athletes' medical information

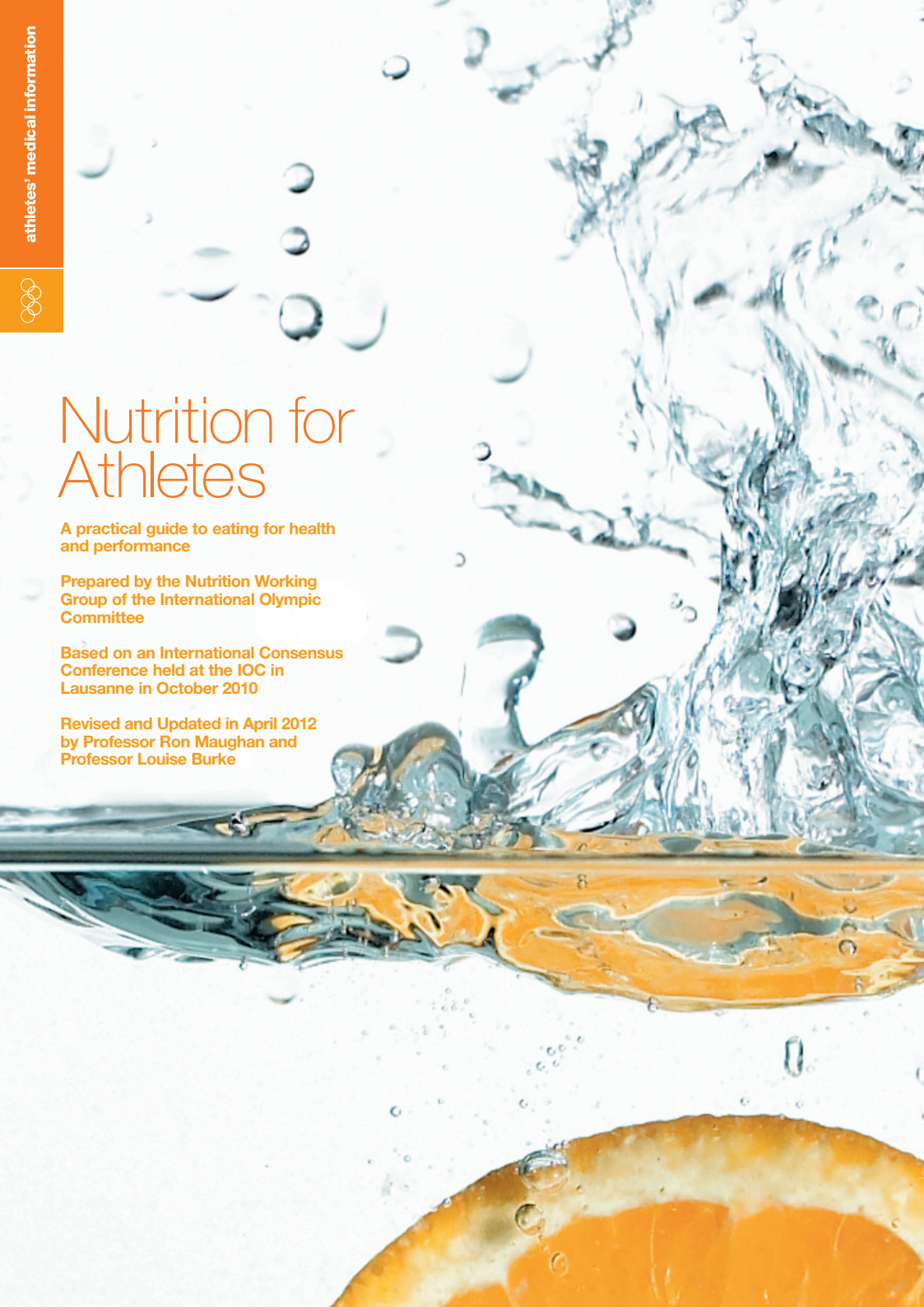
Nutrition for Athletes

A practical guide to eating for health and performance

Prepared by the Nutrition Working Group of the International Olympic Committee

Based on an International Consensus Conference held at the IOC in Lausanne in October 2010

Revised and Updated in April 2012 by Professor Ron Maughan and Professor Louise Burke



Message from Muhtar Kent

Since 1928, The Coca-Cola Company has been a proud supporter of the Olympic Movement. As such, we've been privileged to witness some of the greatest athletic achievements of the past century.

Today, world-class athletes share an unwavering commitment to a balanced nutritional diet and an active, healthy lifestyle. To support you in this regard, The Coca-Cola Company, through our POWERADE brand, has partnered with the IOC Nutrition Working Group and the IOC Athletes' Commission to create this nutrition brochure for all athletes.

Helping you achieve peak performance is the mission of POWERADE, a refreshing beverage designed to prevent dehydration and the onset of fatigue during exercise.

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Your peak performance also depends on a clean and healthy environment, which is one reason Coca-Cola is committed to a vision of "zero waste" through increasingly sustainable packaging and recycling efforts. We're also reducing our potential climate impacts through leading-edge technologies including our hydrofluorocarbon-free (HFC-free) cooling technologies. And we've improved the energy efficiency of our cooling equipment by up to 40 percent since 2000.

On behalf of the more than 700,000 Coca-Cola system associates across 200-plus nations, I congratulate you on your Olympic journey thus far. Everyone at Coca-Cola wishes you the very best as you compete and forge lasting friendships with your fellow Youth Olympians from around the world!

Muhtar Kent
Chairman & CEO
The Coca-Cola Company

Foreword by Dr Patrick Schamasch

The IOC and its Medical Commission are pleased to provide athletes with this updated brochure, developed under the leadership of the IOC 'Nutrition' working group, in close collaboration with the IOC Athletes' Commission.

Its simplicity and reader-friendly layout make this work a reference for all those who, like the IOC Medical Commission, believe that nutrition is one of the decisive elements in high-level athletes' preparations and one of the key factors in athletes' health.

Powerade is the partner of the IOC's Medical Commission for this publication and helps us to spread the information in a worldwide campaign to athletes at all levels.

For all those who, without aspiring to take part in the Olympic Games, place sport and physical activity as a top priority, this brochure will ensure better management of their efforts and preparations.

Patrick Schamasch
Former IOC Medical Director

Key messages

Many factors contribute to success in sport, including talent, training, motivation and resistance to injury. When highly talented, motivated and well trained athletes gather for competition, the margin between victory and defeat is usually small. Attention to every detail can make that vital difference, and nutrition is a key element of the serious athlete's preparation.

Diet affects performance, and the foods that we choose in training and competition will affect how well we train and compete. Athletes need to be aware of their nutritional goals and of how they can select an eating strategy to meet those goals.

Diet may have its biggest impact on training, and a good diet will help support consistent intensive training while reducing the risk of illness or injury. Good food choices can also promote adaptations in muscle and other tissues in response to the training stimulus.

Athletes are all different, and there is no single diet that meets the needs of all athletes at all times. Individual needs also change across the season and athletes must be flexible to accommodate this.

Getting the right amount of energy to stay healthy and to perform well is key. Too much and body fat increases: too little and performance falls and illness results.

Carbohydrate is a key nutrient for energy supply, but carbohydrate needs will depend on the training load and therefore vary from day to day and across the season. Athletes must be aware of foods that are good sources of carbohydrate and make these a focus of their diet.

Protein foods are important for building and repairing muscles, but a varied diet containing everyday foods will generally supply more than enough protein. The timing and type of protein are as important as the amount of protein in the diet. Well-chosen vegetarian diets can meet an athlete's protein needs.

A varied and wholesome nutrient-rich diet that meets energy needs and is based largely on vegetables, fruits, beans, legumes, grains, lean animal meats, oils and carbohydrate should ensure an adequate intake of all essential vitamins and minerals.

Maintaining hydration is important for performance. An adequate intake of fluid before, during (where appropriate), and after exercise is especially important in hot climates. Salt replacement is important when sweat losses are high, but needs vary between athletes.

Athletes are cautioned against the indiscriminate use of dietary supplements, but careful use of a small number of supplements and sports foods may benefit some athletes.

Food is an important part of life, and athletes should enjoy the foods that they eat, confident in the knowledge that they have made wise choices.

This booklet contains information that will help athletes to make informed choices to meet their nutritional needs in different situations. It is no substitute for individual advice from a qualified professional, but tries to give practical information that will be of use to the serious athlete.

Nutrition for the elite athlete

Well-chosen eating practices have much to offer the athlete:

- Fuel to train and perform at the elite level
- Optimum gains from the training program
- Enhanced recovery between workouts and between events
- Achievement and maintenance of an ideal body mass and physique
- Benefits from the many health-promoting components of food
- A reduced risk of injury, overtraining fatigue and illness
- Confidence in being well-prepared to face competition
- Consistency in achieving high-level competition performances
- Enjoyment of food and social eating occasions at home and during travel

Despite these advantages, many athletes do not meet their nutrition goals. Common problems and challenges include:

- Poor knowledge of foods and inadequate cooking skills
- Poor or outdated knowledge of sports nutrition
- Lack of access to dietitians /nutrition professionals or other credible resources
- Inadequate finances
- Busy lifestyle leading to inadequate time to obtain or consume appropriate foods
- Poor availability of good food choices
- Frequent travel
- Indiscriminate use of large amounts of supplements or failure to use evidence-based supplements and sports foods in the appropriate way

The information in this booklet is designed to provide coaches and athletes with an overview of the latest guidelines in sports nutrition. While there is no such thing as a magic diet or food, there are many ways in which eating well can allow athletes at all levels of performance to achieve the specific goals of their training and competition programs.

It makes no sense to train hard and ignore the benefits that follow from good food choices.

Nutrition for Athletes is based on the conclusions of the IOC Consensus Conference on Nutrition for Sport, held in Lausanne in October 2010. We gratefully acknowledge the contribution of the conference participants as the expert scientific sources for this booklet. We are also especially grateful to Powerade for their support.

The information was updated in April 2012 in preparation for the London Olympic Games of 2012 to ensure that athletes have access to the latest information.

This revised version of the booklet was prepared for the **IOC Medical Commission Working Group on Sports Nutrition** by

- Professor Ron Maughan, UK
- Professor Louise Burke, Australia

We thank Dr Patrick Schamasch for his insight and comments in the preparation of this booklet.

Energy needs

Energy intake sets the "budget" from which an athlete must meet their needs for carbohydrate, protein and fat, as well as the range of foods that provide vitamins, minerals and other health-promoting dietary factors. An athlete's energy requirements are made up of several components: baseline metabolic needs (such as the energy required to support cellular maintenance, temperature regulation and immune health), growth, and physical activity. Energy expended in one of these processes is not available for others, so the diet must provide sufficient energy to meet the needs of all essential functions. Physical activity – or in the case of an athlete, the intensity, duration and frequency of training sessions and competition – will play a strong role in determining daily energy requirements.

When daily intake of food energy from carbohydrate, fat, protein and alcohol is equal to energy expenditure, the athlete is said to be in **energy balance**.

Energy balance = Energy intake – energy expenditure

This means there is neither a net loss nor gain from the body's energy stores of fat, protein and carbohydrate. These energy stores play a number of important roles related to exercise performance, contributing to:

- an athlete's size and physique (e.g. body fat stores and muscle mass)
- function (e.g. muscle mass)
- fuel for exercise (e.g. muscle and liver glycogen stores)

Athletes often want to change their energy balance, either to produce an energy deficit (principally to reduce the size of body fat stores) or to achieve an energy surplus (principally to support growth or support the gain of muscle mass). This can be done either by altering energy intake, energy expenditure or both components.

However, an important new concept is that of **energy availability**. This is defined as the energy that is available to the body after the energy cost of physical activity has been deducted from daily energy intake. Energy availability is therefore, the amount of energy that can be expended to look after the body's physiological needs.

Energy availability = Energy intake – Energy cost of training/competition

The body can cope with a small drop in energy availability, but if it becomes too great, this will compromise its ability to undertake the processes needed for optimum health and function.

We now recognise that many health and performance problems commonly seen in athletes are associated with low energy availability – these include menstrual disturbances in female athletes, reduced basal metabolic rate, compromised immunity, poor hormonal function and impaired bone density.

Although any reduction in energy availability has some effect on the body, researchers have identified a threshold below which the consequences are particularly harmful. This is usually discussed in terms of an athlete's Fat Free

Mass (FFM) – i.e. Body mass minus Body fat. This threshold is set at 30 kcal (125 kJ) per kg FFM. Examples of adequate and low energy availability are provided in the table below.

There are three situations that are typically associated with low energy availability.

- Disordered eating and eating disorders. We used to think this was the main cause of energy deficiencies, causing some stigma to the situation. Disordered eating requires early intervention and specialist help, but we now know that many athletes can get into situations of low energy availability without this backdrop
- Restricted eating for weight control or loss or body fat. Many athletes undertake such campaigns with the best of intentions and, often, good reasons. However, the degree of energy deficit achieved by reduced energy intake or increased exercise may be too severe for good health. Even when weight loss is undertaken without any problem behaviour or undue stress, trying to achieve it at too fast a rate is likely to lead to unnecessary compromises of health and performance
- Inadvertent failure to increase energy intake sufficiently during periods of high volume training or competition. Some athletes undertake extremely strenuous training or competition programs. Appetite, time for preparing and eating food, and awareness of intake are just some of the factors influencing our food intake that may not always keep pace, especially when there is a sudden increase in exercise load. The practicality of eating a high energy intake day after day can be challenging for many athletes. Some may be unaware that they are falling behind in meeting their energy needs, or that it is problematic.

