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Electrolyte disorders in athletes

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Abstract

Aim: The majority of reviews on sports nutrition issues focus on macronutrients - carbohydrates, proteins and fat, often disregarding substances such as sodium, potassium, calcium and magnesium. Through the literature, it is clear that there are not enough reviews that focus entirely on the effects of electrolytes mentioned above, in particular on endurance sports. Dyselectrolytemia has been related to health and performance issues in athletes. Moreover, it was scientifically proven that one of the reasons for the development of muscle cramps (EAMC) and hyponatremia (EAH) is electrolyte imbalance. That is why, we create this systematic review in order to report extensively on the role of electrolyte consumption in endurance and ultra - endurance athletes, the connection between the quantity consumed and the development of pathological disorders, the effectiveness of concurrent hydration, and whether an imbalance of this substance contributes to EAH and EAMC.

Methods: As a method of data collection, this study focused on exploring literature from 2019 - 2024. The investigation was carried out using the PubMed research database.
Results: Data presented in this article underline the importance of keeping our electrolyte levels intact. We focused on different situations caused by dyselectrolytemia and its symptoms, as well as possible explanations on how to cure them.
Conclusions: Electrolytes wield the paramount role in our well - being. Its levels differ among athletes. We can easily cross the line which results in dyselectrolytemia, then it causes symptoms like fatigue, dizziness, nausea and vomiting. In addition, it increases the likelihood of infectious diseases, and stress fractures. Hopefully, scientists find a way to prevent it from happening. Those actions contain: proper fluid intake during exercise and enough carbohydrates absorption.

Keywords: electrolytes, sodium, potassium. magnesium, calcium, athletes

1. Introduction:

Electrolytes are a group of chemicals that cannot be produced by the body. That is why extensive or very low consumption of those ingredients can be harmful for our well - being. [9]. Generally speaking, disturbances in the level of electrolytes are common among athletes. Hardly ever it becomes life - threatening.[1]

People lose a large amount of body fluids due to sweating.[9] It is also known that an electrolyte imbalance acts a part in the onset of muscle cramps (EAMC)[9]. Having said that, we must take extreme caution when exercising and never forget to rehydrate. The most effective way to regain electrolyte hemostasis is to drink water that contains additional electrolytes. [6]. Moreover, for ex.: sodium replacement is necessary when the duration of exercise exceeds 2h. [9] The aim of this study is to provide review of the electrolytes and its influence on athletes.

2. Sodium intake and its effect on athletes

Sodium is known to us as one of the main compartments of electrolytes in extracellular fluid. It's function is to drive plasma tonicity. [1] Moreover, it is a prominent compound when it comes to stimulating muscles and nerves. [9] The reference range is 135-145 mmol/L.

Exercise-associated hyponatremia (EAH)

EAH is a state when sodium concentration is beneath 135 mmol/L when exercise for 24h.[14] We can distinguish two states of exercise-associated hyponatremia (EAH) ; first one is a mild hyponatremia and second one is a pronounced hyponatremia (<120 mmol/L). Those two differ in symptoms, a mild state gives no signs, whereas a profound one will lead to central nervous system (CNS) failure. All the symptoms are occurring because of a cerebral edema and respiratory failure. If we don't cure the patient before plasma sodium concentration reaches <110-115 mmol/L, he will definitely die. [4] In fact, death of a athlete has been reported during 2015 Frankfurt European Ironman Championship due to a cerebral edema. [13]

The pervasiveness of EAH relies upon the duration of an endurance performance - low in maraton, high in ultra - maraton). [4] Nowadays, the topic of rehydration is a highly controversial one. In the XX century sportsmen were asked not to consume water during the competition, which led to serious cases of dehydration and hypernatremia.

