendrup, 2014

*NB: These recommendations apply to elite and/or professional endurance athletes. For recreational athletes and sportspeople the recommendations may be lower.*





The human body has over 600 muscles (Silverthorn, 2010)

### Protein

Proteins are essential for a number of processes in the body, including the growth and maintenance of muscle. (EFSA 2010 and 2011) Proteins consist of long chains of amino acids and for each protein the amino acid chain is unique. The essential amino acids are important for protein synthesis. As the body cannot produce them itself, they must be obtained from the food we eat (Cuthbertson *et al.*, 2005; Phillips, 2012; Tipton *et al.*, 1999; Volpi *et al.*, 2003). When there is an insufficient intake of an essential amino acid, protein synthesis may be compromised.

An optimum protein intake for an athlete is the amount that is sufficient to:

- provide all the essential amino acids;
- maintain an optimum protein synthesis for development and maintenance of muscle mass;
- support the body processes in which amino acids play a role. (Phillips, 2012)

**Maintenance and development of muscle**

Just like all other organs in the body, the muscles are renewed on a daily basis. This means that a regular maintenance process of muscle protein breakdown and muscle protein synthesis takes place, known as protein turnover. In order to support muscle growth and development, muscle protein synthesis must be greater than muscle protein breakdown. Exercise training stimulates muscle protein synthesis and is important for development of muscle mass, strength and power. (Silverthorn, 2010)

Athletes generally have a larger muscle mass to maintain and may be training to increase their lean mass. Intensive resistance exercise may also cause muscle fibre damage and so athletes and sportspeople require more protein for muscle repair and regeneration than the general population. These additional protein requirements depend on multiple factors. Generally endurance athletes have a slight to moderately increased protein requirement, whereas the advice for strength athletes is twice that of the general population. The most recent advice from the Academy of Nutrition and Dietetics, Dieticians of Canada and the American College of Sports Medicine (ACSM *et al.*, 2016) advises that protein requirements are dependent on training status (well-trained athletes seem to need a little more than less-trained athletes to make progress (Morton *et al.*, 2017)) and the intensity of the training (the higher the frequency and intensity, the higher the requirement).

**TABLE 6** Recommended protein intake

| Training status | Recommendation protein (g/kg body weight/day) |
|---|---|
| Regular | 0.8 |
| Athlete<br>*(dependent on the training status, training intensity, availability of carbohydrates and energy)* | 1.2 - 2.2 |

ACSM *et al.*, 2016 & Morton *et al.*, 2017

Eating more protein than the recommended amounts seems to have no added value in terms of muscle development. Unlike fats and carbohydrates, proteins are not stored in the body. When more protein is eaten than the capacity to synthesize muscle protein, the 'excess' protein is broken down/burned by the body.

If there is not enough supply of carbohydrates or energy (for example during a long endurance training in which food is limited), in extreme cases proteins can be used as energy sources. It is therefore important for an athlete that the diet meets the energy recommendation so that in most cases this does not form a problem (Gillen *et al.*, 2019; ACSM *et al.*, 2016). When the diet matches the athlete's energy requirements it will usually also contain a sufficient amount of protein.

Particular essential amino acids are important for optimum protein synthesis. The body cannot make the essential amino acids itself and these must be obtained from food.

**Protein quality**

The protein quality of a product can be determined on the basis of three characteristics:

1 the quantity of protein in a food;
2 the quantity of essential amino acids in the protein;
3 the digestibility of the amino acids in the protein in the intestine and, consequently, the availability for absorption by the body. (Tomé, 2012)

9 out of the 20 amino acids that make up proteins are essential amino acids. The daily need for every essential amino acid has been determined (FAO/WHO/UNU, 2007). For an adequate intake of all essential amino acids it is important to consume a combination of various protein sources on a daily basis, as the quantity and composition of essential amino acids differs for each protein source (see table 7). Foods with high-quality proteins provide more essential amino acids.

**TABLE 7** Overview of essential amino acids in mg/g protein of various protein sources

| Essential amino acid* (mg/g protein) | Reference diet** adult | Milk | Whey*** | Casein*** | Eggs | Beef | Soy | Grains | Rice |
|---|---|---|---|---|---|---|---|---|---|
| Lysine | 48 | 83 | 107 | 82 | 72 | 89 | 60 | 23 | 34 |
| Histidine | 16 | 28 | 22 | 29 | 23 | 44 | 25 | 21 | 21 |
| Isoleucine | 30 | 64 | 57 | 62 | 69 | 50 | 42 | 34 | 40 |
| Leucine | 61 | 93 | 129 | 97 | 82 | 79 | 77 | 69 | 77 |
| Valine | 40 | 68 | 53 | 73 | 74 | 53 | 47 | 38 | 54 |
| Methionin, including cysteine | 23 | 32 | 52 | 33 | 51 | 36 | 24 | 36 | 42 |
| Phenylalanine, including tyrosine | 41 | 105 | 76 | 116 | 104 | 91 | 88 | 77 | 94 |
| Threonine | 25 | 51 | 54 | 45 | 50 | 47 | 40 | 28 | 34 |
| Tryptophan | 7 | 14 | 21 | 12 | 16 | 14 | 12 | 10 | 11 |
| **Total of essential amino acids** | **291** | **538** | **571** | **549** | **541** | **503** | **423** | **336** | **407** |

Source: FAO/WHO/UNU Expert Consultation, 2007

* Both the sulphurous (methionine and cysteine) and the aromatic (phenylalanine and tyrosine) essential amino acids are strongly interlinked in the metabolism and so they are often totalled to compare proteins. Therefore sometimes 9 to 11 essential amino acids are mentioned.

