INTERNATIONAL OLYMPIC COMMITTEE

Nutrition for Athletes

A practical guide to eating for health and performance

Prepared by the
Nutrition Working Group of the Medical and Scientific Commission of the International Olympic Committee

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

Revised and Updated in June 2016

Contents

Foreword

by Dr Richard Budgett

The IOC and its Medical and Scientific Commission are pleased to provide athletes participating in the 2016 Games with this updated brochure, developed under the leadership of the IOC's 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 and Scientific Commission, believe that nutrition is one of the decisive elements in high-level athletes' preparations and one of the key factors in athletes' health.

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.

Richard Budgett
IOC Medical and Scientific 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 and a regular meal pattern 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 the key. Too much and body fat increases: too little and performance falls and illness results.

Carbohydrate is a key nutrient for energy supply, and is vital in high intensity effort, 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. Well-chosen vegetarian diets can meet an athlete's nutrient (including protein) needs, but that requires knowledge of different nutrients and meal composition and athletes should seek assistance to make an adequate meal plan. A varied and wholesome nutrient-rich diet that meets energy needs and is based largely on vegetables, fruits, beans, legumes, grains, lean animal meats, fish, 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 necessary when sweat losses are high: needs vary between athletes but food sources are generally sufficient.

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 programme
- 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 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 programmes.

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

Nutrition for Athletes was originally 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.

The information was substantially updated in June 2016 in preparation for the Rio Olympic Games of 2016 to ensure that athletes have access to the latest information.

Energy needs

The amount of energy consumed through different foods sets the daily energy "budget" for the distribution of carbohydrate, protein and fat, as well as vitamins, minerals and other health-promoting dietary factors. An athlete's energy requirements consist 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. The intensity, duration and frequency of training sessions and competition will play a strong role in determining an athlete's daily energy requirements. When daily energy intake is equal to energy expenditure, the athlete is said to be in energy balance.

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, the need for energy is more complex than this and we now use the term 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
(expressed as Kcal per kg Fat free mass.
Fat Free Mass equals body mass minus Body fat)

Athletes are especially vulnerable to changes in energy availability. Research within the last few years has revealed that fast weight loss programmes are associated with health and performance decrements. The consequences of low energy availability include impairment of hormone, immune and metabolic function, in addition to irreversible loss of bone mass, which increases the risk of fractures and injury. The hormonal disturbances can lead to an interruption of a normal menstrual cycle for females, making menstruation irregular or absent for months and years. Menstrual dysfunction may lead to loss of bone mass and osteoporosis, which are in most cases irreversible. Female athletes should therefore treat an interruption to a normal menstrual cycle as a problem that needs early assessment and intervention. There can be several reasons for an irregular or absent menstrual cycle, with one of them being related to low energy availability. Consulting a doctor and a sports nutritionist for an evaluation is a good start.

Some athletes think about food only as fuel for the muscles, while others are more preoccupied with the effects on body composition and fat mass. This is not unusual, especially for athletes in sports that emphasise weight and leanness (e.g. weight class athletes, long distance runners or gymnasts). However, if you experience stress related to meals, associate food with bad conscience or feel stressed and insecure regarding food and body image, you need to seek expert help at an early stage. Early treatment is the key to success when bringing an athlete back to a healthy way of thinking.

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

1. Disordered eating and eating disorders. We used to think this was the main cause of energy deficiencies, causing some stigma to be associated with this. Disordered eating requires early intervention and specialist help, but we now know that many athletes can slip into a situation of low energy availability without having an eating disorder.

2. Restricted eating for weight control or loss or body fat. Many athletes undertake such interventions 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 obviously problem, a fast reduction in body weight will in most cases compromise both health and performance. Athletes should therefore be mindful when they restrict energy intake to lose body weight or fat mass and are recommended to undertake a gradual weight loss approach with professional guiding.

3. Inadvertent failure to increase energy intake sufficiently during periods of high volume training or competition. Some athletes undertake extremely strenuous training or competition programmes. 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 training 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. This might also be the case for adolescent athletes who move away from home to train and study with limited cooking skills and/or financial resources.

Tips for maintaining adequate energy availability

All athletes should be aware of their 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.

Travelling to different countries or changes in home situations can be a challenge for anyone. 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. Sometimes they need help with grocery shopping and how to replace familiar foods with new alternatives. A basic meal plan may be helpful to ensure meal frequency and nutritional variation.