Tips for maintaining adequate energy availability

Be aware of energy needs and how these might vary over time. Be prepared to scale energy intake up and down according to the changing energy costs of daily training or competition. Be aware also of additional needs for growth. Ideas for achieving a high energy intake are found in the next section.

Take care when there is a change in your food environment – particularly when travelling or when changing your home situation. It can take time and a conscious effort to re-establish new eating patterns when opportunities to eat or access to suitable foods are altered.

Do not embark on drastic diets that limit energy intake or food variety. Even when loss of weight or body fat is likely to achieve better health and performance, severe energy restriction is associated with unnecessary consequences of low energy availability. Where possible, plan weight loss programs so that they can be undertaken at a slower and less harmful pace.

If you are developing stress related to food and body image, seek expert help at an early stage.

Female athletes should treat an interruption to a normal menstrual cycle as a problem that also needs early assessment and intervention. If you are unsure about your energy needs and how to achieve them, consult a sports nutrition expert.

Note that the consequences of low energy availability include irreversible loss of bone, as well as impairment of hormone, immune and metabolic function. It's not worth it!

Examples of different levels of energy availability

1. High energy availability for growth or gain of body mass

Energy availability	Example
> 45 kcal (> 189 kJ) per kg fat free mass (FFM)	Athlete A: 65 kg and 20% body fat FFM = 80% x 65 kg = 52 kg Weekly training = 5600 kcal (23.5 MJ) Daily energy intake = 3520 kcal (14.7 MJ) Energy availability = (3520-800)/52 = 52 kcal/kg FFM (219 kJ)

2. Adequate energy availability for weight maintenance

Energy availability	Example
~ 45 kcal (~ 189 kJ) per kg fat free mass (FFM)	Athlete B: 65 kg and 15% body fat FFM = 85% x 65 kg = 55 kg Weekly training = 5600 kcal (23.5 MJ) Daily energy intake = 3285 kcal (13.8 MJ) Energy availability = (3285-800)/55 = 45 kcal/kg FFM (189 kJ)

3. Reduced energy availability but still adequate for healthy weight loss (or weight maintenance at reduced metabolic rate

Energy availability	Example
30-45 kcal (125-189 kJ) per kg fat free mass (FFM)	Athlete C: 55 kg and 20% body fat FFM = 80% x 55 kg = 44 kg Weekly training = 5600 kcal (23.5 MJ) Daily energy intake = 2340 kcal (9.8 MJ) Energy availability = (2340-800)/44 = 35 kcal/kg FFM (164 kJ)

4. Low energy availability – health implications

Energy availability	Example
< 30 kcal (< 125 kJ) per kg fat free mass	Athlete D: 55 kg and 25% body fat FFM = 75% x 55 kg = 41 kg Weekly training = 5600 kcal (2.35 MJ) Daily energy intake = 1980 kcal (8.3 MJ) Energy availability = (1980-800)/41 = 29 kcal/kg FFM (120 kJ)

Changing body composition: gaining muscle and losing body fat

In many sports, success is influenced by an athlete's size and shape. Examples include the importance of being strong and powerful, or simply big and tall, in some sports. In other events, being small and light assists in moving your body over long distances, up hills or in complicated twirls and somersaults. An athlete's appearance may also be a factor in sports that are judged subjectively, or when the athlete is thinking about their public image. Gaining the physique characteristics that are useful for your sport starts with choosing the right parents – we all get a genetic start to life! But some of these elements can also be manipulated through diet and training. Most athletes at some time of their careers set out to alter their body mass, muscle mass or body fat levels – sometimes all at the same time. In other cases, athletes need to take special care to support their needs for growth.

The principles of changing body size and shape are:

- Altering energy balance to promote a loss or gain of body tissue – this can be achieved by changing energy expenditure, altering dietary intake or both
- Undertaking the right training to promote muscle development.

Several other factors are important for staying healthy and achieving successful performance outcomes while achieving physique changes. These include:

- Choosing targets that are achievable and sustainable in view of your genetic blueprint
- Allowing enough time for the targets to be achieved with sensible changes to nutrition and training
- Setting the right time of the sporting season to undertake the changes so that your efforts don't clash with the goals of optimum competition performance. For most athletes, this would mean during the base phases of training
- Avoiding getting too out of shape when injured or on a break between seasons
- Seeking the help of sports nutrition experts who can work with you and your coach to integrate a good nutrition plan into your training program
- Unfortunately, many athletes don't value or understand the importance of these factors.

Some of the dietary strategies that may be important to achieve these goals include

- finding ways to reduce energy intake to assist with loss of body fat, or the prevention of a gain in body fat when training volume is reduced
- finding ways to support the goals of the training needed to increase muscle mass (see protein section)
- finding ways to increase energy intake to support growth and an increase in muscle/body mass.

Useful strategies for reducing or increasing energy intake are provided below.

Strategies for reducing energy intake and/or reducing body fat levels

Set realistic targets: this is a medium-term goal rather than something to be achieved by next week.

Try to create a small energy deficit – around 500 kcal (2 MJ) per day – by reducing energy intake and/or increasing energy expenditure. A small but sustained energy deficit over a longer period will promote fat loss rather than sacrificing muscle mass, and will better support training needs and general nutrition goals. Although many athletes are impatient and like the idea of a quick but drastic weight loss program, the outcomes for body composition changes and training performance are likely to be better than with a large deficit. Remember that adequate energy availability is needed for long term health.

Seek a sports nutrition expert for an assessment of current eating patterns and where small changes can be made. Keeping a food diary of what you really eat can also help to pinpoint habits that should be changed.

Limit portion sizes at meals rather than skipping meals altogether

Use well-chosen snacks between meals to maintain fuel levels for training sessions. Save part of a meal for a later snack, rather than eating extra food

Maintain carbohydrate intake to maintain fuel levels for exercise, especially on days when training intensity and quality is important

Maintaining a good spread of protein intake over the day will help to preserve muscle mass as well as to make meals and snacks filling

Use low-fat strategies in choosing foods and while cooking or preparing meals

Limit alcohol intake or cut it out altogether – it is not an essential part of the diet. In addition, many people lose their good intentions after a few drinks. It is easy to eat snack foods, fast foods or other poor food choices when you become too relaxed

Make meals and snacks more "filling" by including plenty of salads and vegetables and by taking the higher-fibre option

Include low glycaemic index forms of carbohydrate-rich foods (e.g. oats, legumes, dense-grainy breads, berries, apples, etc) to also help with satiety

Choose nutrient-dense foods so that you can meet nutritional requirements from a lower energy intake

Strategies for increasing energy intake to support growth or increase in muscle mass

Set a pattern of frequent meals and snacks during the day rather than simply trying to eat more at meals.

Plan ahead to have suitable foods and drinks available wherever your busy day takes you. It can take some creativity to find foods that are portable and easy to consume when you are "on the run".

A food record can identify the times in a busy day that aren't being well used for fuelling up.

Drinks such as fruit smoothies, liquid meal supplements and fortified milkshakes and juices can provide a substantial source of energy and nutrients that are quick and compact to consume, and less likely to cause gastrointestinal discomfort than bulky foods.

Although it is important to eat fruit and vegetables, and wholegrain cereal foods for their nutrient qualities, overeating these bulky foods can reduce the energy density of your diet. It is OK to include options that are more compact – for example, juices, and some "white" cereals.

Use opportunities before, during and after an exercise session to consume energy and nutrients. Compact forms of carbohydrate and before and during exercise can add energy to the day as well as fuel the session. Sweetened dairy products, liquid meal supplements and fruit smoothies provide a compact source of protein and carbohydrate after the workout.

Notes

Carbohydrates for training and recovery

Carbohydrate, once considered the "backbone" of sports nutrition, has become a topic of debate and differing opinions. Around the world, it typically accounts for about half of our total energy intake. In fact, surveys show that the best endurance athletes in the world (the Kenyan and Ethiopian distance runners) consume diets that are particularly high in carbohydrates. Meanwhile in many Western countries, media reports state that carbohydrates make us fat and unhealthy and the most popular diet books are based on low and moderate carbohydrate eating plans. Many athletes are now confused.

It is true that sports nutrition experts have continued to evolve the recommendations for carbohydrate intakes for athletes as well as the language used to describe them. A central idea that hasn't changed, however, is the importance of the body's stores of carbohydrate as a source of fuel for the muscle and brain during exercise. In many types of sport, low levels of carbohydrate stores are a factor in fatigue and reduced performance. Furthermore, strategies to ensure that stores are increased result in performance enhancements. This will play a key role in competition nutrition.

There are several updates in the way we now think about carbohydrate needs in the everyday or training diet:

The athlete's carbohydrate needs are closely tied to muscle fuel costs of their training. The training load changes from day to day, over the various microcycles and macrocycles in the periodised training calendar, and at different points of the athlete's career. Therefore, the new message is that rather than having a static dietary intake, athletes should vary their carbohydrate intake according to the rise and fall in muscle fuel needs. Some general targets are suggested, but should be fine-tuned according to the athlete's energy budget and feedback from how well they are training.

A further refinement is that athletes should particularly target the days where it is important to train hard, at high intensity or with high quality to ensure that they have adequate muscle carbohydrate (glycogen) stores to fuel these goals.

A great way to assist carbohydrate intake to track with muscle fuel needs is to include additional carbohydrate in meals or snacks before and after a workout. This means when training needs increase, so does carbohydrate intake. Consuming carbohydrate intake during lengthy sessions will also add to the day's carbohydrate target as well as specifically provide fuel for the workout. Many athletes should take this opportunity to practise competition strategies for eating and drinking during the event.

Targets for carbohydrate should be provided in terms or grams relative to the athlete's size (Body mass) rather than as a percentage of total energy intake.

Training load		Carbohydrate intake targets (g per kg of athlete's body mass)
Light	Low intensity or skill-based activities	3-5 g/kg
Moderate	Moderate exercise program (i.e. ~1 hour per day)	5-7 g/kg/d
High	Endurance program (e.g. 1-3 hours per day of mod-high-intensity exercise)	6-10 g/kg/d
Very High	Extreme commitment (i.e., at least 4-5 hours per day of mod-high intensity exercise)	8-12 g/kg/d

Rather than talk about "high carbohydrate diets" and "low carbohydrate diets", we should now consider carbohydrate availability relative to the muscle's fuel needs – is the total intake and timing of the day's intake able to meet the fuel demands of a workout (= high carbohydrate availability), or are carbohydrate stores depleted or sub-optimal in comparison to the muscle fuel demand (= low carbohydrate availability). The table above shows that very different amounts of carbohydrate may be adequate for different training loads. Therefore two athletes could eat the same about of carbohydrate, but according to their training needs, one could achieve high carbohydrate availability whereas the carbohydrate availability of the other athlete is low.

Many athletes do some of their training sessions with low carbohydrate availability – for example, when they train first thing in the morning without breakfast, when they go for a long workout without access to food or a sports drink, or when they reduce their energy intake to reduce body fat levels. This may not be a problem during the base phase of training or on days of light training, when training intensity and quality is low. In fact, some studies suggest that doing some training sessions in this way provides a good stimulus to the muscle to help it adapt to training. Of course, such strategies need to be periodised into the training program so that they don't interfere with training intensity.

When athletes train more than once per day and sessions are close together, speedy recovery of the muscle carbohydrate stores is essential. Consuming carbohydrate-rich foods and drinks soon after the session helps with rapid refueling, since the muscle can't store glycogen effectively in the absence of carbohydrate intake.

When rapid refueling is needed after a session, target a carbohydrate intake of about 1 g per kg of body mass per hour for the firs.important than the amount, and athletes should make choices based on convenience, palatability, cost, and the contribution these foods can make to other nutritional goals.

When it isn't possible to meet these carbohydrate targets during the early hours of recovery, the presence of protein in recovery snacks is likely to promote higher rates of glycogen storage than carbohydrate alone. This is useful since post-workout protein intake addresses other goals of recovery eating.

During longer recovery periods (24 hours), the pattern and timing of carbohydrate-rich meals and snacks does not appear to be critical, and can be organised according to what is practical and comfortable for each athlete. There is no difference in glycogen synthesis when carbohydrate is consumed in liquid form or as solid foods.

It is valuable to choose nutrient-rich carbohydrates and to add other foods to recovery meals and snacks to provide a good source of protein and other nutrients in the total diet.