** The reference pattern should provide adults with the necessary essential amino acids. Source: FAO, 2011.

*** Source: Walstra P *et al.* 2006; Hiprotal Casein Whey 80 (DOMO, FrieslandCampina)

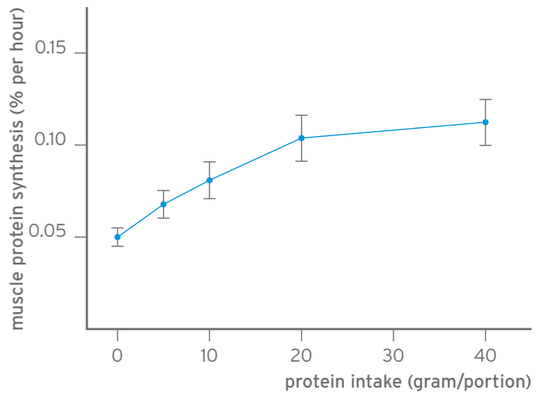




**Timing of protein**

Research has shown that apart from the total quantity of protein, the distribution of the protein intake over the entire day is also important for muscle protein synthesis. To optimize muscle protein synthesis it is recommended to divide the total daily requirement for protein over four to six eating occasions in portions of 0.25-0.3 g protein/kg body weight. In practice this comes down to about 20 grams of protein per meal/snack, as breakfast, lunch, dinner, post- exercise and just before going to sleep. This pattern of protein distribution over the day can enhance muscle growth compared to when the total protein requirement is consumed in three large portions (of more than 40 gram) or over several smaller portions during the day (ACSM *et al.*, 2016; Areta *et al.*, 2013; Moore *et al.*, 2009).

**FIGURE 1** Muscle protein synthesis after exercising for different portions of protein




Source: Moore *et al.*, 2009

Apart from the traditional eating occasions, consuming protein during the recovery period after training or a match is a priority, because heavy exercise stimulates muscle protein synthesis and recovery (Beelen *et al.*, 2010). Also consuming a portion of protein just before going to sleep may stimulate muscle protein synthesis during the night and so helps to optimise the opportunity for recovery overnight (Res *et al.*, 2012; Snijder, 2014). Typically muscle protein synthesis decreases during the night, as the regular muscle protein breakdown continues which results in a negative protein balance in the body in the morning. When athletes consume a portion of protein just before going to sleep, they may benefit from a positive protein balance in the body the next morning, as demonstrated by Res *et al.*, (2012). In this study, consuming 40 grams of casein before going to sleep increased the protein synthesis by 22% during the night.

**Leucine**

For athletes, adequate protein with sufficient essential amino acids is important to support the development and maintenance of muscle mass. Additionally, the essential amino acid leucine, together with exercise training, is an important stimulus for protein synthesis. Studies among younger athletes show that eating 20 grams protein in combination with strength training is adequate to maximize muscle protein synthesis. The 20 gram protein source must be high quality and contain a sufficient amount of the essential amino acid leucine (Moore *et al.*, 2009; Churchward-Venne *et al.*, 2012; Devries *et al.*, 2015). For the elderly, a combination of proteins with a high content of essential amino acids (in particular a high leucine content) seems to be the best choice to support protein synthesis. There is also evidence to suggest that the quantity of protein required for optimum protein synthesis is about 1.5-2 times higher for elderly people as it is for younger people (Wall *et al.*, 2014; Holwerda *et al.*, 2019).

## Fat

Fats are another important constituent of a healthy diet. They provide energy, are essential components of cell membranes and hormones, and necessary for the absorption of fat soluble vitamins in the body (vitamins A, D, E and K). There are no specific dietary recommendations for athletes with respect to fats. The proportion of energy from dietary fat may range between 25-40 en% taking into account the general guidelines on the ratio between saturated and unsaturated fats. Exceptions to this are diets in which the energy intake is below the recommended daily energy intake. In this case the intake of essential fatty acids and fat soluble vitamins may be compromised. For those athletes following energy restricted diets, it is advisable to carry out a detailed dietary analysis to monitor intakes (ACSM *et al.*, 2016).



## Vitamins and minerals

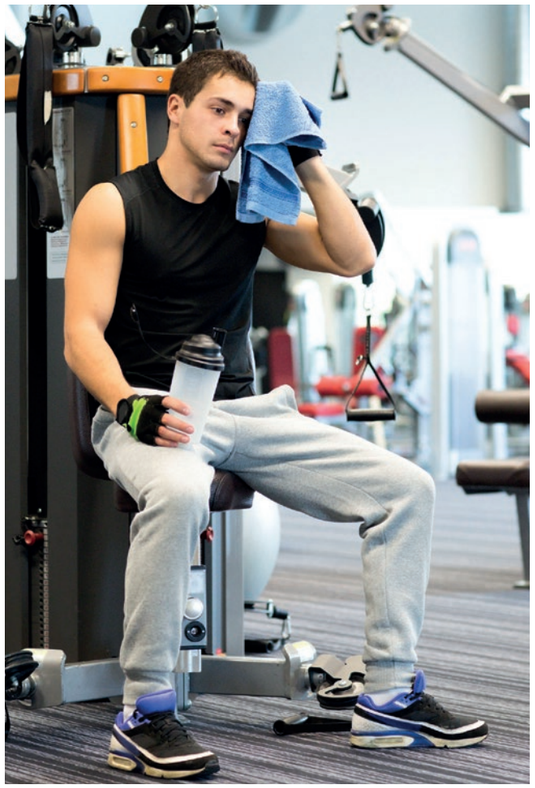
Vitamins and minerals have important roles in various bodily functions. They are co-factors in the release of energy [vitamin B2 (riboflavin) and vitamin B12, calcium and phosphorus] and contribute to the functioning of the nervous system [vitamin B2, vitamin B12 and potassium], bone maintenance [calcium and phosphorus], regular neurotransmission [calcium], functioning of the immune system [vitamin B12], maintenance of normal red blood cells [vitamin B2], regular production of red blood cells [vitamin B12] and protection of the body cells against oxidative damage [vitamin B2]. Additionally, calcium and potassium are involved in muscle contraction and function. Exercise can increase the use and loss of micronutrients in the body and so a higher intake of vitamins and minerals may sometimes be required (ACSM *et al.,* 2016; IAAF, 2013). The diet of an athlete typically contains sufficient vitamins and minerals, as athletes generally eat more than non-athletes due to their increased energy requirements and, consequently, consume more nutrients. However, athletes with a poor food intake or who want to lose weight or have eliminated one or more food groups from their diets or may follow an unbalanced food pattern, may have a shortfall of some vitamins or minerals. Research has shown that particular attention should be paid to the vitamins and minerals calcium, vitamin D, iron and antioxidants (ACSM *et al.,* 2016; IAAF, 2013; Gillen *et al.,* 2016).

