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Nutrition and the brain and prolonged exercise

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Evidence has accumulated to suggest that events arising entirely within the brain can influence an individual's sensation of fatigue and thus potentially affect performance. Interestingly, this opens an opportunity to manipulate the central nervous system through changes in diet or supplementation with specific nutrients, including amino acids (branched-chain amino acids, tyrosine), carbohydrates and caffeine. Some nutritional supplements that may influence performance during prolonged exercise are outlined in the table below.

Supplement	Dose(s) studied	Proposed effect on the brain	Does it influence performance?
Branched-chain amino acids (BCAA)	5–20 g	Reduces brain serotonin production	<ul style="list-style-type: none"> Evidence is generally weak. A few studies suggest an effect, but many more find no benefit May reduce perception of effort and enhance mental performance during exercise
Caffeine	3–10 mg/kg BM	Reduces effect of adenosine in the brain	<ul style="list-style-type: none"> Performance in events lasting more than a couple of minutes can be enhanced by caffeine Alters mood, increases alertness and reaction times Large individual variation in sensitivity to caffeine
Carbohydrate (CHO)	30–90 g/h	Increased energy for the brain. Influences neurotransmission and cerebral metabolism	<ul style="list-style-type: none"> Evidence suggests a benefit to performance in most cases Possible that part of this ergogenic effect is due to influence on the CNS
Tyrosine	5–10 g	Increases production of brain dopamine and noradrenaline	<ul style="list-style-type: none"> Few studies investigating effect of tyrosine on performance, but show no effect on physical performance Some evidence of a benefit to mood, memory and cognitive function

Some points for consideration when using supplements to influence the development of central fatigue

- This is a relatively new area of research in exercise physiology, and there are still many gaps in our knowledge of the effects of these supplements.
- At the moment, consistent benefits to performance during prolonged exercise are only reported with caffeine or carbohydrate.
- This is not to say that amino acid may not be useful, and there is some emerging evidence that various aspects of mental fatigue and cognitive function can be positively influenced. In sports requiring the controlled execution of skills and/or rapid decision making, amino acid supplements may yet prove beneficial.



- Everyone is different, and individuals may experience varying responses to some of these supplements. This is particularly apparent when considering caffeine supplementation: some experience marked effects with small doses, while others display little noticeable effects, even with relatively large amounts. For this reason it is advised that these supplements are used first in training, ahead of competition.
- Some supplement manufacturers have jumped on results of early studies, and introduced products with ingredients that claim to delay 'mental fatigue' (e.g. BCAAs). Often the inclusion of these ingredients is done with little sound evidence, and the amount of ingredient included is very small (a few hundred milligrams).
- The use of some dietary supplements acting on the central nervous system may be potentially harmful to health. A case in note is ephedra, which is found in some herbal supplements and is reported to be used widely in some sports. Ephedra is a stimulant that increases the amount of dopamine within the brain. A number of deaths from heat illness occurring during exercise have been either directly or indirectly linked to this supplement, and its use will result in a positive doping test under current WADA rules.

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Building muscle:

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By far and away the most important factor for increasing muscle mass and strength is resistance exercise training. Even in a fasted state, resistance exercise training promotes the retention of protein and after a period of training there is an increase in muscle mass and strength.

General Nutrition Strategies.

Nutrition can influence the response to resistance exercise training in multiple ways:

- The total energy content of the diet must be sufficient to meet the needs of daily turnover, growth (pediatrics and adolescence) and the energy cost of physical activity.
- An adequate carbohydrate intake also enhances protein retention with the added benefit of maintaining glycogen stores for the endurance component of cycled training (> 7 gCHO/kg/d for women; > 8 gCHO/kg/d for men).
- There is an increase in dietary protein requirements at the onset of resistance exercise training; however, the body adapts to this stress and with time the increase in protein requirements is attenuated. The maximum dietary protein requirement for an elite athlete performing weight training and/or endurance training would be ~ 1.7 g/kg/d.
- Finally, the timing of nutrient delivery around each of the training bouts is particularly important. The early provision of carbohydrates with and without protein in the very early period following endurance exercise has been shown to increase the rate of glycogen resynthesis. Numerous studies have shown that the early provision of carbohydrate and amino acids (protein) in the early period following resistance exercise can enhance protein retention.





Potential Ergogenic Dietary Supplements and Protein Types.