Fortunately, now it is the opposite [13]. However, most cases of EAH is caused by overconsumption of hypotonic fluids, which leads to weight gain. That kind of procedure triggers lower plasma sodium concentration - possibly resulting in EAH.[14]

Prevention strategies of EAH

Hyponatremia is a medical condition where symptoms are often similar to those from dehydration.[14] To prevent it from happening we should imply simple but effective steps such as; educational programs for coaches, athletes, staff that will concentrate on sodium supplementation, recognition and treatment of EAH. [4] In early stage we may encounter dyspnea, lightheadedness, dizziness, nausea and vomiting.[14] To prevent it from happening we can educate athletes towards proper fluid intake during exercise. Their bodies ought to be replenished to prevent dehydration.[16] For patients, who are in a life - threatening position, we must administer rapid initial treatment. According to The Society of Endocrinology and the European Society of Endocrinology intravenous treatment with 150 ml of 3% sodium chloride over 20 min.[10] Another key factor for maintaining strength throughout physical activity is to absorb enough carbohydrates. This action will enable runners to sustain their pace. For 3h exercise we should consume up to 90g/h of carbohydrates. [16]

3. Potassium intake and its effect on athletes

Potassium is the major intracellular cation, the primary function is to regulate resting membrane potentials (e.g., in the heart). The typical reference range is 3.5–5 mmol/L[10].

Potassium is a key factor for coming across well in different athletic disciplines. It is an essential nutrient for human health, vital for numerous physiological functions. It enables muscle contractions and aids in regulating fluid balance, blood pressure, and heart rate. Beyond its involvement in muscle function, it supports nerve activity and maintains proper electrolyte balance, which can be particularly beneficial for athletes during extended practices or games where sweating occurs. Potassium is easily accessible form of energy for athletes. It helps to decrease the amount of lactic acid stored in the muscles, which may lead to fatigue as well as maintain a healthy metabolism. It is also involved in the breakdown of carbohydrates, which helps keep energy levels high during intense physical activity [15].

Endurance athletes often train at a high pace, which can increase their vulnerability to fatigue and muscle damage. To counteract the effects of prolonged or intense training, athletes depend on nutrition to support recovery and overall health. Insufficient energy and nutrient intake over extended periods can elevate the risk of overtraining syndrome (where recovery cannot keep pace with training demands), infectious diseases, and stress fractures. Additionally, other health complications may arise, affecting key systems in our body: gastrointestinal, cardiovascular and endocrine. Based on the findings of statistical analysis of micronutrient intakes in athletes - more than 50% of male athletes did not consume enough potassium and total water. Among women, >50% also did not consume enough potassium [12].

Moreover, the concentration of potassium in the body of athletes is closely related with sweating. Exaggerated sweating leads to major fluid and electrolyte losses, negatively impacting hydration status and potentially impairing performance and health. Roughly 99% of sweat is water, although sweat also contains electrolytes among others - potassium.

The composition of sweat can differ significantly from one another due to factors such as genetics, diet, acclimatization to heat and hydration status. Some people may lose more sodium in their sweat, while others may have higher concentrations of other electrolytes [11].

Summing up - many athletes did not consume the recommended amount of potassium. Inadequate intake of total potassium can undermine training sessions and lead to heat exhaustion [12].

4. Calcium intake and its effect in athletes

Calcium is one of the most plentiful elements in the human body and serves as a key component of mineralized tissues, with over 99% of the body's total calcium stored in them. It has a vital role in skeletal mineralization and is required for proper growth and bone strength. Moreover, it performs many biological functions, such as muscle contraction and nerve impulse transmission [20]. The usual reference range is 2.12–2.6mmol/L. It is regulated by the parathyroid hormone (PTH) via a negative feedback loop [10].

Calcium is among the many nutrients that athletes need to remain healthy. It not only helps to keep bones and muscles strong, but it has also been linked to improved performance in athletes. However, insufficient calcium consumption and elevated calcium depletion may expose a person to osteoporosis. Athletes should make sure to consume an adequate amount of calcium each day, which is around 1500 mg/d. The optimal calcium requirement is 1200 mg/day for adolescents and youth, 1000 mg/day for females aged 25 to 50 years old, and 1500 mg/day for postmenopausal females who are not treated with estrogen replacement therapy. With the proper diet and exercise regimen, they can take advantage of the benefits that calcium provides and optimize their performance.