## Loss of fluids

The amount of fluid lost via sweat during exercise depends on the ambient temperature, humidity, level of activity, body weight, genetic predisposition, acclimatisation and fitness level. Fluid loss can vary considerably between individuals from modest losses of 0.3 litre per hour to as much as 3 litres per hour (Maughan *et al.,* 2015). Loss of fluids of >2% of the body weight may lead to a reduction in aerobic capacity during exercise, as well as decreased cognitive functioning (ACSM *et al.,* 2016). Apart from fluids, minerals (electrolytes) are also lost via sweat, particularly sodium and chloride and to a lesser degree potassium and magnesium. Here large differences between individuals are also observed (ACSM *et al.,* 2016; Maughan *et al.,* 2015).

### Rehydration

Lost fluids should be replenished in order to prevent dehydration, which in turn will affect performance and optimum functioning of the body. Fluid loss should ideally be kept below 2% of body weight. For a person weighing 75 kg this amounts to a maximum of 1.5 kg weight loss as a result of fluid loss (ACSM *et al.,* 2016; IAAF, 2013). The most important factors influencing rehydration and replenishment of fluids, during and after exercise are the volume and the composition of the drink consumed. Drinks containing electrolytes and carbohydrates can help support the maintenance of fluid and electrolyte balance during exercise. The quantity consumed should be tailored according to individual needs as this depends on factors such as the duration of exercise and the opportunity to drink during the activity. Also the volume of fluid that can be tolerated during exercise may vary as some individuals may be susceptible to gastro-intestinal distress (Maughan *et al.,* 2015). Therefore it is important to trial and practise drinking schedules during training. (IAAF, 2013)





An athlete may experience fluid losses between 0.3 to 3 litres per hour during exercise.



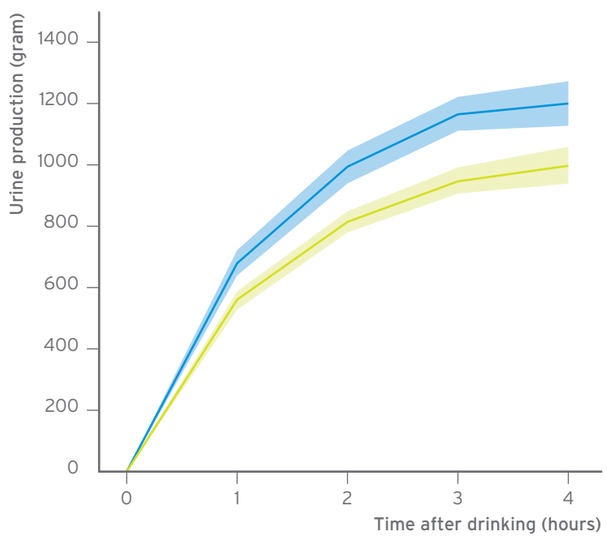
### Timing of fluid intake

The aim is to prevent dehydration where possible. Therefore it is wise to start drinking early on in the training session and to make the most of fluid breaks during a match. Then continue to sip fluids little and often rather than relying on thirst as this is not a good indicator of the need to drink. Once thirst is experienced, there is already is a shortfall in fluid intake.

**Beverage Hydration Index (BHI)**

The aim of fluid intake is to replenish the fluid lost during exercise so it is important that the majority of fluid consumed is retained in the body rather than lost via urine. In order to provide more guidance on this, Maughan *et al.,* (2016) developed a beverage hydration index (BHI), which is a measure of the extent to which the body can absorb and retain the fluid from a drink. During the development of this index the effect on fluid balance of 13 different drinks, from water to milk and an oral rehydration solution (ORS) to beer, were compared. Subjects drank equal quantities of the different drinks, after which the urine volume was measured. ORS and skimmed and full-fat milk produced significantly less urine than other drinks such as water, tea, coke and a sports drink (see figure 2). A lower urine production is an indication that the body can 'use' more fluid for recovering the fluid balance. (Maughan *et al.,* 2016) Figure 3 shows the BHI of the various drinks. Here water is the standard and has a BHI of 1, a BHI of more than 1 means a higher hydration value compared to water, a BHI below 1 means a lower hydration value than water.

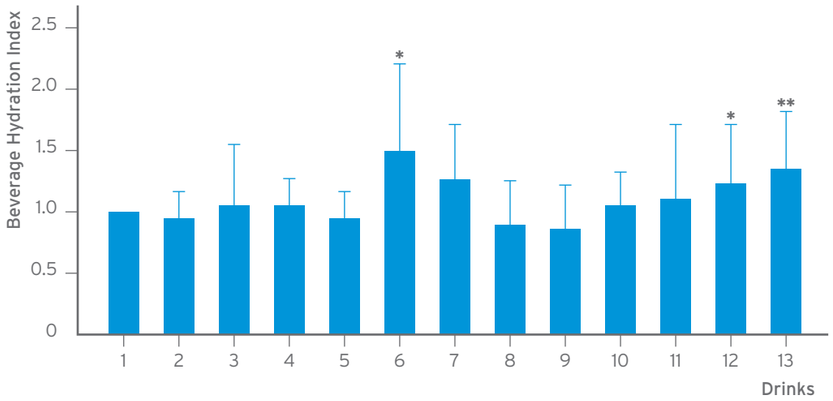
**FIGURE 2** The urine production after drinking various drinks