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 interfere 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 programme

Unfortunately, many athletes don't value or understand the importance of these factors. There are some dietary strategies where it may be beneficial to seek assistance for optimal results. This includes when you want 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
- Support the goals of the training needed to increase muscle mass (see protein section)
- 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

1. Weight target should be realistic: this is a medium-term goal rather than something to be achieved by next week. Weight loss is not helpful if it lead to impaired performance. That alone, should give motivation to do it gradual and safe.

2. 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. Many athletes are impatient and like the idea of a quick but drastic weight loss programme: however, the outcomes for body composition changes and performance are likely to be better with a gradual weight loss programme.

3. Strength training is recommended during the weight loss period, to stimulate muscle growth and minimise loss of muscle mass.

4. Athletes should seek a sports nutrition expert for an assessment and evaluation of current body composition and nutritional status. Access to facilities that can monitor changes in body composition would help to evaluate the effect of the weight loss plan.

5. Limit portion sizes at meals rather than skipping meals altogether.

6. 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 (e.g. Split dinner in two and eat one portion before and one after training).

7. For most athletes, small, but important, changes in everyday meals are needed to gradually reach the planned weight target.

8. Keeping a food diary of what you really eat can also help to pinpoint habits that should be changed.

9. 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 (e.g., split dinner in two and eat one portion before and one after training).

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

11. 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.

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

13. 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.

14. It is easy to eat snack foods, fast foods or other poor food choices when you become too relaxed.

15. Make meals and snacks more “filling” by including plenty of salads and vegetables and by taking the higher-fibre option

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

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

18. It is not a good idea to withhold calories before or after a hard training session if performance and adaptation are the main goals. Some athletes skip the recovery meal to cut back calories and burn fat. However, recovery is even more essential during weight loss, since low energy and carbohydrate availability can impair the immune system in addition to increasing the recovery time.

Adequate energy availability is needed for long term health and performance, so athletes, coaches and all support staff should be aware of signs indicating that energy availability is too low. Signs include: persistent fatigue; impaired recovery and performance; frequent infections and illness; absent or irregular menstrual cycles in females; stress fractures or repeated injuries; loss of motivation; insomnia and sleep disturbances; mood changes. If some of these signs are present, the athlete should slowly increase and stabilise body weight and/or fat mass in a "healthy" state.

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

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

2. 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."

3. A food record can identify the times in a busy day that are not being well used for fuelling up.

4. 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.

5. 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.

6. 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.

7. Sweetened dairy products, liquid meal supplements and fruit smoothies provide a compact source of protein and carbohydrate after the workout.

8. Some athletes want to exercise before breakfast for various reasons. It is ok to do this occasionally, especially if it's a 45-60 minutes low intensity session. However, if you are going to have a harder session with longer duration, it is recommended to eat breakfast first. Otherwise, it may affect the quality of training—not just in the first session, but also in the second session later that day —because glycogen stores are not able to recover between sessions.

9. Sweetened dairy products, liquid meal supplements and fruit smoothies provide a compact source of protein and carbohydrate after the workout.

Carbohydrates

Carbohydrates for training and recovery

Carbohydrate has become a topic of intense 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 current diet books are based on eating plans that are low and moderate in carbohydrate and high in fat. Not surprisingly, many athletes are now confused.

Sports nutrition experts have continued to evolve the recommendations for carbohydrate intake, making it more sport specific and tailored to the individual athlete. However, the importance of the body's stores of carbohydrate as a source of fuel for the muscle and brain during exercise is still a fact. In many types of sport, low levels of carbohydrate stores are a factor in fatigue and reduced performance. Furthermore, strategies to increase carbohydrate availability have been consistently shown to result in performance enhancements, not just in marathon running but in short duration events too. That is why carbohydrate continues to play a key role in competition nutrition.

The athlete's carbohydrate needs are closely related 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 sensible 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 performance in training and competitions.

Athletes should particularly target the days or periods with high intensity and/or high quality training sessions to ensure that they have adequate muscle carbohydrate (glycogen) stores to fuel these goals.

A great way to ensure carbohydrate intake meets muscle fuel needs is to include additional carbohydrate in meals or snacks before and after a workout. This means when training time and/or intensity increase, so should the carbohydrate intake. Consuming carbohydrate during long 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 grams relative to the athlete's body mass rather than as a percentage of total energy intake.

