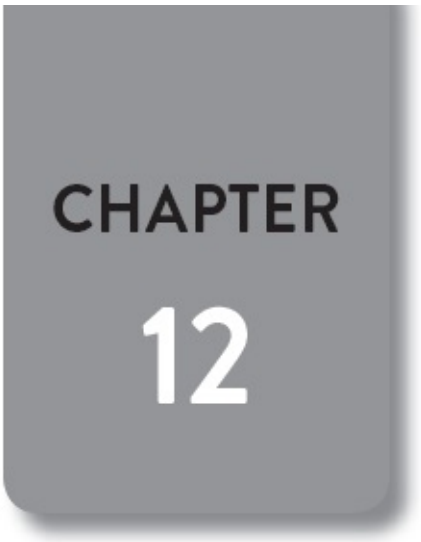

Sports supplements

Michael Leveritt

The preceding chapters have provided an overview of how specific dietary patterns, foods and nutrients can enhance health and wellbeing as well as exercise performance and adaptations to training. We now understand that well-selected nutrition strategies can have a significant positive impact on an athlete's performance and overall wellbeing. While most of the nutritional benefits for an athlete are the result of thoughtfully selected foods and overall dietary patterns, some additional benefit can be gained from specific sports foods and supplements. This chapter will look more closely at the sports foods and supplements used by athletes to enhance performance, promote recovery and facilitate optimal training adaptation.

LEARNING OUTCOMES

Upon completion of this chapter you will be able to:

- define sports foods and sports supplements
- understand placebo and belief effects associated with sports supplements
- briefly describe the mechanism of action of specific supplements that have been shown to enhance exercise performance
- explain the recommended supplement intake protocols for specific supplements that have been shown to enhance exercise performance
- discuss emerging evidence associated with new and potentially beneficial

sports supplements.

SPORTS FOODS

Research in sports nutrition over several decades has identified how different nutrients can enhance exercise performance, improve recovery and modulate training adaptation. This knowledge has subsequently led to the development of specific sports foods. Sports foods are specifically formulated with the aim of helping individuals achieve specific nutritional or sporting performance goals and are designed to supplement the diet of athletes rather than to act as the main source of nutrition. These products are regulated under Food Standards Australia New Zealand's Standard as 'Formulated supplementary sports foods'. It is important to note that this Standard allows the addition of substances that are not permitted or are restricted in other foods, as well as higher levels of some vitamins and minerals, meaning that most of these foods may not be suitable for children or pregnant women. Additionally, in New Zealand sports-related products may also be manufactured under the New Zealand Food (Supplemented Food) Standard 2010 and compliant products can be imported into Australia under the Trans-Tasman Mutual Recognition Arrangement (Food Standards Australia New Zealand 2018).

Foods which fall under this category include sports bars, carbohydrate gels and protein drinks. Over the last decade there has been a large increase in the type and variety of products available, and a huge surge in marketing, increasing the popularity and use of sports foods. The vast majority of these specialised sports foods are simply convenient packages of nutrients that might be easily accessible to an athlete when required. In fact, athletes can often receive the same benefits from consuming these nutrients in regular foods. In many instances, regular foods may actually provide a cheaper, albeit less convenient, alternative. Nevertheless, sports foods may have a role to play in an athlete's diet. For example, we know that consuming protein after resistance training enhances subsequent muscle protein synthesis. Many foods that are good sources of high-quality protein, such as meat, chicken, eggs and dairy foods, require refrigeration and can be difficult to access after a training session. A protein powder that can be mixed with water is an example of a sports food that could be more convenient for an athlete to take to training and then consume immediately after exercise is completed. However, with thoughtful planning it is possible for an athlete to obtain all the nutrients they require through regular foods. For example, high-quality protein in eggs or chicken leftover from the previous evening's dinner could be brought on a sandwich in a cooler bag with an ice block to keep cool until after training.