Examples of nutrient-rich carbohydrate and protein combinations (contains 50-75 g carbohydrate and 15-20 g protein)

- 500-750ml Low Fat Chocolate Milk
- 1-2 sports bars (check labels for carbohydrate and protein content)
- 1 large bowl (2 cups) breakfast cereal with low fat milk
- 1 large or 2 small cereal bars + 200g fruit-flavoured yogurt
- 1 cup baked beans on 2 slices of toast or on a baked potato
- 1 bread roll with cheese or peanut butter + large banana
- 2 cups fruit salad with 200g fruit-flavoured yogurt
- Bagel with thick spread peanut butter + 1-2 cups low fat milk
- 300g (large) baked potato + low fat cottage cheese filling + 1-2 cups low fat milk
- 2-3 slices lean meat and veggie pizza
- 2 cups breakfast cereal with milk
- 400g flavoured yoghurt
- 500-750 ml fruit smoothie or liquid meal supplement
- Thick bread sandwich with meat and salad filling
- 2 cups stir-fry with rice or noodles and meat

Notes

Carbohydrate for competition

In many sports lasting longer than 1 hour, the depletion of carbohydrate stores causes fatigue and a decline in performance over the course of the event. By contrast, nutrition strategies that provide adequate carbohydrate can reduce or delay the onset of this performance decline. Strategies include the intake of carbohydrate in the hours or days prior to the event to ensure muscle and liver glycogen stores are well stocked in anticipation of the fuel needs of the event.

In the absence of muscle damage, the athlete can normalise their muscle glycogen stores with as little as 24 hours of carbohydrate-rich eating and exercise taper.

'Carbo-loading'

Athletes who compete in events lasting longer than about 90 minutes may benefit from 'carbohydrate-loading' for a few days prior to the competition. This strategy involves meeting the highest targets for carbohydrate intake (9-12 g/kg/d) for 24-48 hours while exercise is reduced to an easy taper, and allows muscle glycogen stores to be super-compensated above normal levels. As a result, the athlete should have fuel to exercise longer at their optimal output before they face a performance decline.

One day example of foods providing 630 g of carbohydrate for a carbohydrate loading diet* (for a person weighing 70 kg with an intake of 9 g/kg carbohydrate).

- Breakfast (150 g) = 2 cups cereal with milk + 250 ml fruit juice + 1 banana + 2 thick slices toast + thick spread of jam
- Morning snack (50 g) = 500 ml soft drink
- Lunch (150 g) = 1 large bread roll + 1 medium muffin + fruit smoothie
- Afternoon snack (50 g) = 200 g flavoured yoghurt + 250 ml fruit juice
- Dinner (200 g) = 3 cups cooked pasta 2 cups fruit salad + 2 scoops ice cream + 500 ml sports drink
- Snack (30 g) = 50 g chocolate or dried fruit

(*note that other foods may be added to the meal, such as moderate amounts of protein foods. Many athletes like to follow low fibre eating over their carbohydrate loading days, to ensure that the gut is free of bulky fibre on the day of the event)

Pre-event meal
(1-6 h period before competition)
Athletes sometimes find a set of favourite foods to eat in the hours prior to competition that not only provide extra energy during the event, but also feel 'right' in terms of curbing hunger, quieting their stomach and being convenient as well as practical. In sports that do not cause fatigue or carbohydrate depletion (e.g. gymnastics, sprinting, ski-jumping, etc), the pre-event meal need not be carbohydrate-focussed. However, in events involving exercise of longer than 60 minutes, athletes are advised to use the pre-event meal to top up carbohydrate stores – especially if the event is in the morning after an overnight fast.

The effect of eating carbohydrate in the hours before exercise is to increase the muscle's rate of carbohydrate use. Therefore, the pre-event meal should contain enough carbohydrate to compensate for this "priming" of greater carbohydrate reliance. A carbohydrate intake greater than 1 g/kg body mass should achieve this goal, and pre-event meals which enhance performance in longer events generally provide carbohydrate in the range of 1-4 g/kg. Continuing to consume carbohydrate during the event helps to sustain fuel availability.

A 'mistake' some athletes make is to eat only a small amount of carbohydrate (less than 1 g carbohydrate per kg body mass) during the 1-6 h period before exercise and then fail to consume any carbohydrate during exercise. Unfortunately, this serves to make the body more reliant on body carbohydrate supplies without providing additional resources to sustain this.

Depending on the time of day, the athlete's preferences and the availability of food, an athlete may choose a range of carbohydrate-rich foods and drinks to make up their pre-even meal. The type, timing and amount of foods should be practiced until a successful plan is developed.

**Five different examples of foods that each provide 140 g carbohydrate in a pre-competition meal*
(2 g/kg body mass for a 70 kg person) are:**

- 2.5 cups breakfast cereal + milk + large banana
- Large bread roll or 3 thick slices bread + thick spread honey
- 2 cups boiled rice + 2 slices bread
- 4 stack pancakes + ½ cup syrup
- 60 g sports bar + 500 ml liquid meal supplement or fruit smoothie

(*note that other foods may be eaten at the meal)

Carbohydrate intake during exercise

We have long recognised that performance is enhanced when carbohydrate is consumed during exercise. Benefits include a sustaining of optimum pace, greater time spent at high intensities, and maintenance of skills and concentration. A variety of mechanisms seem to explain this, ranging from the provision of high rates of an additional muscle fuel to making the brain feel happy so that it makes us feel like working harder.

Until recently, we have taken a "one size fits all" approach to carbohydrate intake during exercise lasting longer than 60-90 minutes.

However, there is now good evidence that exercise of different duration and intensities requires a different carbohydrate feeding approach. A range of carbohydrate-containing drinks and foods may be able to supply these targets, as well as other needs such as fluid. These include special sports products such as sports drinks, gels and bars. Many everyday foods and drinks such as fruit, juices and soft drinks and confectionery may also be suitable. The athlete should practice in training to develop a race or event fuelling plan. This plan will need to take into account the opportunities provided in the athlete's event to consume drinks or foods.

Exercise	Duration	Carbohydrate target	Comments
During brief exercise	● < 45 min	Not needed	● A range of drinks and sports products can provide easily consumed carbohydrate
During sustained high intensity exercise	● 45-75 min	Small amounts including mouth rinse	● Opportunities to consume foods and drinks vary according to the rules and nature of each sport ● A range of everyday dietary choices and specialised sports products ranging in form from liquid to solid may be useful ● The athlete should practice to find a refuelling plan that suits their individual goals including hydration needs and gut comfort
During endurance exercise including "stop and start" sports	● 1-2.5 h	30-60 g/h	● As above ● Higher intakes of carbohydrate are associated with better performance ● Products providing multiple transportable carbohydrates (Glucose: fructose mixtures) will achieve high rates of oxidation of carbohydrate consumed during exercise
During ultra-endurance exercise	● > 2.5-3 h	Up to 90 g/h	

Dietary protein for athletes: from requirements to optimum adaptation

Protein needs in sport are another area in which knowledge and practice have evolved. Very early beliefs included the need for high protein intakes or the specific consumption of meat from animals with favourable characteristics for sport (e.g. speed, strength, courage etc). A belief in the benefits of a high protein intake has continued in strength/power sports, although there is generally a shared emphasis between protein-rich foods and specialised protein supplements. For many years there has been debate about the total protein requirements of athletes, with many experts believing that daily needs are elevated above those of sedentary people, but easily achieved within the energy intakes consumed by most athletes. Protein intake targets for both strength and endurance athletes have been set at about 1.2-1.6 g/kg body mass per day. Dietary surveys show that most athletes easily meet these goals, even without the intake of expensive supplements. Athletes who are most at risk of failing to meet these targets are those who restrict their energy intake and food variety.

The new way to consider protein needs, however, is to consider its role in promoting the outcomes of training – and in particular, the way the body adapts to the type of exercise undertaken in each workout. The response to training is specific to the stimulus and proportional to the training load. Every athlete knows that strength training is very different from endurance training, and the result is that the muscle makes more of the specific proteins it needs to cause the muscle to perform better. Dietary protein plays an important role in this response to exercise. The amino acids that make up the proteins in the foods that we eat are used as the building blocks for the manufacture of new tissue, including muscle, and for the repair of damaged tissue. They are also the building blocks for hormones and enzymes that regulate metabolism, support the immune system and other body functions. Protein provides only a small source of fuel for the exercising muscle.

When this approach to protein needs is taken, the focus becomes how to promote optimum protein synthesis in the period of recovery and adaptation from each workout. The following ideas have emerged:

Eating a source of high quality protein soon after exercise is part of the process of promoting muscle protein synthesis. High quality protein, particularly from animal sources (e.g. dairy, meats, eggs etc) is especially valuable.

The amount of protein required to maximise this response to exercise is quite modest – about 20-25 g. Greater amounts of protein than this are simply burned as fuel.

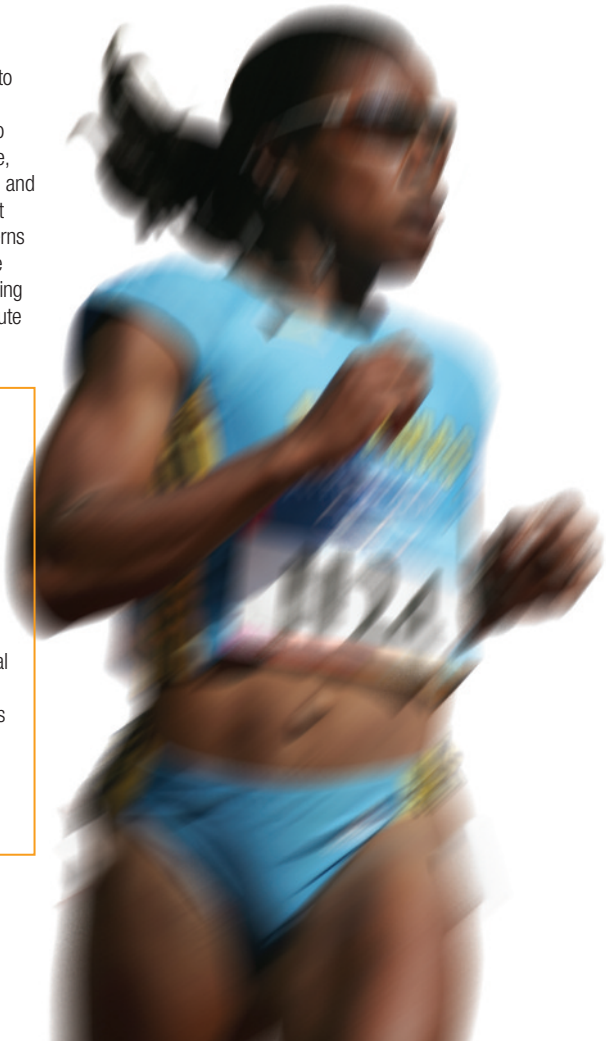
It may help to choose a protein source that is rapidly digested as the post-workout protein boost. Whey protein fits this profile, which explains its popularity for post-workout recovery. This can easily be found in everyday dairy foods and drinks. Nevertheless, sometimes there can be value in using a more compact form that is easy to

carry and prepare around the exercise session – such as a liquid meal supplement or a simple protein powder. There is no justification for the more expensive protein powders or amino acid formulations with extra ingredients and fancy claims.

We know that the muscle is stimulated to increase its protein synthetic rates for up to 24 hours after a workout. How best to organise our protein intake over the day to utilise this is still unknown. It makes sense, however, to spread protein over the meals and snacks consumed over the day. This is not something that our traditional eating patterns always achieve, since most people eat the majority of their protein intake at the evening meal. It may be more sensible to redistribute protein intake to other meals in the day.

Protein rich foods:
10 g protein is provided by:

- 2 small eggs
- 300 ml cow's milk
- 20 g skim milk powder
- 30 g cheese
- 200 g yoghurt
- 35-50 g meat, fish or chicken
- 4 slices bread – 90 g breakfast cereal
- 2 cups cooked pasta or 3 cups rice
- 400 ml soy milk – 60 g nuts or seeds
- 120 g tofu or soy meat – 150 g legumes or lentils
- 200 g baked beans – 150 ml fruit smoothie or liquid meal supplement



Water and salt needs for training, competition and recovery

Athletes generally appreciate the need to drink before, during and after exercise and the importance of sometimes using drinks that contain added carbohydrate and salts. Some athletes, however, do not drink enough while others drink too much so it is important to learn the practical aspects of: a) when it may be helpful to drink during exercise b) how much to drink, c) what type of drinks are best, and d) what modifications should be made in hot or cold environments.

Just as general training and competition strategies should be tailored for individual athletes in accordance with their unique needs and preferences, so should their drinking and eating choices during exercise. Athletes, coaches and trainers should 'fine tune' these recommendation to identify their own winning formula.

When is helpful to drink during exercise?
Fluids consumed during exercise can play a number of roles. These include making the athlete feel more comfortable, replacing a body fluid deficit, and providing a means to consume other ingredients. The importance of each of these roles will vary according to the situation.

It is seldom necessary to drink during exercise that lasts less than about 40 minutes, but some athletes feel better after rinsing the mouth with cool drinks and this should do no harm.

Meanwhile, during training or competitions sessions lasting longer than this, there may be opportunities and advantages to drinking during the session. When it is not possible to drink during 'heavy sweating' type exercise lasting longer than 30 min, an alternative is to hydrate well just before starting the session. The athlete should practise drinking during the 15 minutes before exercise and find how much is initially filling but comfortable once exercise begins (e.g., 300-800 ml).

How Much to Drink?
Sweating causes a loss of water and salts from the body, but water is also continually lost in the breath and through the skin even though these losses may not be obvious. Small losses of water have no effect on performance, but severe dehydration is harmful to performance. There is no clear evidence on the point at which performance begins to be affected and this almost certainly varies between individuals as well as depending on the type and duration of exercise and on the environmental conditions.

