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Educational Paper

Non-nutrients in sports nutrition: Fluids, electrolytes, and ergogenic aids[☆]

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SUMMARY

There is much discussion on what an athlete should be *eating*, but much less reference to *drinking*. Dehydration might decrease both aerobic and cognitive/mental performance. Overhydration might also impair physical ability, and pose a risk for exercise-associated hyponatremia. Athletes and coaches should anticipate possible fluid losses in prolonged events, and calculate appropriate drinking amounts to maintain euhydration. Body weight changes during similar events or training can be used to determine the amount of fluids to be ingested.

Another important adjunct to sports nutrition is the wide range of sports dietary supplements. Such supplements are expected to enhance sport performance, by assisting either weight control, physical and mental performance (e.g. power, speed, endurance, agility), and recovery. Very few dietary supplements have been proven to possess clinically relevant effectiveness, and others are dangerous and illegal. It should be remembered that dietary supplements are not a substitute for a poor diet, that most are not produced or marketed by homogenous standards, that they are not under tight supervision, and that many are marketed without any proof of efficacy.

Persons that are very active, whether professionally or recreationally, could benefit from consulting with sport dietitians in order to verify proper nutrition, hydration, and supplement use.

1. Fluid and electrolyte balance in sports

It is well known that physical activity (PA) causes water and electrolyte losses.[1] A net fluid loss during exercise might cause athlete discomfort, dehydration, and greatly hinder performance. Fluid gain during exercise might also cause discomfort, hinder performance due to the excess weight gained, and might cause exercise-associated hyponatremia[2] and place the athlete in a severe health risk. Alongside proper sports nutrition, athletes and trainers should be educated on appropriate methods of hydration, the recommended composition of fluids, their amounts and timing.

1.1. Hydration effects on performance

Dehydration increases physiologic strain on different body systems, which is reflected by increased core temperature, heart rate and perceived exertion responses to exercise. The greater the body water deficit, the greater the increase in physiologic strain for a given exercise task. Dehydration can hinder performance: losing >2% of body weight (BW) degrades both aerobic and cognitive/mental performance in temperate-warm-hot environments, and greater levels of dehydration will further degrade physical and mental ability.[1] Dehydration of 3–5% BW probably does not hinder strength or anaerobic performance.[1] Dehydration might also result in heat exhaustion/heat stroke, which are caused by an impaired ability to dissipate heat from the exercising body. It is also associated with muscle cramps, and increases the risk and severity of acute renal failure following rhabdomyolysis (the breakdown of muscle brought about by the combination of exercise and heat).[1]

Overhydration might also impair physical ability, and athletes in jumping and sprinting events sometimes prefer a lower body weight, for better performance. Yet the most important aspect of overhydration is the increased risk of Exercise-Associated Hyponatremia (discussed below).

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Learning Objectives

- To understand fluid and electrolyte requirements during exercise.
- To familiarize with the adverse effects of under- and overhydration in sports.
- To obtain practical tools for fluid and electrolyte management in athletes.
- To recognize basic principles of sport supplement use and its scientific basis.
- To know some commonly-used sports supplements, their general properties, and level of scientific proof of safety and efficacy

1.2. Fluid loss in exercise

Water loss during exercise occurs through the respiratory, gastrointestinal and renal systems - and through sweat[1] The volume of metabolic water produced during muscle metabolism (~0.13 g/kcal) roughly equals to the respiratory water losses (~0.12 g/kcal), hence this mode of water loss can be disregarded when assessing fluid balance in exercise. Under normal circumstances, gastrointestinal tract losses are small (~100–200 mL/h). The renal blood flow is markedly reduced in exercise, in order to provide more blood to working muscles. Subsequently, the glomerular filtration rate declines and the tubular fluid reabsorption is increased in compensation. Therefore, urine production during exercise is reduced relatively to resting conditions, but the absolute amounts are highly variable under different climate, exercise and drinking conditions.[1]

Sweating is the primary avenue of water loss during exercise-heat stress. Sweat amounts are also highly variable in different conditions. There is a large inter-individual variability in sweating. In addition, different sport types have different demands from the body's cooling system: some events or training sessions have high intensities or are longer in duration; uniforms, gears and protective equipment, also promote excessive sweating; indoor or outdoor conditions, ambient temperature and humidity, and different seasons, all play a significant role as well in fluid losses of an athlete. Sweat losses in exercise have a wide range of 0.2–3.5 L/h, owing to the different conditions and individual characteristics.