Source: Maughan *et al.,* 2016

| The blue line represents the following drinks: |
|---|
| Water |
| Carbonated water |
| Coke |
| Diet coke |
| Sports drink |
| Beer |
| Coffee |
| Tea |
| Ice tea |
| **The green line represents the following drinks:** |
| Oral rehydration solution |
| Orange juice |
| Full-fat milk |
| Skimmed milk |

**FIGURE 3** The Beverage Hydration Index (BHI) of 13 drinks compared to water




1 Water
2 Carbonated water
3 Coke
4 Diet coke
5 Sports drink
6 Oral rehydration solution
7 Orange juice
8 Beer
9 Coffee
10 Tea
11 Ice tea
12 Full-fat milk
13 Skimmed milk

* P < 0.05; ** P < 0.01 (different from water)

Source: Maughan *et al.*, 2016





## Putting it all into practice: what should athletes eat and drink?

The sports nutrition pyramid has been developed as a guide for athletes on choosing foods to ensure a good dietary intake of all the necessary nutrients. However, further sports specific and individualized nutrition advice from an appropriately qualified sports dietitian or nutritionist is helpful to address particular training and competition goals. In some cases sports supplements may be required.

## Basic nutrition

For athletes too, the starting point for nutritional advice is a healthy, balanced and varied diet based on eating the right amount of foods from each food group, including vegetables, fruit, potatoes, rice, pasta, oil, legumes, nuts, fish, meat, milk and milk products. Eating a wide range of foods from each food group will generally provide the body with the required quantity of energy and essential nutrients. However, due to their higher energy expenditure, athletes need more energy and nutrients which can be achieved by increasing their consumption of foods from each of the basic food groups. So by eating and drinking more, athletes automatically take in more energy from protein, carbohydrate, fats and also more vitamins and minerals.

### Timing of protein-rich products

For athletes undergoing intensive training to improve sports performance, it is important to pay special attention to the distribution of protein intake over the day. Including a protein rich food in each meal and snack (breakfast, lunch, dinner, before going to sleep, and after exercise) can optimize muscle protein synthesis. In general, this is more likely to be achieved with lunch and dinner, but athletes are advised to pay special attention to the other meals and snacks. For example, research has shown that nutritional intakes of elite athletes at breakfast and at night before going to sleep often contains less protein than recommended (Gillen *et al.*, 2016).

**Figure 4**




**TABLE 8** Protein and carbohydrate content in various products (per 100 grams and per portion)

| Product | Nutritional value per 100 g | | | Nutritional value per portion | | | |
|---|---|---|---|---|---|---|---|
| | Energy (kJ/kcal) | Carbo-hydrate (g) | Protein (g) | Portion size (g) | Energy (kJ/kcal) | Carbo-hydrate (g) | Protein (g) |
| Drinking chocolate (semi-skimmed) | 311/74 | 10.9 | 3.7 | 150 | 466/111 | 16.4 | 5.5 |
| Milk (semi-skimmed) | 195/46 | 4.7 | 3.5 | 150 | 292/69 | 7.0 | 5.2 |
| Yoghurt drink (with extra protein) | 322/76 | 9.2 | 5.2 | 150 | 483/114 | 19.8 | 13.8 |
| Yoghurt (semi-skimmed) | 243/57 | 7.8 | 4.8 | 150 | 364/86 | 11.7 | 7.2 |
| Yoghurt Greek style (full-fat) | 551/133 | 4.8 | 5.7 | 150 | 826/200 | 7.2 | 8.6 |
| Cottage cheese (semi-skimmed) | 289/68 | 3.3 | 10.6 | 150 | 434/102 | 5.0 | 15.9 |
| Cheddar cheese 30% fat | 1305/314 | 0.8 | 27.9 | 20 | 261/63 | 0.2 | 5.6 |
| Egg (chicken, boiled) | 95/143 | 0 | 14.1 | 50 | 298/72 | 0 | 7.0 |
| Chicken breast (grilled) | 626/148 | 0 | 32.0 | 100 | 626/148 | 0 | 32.0 |
| Unsalted nuts | 248/581 | 11.6 | 23.8 | 25 | 602/145 | 2.9 | 6.0 |
| Legumes (chickpeas) | 487/115 | 16.1 | 7.2 | 60 | 292/69 | 9.7 | 4.3 |
| Salmon (grilled) | 995/239 | 0 | 24.6 | 105 | 1045/251 | 0 | 25.8 |

Source: Dietplan7 Forestfield software Ltd and data from the manufacturer.



The nutrients that are important for an athlete are naturally found in milk. Dairy protein contributes to the development and maintenance of muscle mass, calcium helps to develop and maintain strong healthy bones, and vitamins B2 and B12 help the body to release energy.

**Milk: a good drink for after exercise?**

The nutritional composition of milk, i.e. the amount of energy, fluid, protein, carbohydrate and electrolytes such as sodium and potassium, suggests that milk can be useful as a drink after exercise. Comparisons with sports drinks with a similar osmolality show that milk is beneficial for restoring fluid balance after exercise (Maughan *et al.*, 2015; Roy, 2008; Shirreffs *et al.*, 2007; Watson *et al.*, 2008, Maughan *et al.*, 2016), possibly because of its favourable composition of electrolytes. The water and electrolytes in milk contribute to the recovery of fluid balance, while the proteins, naturally present in milk, help to repair and regenerate muscles after exercise and the carbohydrate reserves are partially replenished by lactose (Lee, 2008; Shirreffs *et al.*, 2007; Watson *et al.*, 2008). Additionally, the protein in milk can stimulate muscle protein synthesis and the development of muscle mass after strength training, for both men and women in the short as well as in the longer term (Elliot*et al.*, 2006; Hartman *et al.*, 2007; Wilkinson *et al.*, 2007).

