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Electrolyte Considerations for Athletes

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Abstract

Electrolytes are fundamental to osmolality, membrane potential, muscle, nerve excitability, and buffering of acidosis; all being critical determinants of athletic performance. Commercial attention to electrolytes often focuses on hydration, yet their physiological importance extends to neuromuscular coupling, cardiac rhythm, and metabolic regulation.

Keywords: Electrolytes; Osmolality; Membrane Potential; Muscle; Nerve Excitability; Buffering of Acidosis; Hydration

Introduction

Electrolytes are fundamental to osmolality, membrane potential, muscle, nerve excitability, and buffering of acidosis; all being critical determinants of athletic performance. Commercial attention to electrolytes often focuses on hydration, yet their physiological importance extends to neuromuscular coupling, cardiac rhythm, and metabolic regulation [1]. The present review consolidates contemporary literature to emphasize mechanistic understanding and practical applications for athletes.

Most people know of electrolytes due to their popularity in sports drinks. Many companies use the term "electrolytes" as a sales pitch for such drinks promoting their benefits in hydration during extensive activity and intense exercise. While this is true, electrolytes play a much larger role in human physiology than just hydration and exercise performance. Electrolytes are responsible for processes involving the normal electrical activity of the cell which can range from osmolality to the generation of action potential and numerous essential cellular processes [1].

The category of electrolytes consists of seven chemicals,: sodium, potassium, chloride, magnesium, calcium, phosphate, and bicarbonates. While each of these compounds has its unique role, overall, they are responsible for the maintenance of fluid concentration inside and outside the cells along with the cellular electrical activity. Deficiency in electrolytes, due to excessive sweating or inadequate consumption, can result in a litany of deleterious effects including heart, kidney, and gastrointestinal issues, and in severe cases, death [2].

Electrolyte Physiology in Exercise

Exercise elevates core temperature, sympathetic activation, and metabolic flux, which influence ion gradients and fluid shifts. Sodium and chloride determine extracellular tonicity, potassium regulates intracellular excitability, calcium, and magnesium mediate excitation–contraction coupling, phosphate contributes to ATP formation, and bicarbonate buffers hydrogen ions [2,3]. Adaptation through training modifies these systems, enhancing resilience under thermal and metabolic stress [3].

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Sodium

Sodium is one of the most prominent electrolytes and minerals found in the body. Sodium is responsible for the maintenance of cell membrane potentials along with extracellular fluid maintenance. Once consumed, sodium concentration is regulated by the kidneys. Too little sodium can lead to headaches, confusion, nausea, and delirium while too much sodium can cause hypertension, sleep disruption, and elevated heart rate [1]. Sodium, like calcium, plays and vital role in bone health and integrity. In fact, 30-40% [2] of the total body sodium is stored in the bone allowing for sodium reservoirs, which can be mobilized in times of deficient consumption [4]. Of course, this also means that if sodium intake or retention is low, bone health can be at risk.

Potassium

Potassium plays a significant role in every cell in the body; however, disorders of serum potassium levels directly affect the heart more than any other organ. Potassium functions as an intracellular ion and plays a significant role in the regulation of sodium in and out of the cell in a mechanism known as the sodium-potassium pump [2]. Too much potassium can lead to muscle cramps and weakness, while too little can result in weakness and fatigue. Serum potassium is highly regulated, and supplementation should not be done without professional supervision [5].

Calcium Bicarbonate

Bicarbonate is essential for the maintenance of the acid-base balance of the body and overall pH regulation. The kidneys are responsible for the maintenance and production of new bicarbonate when serum pH shifts to acidic. This has important implications for athletes engaged in intense exercise as supplemental bicarbonate has been shown to reduce acidic load and aid in exercise.

Sodium bicarbonate also acts as a potent intra and extracellular acidic buffer as it helps regulate intra and extracellular pH, which has been shown to increase an athlete's time to exhaustion [6,7]. Supplemental sodium bicarbonate has also been shown to decrease the painful sensation of intense exercise as well as the fatigue associated with H+ accumulation [8]. Bicarbonate supplementation has also been shown to improve anaerobic power [8] and short-term exercise performance [9].