Rather than talk about high or low carbohydrate diets we should think about carbohydrate availability relative to the muscle's fuel needs.

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 programme. (i.e. ~1 hr per day)	5-7 g/kg/d
High	Endurance programme. (e.g. 1-3 hrs per day of mod-high-intensity exercise)	6-10 g/kg/d

The total intake and timing of the day's intake should normally be able to meet the fuel demands of a workout (= high carbohydrate availability). In some sessions, carbohydrate stores may be 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, when training intensity and quality is low. According to latest research, low carbohydrate availability limited to 1-3 sessions per week can provide an increased stimulus to the muscle to help it adapt to training. However, such strategies need to be carefully periodised into the training programme, to avoid interference with high quality sessions.

When training more than once per day and sessions are close together, fast recovery of the muscle carbohydrate stores is essential to ensure quality in the last session. Since the muscle is very responsive to carbohydrates immediately after exercise, athletes should consume carbohydrate-rich foods and drinks to stimulate rapid refuelling,

The target of carbohydrate intake during rapid refuelling is about 1 g per kg of body mass per hour for the first 4 hours, with frequent small snacks. The type of carbohydrate is generally less 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 is not 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. Carbohydrates can be consumed in liquid form or as solid foods, with same effect.

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
- 400 g 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

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. 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 optimal muscle and liver glycogen stores. Most athletes can normalise their muscle glycogen stores with as little as 24 hours of carbohydrate-rich eating and exercise taper.

In shorter duration events, complete depletion of carbohydrate stores does not occur, but an adequate supply of carbohydrate fuel remains important. Carbohydrate requires less oxygen than fat to supply energy, which becomes important during high intensity (anaerobic) training and competitions where oxygen is limited (e.g. middle distance running, rowing and wrestling).

We now know that simply putting carbohydrate in the mouth can enhance performance – even if you spit it out again after a few seconds. Receptors in the mouth send signals to the brain that fuel is available and the brain responds by allowing the muscles to work harder.

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 are not so carbohydrate dependent (e.g. gymnastics, sprinting, ski-jumping, etc), there is no need for extra focus on carbohydrates in the pre-event meal. However, in events involving exercise lasting 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 last few hours before exercise and then fail to consume any carbohydrate during exercise. This makes the body more reliant on internal carbohydrate supplies without providing sufficient external carbohydrate to compensate.

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. Sports drinks, gels and bars are easy to consume and readily available. Many everyday foods and drinks such as fruit, juices and soft drinks 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	• Products providing multiple transportable carbohydrates (glucose: fructose mixtures) will achieve high rates of oxidation of carbohydrate consumed during exercise

Dietary Protein

Dietary protein for athletes: from requirements to optimum adaptation

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 1.2-1.8 g/kg body mass per day. Dietary surveys show that most athletes easily meet these goals, even without the intake of expensive supplements. In addition, a frequent meal pattern to spread the protein over the meals and snacks consumed over the day will ensure a good protein availability during growth and repair. Athletes who are most at risk of failing to meet these targets are those who restrict their energy intake and food variety.

Protein has a great 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 reach a higher level of performance.

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 new tissue and to repair 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, but has a substantial anabolic effect on protein synthesis when combined with exercise. Thus, a recovery meal should include 20-25g high quality protein, to maximise training adaptations and recovery. It is the essential amino acids in the protein we eat that stimulate the anabolic response, so the amount of essential amino acids in the protein source is crucial. Proteins from animal sources (e.g. dairy, meats, eggs, etc) where 40-50% of the total protein is provided by essential amino acids are high quality proteins.

Food or supplements?

Well-chosen foods and drinks can easily meet the demands for protein and carbohydrate necessary for recovery. However, sometimes, especially during travelling and competitions, it can be useful to have a compact recovery meal that is easy to carry and to prepare, and that we know will supply the necessary nutrients – such as a liquid meal supplement, recovery shake or protein powder.

With this approach to protein needs, 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, so there is no justification for 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. It makes sense 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 some of this 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.

When is it 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, unless the athlete starts the session dehydrated, but some athletes feel better after rinsing the mouth with cool drinks. During long training sessions or competitions, there may be opportunities and advantages to drink during the session. When it is not possible to drink during 'heavy sweating' type exercise lasting longer than 30 minutes, an alternative is to hydrate well just before starting the session. Athletes should practise drinking during the 15 minutes prior exercise, in a comfortable amount (e.g., 300-800 ml).