## Sports-specific nutrition

Apart from eating 'regular' foods, it may be convenient for an athlete to make use of sports-specific nutritional products. These sports foods have been specifically developed for use immediately before, during or after training and exercise, and include sports drinks, sports bars, sports gels and protein shakes. Immediately before and after exercise the emphasis is placed on providing fluid and energy (carbohydrates) in a readily available form so as to avoid gastro intestinal complaints. Protein is also important during the recovery phase after exercise, because of the role it plays in the maintenance and development of muscle mass. The need for these products depends on the type, duration and intensity of the exercise and with longer and more intense the exercise, there tends to be a greater use of supplementary sports-specific nutrition.



**Casein and whey protein**
Sports nutrition products with protein contain various different protein sources. Often whole milk protein is used because of its high protein quality, taste and availability, but it is sometimes also used in a 'separated' form as casein and whey protein. A protein bar usually contains a combination of casein, which gives a dry, powder-like structure and whey protein, which gives a sticky structure. Powder mixtures mainly contain whey protein in the form of a whey protein concentrate (powder with 80% protein) or whey protein isolate (90% protein). Whey protein is also easier to use in acidic drinks. Casein is often referred to as the 'slow' protein and whey the 'fast' protein. This is because whey generally gives an amino acid peak in the first two hours after consumption, whereas the amino acids in casein are released over a period of approximately six hours (Dangin *et al.*, 2011; Lacroix *et al.*, 2006; Pennings *et al.*, 2011). Therefore, whey protein is often used in the period immediately after exercise following matches or training sessions (Devries *et al.*, 2015). Casein is mainly recommended for consumption just before going to sleep.



## Supplements

Good basic nutrition usually provides an athlete with sufficient nutrients and additional supplements (such as vitamin tablets) are not needed. Still, in some cases a shortage of certain nutrients may occur with an athlete, such as iron or vitamin D. Athletes who have to keep an eye on their weight, and vegetarians or athletes who follow a restrictive diet should pay extra attention to these nutrients. In such cases a supplement can be useful to complement dietary intake. Also performance enhancing ergogenic aids, such as creatine, caffeine and β-alanine, are available. The use of supplements must be carefully considered with respect to safety because they can be contaminated with banned substances. Therefore athletes are advised to make use of supplements that have been Batch Tested in accordance with UK Sport anti-doping guidelines (UKAD) and/or the WADA (World Anti-Doping Agency).

**Proven performance-enhancing effect**
The Australian Sports Commission (AIS) has made a distinction in the classification of supplements (AIS, 2015). Furthermore, according to EFSA, there is only sufficient scientific evidence for the effect of creatine on exercise performance. A daily intake of 3 grams creatine has been shown to increases exercise performance during repetitive, explosive, short-duration and high-intensity exercise (EFSA, 2011). Therefore it is relevant to strength and power sports such as sprinting and weightlifting. According to EFSA there is insufficient scientific evidence for the effect of the other supplements and no further applications for assessing specific supplements have been submitted to EFSA.



# Tips for athletes

For effective replenishment and recovery after exercise, it is important to properly distribute the intake of macronutrients, in particular protein, over the day. However, what about the timing and amount of nutrients before, during and after exercise? This section includes tips for athletes.

## Before exercise

- Do not skip meals or snacks before exercise. This can result in early muscular fatigue due to a reduced supply of glycogen to exercising muscles.
- Also avoid exercising with a full stomach. Allow two hours after eating a full meal before exercise as there is a need for increased blood flow to the gut to supply oxygen and energy for digestion. Oxygen and energy are also required during exercise, and so this results in a situation whereby both processes are competing for blood flow and gastro intestinal distress may occur.
- Drink 5-10 ml water or sports drink per kilogram body weight 2 to 4 hours before exercise. This allows enough time to optimise hydration status before exercise and to pass any excess fluid via the urine (ACMS *et al.*, 2016).
- If eating before exercise is unavoidable, try not to have a heavy meal and go for something lighter instead such as a filled sandwich and some fruit. Avoid foods high in fat, protein or fiber such as meat, potatoes, oily fish, egg, vegetables or legumes. Be careful with spicy food and avoid ice-cold and carbonated drinks. These foods may trigger gastro intestinal

disturbances when consumed close to exercising. This also sometimes holds true for milk products.
- Ideally choose something to eat just before exercise that is easily digested and provides energy in a readily available form, such as a currant bun or a sports bar/gel (ACSM *et al.,* 2016; IAAF, 2013) or a sports drink with carbohydrate 5 minutes before the start (van Loon, 2013).

### During exercise

- Drink water during exercise to replenish fluid losses. Begin drinking sooner rather than later as when you feel thirsty you are already becoming dehydrated.
- For more intense exercise lasting longer than 1 hour choose a sports drink with carbohydrate as it is important to maintain the glycogen supply in muscles during exercise. Such drinks are not suitable for weight loss as sports drinks contain sugar and provide additional calories. Choose water instead (Beelen *et al.,* 2010; Beelen *et al.,* 2015; IAAF, 2013; Jeukendrup, 2014; Stellingwerff *et al.,* 2014).
- As individuals are different in the way in which food and drink can be tolerated during exercise, it is wise to experiment with this during training sessions and try to find out what works best.