Athletes are often advised to drink only when thirsty, but this may not always be a reliable guide. Furthermore, the rules and opportunities to drink fluids in many sports may not coincide with the times that thirst hits. A more targeted option is to develop a fluid plan to fit the sport, the individual and other nutritional needs. As a starting point, the athlete should try to drink at a rate that replaces enough of their sweat losses so that the overall fluid deficit for a training session or competition is kept to no more than about a 2% loss of body mass (i.e. 1.0 kg for 50 kg person, 1.5 kg for a 75 kg person, and 2 kg for a 100 kg person). In warm environments, dehydration and exercise

intensity interact to increase the risk of impaired performance and heat illness. When rates of sweat loss are very high, it isn't always practical to drink enough to keep fluid deficits below this target. A more feasible alternative is simply to try to minimize dehydration.

In some situations, athletes over-hydrate during exercise – drinking more than their sweat losses. There may be some reasons when this is justified; for example, the case of the athlete who starts a workout or event already dehydrated. However, problems can occur when the fluid intake is excessive, leading to a serious problem called hyponatraemia (dilution of blood sodium concentrations). This is most often seen in recreational exercisers who work at low intensities but drink large volumes of fluid in the belief that they are doing the right thing.

In all of these situations, it can help for an athlete to have a feel for their typical sweat rates and how hard or easy it is to drink to keep pace with these. The guide below provides some ideas on to how to check this.

When do you need more than water?
Although hydration is a key focus of nutrition strategies during exercise, fluids consumed during exercise can contain a range of ingredients. In terms of proven performance benefits, no nutrients match water and/or carbohydrate.

During exercise lasting longer than 1 hour and which elicits fatigue, athletes are advised to consume a source of carbohydrate that is rapidly converted to blood glucose. This generally improves performance – allowing the athlete to maintain pace, skills and concentration instead of succumbing to fatigue. As outlined in the earlier section on Carbohydrates in competition, the targets for carbohydrate during exercise will vary according to the athlete's preparation (how well fuelled), the fuel needs of the event (duration and intensity of the session) and individual tolerance.

The use of commercial sports drinks with a carbohydrate content of about 4-8% (4-8 g/100 ml) allows carbohydrate and fluid needs to be met simultaneously in most events. This carbohydrate can come from sugars (i.e., sucrose, fructose, glucose), maltodextrins or other rapidly digestible carbohydrates. It is best for athletes to stick to well-known sport drinks with which they are familiar to avoid gastrointestinal distress or other consequences. Some athletes can tolerate more concentrated drinks, especially if these contain mixtures of sugars. Practising with these drinks in training will help the gut to cope better during competition.

Typically, when carbohydrate is consumed during exercise, it is best consumed in a pattern of frequent and continued intake. This will provide a constant stimulation of the brain and central nervous system, or when needed, a constant source of additional fuel for the muscle.

Sodium should be included in fluids consumed during exercise lasting longer than 1-2 hours or

by individuals during any event that stimulates heavy sodium loss (i.e., more than 3-4 grams of sodium, see next page for assessment).

Caffeine contained in commonly available beverages and foods can enhance endurance or performance during the later stages of prolonged exercise. This benefit can be obtained with relatively small doses of caffeine (about 2-3 mg/kg body mass or 100-200 mg caffeine). This is equivalent to 1-2 cups of brewed coffee or 750-1500 ml of a cola beverages as commonly consumed by people of various cultures. Various sports products (gels, drinks etc) may also provide a convenient low dose serve of caffeine.

Rehydration after exercise

Replacement of water and the salts lost in sweat is an essential part of the recovery process. Since sweat and urine losses continue to occur during recovery, the athlete will need to drink about 1.2-1.5 litres of fluid for each kg of weight loss in training or competition to compensate and fully restore fluid losses.

Sodium, the main salt lost in sweat, also needs to be replaced. Sodium replacement can be achieved via sodium-containing fluids such as sports drinks and pharmacy oral rehydration solutions. However, simply a meal or snack can supply the salt that is needed. This may be because the foods are salt-containing (e.g. breads, breakfast cereals, cheese, processed meats) or because salt is added in the preparation or serving of the meal.

Recovery after exercise is part of the preparation for the next exercise session, and rehydration should be considered as an important part of the equation.

Special strategies

Athletes who have dehydrated to make weight will need special strategies for drinking before and during competitions to optimise performance. These athletes will benefit from the advice of a qualified and experienced sports nutrition professional.

Athletes training and competing while practising fasting during the month of Ramadan must rehearse a hydration strategy that preserves performance and protects health.

Just like new shoes, don't try out new plans for fluid and fuel intake during important competition. Do it in practice and find what fits you best.

Practical ways to assess and manage hydration

Severe dehydration impairs performance and increases the risk of heat illness, but drinking too much can also be harmful or uncomfortable. Every athlete is different because they have different sweat losses and different opportunities to drink fluid during their workouts and events. You need a personal hydration plan and YOU have to play a role in developing this

Remember that humans do not adapt to dehydration, but may learn to complain less about it. Three simple steps may help to guide your hydration practices

1. Start the session well hydrated. If you are passing urine less often than normal, you may be dehydrated. If urine colour becomes darker than what is normal for you, then you may not be drinking enough. Check your urine colour against the chart.

Note that the aim should NOT be for your urine to be as pale as possible. Drinking too much can be uncomfortable and, if excessive, possible harmful. The aim is to develop fluid practices over the day that keep pace with regular fluid needs and special losses from exercise or hot environments. As losses change, so should drinking practices. It makes since to spread fluid intake over the day rather than trying to play catch up at the end. Drinking more than you need in the late part of the day can mean interrupted sleep due to toilet breaks.

2. Develop a drinking plan for training and competition that is right for you. This should be based on several pieces of information including your typical sweat losses, the opportunities to drink in your sport, and feedback from comfort and thirst.

Monitor your sweat losses and the success of your drinking plan during training sessions in different situations (see box). How did you feel? How did you perform? What was your weight loss over the session? This should generally not exceed about 1-2% of body mass. If you lost more than this, you probably did not drink enough. Drink more next time. If you lost less, you might have drunk too much. Did it make you feel uncomfortable? Did you take time out to drink that was unnecessary?

Drinking so much that you gain weight during competition is never likely to be a good idea. The only time you might need to do this is when you have been dehydrated at the start of the event.

3. If you are a "salty sweater", you may need drinks with more salt and may need more salt in food when sweat losses are high. To check whether you are a salty sweater, wear a black T-shirt in training and look for salt stains (white powder) under the arms and on the chest.

High salt losses may be a contributing factor in some cases of muscle cramp. Sports drinks with higher salt (sodium) levels (e.g. 300-500 mg sodium per 500 ml liquid) may help reduce the risk of cramps.

How to estimate sweat losses and sweat rates:

1) Measure body mass both before and after at least one hour of exercise under conditions similar to competition or a hard practice.

2) Take these body mass measurements wearing minimal clothing and while bare footed. Towel dry after exercise and obtain body mass as soon as is practical after exercise (e.g. less than 10 min, and before eating, drinking or going to the toilet).

Example: Pre-exercise weight = 74.5 kg
Post-exercise weight = 72.8 kg
Fluid deficit = 1.7 kg

3) Estimate the weight of any fluid or foods you have consumed during the workout

Example: 800 ml of fluid = 800 g or 0.8 kg).

4) Sweat loss (Litres) = Body mass before exercise (in kg) - Body mass after exercise (kg) + weight of fluids/foods consumed (kg).

Example: 74.5 kg – 72.8 kg = 1.7 kg deficit
+ 0.80 kg (800 ml fluid) = sweat loss of 2.5 kg or 2500 ml.

To convert to a sweat rate per hour, divide by the exercise time in minutes and multiply by 60.

5) Your weight deficit at the end of the session provides a guide to how well you hydrated during the session, and how much you need to rehydrate afterwards.

To convert kg to % body mass, divide the weight deficit by starting body mass and multiply by 100:

Example: 1.7 kg/74.5 X 100 = 2.3%

Note: 2.2 pounds equals 1.0 kg and converts to a volume of 1.0 litre or 1,000 ml or 34 ounces of water.

1 Pale Yellow

2 Straw

3 Golden Yellow

4 Golden Orange

5 Pale Amber

6 Amber

7 Rich Golden Amber

8 Copper Brown

9 Orange Brown

10 Mid Brown

11 Ruby Brown

Use this chart (left) to check your urine colour. If the colour is dark, you may need to drink more.

Vitamins, minerals and phytochemicals

Vitamins and minerals are chemicals that help the body to function smoothly by acting as co-factors in metabolism. Some vitamins and minerals also have a role as antioxidants to mop up the free oxygen radicals that are formed as a by-product of metabolism. Other minerals form important tissues such as the calcium in bones. In short, they are important for maintaining optimum health and function. Athletes often want to know if their training programs create special needs for additional intakes of vitamins and minerals. It is likely that this might be the case for at least some nutrients, but a well-chosen diet based on adequate energy intake can easily meet any increased demands.

Dietary surveys show that most athletes are well able to meet the recommended intakes for vitamins and minerals by eating everyday foods, such as fruits, vegetables, whole grains, lean dairy and meats. Those at risk of sub-optimal intakes of these micronutrients include:

- athletes who restrict their energy intake, especially over long periods to meet weight loss goals
- athletes who follow eating patterns with restricted food variety and reliance on foods with a poor nutrient-density

The best way to correct this situation is to seek advice from a sports nutrition expert such as a sports dietitian. When food intake cannot be adequately improved – for example, when the athlete is travelling in a country with a limited food supply - or if an individual is found to be suffering from a lack of a particular vitamin or mineral, then short-term supplementation may be warranted. This should be undertaken with the advice of a qualified sports nutrition expert. In general, a broad-range multivitamin/mineral supplement is the best choice to support a restricted food intake, although targeted nutrient supplements may be necessary to correct an established nutrient deficiency.

There are some special micronutrients and other food chemicals that merit special mention and discussed below.

Antioxidant nutrients

We know that free oxygen radicals are produced during normal metabolism, and that our body develops antioxidant defence systems to neutralise these chemicals and the damage they can cause. We also know that exercise causes an increased production of these radicals, and many athletes feel that antioxidant supplements may help to protect them against this elevated level of harm. Vitamins C and E supplements have been popularly used for this purpose.

More recently, however, there have been changes to such thinking.

It seems unnecessary to provide large doses of a few antioxidant vitamins when the body has its own mechanisms to increase a more complex antioxidant defence system. In fact, supplementation may unbalance the system and cause more harm than good.

There may be some benefits associated with the production of free oxygen radicals – new evidence shows that they function as signals to promote important adaptations to training. It is possible that the use of antioxidant supplements may actually neutralise some of the signalling that underpins recovery and adaptation to a workout, which means that antioxidant supplementation could reduce the effectiveness of a training program.

Foods contain a large variety of health promoting chemicals in addition to vitamins and minerals. These products – usually called phytochemicals or phytonutrients – promote function and health in our body as antioxidants, anti-cancer agents, and many other roles. The names of some of the chemicals include quercetin and ECGC., New studies are continually investigating whether supplemental forms of these products could be useful for health and performance. To date, these studies haven't been able to translate the potent health benefits known about these products into a functional output. Therefore, at present, the most effective way to approach these chemicals is though eating them in plentiful amounts in food.

Ideas for promoting dietary variety and nutrient-rich eating to achieve a plentiful intake of vitamins, minerals and phytochemicals:

Be open to trying new foods and new recipes and make the most of foods in season.

Explore all the varieties of different foods such as different types of fruits, vegetables and grains

Mix and match foods at meals, such as salads and soups.

Think carefully before banishing a food or group of foods from your eating plans.

Find substitution foods that have similar nutrients when excluding a food group from your diet.

Include fruits and/or vegetables at every meal and snack. The strong and bright colours of many fruits and vegetables are a sign of a high content of various vitamins and phytonutrients. Aim to fill your plate with a rainbow of highly coloured foods to ensure a good intake of these health-promoting dietary compounds.

Vitamin D

Vitamin D is classified as a fat-soluble vitamin which acts as a hormone. It has important functions in the body including maintenance of good bone health, muscle function and immunity. Vitamin D is found in some foods, but our major source comes from sunshine exposure. There is evidence that many people have deficient or sub-optimal vitamin D status. Vitamin D deficiency can lead to several health issues including increased risk of bone injuries, chronic musculoskeletal pain and viral respiratory tract infections. Reversal of sub-optimal vitamin D status in athletes may have beneficial effects on athletic performance and health.

Athletes at risk of vitamin D deficiency include those who have the following characteristics:

- train indoors
- have dark skin
- live further away from the equator
- wear clothing that covers most or all of their body
- regularly use sunscreen or consciously avoid the sun

Such athletes should be screened for poor vitamin D status and if levels are sub-optimal, a course of vitamin D supplementation, and perhaps judicious, sunshine exposure should be undertaken under medical supervision.