SPORTS SUPPLEMENTS

Sports supplements are different from sports foods because they typically contain unusual amounts of nutrients or other components of foods that would not normally be obtained through food alone. There are many sports supplements that are marketed as being able to enhance exercise performance, but the scientific evidence to support the proposed benefits is not convincing for several supplements. Nevertheless, the way in which many sports supplements are marketed makes them very attractive to athletes and exercising individuals. In fact, many athletes hold strong beliefs about the positive effects of certain supplements. This may be due to a genuine benefit, or it may be due to a placebo or belief effect. The **placebo effect** occurs when an individual experiences or perceives a benefit from a supplement due to the belief that it will be beneficial rather than as a result of any direct physiological effect. Many scientists discount placebo effects as not being real, and these effects are often tightly controlled for in experiments evaluating the effectiveness of a sports supplement. However, there have also been well-controlled studies investigating the placebo effect using supplements such as caffeine that are known to enhance performance. These studies have shown that exercise performance is enhanced when participants are told they are receiving the supplement despite actually being given an inactive substance (Beedie & Foad 2009). Interestingly, although the placebo effect enhances performance, the magnitude of this effect is usually slightly less than the amount of performance improvement observed from the actual supplement. These studies have clearly shown that some placebo effects are likely to occur with sports supplements. Interestingly, this may have some implications for ethical practice in sports nutrition (Halson & Martin 2013). It might not be considered ethical to deliberately deceive an athlete by advising them to consume a supplement that does not cause any performance-enhancing physiological effects. However, most athletes want to perform at their best regardless of how that is achieved and are more than willing to consume sports supplements, even if the benefits are only due to a placebo effect. This area is complex, but the placebo effect should be taken into consideration when providing advice about sports supplements and also when monitoring the effects of sports supplements.

Placebo effect

When an individual experiences or perceives a benefit from a supplement due to the belief that it will be beneficial rather than any direct physiological effect.

Despite many sports supplements lacking scientific evidence to support their marketing claims, a number of sports supplements have been shown to be effective at enhancing performance under certain conditions. The Australian Institute of Sport has developed a classification system that ranks sports supplements into groups based on scientific evidence and other

practical considerations that determine whether a product is safe, legal and effective at improving sports performance. There are four categories of sports supplements in this system:

1. **Group A Supplements**—there is sufficient scientific evidence to recommend these supplements in specific situations using evidence-based protocols.
2. **Group B Supplements**—research is promising regarding the benefits of these supplements, but it is inconclusive to date and these supplements should only be used if they are part of a research project or when it is possible to monitor how athletes respond.
3. **Group C Supplements**—there is very little scientific evidence that these supplements are beneficial and supplements in this category are generally not recommended.
4. **Group D Supplements**—these supplements are either banned or are at high risk of contamination with substances that could lead to a positive drug test and are definitely not recommended for athletes.

This framework provides a useful guide for athletes, coaches and sports nutrition practitioners when deciding on which supplements to include in their overall sports nutrition program. The list of supplements in each category changes over time as new evidence emerges about each of the different supplements. We will focus on the Group A supplements in this chapter. A range of sports foods and medical supplements are currently included in Group A, in addition to the following sports supplements:

• caffeine

• creatine

• nitrates

• bicarbonate

• beta-alanine.

Caffeine is one of the most widely used pharmacologically active substances in the world and has been shown to improve performance in a variety of exercise tasks. Caffeine is present in many commonly consumed foods and in beverages such as coffee, tea, chocolate- and cola-flavoured beverages. The physiological effects of caffeine occur due to its similarity to the **adenosine** molecule. Among its many actions, adenosine causes a decrease in alertness and arousal when it binds to receptors on the surface of cells in the brain. Caffeine also binds to these receptors and blocks the effects of adenosine.

Adenosine

A chemical that naturally occurs in humans and which causes a decrease in alertness and arousal when it binds to receptors on the surface of cells in the brain.

Therefore, caffeine can increase alertness and arousal and subsequently reduces the perception of effort during exercise. The reduced perception of effort during exercise can enhance performance by delaying fatigue and allowing an athlete to exercise at a higher intensity for longer periods of time.

Interestingly, the dose of caffeine required to achieve optimal improvements in exercise performance is relatively small. Doses of approximately 3 mg/kg body mass appear to be most effective, with no additional benefit occurring with higher doses (Desbrow et al. 2012). This dose is equivalent to approximately 600 millilitres of a standard energy drink or two cups of coffee and is actually quite similar to the usual daily consumption of caffeine for many adults. Consumption of caffeine at these relatively low doses is unlikely to result in any negative side-effects in most people, which is perhaps one reason why caffeine use in sport has not been restricted since 2004. Caffeine has been shown to improve performance when consumed in tablet form, coffee or in energy drinks (Quinlivan et al. 2015). However, the amount of caffeine in coffee can vary significantly. In fact, some Australian studies have shown that there is a tenfold difference in the caffeine content of coffee purchased at different retail outlets (Desbrow et al. 2007). Using energy drinks as a source of caffeine can also have limitations for athletes. Some athletes experience uncomfortable gastrointestinal symptoms when energy drinks are consumed before exercise. Therefore, it is recommended that caffeine be consumed in tablet form when used as a sports supplement in order to be certain of the exact dose ingested and to reduce any unwanted gastrointestinal side-effects.

