Sport supplements Radboud Sports Centre

The food pyramid consists of 3 levels. The bottom level of the pyramid (basic nutrition) is the foundation and is important for everyone, including athletes. When basic nutrition proves to be insufficient for an athlete and supplementation is necessary, the middle level of the pyramid can be relevant to optimize nutrition status and sport performance; sports specific nutrition.

This document revolves around the top level of the sports nutrition pyramid and provides an understanding in sport supplementation based on the most recent scientific insights. Nutritional supplements and doping will also be pointed out briefly in this section. Consult a sports dietician before using a sports supplement, because (s)he is acquainted with/informed about the recent developments concerning these products. A sports dietician can tell you whether a supplement could be appropriate for you and in which doses it can be used safely.
§1 Sports supplements versus nutritional supplements

Sports supplements
Sports supplements are nutritional supplements that can have a stimulating (ergogenic) effect on sports performance. Sports supplements can only work optimally if the basic and sports nutrition requirements are fully met. Read more about sports supplements in the next paragraph.

Nutritional supplements
If an athlete, in despite of a balanced diet, it is not able to ingest enough nutrients, supplementation in the form of nutritional supplements might be necessary, for example, vitamins and minerals (micronutrients). The amount of micronutrients that the body needs will ensure a normal, healthy metabolic function. A good and varied basic nutrition will provide sufficient micronutrients in most cases. An excessive intake of micronutrients does not have a performance enhancing effect, but can be detrimental to your health. This might result in a risk for a vitamin A, B1, B2 and D deficiency for these athletes. There is one study in which they researched athletes who did not use sports nutrition (sports bars, sports gels, sports drinks and such), and they were more likely to be deficient in vitamin B3, C and the mineral Selenium. Well-trained female athletes of reproductive age also had an increased risk of an iron deficiency.

For athletes that avoid certain food groups (such as meat and dairy) for example, vegetarians and vegans, it is important to monitor that they ingest enough vitamin B2, B12, D, and the minerals calcium, iron and zinc.

If you wonder whether you consume sufficient nutrients, you could monitor your food intake for 3 days (an exercise day, a non-exercise weekday and a weekend day) to a whole week. You could use an app such as MyFitnessPal and FatSecret. Contact a physician or a dietitian if you have doubts about your micronutrient status before you start using (multi-)vitamins. An exception is vitamin D. According to a guideline by the Dutch Health Council, every Dutch person aged 0-4 and 50-70 should take a vitamin D supplement of 10 micrograms, and people older than 70 should take a supplement of 20 micrograms, because this nutrient is chronically consumed in insufficient amounts. Supplementation is not necessary for persons age 4-50 with light skin and adequate exposure to sunlight between March and November, but the rest of the year they should take a vitamin D supplement as well (1)(2)(3).
§2 Ergogenic aids

Not all supplements have a proven ergogenic effect. Primarily the supplements that have a scientifically proven ergogenic effect will be depicted in this paragraph.

β-alanine (bèta-alanine)
This supplement can postpone lactic acid build up in the muscle cells of athletes that need to exercise at high-intensities between 60 seconds and 4 minutes. Examples are: anaerobic (without oxygen) exercise such as a 400 m sprint or skating for 1500 m. β-alanine does not seem to have an ergogenic effect in power or endurance sports.
β-alanine is an amino acid that is converted into carnosine in the body. Because carnosine is converted to β-alanine and histidine by the gastrointestinal tract, there are no benefits to consume carnosine directly. By enough basic nutrition, enough histidine is ingested. It is the supplementation of a large amount of β-alanine in relation to histidine that provides ergogenic benefits. Supplementation with β-alanine increases the concentration of carnosine in the cell, which stalls the accumulation of lactic acid. A possible side effect of β-alanine (in high doses) is paraesthesia (skin tingling) (4)(5)(6).

Caffeine
Caffeine has central nervous system stimulating properties that can improve (sustained maximal) endurance exercises, such as time trial performance and intermittent high-intensity exercises with a prolonged duration, like team sports. Caffeine delays the perception of being fatigued, increases fat oxidation and decreases the breakdown of glycogen (so the body can obtain energy from fat for a longer period of time, which spares the glycogen storage). The literature is inconclusive when it comes to advances of caffeine in strength and power sports, but it seems that caffeine can primarily improve knee extensor strength. Especially endurance athletes and team sport (e.g. soccer) athletes could benefit from this supplement. However, not everyone experiences the ergogenic effects of caffeine. Caffeine as an ergogenic supplement seems to be less advantageous in people who are used to drinking (a lot of) coffee, but more research is needed.
In high doses, but sometimes also in smaller doses, caffeine can cause the following complaints: heart palpitations, restlessness, insomnia, headaches, nervous irritability, muscle spasms, trembling and elevated blood pressure. Therefore, pre-workouts, which often contain large amounts of caffeine, should be used with caution. In any case: stick to the maximum dosage that is written on the box or bottle. Caffeine has a diuretic effect, but with moderate consumption, water-electrolyte imbalances will not occur (7)(8)(9)(10).
L-Carnitine
Carnitine is a non-essential amino acid that plays a part in fat oxidation. Research shows that supplementation with carnitine facilitates weight loss, possibly by increasing fat oxidation but that the effect diminishes after a while. The objective of supplementation is to increase the concentration of carnitine in the muscles. Intravenous administration leads to a further increased plasma concentration (and consequently to a better effectiveness) than oral administration. In addition, if taken orally, carnitine is converted into a metabolite by intestinal bacteria, which could increase the risk of coronary diseases. Therefore, more (long term) research is needed to determine the effectiveness and safety of oral carnitine supplementation as an aid for (long term) weight loss (11,12).