Iron

Iron plays an important role in the transport of oxygen in the blood (as haemoglobin) and muscle (as myoglobin), and inadequate iron status can obviously impair performance and recovery. There is some evidence that an athlete's iron requirements may be elevated due to increased levels of loss due to their training load. However, most athletes who become iron deficient or anaemic do so because of poor iron intake. Athletes who are at high risk of such problems are those who restrict energy intake and dietary variety. Since meats, including fish and poultry, are a major source of well absorbed iron, vegetarian eaters will need to plan their meals carefully to find alternative iron sources. Females are also at risk because of increased iron requirements due to menstrual blood losses matched against a smaller food intake. Iron-rich eating will help to reduce this risk. Athletes who are at risk of poor iron status should be monitored periodically. Athletes who are undertaking altitude training also need to have iron status monitored to ensure they have sufficient iron stores to allow the adaptations to their specialised training demands. Routine use of iron supplements is not recommended: too much iron is just as harmful as too little. Self-medication with iron supplements may not address the real causes of an athlete's fatigue or other issues of poor eating.

Iron rich eating strategies.

Consume moderate servings of red meats (well-absorbed iron) in 3-5 meals per week.

Choose iron-fortified cereal products such as breakfast cereals.

Combine plant and non-meat sources of iron (e.g. legumes, cereals, eggs, green leafy vegetables) with food factors that enhance iron absorption.

These include vitamin C and an iron enhancing factor found in meat/fish/chicken. Examples of clever matching include fruit juice or fruit with breakfast cereal, or chilli con carne (meat and beans).

Calcium

Calcium is important for healthy bones, especially in adolescents and in female athletes, so it is important to ensure adequate calcium intake. The best sources of calcium are dairy foods, including low fat varieties.

Calcium rich eating strategies.

Each athlete should aim to include at least 3 servings of these foods in their daily eating plans:

- glass of milk
- slice of cheese
- carton of yoghurt.

Additional daily servings are required during growth spurts in childhood and adolescence, and for pregnancy and lactation

Calcium fortified soy foods may provide a useful substitute when an athlete cannot consume dairy foods.

Supplements and sports foods

Athletes look to sports foods and nutritional supplements for many benefits, including those listed below

- promoting adaptations to training
- increasing energy supply
- allowing more consistent and intensive training by promoting recovery between training sessions
- maintaining good health and reducing interruptions to training due to chronic fatigue, illness, or injury
- enhancing competitive performance
- providing a convenient source of nutrients that are easy to consume when everyday foods are unavailable or impractical to eat. This is most often the case just prior to, during, or after an exercise session.

Sports foods are generally manufactured to achieve the last of these goals. By providing a practical way to meet special nutrition needs they may indirectly assist the athlete to achieve some of the benefits on the list. Examples of useful sports foods include:

- sports drinks (providing fluid, electrolytes and carbohydrate during exercise)
- sports gels (additional carbohydrate intake, especially during exercise)
- liquid meals (carbohydrate, protein, vitamins and minerals for a pre-event meal, post-exercise recovery or a high-energy diet)
- sports bars (carbohydrate, protein, vitamins and minerals – often a solid form of the liquid meal)

Of course, the cost of these sports foods must be considered before using them. Athletes should recognise that the sports food market includes products that are carefully manufactured to provide nutrients to meet well documented goals right through to gimmicky items that have a poor composition or the addition of ingredients with a poor evidence base.

The use of pills, potions, powders and other sports supplements is widespread among athletes, but few products are supported by sound research and some may even be harmful to the athlete. Athletes should carefully examine the risks and rewards of individual supplements before using them.

Where there is a demonstrated deficiency of an essential vitamin or mineral, and an increased intake from food is not possible, a supplement may be h. For example, other sections of this booklet have noted that athletes with a diagnosed deficiency of iron or vitamin D may benefit from a course of supplements, but this should be done only if a blood test shows it to be necessary. The use of supplements, however, does not compensate for poor food choices and an inadequate diet. A much better option is to learn about nutrition and foods so that you can choose foods to ensure that your nutritional needs are met. A well-chosen diet will promote an adequate intake of the essential vitamins and minerals.

Protein powders and supplements

Protein supplements, high protein bars and amino acid preparations are among the biggest selling sports nutrition products. An adequate intake of protein is essential for muscle growth and repair, but this can usually be achieved from everyday foods and expensive supplements are seldom required. When there is a case for a more practical source of high quality protein, the preferred protein supplements are listed below:

Protein-carbohydrate supplements (known also as liquid meal supplements). These provide an easily prepared and rapidly digested source of the major nutrients needed for recovery after exercise (helping with repair, rehydration and refuelling). In addition, they can provide an easily consumed source of energy or help meet energy and nutrient needs while travelling.

A simple whey protein powder; whey, is a high quality milk protein, that provides a rapidly digested source of leucine and other essential amino acids. A whey protein powder may be useful when repair and adaptation is the main recovery need, or when a quick fix is needed to add quality protein to a sub-standard meal. There is no evidence that fancy versions of whey protein, with special preparation techniques or other ingredients, are superior to simpler products. A serving that provides 20-30 g of whey protein is adequate to meet needs at a single meal or snack.

Fat reduction and muscle building

A huge array of supplements, claiming to reduce body fat levels and build bigger and stronger muscles – appeal to athletes and non-athletes alike.

The reality is that most products that are effective in doing increasing lean tissue and decreasing body fat are either on the banned list or are associated with serious health risks (or both). Many weight-loss supplements have been shown to contain prohibited drugs that are not listed on the label, which can lead to failed drug tests.

Compounds in the muscle building category include chromium, boron, hydroxymethylbutyrate (HMB), colostrum and others. Based on current research, none of these has anything worthwhile to offer the athlete.

Increasing energy supply

Supplements in this category include pyruvate and ribose as well as some more exotic herbal preparations. None of these products is likely to improve performance and, in spite of advertising claims, none is supported by good independent evidence. One exception to this rule may be carnitine. There is now limited evidence that carnitine can affect exercise metabolism in some circumstances, but the evidence for performance effects is not yet convincing.

Nutrition and the immune system

There is some evidence that athletes who are training hard may be at increased risk of minor illnesses and infections. In themselves, these are generally trivial, but they can interrupt training or cause an athlete to miss important competitions. Hard training may compromise the body's immune system, and high levels of stress hormones reduce its ability to fight these infections.

Many nutrition supplements, including glutamine, zinc, echinacea, colostrum and others, claim that they can boost the immune system, but there is no strong evidence that any of these products are effective. The best strategies to support a healthy immune system include scheduling appropriate rest periods, and matching energy and carbohydrate intake to fuel needs. There is good evidence that carbohydrate intake during prolonged exercise reduces the release of stress hormones. There is also evidence that probiotics, such as the lactobacillus found in yoghurts, may also assist gut health and the immune system.

Supplements for bone and joint health

Hard exercise training puts extra wear and tear on the bones, joints and associated structures, and numerous supplements are claimed to protect and repair these tissues.
Healthy bones need a good supply of calcium, magnesium, phosphorus, Vitamins D and C and protein. In most cases these nutrients can be supplied by a well-chosen diet and appropriate sunshine exposure. Athletes who suffer from problems related to sub-optimal bone density should seek professional advice and supervised treatment from a sports physician.

Glucosamine, chondroitin, methylsulphonylmethane (MSM) and other products are promoted for joint health. There is some evidence that long-term (2-6 months) glucosamine treatment can provide subjective relief in elderly individuals suffering from osteoarthritis, but evidence is lacking for a benefits such as a "joint protective" effect from high-intensity training in healthy athletes.

Supplements that might work

Some supplements do offer the prospect of improved performance for some athletes in specific events. These supplements include creatine, caffeine, bicarbonate, β-alanine and perhaps a very few others.

Creatine. Creatine supplements can increase the amount of high energy phosphocreatine stored in the muscles, and may improve performance in single or multiple sprints. Supplementation may also lead to gains in strength and/or muscle mass, which is helpful for some athletes but the extra weight may be harmful for others. As with all supplements, exceeding the maximum effective dose is not helpful. Creatine is normally found in meat and fish, but the effective doses (10-20 g per day for 4-5 days to load, and then 2-3 g per day for maintenance) are more than is found in normal foods. Creatine supplementation does not appear to be harmful to health.

Caffeine. A small amount of caffeine (1-3 mg/kg) can help performance in prolonged exercise and may also be helpful in exercise of shorter duration. Such moderate doses can be found in everyday amounts of coffee, cola drinks and some sports products (e.g. gels). For example, 100 mg of caffeine is supplied by a small cup of brewed coffee or 750 ml of a cola drink. Larger doses of caffeine do not seem to be more effective, and may have negative outcomes such as anxiety, gastrointestinal distress, over-arousal and poor sleep patterns. This is likely to be a problem in multi-day events and in sports involving heats and finals.

Energy Drinks. These sugary caffeinated drinks should not be confused with sport drinks that are designed to rehydrate the body during exercise. In fact, energy drinks are a poor choice to consume when exercising (especially in the heat) due to high sugar content that can impair fluid absorption. While energy drinks may seem refreshing and hydrating, they should not be consumed before, during, or after exercise when you need to replace sweat loss. These drinks may also be potentially dangerous if used in excess or in combination with other stimulants or alcohol. Lastly, energy drinks may be tainted with prohibited substances, such as those derived from unregulated herbals. Most drinks are not tested for purity or contamination, and could lead to a positive doping test.

Buffering agents. During very hard exercise, the muscles produce lactate and hydrogen ions (acidity). This is both good (giving energy to allow hard efforts) and bad (causing pain and interfering with muscle function). In the same way that excess stomach acidity can be neutralised by taking bicarbonate, so can taking sodium bicarbonate in a dose of about 0.3 g per kg body mass before an event provide the blood with extra capacity to buffer the acidity produced by the muscle. This can reduce the fatigue and performance decline seen in all-out events lasting from about 30 seconds to 8 minutes, and perhaps in team games in which there are repeated efforts of this nature.

There is a risk of gastrointestinal problems, and athletes should experiment in training. Sodium citrate is another buffering agent, but appears less effective. More recently, chronic intake of β-alanine supplement over 4-10 weeks has been shown to increase muscle levels of carnosine, an important buffer. There is some evidence that this might improve performance in some high intensity exercise models, but further work is required to be sure of the range of situations in which it might be useful. In some events there may be benefits from combining β-alanine supplementation (internal muscle buffer) and bicarbonate loading (external buffer in the blood) to maximise buffering potential.

Nitrate. Short-term supplementation with nitrate may reduce the amount of oxygen required to do a set amount of work. This increased efficiency might improve performance in events lasting a few minutes or longer. Many vegetables, including beets, are high in nitrate; thus, beetroot juice has become a popular supplement with athletes. More research is needed to confirm the efficacy of beetroot juice/nitrate supplementation on performance and to determine the range of events in which it might be useful. Although increasing nitrate intake through vegetable consumption is not harmful, the safety of using nitrate powders is yet to be studied.

Supplements and doping

Athletes who are liable for drug testing under national or international programs should be especially cautious about supplement use. Some supplements are prepared in unhygienic conditions and contain toxins that may cause gastrointestinal problems. Others do not contain some or all of the ingredients - especially the expensive ones – that are listed on the label. Contamination of dietary supplements with substances that may cause an athlete to fail a doping test is widespread – some surveys have suggested that as many as one in four supplements may result in a positive test. These prohibited compounds have not been declared on the label, so there is no way for the athlete to know that they are present. Purchases through the internet pose an even greater risk, and extreme caution should be taken. A sports nutrition expert should be consulted before taking any supplements.

At present, there can be no guarantee of the purity of any commercial supplement. The only way to be sure is to avoid supplements altogether, but many athletes are unwilling to accept this advice. The sensible athlete will want to see very good reasons for using a supplement and a very low risk of an adverse test before deciding to use it.

Many herbal supplements claim to increase testosterone levels and hence have an anabolic action. These supplements include the follwoing: Tribulis Terrestris; Chrysin; Indole-3-Carbinol; Saw Palmetto; Gamma-oryzanol; Yohimbine; Smilax; Mummio. These claims are based on studies in test tubes and none have been shown to work in humans. Athletes are cautioned against the use of these supplements.

Athletes must be aware of the strict liability principle that makes them responsible for everything they eat and drink. Ignorance is not an acceptable excuse for a positive doping result.

Check all supplements with a medical officer or qualified sports nutrition professional. If there is any doubt at all, don't take it.

Issues to consider when deciding to use a sports food or supplement

- Is it safe?
- Is it legal?
- Is there evidence that it works at the dose recommended?
- Am I aware of the correct protocols of how and when to take it?
- Can I afford it?

Nutrition needs for special populations

The young athlete

Every child and adolescent around the world should have the opportunity to participate in sport and should be encouraged to do so. Sport offers the benefits of aerobic fitness, skill development, and experience working in a team environment. Girls and boys can start practising and competing at an early age, though the focus should be on fun and skills development rather than performance. Nonetheless, most children are naturally competitive and it would be a mistake to suppress this instinct. Those with particular talent may progress to serious training and competition, but others continue for reasons of recreation, fitness or social contact.

Training issues

Depending on the age and calibre of the young athlete, "training" may range from the weekly school PE lesson to structured sessions at a local club. The goals of training may range from simply having fun to a progressive program aimed at developing the skills and specific fitness and physique required to progress to serious competition. Talented young athletes may be invited to train with another age group or with a senior squad, often in addition to their involvement with their age-group team.