Caffeine is most effective when consumed approximately one hour before exercise, although many studies have shown caffeine enhances performance when it is given to participants at a variety of different times before and/or during the exercise task. It has even been shown that very small amounts of caffeine consumed in cola beverages can enhance performance in the concluding stages of an endurance exercise task. The benefit to performance in this instance actually occurred despite very little change in the caffeine concentration in the blood. In fact, the amount of caffeine appearing in the blood does not seem to be related to the performance benefit. Nevertheless, the studies that have directly compared different times of ingestion suggest that approximately one hour before exercise is optimal, but there may well be variations to this for different individuals.

Contrary to popular belief, caffeine consumption does not cause

dehydration during exercise. Even though caffeine acts as a mild diuretic by causing small increases in urine volume, these effects are negated by exercise, possibly due to the changes in hormones and cardiovascular function during exercise (Zhang et al. 2015). In fact, caffeine has actually been shown to cause similar performance benefits when consumed before exercise performed in hot conditions compared with more neutral environmental conditions.

Regular consumption of caffeine can cause the body's cells to adapt and generate more adenosine receptors. This has the potential to make regular caffeine consumers less able to experience the performance enhancements associated with caffeine supplementation. However, studies have shown that individuals who normally consume large amounts of caffeine in their diet still receive similar benefits when consuming caffeine before exercise compared with athletes who do not consume much caffeine on a regular basis. It also does not appear that there is any benefit gained from abstaining from caffeine for a few days before using a caffeine supplement. It is important to note that, while we are confident that caffeine supplementation is effective at improving exercise performance, there are a limited number of studies that have thoroughly investigated the factors that might moderate the ergogenic effects of caffeine and more research in this area is certainly warranted.

Creatine has been used by athletes as an **ergogenic aid** for several decades. Supplementation with creatine monohydrate increases the creatine pool in muscles which allows for more rapid ATP regeneration during repeated bouts of high-intensity exercise (see Chapter 2). This mechanism may enable a higher training intensity and improved adaptation to training, particularly resistance training which involves repeated, high-force muscle contractions. Creatine supplementation also appears to positively influence anabolic processes in muscles, which results in an increase in lean muscle mass after supplementation. Many studies have shown that creatine supplementation during a period of resistance training enhances gains in muscle strength and lean body mass. Typical creatine supplementation protocols involve a short loading phase, lasting 5–7 days, during which 20 g/day of creatine monohydrate is consumed in four daily intakes of 5 grams each, evenly spaced throughout the day. This is then followed by a maintenance phase in which 3–5 g/day is consumed. The maintenance phase typically lasts for the duration of the training cycle in which improvements in maximal muscle strength and lean body mass are the primary goals.

Ergogenic aid

Any substance or aid that improves physical performance.

Dietary nitrate is becoming increasingly popular as a sports supplement due

to its capacity to enhance endurance exercise performance (McMahon et al. 2017). Many green leafy vegetables and beetroot are examples of foods with a high nitrate content. The nitrate content of foods can vary significantly due to growing conditions and loss of nitrate during cooking and preparation, which makes it difficult to predict how much dietary nitrate is being consumed through different foods. There are now many sports foods and beverages available that are made with concentrated beetroot juice and contain a known amount of nitrate. Once ingested, dietary nitrate can be converted to nitrite by bacteria in the mouth. Circulating nitrite is then converted into nitric oxide in blood and other tissues. Enhancing nitric oxide availability may improve muscle function and consequently exercise performance. Nitrate supplementation appears to specifically enhance the efficiency of oxygen use during exercise, which allows individuals to perform greater work for the same energy cost (Jones 2014). This results in an improved capacity to exercise at a fixed intensity for a longer duration before exhaustion occurs. Daily intake of 400–500 milligrams of nitrate for approximately one week appears to be most effective at enhancing performance; however, benefits have also been shown after a single dose consumed 2–3 hours before exercise. Interestingly, the benefits of dietary nitrate supplementation are less evident in highly trained athletes, particularly when exercise performance is measured via a time-trial test rather than time to exhaustion tests. This suggests that recreational exercisers are likely to experience improved exercise performance after nitrate supplementation. However, elite athletes may wish to monitor their individual response to nitrate supplementation to determine if this is likely to be an effective nutrition strategy that contributes to their performance goals.