Understanding and anticipating fluid losses in a specific event is important in order to calculate the required drinking amounts. In preparation for a training session or a competition, athletes and trainers should:

- Know the personal sweat loss of an individual athlete, from previous training sessions through pre- and post- exercise weighing
- Know the expected climate and gear in the specific location
- Aim for a few days of heat acclimatization (if traveling to a location with a significantly different weather).

1.3. Hydration assessment

Because sweat loss differs greatly between different settings, there can be no "one size fits all" recommendation for the absolute amount of water to be ingested by an individual during exercise.[1] Fluid losses in a specific event must be properly anticipated, in order to calculate the required drinking amounts. In theory and in practice, hydration status and changes can be assessed by two simple means: body weight changes, and urine color. Athletes should monitor their hydration status by employing simple urine and body weight measurements. An individual with a urine specific gravity $\leq$1.020 or a solute concentration of $\leq$700 mOsmol/kg is considered euhydrated. Several days of first morning body weights can be used to establish a true baseline body weight, which can also represent euhydration.

Body weight changes during events or training sessions are used to reflect sweat losses during exercise. The difference in weight before and after an exercise session can reflect the amount of water lost from the body, and may therefore suggest the amount of fluids to be ingested to maintain euhydration.

1.4. Exercise-associated hyponatremia

Exercise-Associated Hyponatremia (EAH) is the occurrence of hyponatremia (Na^+<135 mmol/L) during or up to 24 h after prolonged physical activity.[2] Early signs and symptoms of EAH can include bloating, "puffiness", nausea, vomiting, and headache, which are very non-specific, and hence require a high index of suspicion for accurate diagnosis. More serious signs and symptoms, resulting from central nervous system involvement, include alteration of mental status, seizures, obtundation, coma and even death.[2] The definitive emergency treatment of symptomatic EAH is immediate onsite administration of intravenous hypertonic saline by trained medical personnel.

EAH is usually a *dilutional* hyponatremia, which means that it is caused by a relative higher increase in total body water than in sodium. The primary etiologic factor identified is the consumption of fluids in excess of losses.[2,3] Because exercise can trigger an inappropriate secretion of the anti-diuretic hormone (SIADH), water is essentially retained[2] Drinking in the presence of SIADH further causes fluid retention.

Recognized risk factors for EAH can be divided into those which are athlete-related, and those which are event-related.[2]

- Athlete-related factors are:
  - excessive drinking behavior
  - weight gain during exercise
  - having a low body weight
  - female sex
  - slow running or performance pace
  - event inexperience
  - use of non-steroidal anti-inflammatory agents.
- Event-related risk factors are:
  - high availability of drinking fluids
  - long duration (>4 h of exercise)
  - unusually hot environmental conditions
  - extreme cold temperature.

In order to prevent EAH, athletes should therefore avoid excess fluid intake during exercise, which could reflect as weight gain. Even maintenance of body weight has been associated with EAH,[3] but most cases occurred in the setting of overhydration.

In practice, athletes should expect to lose 1–2% body weight (not >2%, to prevent hindering performance) - and never to gain weight during exercise. Trainers and athletes should monitor pre- and post- exercise body weight, both to become acquainted with fluid balance of the specific individual, and also to avoid weight gain. Ingestion of electrolyte-containing sports drinks cannot prevent the development of EAH in athletes, as all such drinks have [Na+]<135 mmol/L, which makes them essentially hyponatremic. Even administration of isotonic saline will not increase [Na+] in SIADH, because the infused sodium will be excreted in the urine – while the water is retained.[2] There is conflicting evidence as to the