Competition issues

For the youngest age groups, there should be no special need for any change to diet in the days before competition or on competition day itself. The main dietary aims are to minimise the risk of gastrointestinal upset and to avoid problems of dehydration on hot days. It may be best to avoid solid food for 2-3 hours before competition – the combination of exercise and nerves can cause some gastric distress.

Children can often be out in the sun for many hours on sports days, and adults should be vigilant to ensure frequent application of sun cream and be aware of any child who seems to be having problems. Ample fluid should be available, and children may need to be reminded to take small amounts of drinks at regular intervals.

Special issues and eating strategies:

Parents are often asked to serve as coaches and trainers of age-group teams. They may accept these positions without an appreciation or knowledge of the nutritional needs of the sport or young people, and without any resources to implement an effective training and diet program. It is important that education resources are made available to these coaches so that they can guide young athletes into good habits.

Athletes should be encouraged to develop good nutritional habits at an early age. Adolescence is a time marked by an increased independence, and this extends to greater freedom of food choice and responsibility for food preparation. The promise of sporting success may provide strong motivation to develop good dietary practices. Information and the example of good role models may help a young person to develop sound eating practices in everyday (training) diets as well as the specific preparation for competition.

The physiology of children and adolescents differs from that of adults in several ways. The mechanisms of thermoregulation are less effective in children, and special attention must be paid to the environment, activity patterns, clothing and hydration to avoid problems of hyperthermia or hypothermia.

The growth spurts during childhood and adolescents require nutritional support including adequate intake of energy, protein and vitamins and minerals. Active young people may find it difficult to meet their needs for energy and nutrients when the costs of training and growth are added. Young people may not have developed the nutritional knowledge and time management skills to fit in all the eating occasions required to achieve high energy, nutrient-rich eating.

Although the rate of obesity in children is still rising, active youngsters and young athletes still need a plentiful supply of energy from foods, including nutritious snacks between meals and energy-containing drinks. A snack before and after school or afternoon activities will be valuable in providing extra fuel for the session as well as an energy boost during the long period between lunch and dinner.

Young athletes have been shown to drink more of a flavoured drink than water during activity, which may be an important consideration for promoting fluid intake, especially if exercise is in the heat. They may also be involved in sports in which there are benefits to consuming carbohydrate during exercise to supply an additional source of muscle fuel. Therefore, there may be legitimate benefits to making sport drinks available to young athletes during exercise.

After exercise, recovery is promoting by speedy intake of protein, carbohydrate and fluids. Snacks consumed before and after the workout may need to be eaten in the car or while travelling between activities. However, there are many portable nutrient-rich choices that can be consumed "on the run" including sandwiches, cereal and milk, flavoured milk drinks, yoghurt and other dairy foods, fruit and dried fruit/nut mixes. It is not always possible to find appropriate choices at sporting venues, so it is wise to plan ahead. Many children and adolescents are not aware of their hunger until they become fatigued or suddenly ravenous so it is good to educate them about being organised and preparing ahead of time.

Many young athletes are eager to increase the rate of their growth and muscular development in pursuit of the physique of an adult. While growth and maturation are genetically determined, high-energy eating plans can assist the young athlete to maximise the outcomes of growth and specialised training programs.

Young athletes eating a wide range of foods should not need to use dietary supplements, including the use of energy drinks that contain high amounts of caffeine and are not suitable for young athletes. Athletes and coaches should be aware that supplements do not provide a short cut to success.

Ways to encourage good nutrition practices in children

Encourage children to become involved in menu planning for the family meals, and for special needs associated with their training and competition sessions.

Encourage positive messages that good eating practices, involving good choices of foods and drinks, are part of the formula for sporting success, and a healthy life.

Plan ahead to have nutrient-rich snacks to meet energy needs over the day, and the special needs of fuelling up for sport or recovering after the session. Some preparation is needed to have these choices on hand throughout the day, and before or after sport.

The female athlete

As well as the specific nutritional needs of their sport, female athletes face some additional dietary needs and challenges to their male counterparts:

- Having additional requirements for some nutrients (e.g. iron).
- Having lower energy requirements due to low body mass and muscle mass, and perhaps a lighter training load.
- Facing pressure to achieve lower levels of body fat than seems natural or healthy for their body.
- Greater risk of succumbing to stress related to body image and food.

Information related to good practice in these areas is found in other sections of this booklet. However, it is worth noting here that there is enormous pressure on many female athletes to achieve an unrealistic body mass and body fat level. This can compromise both short-term athletic performance and long-term health, with the real possibility of harm to reproductive and bone health. Any athlete with menstrual irregularities should treat this as a possible warning sign, and seek professional advice. Female athletes, and indeed any athlete who develops stress related to eating and their physique, should seek expert help at an early stage.

Eating while travelling

Most elite athletes are well-seasoned travellers, seeking competition or specialised training environments far away from home. In many team sports, high-level competition is organised in a national or regional league that requires weekly or biweekly travel to matches. Frequent travel can pose a number of challenges, some of which are listed below:

- Disruptions to the normal training routine and lifestyle while en route.
- Changes in climate and environment that create different nutritional needs.
- Jet lag
- Changes to food availability, including absence of important and familiar foods.
- Reliance on hotels, restaurants and takeaways instead of home cooking.
- Exposure to new foods and eating cultures.
- Temptations of an "all you can eat" dining hall in an Athletes' Village.
- Risk of gastrointestinal illnesses due to exposure to food and water with poor hygiene standards.
- Excitement and distraction of a new environment.
- Changes in digestion and/or pattern of bowel movements due to travel.

The keys to eating well while travelling are provided below:

1. Planning ahead

Investigate food patterns and availability at your destination before you leave home. Competition organisers and athletes who have undertaken this event on previous occasions may be able to supply useful information on what to expect. This may help you to plan useful food supplies to take on your travels that can replace missing and important items.

Contact the catering organisers at your destination to let them know of your special dietary needs and your needs for meal timing and menus.

Make an eating plan for travel that incorporates the best of the available food supplies (e.g. airline catering, restaurants en route) as well as self-supplied snacks.

2. Eat and drink well while on the move

Recognise that enforced rest while travelling will reduce energy needs, but create more opportunities for excessive energy intake if you succumb to "boredom eating". Be aware of eating to real need.

When moving to a new time zone, adopt eating patterns that suit your destination as soon as the trip starts. This will help to adapt your body clock.

Be aware of unseen fluid losses in air conditioned vehicles and pressurised plane cabins. Have a drink plan that keeps you well hydrated.

3. Be wary of food and water hygiene

Find out whether it is safe to drink the local water supply. If risky, stick to sealed bottles of water and other drinks or hot drinks. Be wary of ice added to drinks – it is often made from tap water.

In high-risk environments stick to food produced in good hotels or well-known restaurants. Avoid eating food from local stalls and markets, however tempting it is to have an "authentic cultural experience".

Stick to food that has been well-cooked, and avoid salads or unpeeled fruit that has been in contact with local water or soil.

4. Choose well from local cuisine and supplement with non-perishable food supplies brought from home.

It is often a good idea to bring some snacks and favourite foods with you, especially if you are away from home for a long time and your favourites are not available at your destination. Remember, though, that many countries prohibit the import of fresh foods: check ahead to see what is permitted so you can avoid having prohibited items confiscated at the airport. Do not take the risk of trying to smuggle food – you may be refused entry.

Ideas for portable foods for the travelling athlete:

- Breakfast cereal
- Powdered milk
- Cereal bars and granola bars
- Rice cakes, crackers, pretzels
- Spreads – honey, jam, peanut butter
- Portion packs of canned fruit
- Tinned or vacuum packed tuna, baked beans
- Powdered sports drinks, liquid meal supplements, whey protein powder
- Meal replacement bars and sports bars
- Dried fruit and nuts

5. Use clever tactics in restaurants and when choosing takeaways

Stick to an eating plan based on what you normally eaten at home or your new nutritional needs, rather than being mesmerised by all the food being offered.

Where possible, organise menus and meal times with restaurants ahead of time, especially when dining with a large group. It is useful to be able to arrive at the restaurant with the meal all ready to be served.

Where possible, consider the advantages of buffet style meal service. It is usually more cost-effective and offers more flexibility in allowing athletes to choose their individual needs and likes.

Be assertive in asking for foods to be prepared to your needs – for example, with low fat cooking methods, or with an added carbohydrate serving.

Avoid hanging around in restaurants or dining halls for entertainment – it can often lead to unplanned and unnecessary eating.

Remember that your normal eating patterns probably involve well-timed and well-chosen snacks. If your new catering arrangements provide only for main meals, ensure that the menu at meals includes some items that can be taken away for snack needs.

Special tips for eating in an Athlete Dining Hall are provided in the next section.

Eating in an Olympic Village Dining Hall

Imagine being able to eat in a self-serve restaurant that is open 24/7, has an almost unlimited menu from International cuisines, input from some of the best caterers and sports nutrition experts in the world, and is free! How could you go wrong?

Unfortunately, although the Olympic Village Dining Hall provides a benchmark in catering for athletes and is a memorable experience for many Olympians, some of those memories may be of lost opportunities and poor nutrition outcomes rather than the opposite. Some athletes fail to achieve the potential of the dining experience and adopt poor nutrition practices at a critical time in their sporting careers. The fault is not the Dining Hall itself, but the failure of some athletes to recognise and respond to the challenges of this new eating environment.

A sudden switch to communal cafeteria-style eating creates the following issues that may be new to many athletes:

Great quantities and many different choices of food. Many athletes are not used to unlimited access to so many wonderful foods. The temptations and opportunities to overeat can be so overwhelming that they become the major reason for weight gain.

Different and unusual foods. Although the menu includes cuisine from around the world, inevitably some athletes find themselves without access to their favourite foods or important menu items in their usual competition repertoire. Athletes may be reluctant to try new things, finding themselves unable to eat enough food or their special nutritional requirements for competition preparation and recovery.

Food boredom. Many athletes live in the Olympic Village for 3-4 weeks. Although this is an exciting period, for the athlete who is training through to competition on the last days of the Games, the daily routine can lose its novelty surprisingly quickly. Even though more choice is offered than most people ever see in their normal lives, the "sameness" of the environment and of repetitive eating habits can become boring. It doesn't help if the athlete has developed the practice of piling a "bit of everything" on their plates at each meal so that there is no new theme or change of menu. Strangely enough, some athletes who are surrounded by fantastic food can become disinterested in eating and find meal times a chore.

Lack of knowledge of the nutritional characteristics of Dining Hall choices. Many athletes don't read English or have a huge knowledge of food from outside their region. They may find it hard to understand what is being offered in the Dining Hall or how to make good choices.

Lack of understanding of how to meet special food needs. Athletes with food intolerances and allergies may not be confident of finding foods that meet their dietary restrictions.

Lack of supervision. For some athletes, the Olympic experience may be their first experience away from the guidance of their parents or

coach. It can be easy to become distracted. Some studies show that our food intake increases as we increase the size of the company sharing our mealtimes. Surrounded by the eating habits of other athletes, it may be difficult to concentrate on your own nutritional goals.

Social eating. An athlete may not have much time or scope for leisure activities during the last busy periods of competition preparation. Alternatively, their competition taper and time away from their usual world of training, study, medical appointments and across town travel may suddenly create a lot of free time in the day. In any case, the Dining Hall becomes a meeting place and entertainment hub where social eating or eating for enjoyment rather than real needs can sabotage the athlete's eating plan.

Many of these issues are faced by athletes who live in University dorms or Specialised Training facilities with cafeteria style eating. With some insight into the new environment and food challenges, sound eating practices can be achieved.

Tips for eating well in communal cafeteria style Dining Halls:

Be clear about your eating goals and how these change during different phases of training and competition.

Be focussed on what you need to eat rather than what other athletes are eating.

On your first visits to the Dining Hall, learn the layout including the different food stations and what they have to offer. Work on the philosophy that there is plenty of time to gradually work your way around the menu options, rather than having to try it all at once. This reduces both the risk of overeating and of developing food boredom. If the menu is available, you can plan ahead to make the most of what is on offer. Within a single meal, survey some options before making a considered choice.

Learn to understand the menu cards and nutritional labels offered. Many foods will have symbols to let you know about the nutritional characteristics of a food, or the presence or absence of ingredients that you need to avoid. If you have doubts, seek advice from Dining Hall staff, particularly the designated nutrition experts or personnel in a Nutrition kiosk. It is likely that your special nutritional needs are available or can be arranged, if they are not immediately obvious.

Find ways to keep yourself busy and entertained, especially during the taper before competition when your energy needs are reduced, or when you are nervous and more vulnerable to temptation. Don't go to the Dining Hall unless it is time for a meal or snack, and move to a new venue to hang out once you have finished eating.

Allow yourself to have some treats or special foods, especially after your event is finished. However, keep perspective on the importance of eating well for your event.

Environmental challenges

Athletes train in every country of the world, and they may face a number of different environmental challenges. The athlete who trains outdoors in winter in Russia or the American mid-West is confronted with wind, snow and bitter cold, while the Saudi Arabian athlete who trains in mid-summer may face temperatures of 50°C and high humidity. In every case, however, athletes learn to cope and it is often a matter of pride never to miss a session because of adverse weather conditions.

Athletes are sometimes required to compete in environments that are very different from those they are accustomed to at home, and this can pose special challenges. Every challenge, though, should be seen as an opportunity, and nutritional strategies can be adopted to help athletes cope with environmental extremes.