How much to drink?

Sweating causes a loss of water and salts from the body. Small losses of water have no effect on health or performance, but severe dehydration will impair performance. There is no clear evidence on the point at which performance begins to be affected and this will vary 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. Athletes 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). Hot environments, dehydration and exercise reinforce each other and increase the risk of impaired performance and heat illness. When rates of sweat loss are very high, it is not always practical to drink enough to keep fluid deficits below this target. A more feasible alternative is simply to try to minimise dehydration.

In some situations, athletes over-hydrate during exercise if drinking more than their sweat losses. Most times this is harmless, but problems can occur when the fluid intake is rapid and excessive, leading to a serious problem called hyponatraemia (dilution of blood sodium concentrations). This is mostly 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 know 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, and can help athletes to make an optimal hydration plan in different environments.

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. 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. As outlined in the earlier section on Carbohydrates in competition, the targets for carbohydrate during exercise will vary according to the athlete's preparation), 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 use sports drinks they are familiar with to avoid gastrointestinal distress or other negative consequences. Some athletes can tolerate concentrated drinks, whereas others are more sensitive to intake of carbohydrates. Practising a hydration plan during 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 sessions 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, for example in hot and humid climate)

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 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, a meal (e.g. bread, breakfast cereal, cheese, and processed meats), snack (e.g., peanuts, crackers) or use of table salt on the food can supply the salt that is needed

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

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. Making a personal hydration plan is a good strategy.

Remember that humans do not adapt to dehydration, so here are three simple steps that may help to guide your hydration practices:

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 with extra losses from exercise or hot environments. As losses change, so should drinking practices. It is beneficial to spread fluid intake over the day rather than trying to play catch-up at the end.

Drinking more than you need in the later part of the day can interrupt sleep due to toilet visits.

Develop a drinking plan for training and competition that suits 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.

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 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

Use this chart 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 programmes 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. When food intake is suboptimal, 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 guidance from 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.

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 often been used for this purpose.

However, recent research shows that, supplementation may cause more harm than good. There may be some benefits associated with the production of free oxygen radicals, as they function as signals to promote important adaptations to training. It is possible that the use of single antioxidant supplements may actually neutralise some of the signaling that underpins training adaptation, which means that antioxidant supplementation can reduce the effect of exercise However, high intakes of foods rich in antioxidants, will probably not have the same blunting response, as food contains a variety of antioxidants that work together, whereas high doses of single antioxidants may create imbalance in the system.

Foods contain a large variety of health promoting chemicals in addition to vitamins and minerals. These compounds – usually called phytochemicals or phytonutrients – promote function and health in our body as antioxidants, anti-cancer agents, and many other roles. Scientists are continually investigating whether supplemental forms of these products could be useful for health and performance, but they have not been able to translate benefits 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 high 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 berries, 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 high-factor sunscreen or consciously avoid the sun

Such athletes should be screened for poor vitamin D status and if levels are sub-optimal, supplementation, and perhaps careful 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 or poor intestinal absorption. 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 since 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 chili 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 on daily basis. The best sources of calcium are dairy foods, including low-fat dairy choices.

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, for pregnancy and lactation and for athletes with poor bone mineral status.

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)

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 benefit of individual supplements before using them.

The use of supplements does not compensate for poor food choices and an inadequate diet. A much better option is to learn how you can choose foods to ensure that your nutritional needs are met.

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 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. The reality is that most products that are effective in increasing lean tissue and decreasing body fat are either on the prohibited 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 a positive 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.

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

Intense exercise puts extra strain on the bones, joints and related 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, possibly ß-alanine and nitrate, 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. The small (1-3 kg) weight gain that often occurs may be beneficial but can be a concern in weight class sports. Creatine is normally found in meat and fish, but the doses that are commonly used (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. As with all supplements, exceeding the maximum effective dose is not helpful. Creatine supplementation does not appear to be harmful to health.

Caffeine. A small amount of caffeine (1-3 mg/kg) can increase performance in different sports. 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 can be a problem in multi-day events and in sports involving heats and finals. The athlete has to try different doses and evaluate the effect in training situations. A caffeine protocol with intakes related to peak concentration in blood, should be followed.

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, some 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). Supplementing with sodium bicarbonate in a dose of about 0.3 g per kg body mass before an event provides the blood with extra capacity to buffer the acidity produced by the muscle. This can postpone fatigue and the performance decline seen in all-out events lasting from about 30 seconds to 10 minutes. 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 ß-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 ß-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 athletic 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.