### After exercise (recovery phase)

- Allow sufficient rest after a heavy training session or match to give the body an opportunity to fully recover. Fluid and glycogen replenishment must take place and the repair and regeneration of the damaged muscle fibres. Good recovery is very important to enable good training adaptations which in turn support performance gains, for example in preparation for an important match.
- The first 2 hours after exercise are crucial as the body is most receptive for recovery and replenishment of muscles glycogen stores (Beelen *et al.,* 2010).
- Rapid rehydration can be achieved by drinking 1.2-1.5 litre fluid for every kg body weight lost during exercise. Drinking sports drinks and eating a salty meal or snack replenishes the loss of electrolytes (ACMS *et al.,* 2016; IAAF, 2013; Beelen *et al.,* 2015).
- For more rapid replenishment of glycogen, carbohydrate can be taken up to 2 hours after exercise (Beelen et al, 2010). To optimize glycogen stores immediately following exercise 1.2 grams carbohydrate/kg/hour is advised for endurance athletes.
- Scientific research shows that for optimum support of the muscles 20 grams protein should be taken after exercise, particularly after resistance training. It is best to consume this quantity of protein within 30 minutes to 2 hours after exercise when the muscles are most receptive to recovery and the body can make optimum use of the protein. This holds true for both endurance and strength training (Beelen *et al.,* 2010; Philips, 2012,ACMS *et al.,* 2016; Areta, 2013; IAAF, 2013; International Olympic Committee, 2010; Moore, 2009).
- Therefore, preferably plan meals (breakfast, lunch or dinner) after exercise so the body can then immediately replenish the energy, macronutrients and micronutrients that have been used during exercise.
- No time for a meal? Then take a protein-rich snack as soon as possible after exercise, for example a bowl of quark or a protein shake, in order to stimulate protein synthesis.
- The body needs energy and nutrients for growth, development and recovery during the night as well. Just before going to sleep is a perfect time for a '20 grams portion' of protein. So avoid the dessert after your evening meal (a main meal usually contains more than enough protein) and instead go for a good bowl of yoghurt or quark just before going to sleep.



Choose a product that provides about 20 grams protein 30 minutes to 2 hours after exercise.



# Role of nutrition in strength, endurance and team sports

Different sports place different demands on the body. Therefore there are different considerations with respect to nutrition. Generally, nutrition for endurance sports is mainly focused on keeping up with fluid and energy requirements in the body and ensuring a good recovery. In the case of strength sports development and regeneration of muscle mass is an important focus. Team sports are often a combination of endurance and strength with exercise of varying levels of intensity (explosive bursts, alternated with lower intensity phases), lasting between 60 to 90 minutes.

## Strength sports

Muscle is an active tissue in which breakdown of muscle protein and muscle protein synthesis (protein build-up) continuously take place. Muscle mass increases when the build-up exceeds the breakdown. Strength training stimulates muscle protein synthesis and results in an increase in lean mass and a decrease in fat mass (Phillips, 2012). An increased muscle mass from a higher muscle protein synthesis can only take place when an adequate supply of high-quality protein or sufficient (essential) amino acids are available. Therefore good basic nutrition with sufficient fluids and protein-rich foods distributed evenly throughout the day in 4-6 meals or snacks providing 20-25 grams protein are particularly important for strength athletes. When day to day nutrition does not provide sufficient protein or it is not always possible to eat at a particular time (e.g. after training), then protein replenishment in the form of sports-specific foods can provide a solution (Cermak *et al.*, 2012; Snijder, 2014).



**TABLE 9** Example menu for a male strength athlete (85 kg, 180 cm and 35 years old)

| **Total: 2983 kcal; 158 g protein; 430 g carbohydrate; 21 en% fat** |
|---|
| **Breakfast: 534 kcal; 39 g protein; 89 g carbohydrate** |
| Sandwich of 2 slices of wholemeal bread with cheese spread and sliced cucumber |
| 1 bowl of low fat thick strained yoghurt (150 ml) with 2 tablespoons of muesli and 2 tablespoons of raisins |
| 1 mandarin |
| Water or coffee/tea with milk (no sugar) |
| **Between meals: 404 kcal; 10 g protein; 74 g carbohydrate** |
| 1 pear |
| 1 wholemeal fruit bun |
| 1 slice of wholemeal bread with margarine and jam |
| Water or coffee/tea with milk (no sugar) |
| **Lunch: 585 kcal; 31 g protein; 81 g carbohydrate** |
| 1 toasted sandwich made with 2 slices of wholemeal bread and a slice of reduced fat (30% fat) cheddar cheese |
| 1 small wrap with cottage cheese and slices of tomato |
| 1 wholemeal cracker with fruit spread |
| 1 bowl of raw vegetables |
| 1 glass of semi-skimmed milk (150 ml) |
| **Between meals: 349 kcal; 10 g protein; 47 g carbohydrate** |
| 1 slice of ginger cake |
| 1 wholemeal cracker with goat's cheese |
| 1 small handful of assorted nuts and raisins |
| 1 small bunch of white grapes |
| Water or coffee/tea with milk (no sugar) |
| **During training (45-75 minutes)** |
| Water |
| **Dinner: 590 kcal; 47 g protein; 77 g carbohydrate** |
| 5 tablespoons of wholemeal pasta |
| 1 chicken breast, grilled (100 g) |
| Stir-fry vegetables with oriental style sauce (200 g) |
| Water |
| **Before going to sleep: 478 kcal; 21 g protein; 61 g carbohydrate** |
| Powershake with banana and peanut butter (made from 1 banana, chopped, 250 ml yoghurt, 2 tablespoons of peanut butter or almond paste, 1 tablespoon of honey, a generous pinch of cinnamon) |