London enjoys a temperate climate and there are unlikely to be any extreme conditions at the 2012 Games. Weather records show that the daily temperature high in July and August is likely to be between 21 and 24 °C with moderate humidity, falling to 10 - 12 °C at night. The temperature, however, may reach 35°C, which is enough to affect performance and requires some attention from all competitors. Weather forecasts may be unreliable, and the weather can change very quickly, so you should be prepared for all eventualities.

Special issues for exercise in hot climates

Most athletes enjoy opportunities for warm-weather training and competitions, but these can be challenging for all athletes, especially endurance and team sports athletes.

Those who normally live in cold climates will benefit from a period of heat acclimation before competing in major events held in a hot climate. It is also essential for these athletes to gain heat experience so that they know how to adapt training and competition strategies, as well as drinking behaviours and lifestyle factors when they are suddenly exposed to hot weather.

Heat acclimation is achieved best by undertaking a series of exercise sessions in a warm environment. Undertaking 10-12 workouts of about 60-100 minutes of modest exercise at intervals of not more than 2-3 days will achieve this.

Athletes not used to hot weather must be aware of the need to make some changes to their routine. Some suggestions are provided below:

It may be necessary to modify the warm-up and reduce the amount of clothing worn to prevent over-heating and excess sweat loss before the event begins.

Extra fluids may be necessary. Since cool fluids will be more palatable, insulated drinks bottles are valuable.

There are many strategies involving ice vests, icy towels or cool baths that can help to cool athletes before, during or after sessions in hot environments. Some athletes also drink cold and icy fluids to contribute to these cooling strategies. Since it requires moderate-large volumes of fluid intake to make a difference to body temperature, these and all strategies should be well practised before attempting in a competition setting.

The athlete should consider the side-effects or associated outcomes of all hot weather strategies. For example, an increased intake of sports drinks to meet additional fluid needs will also increase the athlete's energy intake and affect energy balance.

Special issues for exercise at moderate altitudes

Athletes often undertake a period of specialised training at moderate altitudes to use the physiological adaptations it stimulates to assist with their competition preparation. Listed below are a number of adjustments that may help the athlete cope with altitude training:

Altitude camps are often a period of intensified training. The athlete may need to alter their energy intake to allow for the increased training load and the additional stresses of altitude.

As well as the additional muscle fuel costs of the increased training load, there is an increase in carbohydrate use during exercise at altitude. The athlete should be more aggressive with refuelling strategies during a workout, and over the day.

The cold and dry conditions at moderate altitudes cause an increase in water losses during breathing. This can lead to a substantial increase in fluid losses at moderate altitude compared with sea level. The athlete should take additional care to check fluid status over the day and during exercise sessions when they move to a higher altitude, since habitual drinking patterns may need to be adjusted to keep pace with these losses.

Since a move to a higher altitude may increase oxidative damage during exercise, athletes should ensure that their diet is rich in fruits and vegetables to provide essential antioxidants.

Good iron status is needed to maximise erythropoiesis (red blood cell production), which is an adaptive response to altitude exposure. Therefore athletes should consume adequate amounts of iron-rich foods. It may be worth checking iron status before undertaking altitude training.

Special issues for exercise in poor air quality

Athletes often have to train or compete in the polluted environments of big cities, and are faced with high levels of fumes, smog and dust. This can pose special challenges for athletes with respiratory problems such as asthma, but all athletes and support staff may experience minor respiratory problems in some environments. Air quality in London during the Games should be better than in many recent major Championship events.

It has been suggested that antioxidant supplements may help reduce the severity of symptoms by neutralizing free radicals produced in response to airborne pollutants, but the evidence for this is far from clear. Nonetheless, it seems sensible to ensure an adequate intake of fresh fruits and vegetables to ensure good antioxidant defences.

Cultural and regional issues

An infinite variety of different food combinations can be chosen by athletes to meet their nutritional goals. All the essential nutrients can be obtained in adequate amounts from normal foods. Variety is a key to meeting nutrient needs, but many different foods can be interchanged. Preferred sources of carbohydrate may be bread, rice, pasta, potato, couscous, or the maize porridge favoured by many Kenyan athletes. Protein will be provided by many different foods; the obvious protein-rich foods are meat, fish, eggs and dairy produce, but bread, cereals, pasta, lentils and beans also contribute protein to the diet. The commonly available fruits and vegetables will differ from region to region, although many staples or favourites are exported around the globe.

Our eating habits are much more international than they were, and athletes can enjoy foods from different countries of the world. Ethnic restaurants can be found in almost every major city of the world and London is especially well-served with examples of world cuisine. A visit to a restaurant that serves familiar foods may be a special "treat" for athletes and a chance to escape from the Village environment, but these should be checked beforehand. The advice of local athletes may be useful in identifying suitable options.

Considerations for Vegetarians

Many athletes, often endurance athletes and/or female athletes, adopt a vegetarian lifestyle. This personal choice can be very healthy, and is in no way incompatible with success in sport. However, it does mean, that athletes must be more aware of the food choices that they make in order to maintain energy levels, meet training and recovery needs, and to support proper immune function.

Plant-based, high fibre diets are bulky to consume and may cause an inadvertent reduction in total energy intake. This may increase the risk of inadequate energy availability and athletes should monitor body mass and body composition to ensure energy needs are being met.

Some athletes may use vegetarianism as a means to restrict energy intake in order to achieve a desired physique: this seems to be more common in female athletes but affects men too. All athletes should seek help from a trusted health professional if they feel out of control with calorie restriction and/or trying to achieve excessive leanness. Severe calorie restriction may compromise performance as well as reproductive health and bone health.

Although most vegetarians meet or exceed their protein requirements, however, plant protein quality and digestion is decreased and often requires an intake of approximately 10% more protein than if consuming animal proteins. Therefore, protein recommendations for vegetarian athletes are approximately 1.3-1.8 g/kg/day from a variety of plant protein sources. This fact may be of more concern for vegans - those who avoid all animal proteins, including fish, eggs and milk products.

It is still important to find a source of high quality protein to consume in the recovery from key workouts and events. Dairy or soy milk products may be suitable choices for vegetarians and vegans, respectively.

If there are no animal foods in the diet, then a vitamin B12 supplement may be necessary. Some vegan food products, such as meat substitutes are B12 fortified – so it is important if you adopt a vegan lifestyle to learn to read food labels.

Avoiding red meat means that special attention must be paid to ensuring that the diet contains enough iron, especially during periods of rapid growth (e.g., adolescence), for women because of losses during menstruation, and before going to altitude for training or competition. Iron intake from plant sources, should be combined with other foods that aid iron absorption: for example, iron-fortified breakfast cereals, consumed at a meal containing vitamin C (a glass of orange juice).

Dairy produce should be included in the diet to ensure an adequate calcium intake, but many calcium-fortified foods are also available. Vegetarian athletes may also be at risk for low intakes of fat (essential fatty acids are especially important), riboflavin, vitamin D, and zinc which should be monitored and supplemented in the diet if necessary.

Fasting for Ramadan

There may be special circumstances that cause athletes to change their normal training and dietary habits. Many Muslims avoid food and fluid intake during daylight hours during the holy month of Ramadan. This can mean changes to training times, especially in very hot weather, to ensure that adequate hydration is maintained. Where athletes must compete during Ramadan, they should be aware of strategies that allow their food and fluid intake from nightfall to dawn to maximise recovery after sessions and preparation for the next day. During phases of training, it may be possible to move the time of workouts to better coincide with their opportunities to consume foods and drinks. Performance will not necessarily suffer if the athlete is well prepared, and it is recommended that the athlete receive specialised advice from training and nutrition experts before deciding how to approach their sporting commitments during Ramadan.

Nutrition for strength sports

Examples:
Olympic weightlifting, powerlifting, throwing events, 100-200 m sprints, body building.

Features and Challenges

- Periodised training involves resistance workouts, plus sport-specific workouts such as plyometrics, lifting, throwing.
- Goals are enhance power and strength, and in the case of body builders, to increase muscle hypertrophy (size).
- Main nutrition goals related to resistance training are:
  - Fuelling training sessions
  - Recovering from training sessions
  - Maximising adaptations including an increase in muscle mass
- There is a culture of interest in high protein intakes
- There is a culture of interest in supplements
- In case of bodybuilders, there is a culture of extreme diets to "cut up" for competition
- In case of lifters, there is a culture of "making weight" for competition weight divisions
- Competitive events often involve multiple throws or lifts, or rounds (e.g. heats and finals)

Top 10 eating strategies for strength sports:

- Consume a diet high in energy to support levels of high lean mass
- Consume adequate carbohydrate to fuel resistance training since this is glycogen-using
- Consume adequate but not excessive amounts of protein since these foods are expensive and may displace carbohydrate needs
- Consume a source of high quality protein (20-25 g) soon after resistance workouts
- Spread protein intake over the day
- Select low fat protein options to avoid unnecessarily high intakes of saturated fat.
- Avoid extreme dieting behaviour prior to body building competition – rather, achieve loss of body fat by safe and longer-term methods
- Avoid extreme weight loss behaviour prior to weight lifting competition. Choose a suitable weight class and allow adequate time if weight loss is required to achieve this target. Small amounts of weight loss in the days before competition may be safely achieved
- For athletes participating in throwing and sprinting events, choose a pre-event meal that keeps you comfortable throughout the competition. If there are rounds in your event or time between throws, make sure you have access to fluids and foods to keep you appropriately fuelled and hydrated.
- Seek the advice of a sports nutrition expert if you are unable to meet your goals easily or want specialised advice on supplement use.

Nutrition for power sports

Examples:
Middle distance running, track cycling, rowing, canoeing/kayaking and swimming.

Features and Challenges

- Success is defined by the ability to produce very high power outputs for races ranging 1-10 minutes
- The continuum of fuel systems need to be well developed, requiring a highly periodised training program
- Nutrition goals change substantially with the different phases of training:
  - General preparation: high training volume training, manipulation of body composition
  - Specific preparation: high intensity training, often with specialised periods such as altitude training
  - Taper/competition: lower volume/high intensity; race focus, avoidance of weight gain
  - Transition: light training, small weight gain usual
- Goals during training include achieving ideal physique, usually involving low body fat levels, and in some sports, muscularity. Competition physique may only be maintained for a short period. Some loss of physique during off-periods of the year but athletes should try to minimise this
- Performance of a race may be limited by build-up of acidity as a by product of sustained high-intensity work
- Competitive events often involve multiple rounds (heats, semis, finals etc)

Top 10 eating strategies for power sports:

- Vary energy intake between training phases according to the training load.
- Consume moderate-high levels of carbohydrate according to the fuel needs of the training phase
- Consume fluids and carbohydrate during prolonged training sessions to support hydration and fuel needs
- Consume a source of high quality protein (20-25 g) and carbohydrate soon after key workouts to promote refuelling and adaptation
- Achieve competition physique goals gradually with major effort during base phase and fine tuning just prior to racing season
- Consider the use of supplements carefully. Options that power athletes might use include buffers that are intracellular (β-alanine) and extracellular (bicarbonate)
- Choose a suitable pre-event meal that keeps you comfortable during your event.
- If there are heats and finals in your event, and especially, if you are competing in more than one event in a session, make sure you have access to fluids and foods to recover between races
- Look after special needs for specialised training phases such as altitude training. This may alter energy and fuel needs, fluid losses and iron requirements
- Seek the advice of a sports nutrition expert if you are unable to meet your goals easily or want specialised advice on supplement use

Nutrition for endurance sports

Examples:
Marathon, triathlon and road cycling.

Features and Challenges

- Success is defined by the ability to sustain performance over prolonged periods
- Nutrition goals change according to phase of training
  – General preparation: high training volume training, manipulation of body composition
  – Specific preparation: high intensity training, often with specialised periods such as altitude training
  – Taper/competition: lower volume/high intensity; race focus, avoidance of weight gain
  – Transition: light training, small weight gain usual
- Goals during training include achieving ideal physique, usually involving low body fat levels, and in some sports, muscularity. Competition physique may only be maintained for a short period. Some loss of physique during off-periods of the year but athletes should try to minimise this
- Athletes are often at risk of developing issues with eating and body image
- Fatigue or decline in performance during a race may be caused by dehydration, fuel depletion, gastrointestinal discomfort and other factors
- Opportunities for fluid and fuel intake during a race vary according to the sport, but usually require the athlete to eat or drink "on the move". Supplies may be provided at feed zones or from team support crews or may need to be carried by the athlete.
- Competition phases differ according to sports from marathon racing where athlete may undertake 1-2 major competitions per year to road cycling where professional cyclist may compete on 100 days of year

Top 10 Eating strategies

- Vary energy intake between training phases according to the training load. Maintain adequate energy availability
- Consume moderate-high levels of carbohydrate according to the fuel needs of the training phase
- Consume fluids and carbohydrate during prolonged training sessions to support hydration and fuel needs
- Consume nutrients after training sessions to target elements of recovery – this includes fluids and electrolytes for rehydration, carbohydrate for refuelling and a source of high quality protein (20-25 g) to promote muscle adaptation
- Set safe and achieve physique goals for training gradually, with major effort during base phase and fine tuning just prior to racing season
- Prepare for competition with carbohydrate fuelling techniques suited to the fuel needs of the event. For events lasting longer than 90 minutes, consider carbohydrate loading over the 2-3 days prior to the race.