Creatine
Supplementation with creatine monohydrate, CrH$_2$O, (further named: creatine) can lead to a larger muscle circumference and increased strength because it makes more intensive training possible; the time until fatigue sets in is prolonged. This is caused by the multifarious properties of creatine; it increases the re-production speed of ATP in the cell during short term power bouts, it somewhat delays the development of lactate, it increases the amount of fluid within the cell which ensures a bigger supply of nutrients and it increases muscle protein synthesis.
Creatine can be useful in sports that require intensive or repeated explosive movements with short periods of rest between sets. Creatine does not benefit aerobic exercise.
In about 30% of the users, creatine is ineffective (the so-called ‘non-responders’). Older people often notice less or no effect when using creatine.
Because it predominantly occurs in meat, poultry and fish, vegetarians and vegans in general profit from creatine, because they do not ingest much or any creatine through their basic diet.
Possible side effects are: fluid retention, muscle cramps (anecdotally) and gastrointestinal problems (anecdotally).
In healthy people, the use of creatine doesn’t lead to liver or kidney problems (3)(7)(13).

Caffeine combined with creatine
Caffeine possibly diminishes the ergogenic effect of creatine if high doses of caffeine are consumed for longer periods of time. Therefore, it can be wise to refrain from coffee a few hours before or shortly after ingesting creatine if you notice that the effect of creatine is impaired or if it declines (14,15).
L-terine
Leucine can lead to an increase in muscle mass. It has an increasing effect on muscle protein synthesis (MPS) when 1 to 5 grams of leucine are ingested during a meal that contains protein. A higher supplementation than 5 grams of leucine does not increase MPS further. This means that a meal with a suboptimal amount of protein, but sufficient leucine, can lead to the same extent of MPS as a meal with sufficient protein. This makes this supplement interesting for athletes who want to build muscle mass, prevent muscle loss or optimize muscle recovery, but (occasionally) consume a diet with a suboptimal amount of protein. For instance, the addition of leucine to a vegetarian meal, which usually contains (far) less leucine than animal protein sources, can lead to an increase of MPS. Keep in mind that muscle mass can only increase if there is more synthesis than breakdown (16–18).

Nitrate
Nitrate (NO\textsubscript{3} \textsuperscript{-}) enables the body to sustain the same physical effort with less oxygen and it allows an athlete to perform better with the same amount of oxygen. The exact mechanism behind the effectiveness of nitrate is still being studied, but it enhances the efficiency of the mitochondria in the muscle cells, which improves the oxygen uptake by the muscle cells. This means that nitrate can be beneficial for endurance athletes. The difference in performance with and without nitrate supplementation is less pronounced in trained (elite) athletes than in less trained athletes. A few possible explanations are that well-trained athletes have a higher dietary nitrate intake or that they are closer to their maximal performance, while a less trained athlete still has more room for improvement.

Nitrate (NO\textsubscript{3} \textsuperscript{-}) naturally occurs in red beets and vegetables such as arugula and spinach. The nitrate is converted to nitrite (NO\textsubscript{2} \textsuperscript{-}) by bacteria in the mouth and subsequently into nitric oxide (NO) in the stomach. Nitrate only has an ergogenic effect in high doses, which makes a concentrated form the most practical to ingest. The use of toothpaste and mouth wash before and after drinking beet root juice is discouraged because it kills bacteria needed to convert nitrate into nitrite.

In lower doses (for example a portion of vegetables that are rich in nitrate), nitrate has (slight) blood pressure lowering properties, causing it to have a favourable effect on the prevention and treatment of coronary diseases. An excessive dose of nitrate can lead to gastrointestinal distress. A concentrated form of nitrate can lead to dizziness in athletes with a low blood pressure (5,19–22).
Sodium bicarbonate
Sodium bicarbonate (NaHCO₃) makes it possible to prolong intense exercise. It works as a buffer by lowering the acidity of the blood (by neutralising hydrogen ions, H⁺), so that the acidity in the muscle remains balanced for a longer period of time. Literature is unequivocal about the effectiveness of sodium bicarbonate. However, there is consensus within sports dietetics about the possible performance enhancing properties in short (1-7 to 10 minutes) and prolonged (30-60 minutes) intermittent exercise. This means that this supplement can be interesting for team sport and endurance athletes, as long as the exercise is (intermittently) intense and lasts between 1 and 10 or between 30 and 60 minutes. Trained athletes seem to benefit more from this supplement, but it is a matter of trial and error to determine if it works, and if it does work, which dose and time of administration achieve the best results in every individual athlete.
A single dose of sodium bicarbonate already exceeds the recommended daily allowance of sodium extensively. As a consequence, this supplement is not suitable for athletes with high blood pressure.
Sodium bicarbonate is the same as the baking powder available in supermarkets and Asian shops. However, ingesting loose baking powder is not a good idea. When it comes in contact with stomach acid it is converted into, amongst others, carbon dioxide, which can result in gastric complaints. Because of this, the sodium bicarbonate will not reach the bloodstream and will fail to be effective. Capsuled sodium bicarbonate will not be affected by gastric acid, making it a more effective method of administration.
Possible side effects of this supplement include gastrointestinal problems; using an intake protocol and writing down your experiences can be a useful tool to avoid gastrointestinal problems (3,23).