Source: Dietplan7 Forestfield software Ltd



**TABLE 10** Example menu for a female strength athlete (70 kg, 170 cm and 35 years old)

| **Total: 2674 kcal; 146 g protein; 367 g carbohydrate; 23 en% fat** |
|---|
| **Breakfast: 533 kcal; 37 g protein; 86 g carbohydrate** |
| Sandwich of 2 slices of wholemeal bread with cheese spread and slices of cucumber |
| 1 bowl of low fat strained yoghurt (150 ml) with 1 tablespoon of muesli and 2 tablespoons of raisins |
| 1 apple |
| Water or coffee/tea without sugar and milk |
| **Between meals: 313 kcal; 9 g protein; 40 g carbohydrate** |
| 1 small bunch of white grapes |
| 1 slice of gingerbread |
| 1 small handful of assorted nuts and raisins |
| Water or coffee/tea without sugar and milk |
| **Lunch: 493 kcal; 30 g protein; 60 g carbohydrate** |
| 1 toasted sandwich made of 2 slices of wholemeal bread and a slice of reduced fat (30% fat) cheddar cheese |
| 1 small wrap with cottage cheese and slices of tomato |
| 1 bowl of raw vegetables |
| 1 glass of semi-skimmed milk (150 ml) |
| Water or coffee/tea without sugar and milk |
| **Between meals: 211 kcal; 7 g protein; 39 g carbohydrate** |
| 1 kiwi |
| 1 currant bun |
| Water or coffee/tea without sugar and milk |
| **During training (45-75 minutes)** |
| Water |
| **Dinner: 603 kcal; 43 g protein; 79 g carbohydrate** |
| 1 onion, fried |
| 2 teaspoons of curry powder |
| 3 serving spoons of rice |
| 1 piece of grilled chicken (100 g) |
| 2 serving spoons of boiled peas (frozen) |
| 1 serving spoon of boiled carrots |
| Water or coffee/tea without sugar and milk |
| **Before going to sleep: 478 kcal; 21 g protein; 61 g carbohydrate** |
| Powershake with banana and peanut butter (made from 1 banana, chopped, 250 ml yoghurt, 2 tablespoons of peanut butter or almond paste, 1 tablespoon of honey, a generous pinch of cinnamon) |

Source: Dietplan7 Forestfield software Ltd





## Endurance sports

For endurance athletes good basic nutrition with sufficient carbohydrate is important to ensure the right balance between training and carbohydrate intake to optimize glycogen stores. During intensive training sessions or a race it is also important for an endurance athlete to limit the loss of fluids, to prevent dehydration and help prevent gastro intestinal distress and to provide sufficient energy as carbohydrate. The aim is to quickly absorb fluids and fuels and most sports drinks consist of water with some salt and sugars to speed up absorption (Beelen *et al.*, 2010; Beelen *et al.*, 2015; Jeukendrup, 2014). In the recovery phase after prolonged exercise muscle repair and regeneration is also important for endurance athletes. Therefore an endurance athlete is also advised to have 20 grams of protein within the first 2 hours after a training session or race.



**TABLE 11** Example menu for a male endurance athlete (75 kg, 180 cm and 35 years old)

| **Total: 2878 kcal; 128 g protein; 484 g carbohydrate; 18 en% fat** |
|---|
| **Breakfast: 537 kcal; 34 g protein; 93 g carbohydrate** |
| 1 slice of wholemeal bread with cheese spread and cucumber |
| 1 bowl of low fat strained yoghurt (150 ml) with 3 tablespoons of muesli and 2 tablespoons of raisins |
| 1 pear |
| Water or coffee/tea without sugar and milk |
| **Between meals: 373 kcal; 6 g protein; 77g carbohydrate** |
| 1 wholemeal cracker with margarine and jam |
| 3 dried figs |
| 1 banana |
| Water or coffee/tea without sugar and milk |
| **Lunch: 387 kcal; 21 g protein; 46 g carbohydrate** |
| 1 slice of wholemeal bread with fresh goat's cheese, 1 teaspoon of honey, pine nuts and rocket |
| 1 small wrap with cottage cheese and slices of tomato |
| 1 bowl of raw vegetables |
| 1 glass of semi-skimmed milk (150 ml) |
| **Between meals: 180 kcal; 6 g protein; 31 g carbohydrate** |
| 1 slice of wholemeal bread with margarine and apple spread |
| 1 wholemeal biscuit |
| 1 mandarin |
| Water or coffee/tea without sugar and milk |
| **During training (1-2.5 hours): 218 kcal; 0 g protein; 54 g carbohydrate** |
| 1 bottle (330 ml) of high-energy sports drink |
| **Dinner: 591 kcal; 37 g protein; 93 g carbohydrate** |
| 4 serving spoons of rice |
| 1 piece of fried tilapia fillet (120 g) |
| 3 serving spoons of stir-fried vegetables with oriental sauce (200 g) |
| Water |
| **Before going to sleep: 592 kcal; 23 g protein; 69 g carbohydrate** |
| Hot coffeechoc (made from 250 ml skimmed or semi-skimmed milk, 1 tablespoon brown sugar, 1 tablespoon cocoa powder, 1 tablespoon (decaf) instant coffee) |
| 1 currant bun with margarine |
| 1 small handful of unsalted nuts |

Source: Dietplan7 Forestfield software Ltd



**TABLE 12** Example menu for a female endurance athlete (65 kg, 170 cm and 35 years old)

| **Total: 2552 kcal; 127 g protein; 396 g carbohydrate; 18 en% fat** |
|---|
| **Breakfast: 620 kcal; 33 g protein; 105 g carbohydrate** |
| 1 slice of wholemeal bread with margarine and apple spread |
| 1 bowl of low fat strained yoghurt (150 ml) with 2 tablespoons of muesli and 3 tablespoons of raisins |
| 1 mandarin |
| Water or coffee/tea without sugar and milk |
| **Between meals: 219 kcal; 4 g protein; 49 g carbohydrate** |
| 3 dried figs |
| 1 apple |
| Water or coffee/tea without sugar and milk |
| **Lunch: 414 kcal; 26 g protein; 46 g carbohydrate** |
| 1 toasted sandwich made of 2 slices of wholemeal bread and a slice of reduced fat (30% fat) cheddar cheese and slices of tomato |
| 1 wholemeal cracker with cottage cheese |
| 1 glass of semi-skimmed milk (150 ml) |
| **Between meals: 136 kcal; 3 g protein; 25 g carbohydrate** |
| 1 wholemeal biscuit |
| 1 small bunch of white grapes |
| Water or coffee/tea without sugar and milk |
| **During training (1-2.5 hours): 218 kcal; 0 g protein; 54 g carbohydrate** |
| 1 bottle (330 ml) of high-energy sports drink |
| **Dinner: 431 kcal; 33 g protein; 63 g carbohydrate** |
| 1 large wrap |
| 80 g fried chicken breast |
| 1 tablespoon of pesto |
| 1 serving spoon of stir-fried vegetables with mushrooms |
| 1 serving spoon of chickpeas |
| 1 bowl of raw vegetables |
| Water |
| **Before going to sleep: 553 kcal; 27 g protein; 52 g carbohydrate** |
| Hot coffeechoc (made from 250 ml skimmed or semi-skimmed milk, 1 tablespoon brown sugar, 1 tablespoon cocoa powder, 1 tablespoon (decaf) instant coffee) |
| 1 slice of wholemeal bread with fresh goat's cheese and honey |
| 1 small handful of assorted nuts and raisins |