- Choose a pre-race meal that promotes additional fuelling but leaves the gut feeling light and comfortable for the race
- Develop a plan of eating and drinking during the race to maintain adequate hydration and additional carbohydrate depending on the fuel needs of the event. Carbohydrate goals may range from small frequent "tastes" during brief events (45-75 min) to aggressive intakes of up to 80-90 g/h in ultra-endurance races (> 2.5 h). Practise the plan in training to perfect it.
- Consider the use of sports foods and supplements carefully: options include caffeine, sports gels/bars/drinks.
- Look after special needs for specialised training phases such as altitude training. This may alter energy and fuel needs, fluid losses and iron requirements
- Seek the advice of a sports nutrition expert if you are unable to meet your goals easily or want specialised advice on supplement use

Nutrition for aesthetic and weight class sports

Examples: figure skating, gymnastics, diving, combative sports, lightweight rowing.

Features and Challenges

- Success in the aesthetic sports may be defined at least partially by the athlete's appearance and a subjective judgement of how it conforms to ideal in that sport
- Physical skills may be assisted by a small and light physique that makes it easy to move in a small space
- Athletes in some sports are classified in weight division to promote competition between people of similar size and strength. In these sports, there is a culture of "making weight" for competition weight divisions
- Training loads vary according to the sport but and may range from high volume/intensity (lightweight rowing) to lengthy but moderate in energy expenditure (e.g. gymnastics)
- The emphasis on low body mass and low body fat levels creates an increased risk of issues with eating and body image

Top 10 Eating strategies

- Maintain adequate energy availability for your training and competition energy expenditure. Factor in needs for growth
- Consume moderate-high levels of carbohydrate according to the fuel needs of the training phase
- Choose weight and body fat goals that are achievable and support long-term health and performance
- Choose nutrient dense foods, and a good spread of high quality protein over the day so that you maximise your ability to meet nutritional goals
- In weight category sports, choose a weight division that can be achieved safely and within minimal stress
- If you feel you are developing issues with food related stress, seek intervention at an early stage
- Prepare for competition by fine-tuning weight, without the need for extreme weight loss measures
- If you have made weight using techniques based on mild dehydration and reduction in food intake, use the period after the weigh in to rehydrate and fuel up for the event.
- Consider the use of supplements carefully: there are no magic pills or potions that promote loss of body fat
- Seek the advice of a sports nutrition expert if you are unable to meet your goals easily or want specialised advice on managing your weight and physique goals

Notes

Nutrition for team sports

Examples:
football codes, basketball, field hockey, netball.

Features and Challenges

- Nutrition goals change according to phase of highly periodised yearly calendar
  - General preparation: high training volume training, manipulation of body composition
  - Pre-season preparation: Increase in skills and tactical training; practice games
  - Competition: may involve a large number of games, with 2-7 days recovery
  - Off-season: no scheduled training
- Work patterns involve high-intensity intermittent exercise with brief recovery intervals: patterns vary between players and between matches
- Success is determined by overlay of skills on these work patterns, requiring concentration and judgement
- A range of desirable physiques exists according to sport and to position within a team: may include need for bulk and muscularity or leanness and low body fat levels
- Competition may be in weekly fixture or in tournament format: both require recovery after match
- Fatigue or decline in performance during a match may be caused by dehydration, fuel depletion, gastrointestinal discomfort and other factors
- Opportunities to consume fluids and carbohydrate during a match vary according to the rules of the sport. There may be breaks between periods, substitutions or informal breaks in play that allow nutritional support
- In many team sports there is a culture of alcohol misuse after matches and during the off season

Top 10 Eating strategies

- Periodise energy and carbohydrate intake according to the fuel needs of the training/competition phase
- Consume fluids and carbohydrate during prolonged training sessions to support hydration and fuel needs
- Consume nutrients after training sessions or matches to target elements of recovery – this includes fluids and electrolytes for rehydration, carbohydrate for refuelling and a source of high quality protein (20-25 g) to promote muscle adaptation
- Set safe and achieve physique goals for training gradually, with major effort during base phase and fine tuning prior to competition season. Avoid large loss of conditioning during the off-season
- Prepare for matches with carbohydrate intake suited to the fuel needs of the event. Midfield players and others with heavy workloads should consider more aggressive carbohydrate intake in the 1-2 days prior to the match.
- Choose a pre-match meal according to the time of day that promotes additional fuelling but leaves the gut feeling comfortable

- Develop a plan of eating and drinking during the match according to the available opportunities. Aim to maintain adequate hydration and additional carbohydrate depending on the fuel needs of the event. Carbohydrate goals may range from small frequent "tastes" during brief matches (45-75 min) to intakes of 30-60 g per hour for matches of 60-90 min. Practice the plan in training sessions and pre-season games to perfect it.
- Develop a sensible attitude to alcohol intake
- Consider the use of sports foods and supplements carefully: options include caffeine, sports gels/bars/drinks.
- Seek the advice of a sports nutrition expert if you are unable to meet your goals easily or want specialised advice on managing your weight and physique goals

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Notes

IOC Consensus Statement on Sports Nutrition 2010

Diet significantly influences athletic performance. All athletes should adopt specific nutritional strategies before, during and after training and competition to maximise their mental and physical performance. Evidence-based guidelines on the amount, composition, and timing of food intake have been defined to help athletes perform and train more effectively, with less risk of illness and injury.

Athletes will benefit from the guidance of qualified sports nutrition professionals who can advise on their individual energy, nutrient and fluid needs and help develop sport-specific nutritional strategies for training, competition and recovery. Energy demands depend on the periodised training load and competition program, and will vary from day to day and across the season. A diet that provides adequate energy from a wide range of commonly available foods can meet the carbohydrate, protein, fat and micronutrient requirements of training and competition. An appropriate diet will help athletes reach an optimum body size and body composition to achieve greater success in their sport.

Careful selection of nutrient-rich foods to reduce the risk of developing nutrient deficiencies that impair both health and performance is especially important when energy intake is restricted to reduce body and/or fat mass. During high-intensity training, particularly of long duration, athletes should aim to achieve carbohydrate intakes that meet the needs of their training programs and also adequately replace carbohydrate stores during recovery between training sessions and competitions. Dietary protein should be consumed in daily amounts greater than those recommended for the general population, but a varied diet that meets energy needs will generally provide protein in excess of requirements.

Foods or snacks that contain high-quality proteins should be consumed regularly throughout the day as part of the day's total protein intake, and in particular soon after exercise, in quantities sufficient to maximise the synthesis of proteins, to aid in long-term maintenance or gain of muscle and bone and in the repair of damaged tissues. Ingestion of foods or drinks providing 15-25 g of such protein after each training session will maximise the synthesis of proteins that underpins these goals. For events lasting an hour or more, the athlete should aim to begin competition with body carbohydrate stores sufficient to meet their needs by consuming carbohydrate-rich foods in the hours and days beforehand.

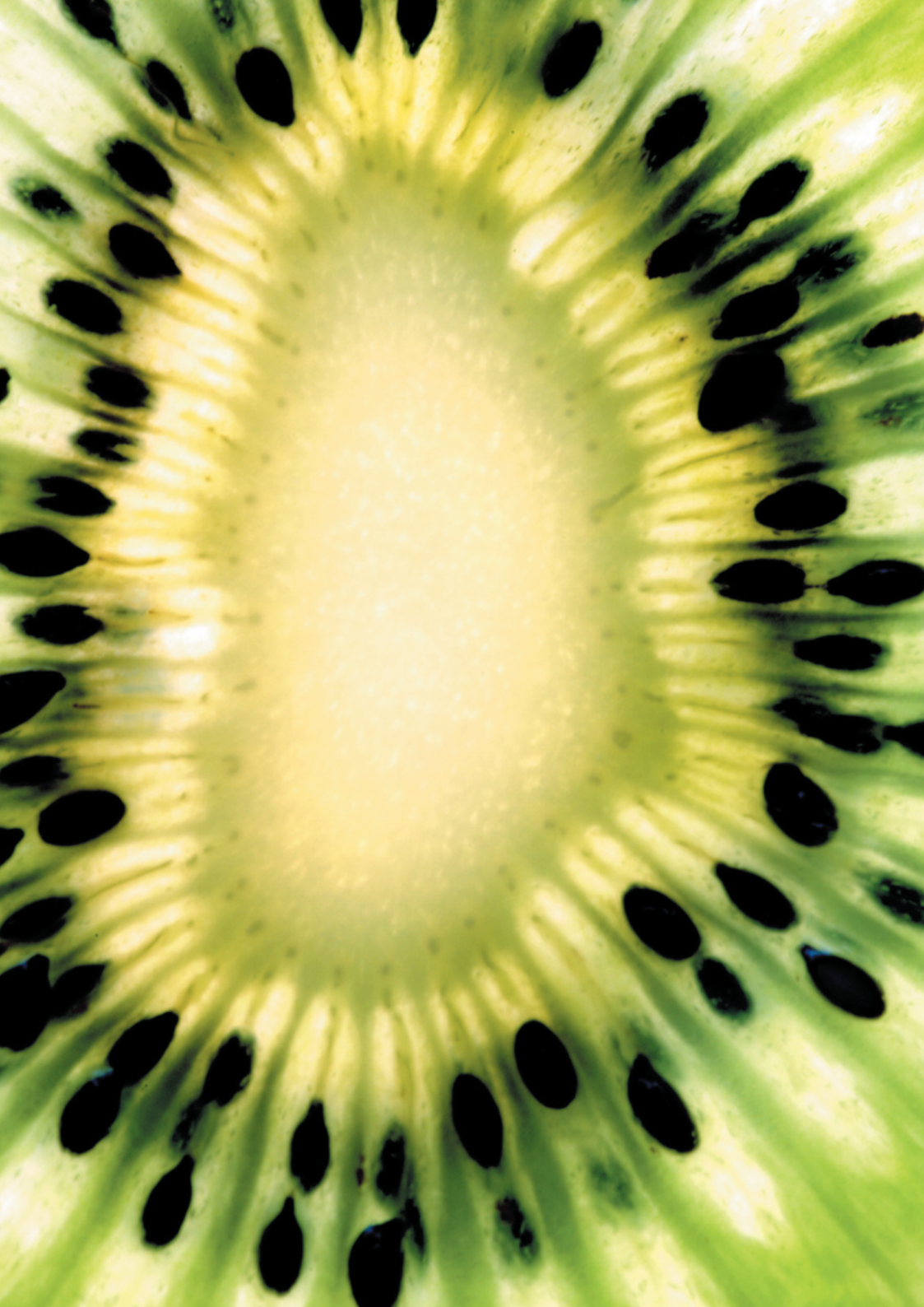
Ingestion of even small amounts of carbohydrate during exercise can enhance cognitive and physical performance in competition lasting one hour. As the duration of the event increases, so does the amount of carbohydrate needed to optimise performance. To achieve the relatively high rates of intake (up to 90 g/h) needed to optimise performance in events lasting more than about 3 hours, athletes should practise consuming carbohydrate during training to develop an individual strategy, and should make use of sports foods and drinks containing carbohydrate combinations that will maximise

absorption from the gut and minimise gastrointestinal disturbances. Dehydration, if sufficiently severe, can impair performance in most events, particularly in warm and high-altitude environments. Athletes should be well hydrated before exercise and drink sufficient fluid during exercise to limit dehydration to less than about 2% of body mass. Chilled fluids may benefit performance in hot conditions.

Athletes should not drink so much that they gain weight during exercise. Sodium should be included when sweat losses are high, especially when exercise lasts more than about 2 hours. During recovery from exercise, rehydration should include replacement of both water and salts lost in sweat. When athletes must compete in several events in a short time-period, strategies to enhance recovery of fluid and fuel are important. Low energy availability should be avoided, as it can impair performance and adaptation to training and may be harmful to brain, reproductive, metabolic and immune function, and to bone health.

Dieting in young athletes should be discouraged. Robust immunity and reduced risk of infection can be achieved by consuming a varied diet adequate in energy and micronutrients, ensuring adequate sleep and limiting other life stress. Athletes should be particularly aware of their needs for calcium, iron and Vitamin D, but the use of large amounts of some micronutrients may be harmful. Athletes at risk of disordered eating patterns and reproductive disorders should be promptly referred to a qualified health professional for evaluation and treatment. The use of supplements does not compensate for poor food choices and an inadequate diet, but supplements that provide essential nutrients may be a short-term option when food intake or food choices are restricted due to travel or other factors. Vitamin D may be needed in supplemental form when sun exposure is inadequate.

Of the many different dietary ergogenic aids available to athletes, a very small number may enhance performance for some athletes when used in accordance with current evidence under the guidance of a well-informed professional. Athletes contemplating the use of supplements and sports foods should consider their efficacy, their cost, the risk to health and performance, and the potential for a positive doping test. Supplement use in young athletes should be discouraged, and the focus should be on consuming a nutrient-rich, well-chosen diet to allow for growth while maintaining a healthy body composition. To enjoy all the benefits of sport, athletes, whether they compete at the elite level or exercise on a recreational basis, should adopt specific nutrition strategies that can optimise mental and physical performance and support good health.

Lausanne, 27 October 2010

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