HMB
HMB (in full: β-hydroxy β-methyl butyrate) is formed when the amino acid leucine is processed in the body. The exact mechanism is still unknown, but research among catabolic patient groups shows that HMB has an anti-catabolic (mitigating muscle breakdown) effect. Scientific evidence within the scope of the effectiveness of HMB is still inconclusive. A few studies found an anti-catabolic effect, while others found no effect. This could be explained by the research methodology (training protocols), such as the intensity of exercise performed by the participants in the study; high-intensity exercise leads to a higher muscle protein synthesis, consequently showing an increased effect of HMB supplementation in those circumstances. Therefore, it seems that HMB-supplementation can ensure that inevitable muscle breakdown only occurs in a limited extent. Training would then result in an increased amount of muscle mass, but further long-term research is necessary (24,25).
BCAA
BCAA is an abbreviation for ‘Branched Chain Amino Acids’ and are composed of the amino acids leucine, isoleucine and lysine. BCAA’s are popular among strength athletes because they are said to increase muscle protein synthesis, stimulate muscle glycogen resynthesis and thus increase muscle mass, but there is not much evidence for the latter. In fact, it is possible that ingesting BCAA’s has no added value, since all 3 amino acids (valine, leucine and isoleucine), use the same transport system in the body. The muscle protein stimulating effect of BCAA’s seem to be primarily caused by leucine (see: \textit{L-leucine})(5,16,26).

§3 Doping
Doping refers to substances and methods that are prohibited by the World Anti-Doping Agency (WADA). The WADA was founded with the aim of bringing consistency to anti-doping policies and regulations within sport organizations and governments across the world. On their website, the 2017 Prohibited List can be found, which includes prohibited substances and methods in the following 3 categories:
1. substances and methods that are prohibited at all times (for instance: anabolic androgynous steroids (AAS), hormone and metabolic modulators, diuretics and masking agents),
2. substances that are prohibited in competition (for instance: stimulants and cannabinoids), and
3. substances that are prohibited in particular sports (alcohol in for instance archery and beta-blockers in for instance skiing).
These substances and methods can have a performance enhancing effect, but often entail severe health risks (27,28).

\textit{Sports supplements in competitive and professional sports}
Sports supplements (and their ingredients) that are not mentioned on the WADA-list of prohibited substances seem safe, but could be contaminated with prohibited substances (traces of prohibited substances unintentionally ended up in the supplement during the production process) or deliberately ‘boosted’ with prohibited substances (also known as ‘spiking’). This is especially important for competitive athletes who may be subjected to drug testing. In reaction to the risk for top-class athletes, the Dutch safety system nutritional supplements top-class sports (’Nederlands Zekerheidssysteem Voedingssupplementen Topsport’ (NZVT)) was founded. Everyone who wants to make sure a certain supplement of a particular brand is safe (not ‘spiked’), can check the safe list on the NZVT-website. This diminishes the chance of a positive drug test for the user of a particular supplement (28).
§4 Important note

A well-constructed, periodised training schedule that is specified to the goal of the athlete, an optimal nutrition plan and the right balance between exertion (exercise) and recovery are the basis to accomplish your personal sports goal(s). It is the RSC’s opinion that with will power, perseverance and belief in your own abilities, it is very well possible to realize your personal sports goal(s), without the use of doping.

§5 Links and apps

- Check the website www.eigenkracht.nl/english for more information on (sport) supplements and doping.
- The NZVT-database can be consulted via: www.dopingautoriteit.nl/nzvt/disclaimer, but it is only available in Dutch. However, there are a few safety systems that are somewhat comparable to the NZVT:
  - Informed Sport (www.informed-sport.com/),
  - Kölner Liste (www.koelnerliste.com/),
  - Banned Substances Control Group (https://www.bscg.org/),
  - NSF International (www.nsf.org/services/by-industry/dietary-supplements/certified-for-sport) and
    - Informed Choice (www.informed-choice.org/).
- Lastly, if you can read Dutch, you can download the ‘dopingwaaier’ and the ‘supplementenwijzer’ on your smartphone if you want to check if the drug/pharmaceutical or nutritional supplement you (want to) use is checked for the presence of doping. The apps also provide information on whether a particular drug is illicit or not.
References