Source: Dietplan7 Forestfield software Ltd





## Team sports

Team sports are characterised by high intensity intermittent exercise of varying levels of intensity (explosive bursts alternated with lower intensity phases), lasting between 60 to 90 minutes. This makes team sports a combination of strength and endurance activity. Of course, good basic nutrition is important for team sport athletes with special attention to ingesting sufficient fluids and carbohydrates to support exercise for periods lasting longer than an hour. Good recovery is also important for replenishing the glycogen stores and protein for repair and regeneration of muscle. Elite team sports athletes are advised to take a portion of 20 grams protein in the first 2 hours after a heavy training session or match.





**TABLE 13** Example menu for a male team athlete (75 kg, 180 cm and 35 years old)

| **Total: 2998 kcal; 134 g protein; 458 g carbohydrate; 21 en% fat** |
|---|
| **Breakfast: 726 kcal; 34 g protein; 122 g carbohydrate** |
| 4 slices of dark rye bread, 4 tablespoons of strawberry jam, 100 ml soft curd cheese, 120 g strawberries, 4 leaves of fresh mint |
| 1 slice of wholemeal bread with peanut butter |
| 1 kiwi |
| Water or coffee/tea without sugar and milk |
| **Between meals: 289 kcal; 6 g protein; 49 g carbohydrate** |
| 1 currant bun with margarine |
| 1 pear with skin |
| Water or coffee/tea without sugar and milk |
| **Lunch: 516 kcal; 32 g protein; 63 g carbohydrate** |
| 1 toasted sandwich made of 2 slices of wholemeal bread and a slice reduced fat (30% fat) cheddar cheese |
| 1 small wrap with cottage cheese and slices of tomato |
| 1 bowl of raw vegetables |
| 1 glass of semi-skimmed milk (200 ml) |
| **Between meals: 277 kcal; 6 g protein; 53 g carbohydrate** |
| 1 slice of wholemeal bread with margarine and jam |
| 1 banana |
| Water or coffee/tea without sugar and milk |
| **During training (1-2.5 hours): 218 kcal; 0 g protein; 54 g carbohydrate** |
| 1 bottle (330 ml) of high-energy sports drink |
| **Dinner: 530 kcal; 36 g protein; 69 g carbohydrate** |
| 4 serving spoons of pasta |
| 80 g grilled pieces of chicken breast |
| 1 tablespoon of pesto |
| 3 serving spoons of Italian stir-fried vegetables |
| Water |
| **Before going to sleep: 442 kcal; 20 g protein; 46 g carbohydrate** |
| 1 bowl of semi-skimmed yoghurt (200 ml) with 2 tablespoons of muesli and 2 tablespoons of raisins |
| 1 muesli bun |
| 1 small handful of unsalted nuts |

Source: Dietplan7 Forestfield software Ltd



**TABLE 14** Example menu for a female team athlete (65 kg, 170 cm and 35 years old)

| **Total: 2650 kcal; 115 g protein; 429 g carbohydrate; 18 en% fat** |
|---|
| **Breakfast: 726 kcal; 34 g protein; 122 g carbohydrate** |
| 4 slices of dark rye bread, 4 tablespoons of strawberry jam, 100 ml soft curd cheese, 120 g strawberries, 4 leaves of fresh mint) |
| 1 slice of wholemeal bread with peanut butter |
| 1 kiwi |
| Water or coffee/tea without sugar and milk |
| **Between meals: 210 kcal; 4 g protein; 41 g carbohydrate** |
| 3 dried figs |
| 1 wholemeal biscuit |
| Water or coffee/tea without sugar and milk |
| **Lunch: 511 kcal; 27 g protein; 60 g carbohydrate** |
| 1 toasted sandwich made of 2 slices of wholemeal bread and a slice reduced fat (30% fat) cheddar cheese and slices of tomato |
| 1 wholemeal cracker with margarine and apple spread |
| 1 bowl of raw vegetables |
| 1 glass (200 ml) of semi-skimmed milk |
| **Between meals: 136 kcal; 3 g protein; 29 g carbohydrate** |
| 1 mandarin |
| 1 slice of gingerbread |
| Water or coffee/tea without sugar and milk |
| **During training (1-2.5 hours): 218 kcal; 0 g protein; 54 g carbohydrates** |
| 1 bottle (330 ml) of high-energy sports drink |
| **Dinner: 472 kcal; 30 g protein; 65 g carbohydrate** |
| 1 large wrap |
| 80 g smoked salmon |
| 1 tablespoon of dairy spread |
| 1 serving spoon of stir-fried vegetables with mushrooms |
| 1 serving spoon of chickpeas |
| 1 bowl of raw vegetables without dressing |
| Water |
| **Before going to sleep: 377 kcal; 18 g protein; 57 g carbohydrate** |
| 1 bowl of low fat strained thick yoghurt (200 ml) with 1 tablespoon of muesli and 2 tablespoons of raisins |
| 1 wholewheat cracker with fresh goat's cheese and honey |
| 1 small handful of assorted nuts and raisins |

Source: Dietplan7 Forestfield software Ltd





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## Notes

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SENr The Sport and Exercise Nutrition Register

UK active MEMBER