Performance in short-duration, high-intensity exercise can be improved after the ingestion of sodium bicarbonate (Peart et al. 2012). Increasing bicarbonate in the blood enhances the capacity to buffer acid produced by the muscle during exercise (see Chapter 2). This has the potential to delay fatigue during high-intensity exercise. Although there is a clear mechanistic rationale for bicarbonate to enhance performance, not all studies show a performance benefit. This may be due to side-effects associated with gastrointestinal discomfort offsetting the benefit of an improved buffer capacity. As with nitrate supplementation, the benefits of bicarbonate ingestion appear to be less evident in highly trained individuals, possibly due to the already high buffer capacity developed through training in this population. Doses of 200–400 mg/kg body mass consumed 60–90 minutes before exercise appear to be optimal, but it is recommended that athletes trial this on several occasions during training to ensure that no adverse gastrointestinal side-effects are likely to occur in competition.

Beta-alanine is a component of the dipeptide carnosine, which plays a role in buffering acid produced in the muscle during high-intensity exercise (see Chapter 1). This has the potential to delay fatigue and enhance performance, particularly in events lasting approximately 1–4 minutes. Beta-alanine supplementation over several weeks has been shown to result in increased muscle carnosine and improved performance in short-duration (1–4 minutes), high-intensity exercise. A daily dose of 6.4 grams is used in most studies and it appears that at least four weeks of beta-alanine supplementation is required to elevate muscle carnosine concentration. However, further increases in muscle carnosine concentration are observed after ten weeks of supplementation. The daily dose is usually consumed on 3–4 occasions spread throughout the day in order to reduce the acute side-effects associated with consumption of large doses of beta-alanine. Side-effects can include tingling, flushing and a prickly sensation on the skin which peaks around 30–60 minutes after the ingestion of beta-alanine. The **protocol** for beta-alanine supplementation is much more difficult for athletes to adhere to than protocols for other supplements, as it involves several daily doses taken for several weeks. Therefore, beta-alanine supplementation is only recommended for highly motivated athletes who are able to commit to a relatively long supplementation regime.

Protocol

The official procedure or set of rules or methods that need to be followed.

Supplements such as caffeine, creatine, nitrate, sodium bicarbonate and beta-alanine have all been shown to enhance exercise performance in many different studies. Most studies compare the effects of a single supplement against a placebo under relatively well-controlled conditions. However, many athletes looking for a competitive edge will consume multiple supplements at the same time in order to derive as much benefit as possible. Unfortunately, the beneficial effects of taking multiple different supplements may not be additive. Findings of studies investigating combinations of supplements are somewhat inconsistent, with some showing additive effects and others showing that performance gains from multiple supplements are no greater than those from a single supplement. Research into the effects of consuming multiple supplements is relatively scant at present due to the difficulty of conducting studies involving multiple interventions. While further research is required, it is also likely that different athletes will have somewhat different responses to each supplement. It is therefore important for athletes to monitor and evaluate their own individual responses to supplements to most effectively use sports supplements to enhance their performance.

Research into sports supplements continues to evolve and there are many

new supplements that have shown promising results, but there is not enough scientific evidence to date to provide clear recommendations on the benefit of these supplements. Examples of these supplements include pickle juice (any sort containing salt and vinegar) to reduce muscle cramps; tart cherry juice to enhance recovery; citrulline, carnitine and quercetin for enhanced endurance performance; curcumin for reducing inflammation and enhancing recovery; glutamine for enhancing immune function; and gelatin for enhancing tissue repair and injury prevention. All of these supplements have the potential to provide significant benefit, but the evidence is insufficient at the moment to be confident that most athletes will respond positively when these supplements are consumed.

SUMMARY AND KEY MESSAGES

Thoughtfully selected foods and overall dietary patterns can enhance an athlete's performance. Small additional benefits are possible through the intake of sports foods and sports supplements. The mechanism of action of sports supplements is complex and the benefits of most supplements are usually specific to a certain type of exercise or sport activity. Supplements such as caffeine, creatine, bicarbonate, nitrate and beta-alanine have the strongest scientific evidence supporting their benefits in sport.

Key messages

- Most of the benefits of nutrition for an athlete are the result of thoughtfully selected foods and overall dietary patterns.
- Sports foods are specially formulated products in which nutrients are packaged in convenient forms for athletes and exercising individuals to help them achieve specific nutritional or performance goals.
- Sports supplements are different from sports foods because they typically contain unusual amounts of nutrients or other components of foods that would not normally be obtained through food alone.
- Sports supplements that have good evidence for enhancing performance include caffeine, creatine, bicarbonate, nitrate and beta-alanine.
- There is also emerging evidence for the benefits of pickle juice, tart cherry juice, citrulline, carnitine, quercetin, curcumin, glutamine and gelatin.
- Given individual variation in how athletes respond to different supplements, it is important that athletes monitor and evaluate their own individual responses to supplements in order to receive the greatest benefit.

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