Many studies have shown that the adequate intake of calcium can enhance physical performance in athletes, as it plays a crucial role in maintaining muscle strength, which is a key element for exercise performance. Additionally, it may help reduce injuries and improve recovery time. Calcium is recognized for its role in safeguarding bones and joints against the strain resulting from ongoing physical activity. Conversely, improving calcium status with 2000 mg of calcium supplementation has been shown to reduce the risk of developing a stress fracture. Calcium also helps to convert carbohydrates and fat into energy, which can contribute to performance improvement. It also helps in reducing fatigue and delaying the onset of muscle soreness.

Calcium can be found in many common foods including milk, yogurt, cheese, and dark leafy greens. Other sources include tofu, nuts, fish, and fortified cereals. Additionally, athletes may consider calcium supplements if they are unable to receive the recommended daily intake from their diet. It is important to note that the amount of calcium an athlete needs daily may vary depending on their weight and activity level. Skeletal muscles' ability to contract and relax depends in part on calcium. The importance of it binding to troponin C for the contraction of muscles has the potential to influence performance.

While it is true that training leads to higher calcium loss, primarily through perspiration, the foundations of bone mineralization are calcium, vitamin D, and physical activity. However, in rare circumstances, especially if the diet is low in its nutrient density, physical activity might endanger bones [17]. The muscle contractions put a mechanical strain on bone and significantly impact bone density, size and strength [21].

In connection with the above every athlete should place a high priority on developing and maintaining optimal bone health, since vigorous physical activity increases the stress fractures risk [17].

5. Magnesium intake and its effect in athletes

This paramount compound can be found in bones. It's role in human body is being a co-factor for many enzymes - that is why it helps with nerve conduction and muscle contraction. [10] It is a key factor for over 300 metabolic reactions in the body. Research has shown that exercise induces a redistribution of magnesium in the body.[17] Standard range is 0.7-1 mmol/L. [10]

Changes in Mg2+ levels are exceptionally rare. However, when they occur they are coupled with exercise-associated disorders such as; gastrointestinal losses. As follows from dietary surveys, magnesium intake less than 260 mg/day (M) and 220 mg/day (F) may result in a magnesium deficiency. [18] Athletes are prone to have restrictive diets and extensive exercise, which result in low plasma levels of magnesium.. Then, they encountered medical problems with carpopedal cramps. [1] The study conducted by De Sousa et.al showed that all athletes had lower magnesium intake, especially females. As a conclusion they said that better nutrition guidelines are needed for adolescents. [17] Magnesium deficiency is linked with lower bone mineral density. Researcher named Matias examined if magnesium intake mediates the association between bone mineral density and soft tissue using X-Ray. Results were shocking: they encounter significantly lower than recommended intake of magnesium among athletes.[17]

Most people who encounter hypomagnesemia have their magnesium levels in between 0.4-0.7 mmol/L, they do not need treatment, unless symptomatic. Some athletes present with <0.4 mmol/L magnesium level, they ought to be prescribed replacement therapy - Magnaspartate 243 mg or Glycerophosphate tablets (24 mmol). [10]

On the other hand, hypermagnesemia is usually caused by excess ingestion of magnesium. We can divide hypermagnesemia into two main stages: mild and severe toxicity. First one, can be dealt with via Furosemide intravenous injection. Second, requires 10-20 mL of IV calcium gluconate 10% and often a respiratory support. [10]

Generally speaking, equal levels of Mg have a positive effect on muscle performance for ex. grip strength, leg power, knee extension. Moreover, Mg supplementation improves our functional indices such as quadriceps torque. Magnesium is also vital for an elderly people - it improves chair stand time. [19]

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