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

Supplements and doping

Athletes who are liable for drug testing under national or international programmes 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.

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.

Supplements and health

Most supplements are produced by companies that ensure high standards of quality control in the production process. Unfortunately, though, there are some exceptions and recent reports show adverse health outcomes in users of some supplements. Many of these effects are not immediately apparent, and some may have irreversible effects on health. Although the risk may be small, it is nevertheless real.

Issues to consider when deciding whether 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 on the road"

Eating while travelling

Most elite athletes are frequent travelers due to competition or specialised training environments far away from home. Frequent travel particularly to destinations far away from home, can pose a number of challenges, some of which are listed below:

- Disruptions to the normal training routine and lifestyle while travelling.
- 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.
- Risk of gastrointestinal illnesses due to exposure to food and water with poor hygiene standards.
- Changes in digestion and/or pattern of bowel due to changes in circadian rhythm.

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) as well as self-supplied snacks. Airlines companies offer special foods upon request. This could be provided either by your booking agent or personal contact with your airline. Some airlines require the information upon reservation others are more flexible.

2. Eat and drink well while on the move

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". Bring your own food, so that you can regulate your meals according to the new destination.

Be aware of "invisible" fluid losses in air conditioned vehicles and pressurised plane cabins. Have a drinking plan that keeps you well hydrated, and avoid beverages that include alcohol.

3. Be wary of food and water hygiene

Find out whether it is safe to drink the local water. If not, buy sealed bottles of water and other drinks. Be wary of ice cubes added to drinks – they are often made from tap water.

In high-risk environments:

- Eat well cooked food produced in good hotels or well-known restaurants.
- Avoid salads or unpeeled fruit
- Avoid food from local stalls and
- Avoid ice cubes
- Avoid milk based ice-cream
- Maintain general good hygiene routines

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
- 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 eat at home or your new nutritional needs, rather than being overwhelmed by all the food on offer.

Where possible, organise menus and meal times with restaurants ahead of time, especially when dining with a large group.

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.

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

Although the menu in the Olympic village includes cuisine from around the world, some athletes find themselves without access to their favourite foods or important menu items in their usual competition preparation. 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.

Lack of knowledge of the nutritional characteristics of Dining Hall choices. Many athletes do not read English and many have limited 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. It is important to give athletes information they need to secure proper nutrition habits during the Games.

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, although allergens should be well marked.

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. Surrounded by the eating habits of other athletes, it may be difficult to concentrate on your own nutritional goals.

Social eating. The Dining Hall usually becomes a meeting place and entertainment hub where social eating or eating for enjoyment rather than real needs can disrupt 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 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.

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.

Allow yourself to have some treats or special foods, especially after your event is finished.

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.

Olympic competitions will take place in 32 venues in Rio de Janeiro, plus five football co-host cities: Belo Horizonte, Brasília, Manaus, Salvador and São Paulo. August is mid-winter in the Southern Hemisphere, and weather records show that the daily temperature for Rio in August averages 19°C at night and up to 26°C during the day. While this is higher than the optimum for endurance events, it is not oppressive: all athletes should be able to cope, and many will enjoy these conditions. 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 strategies should be well practised before attempting them 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 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 Rio during the Games is unlikely to be very different from that encountered by athletes 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. In Rio, dishes that contain cassava (also under the names of tapioca or manioc) are rich in carbohydrates 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.

Ethnic restaurants can be found in almost every major city of the world and Rio is 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, but plant protein quality is lower, so approximately 10% more protein is recommended than if consuming animal proteins. Therefore, protein recommendations for vegetarian athletes are approximately 1.3-1.9 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

The Rio Olympic Games of 2016 begin on Friday, August 5 and end on Sunday, August 21. The holy month of Ramadan in 2016 begins on 6 June and ends on 5 July and this falls in a period when many athletes are finalising their preparations for competing in Rio. Some will take part in selection events during this time.

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. Sleep is often neglected, but athletes observing the Ramadan fast must be especially careful to ensure adequate sleep.

The month that elapses between the end of Ramadan and the opening of the Rio Games should allow any athlete to ensure a full return to their normal routine well before they have to compete in Rio.

IOC Consensus Statement on Sports Nutrition

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 programme, 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 to 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 programmes 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.

Athletes 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.

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