There have been a large number of nutritional compounds that have been studied as potential ergogenic (work enhancing) aids to enhance the gain in muscle mass following a period of resistance exercise training. There are very few compounds that have consistently been shown to have any influence whatsoever on strength or muscle mass gains following resistance exercise training. Specific whey protein supplements have been widely promoted in the lay press with little to no evidence of any superiority over optimal nutrition practices involving a high biological value protein such as milk which contains both casein and whey. There is some evidence that milk proteins are superior to soy protein with respect to protein accretion after a period of resistance exercise training and it is likely that characteristics such as the time course of absorption (whey = fast; casein = slow) and other bio-active components of milk protein can enhance protein retention.

There is some evidence that β -OH-methyl butyric acid (β -HMB) can enhance strength gains; however, it has not been compared directly to an optimal nutritional regiment (early provision of carbohydrate and protein following resistance exercise training). Creatine monohydrate is a guanidino compound that is consumed in meat containing products and is synthesized from liver, pancreas and kidney. A number of studies have shown that creatine supplementation (5 to 10 g/d) during a period of resistance exercise training can enhance the gains in fat free mass and strength. A problem with this research is that the creatine supplement is usually compared to a true placebo. We have found that the early provision of carbohydrate (50 g) + casein (10 g) after a work-out given over a period of 2 months of resistance exercise training, resulted in similar strength gains as compared to training with the immediate post-exercise consumption of creatine (10 g + 50 g of carbohydrate).

The most effective strategy to increase strength and muscle mass is proper resistance exercise training while consuming adequate energy, carbohydrate and protein. A diet supplying a mixed protein source or a higher biological value protein (milk, egg white, etc.) at 1.7 g/kg/d would meet the needs of essentially every athlete under any circumstance and is readily provided from food provided that the athlete is not restricting energy intake. Consumption of protein supplements or food to get a protein intake beyond this level does not make sense economically or scientifically. The timing of carbohydrate and protein replenishment in the post-exercise period is particularly important to optimize protein balance and also to replenish glycogen stores (particularly if an athlete is training twice a day). For a sprint/power athlete trying to put on muscle bulk and gain strength, creatine supplementation may enhance some of the strength and muscle mass gains at least during the first 4 to 6 months of training.



Suggested additional resources

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2. Tarnopolsky M. Protein requirements for endurance athletes. *Nutrition* 2004;20(7-8):662-668.
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Weight management

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Many athletes, although not overweight, still would like to lose body weight and in particular body fat. For some this is an advantage because it increases the power to weight ratio (for example jumping events) for others it is simply because they can reduce the energy expenditure when carrying a lower body weight (for example running). Weight loss may not always be a good idea and can even be detrimental to performance. For other athletes weight gain and increases in muscle mass may be a concern. This is covered in "Building Muscle" by Dr Mark Tarnopolsky and therefore we will focus mostly on weight loss here.

A first step is to define weight loss goals. These goals should be carefully thought about and defined. Is it really desirable to lose body weight? Weight loss may be useful in some cases but in others it will do more harm than good. Whether it is a good idea or not depends primarily on the body fat percentage. Although individual differences exist, it is not recommended to go below a body fat percentage of about 5% for men and 12–14% for women. Fat has important bodily functions and these will be compromised at extremely low fat levels. The goals also have to be defined with the time schedule in mind. How much weight do you need to lose and how much time is there to achieve this. A realistic weight loss is about a kilogram every two weeks, so to lose 3 kilograms at least 6 weeks are needed. A more rapid weight loss will make it impossible to train adequately.

When the energy intake equals the energy expenditure you will be in energy balance. When you eat less than you burn, you are in negative energy balance and as a result you will lose weight. When you eat more than you expend, you are in positive energy balance—and in this case you will gain weight. A negative energy balance is necessary to lose weight and there are two ways to induce a negative energy balance:

1. Reducing energy intake
2. Increasing energy expenditure

A combination of these two seems to be the best method for long term body weight loss. Besides a negative energy balance, you also must be in negative fat balance in order to lose body fat. This generally means reducing the fat intake, but including aerobic work in training sessions is another way of moving to a negative fat balance. Reducing the fat intake can be very effective because fat is very energy dense, high fat foods generally taste good and this leads to a tendency to eat more. Fat is efficiently stored and requires very little energy for digestion and fat intake does not stimulate fat burning.



High protein diets have been suggested to reduce appetite and lead to better weight loss results. In addition many supplements are on the market claiming to increase fat metabolism and weight loss. However, these supplements have either no evidence base or have very small effects in comparison to manipulations of macronutrient intake.

Another approach that athletes have tried in the past is not eating in the morning and sometimes even skipping lunch. This is not advised because it will increase hunger feelings later in the day; with one single very large meal, the reduction in intake can easily be compensated.