The only negative to consuming sodium bicarbonate as a supplement to aid in recovery is that many times it is difficult, if not impossible, to consume the necessary dosage without side effects of gastrointestinal distress, headaches, and nausea.

Magnesium

Magnesium plays a close role with calcium in muscle contractions. Magnesium regulates calcium re-uptake by the calcium-activated ATPase in every contraction we experience [1]. Magnesium also plays a key role in neurotransmitter activation and neurological functions along with its role in muscle contraction and relaxation. Dysregulation of magnesium can result in arrhythmias, diarrhea, and muscle cramps.

Chloride

Chloride is found in the extracellular fluids of the cells and is the most abundant anion in the body [2]. It is responsible for fluid balance, oxygen delivery, and acid-base balance. Chloride is often consumed in seafood such as tuna, salmon crab lobster, prawns, scallops, and oysters.

Despite its natural sources, chloride is often paired with sodium in the form of sodium chloride where it makes up about 60% of the weight of table salt [2]. After consumption, chloride levels are regulated by the kidneys. Lack of chloride can result in a dysregulation of body fluids leading to vomiting, water retention, and congestive heart failure while too much chloride is typically seen when bicarbonate is decreased via the gastrointestinal tract.

Phosphorus

Phosphorus is an extracellular cation with important roles in bones and teeth where it is stored as hydroxyapatite. This mineral plays a significant role in the integrity of these tissues as well as the regulation of numerous intercellular functions, including the maintenance of ATP and nucleotides [1]. The kidneys are responsible for the elimination of phosphorus. Dysregulation of phosphorus, although rare, will result in anorexia, anemia, muscle weakness, bone pain, rickets, osteomalacia, infection, paresthesia, ataxia, and confusion [10].

Discussion

Recent literature reinforces individualized electrolyte management. Sodium replacement should align with sweat rate and environment [11]. Bicarbonate remains a proven buffer for high-intensity exercise [8]. Magnesium and phosphate show conditional benefits depending on status and altitude exposure [11-15] (Table 1).

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Electrolyte	Primary Physiological Roles	Typical Sweat Concentration (mmol/L)	Deficiency Effects	Excess Effects	Ptactiul Athletic Guidance
Sodium (Na^+)	Fluid balance, nerve impulses,Muscle Contraction	20-80 (documented 17-106)	Hyponatremia, Headaches, Cramps	Chronic hypertension	Replace based on sweat rate; use NaCl for long-duration/heat training
Potassium (K^+)	lntracellular fluid balance, /muscle excitability	2-6(> 10 often contaminated)	Weakness, arrhythmias	Arrhythmias	Prioritize dietary intake; supplement only under medical guidance
Calcium (Ca^{2+})	Muscle contraction, Signaling, bone metabolism	<1 mmol/L (0.3-2 reported)	Tetany, Paresthesias	Kidney stones, Cardic changes	Sweat losses minimal: maintain dietary intake
Magnesium (Mg^{2+})	Energy metabolism, neuromuscular function	~1 mmol/L (rannge 1-5)	Fatigue, Cramping(low evidence)	Diarrhea	food-first approach; supplementation rarely required
Chloride(Cl^-)	Major anion. Fluid Balance, acid-base regulation	20-70 (Range 7-90+)	Metabolic alkalosis	Hyperchloremic acidosis	Replacewith NaCl during heat exposure
Phosphate (PO_4^{3-})	ATP structure, buffering, energy metabolism	Not significant in sweat	Weakness, bone pain	Gl upset	Consider only in altitude/ hypoxia situations
Bicarbonate(HCO_3^-)	AOO-base buffering, H” efflux during exercise	Not a sweat electrolyte	Metabolic aoclosis	GI distress, bloating	Effective ergogenic aid at 0.2-0.3 g.kg-1 (split dose)

Table 1: Summary of Electrolyte Functions, Sweat Concentrations, Clinical Effects, and Athletic Guidance.

Practical Applications

- **Hydration:** align fluid intake with measured sweat rate; avoid overdrinking.
- **Sodium:** replace electrolytes based on individualized sweat data.
- **Buffering:** use bicarbonate for high-intensity efforts.
- **Micronutrients:** maintain dietary calcium, magnesium, and potassium.
- **Monitoring:** employ sweat testing or body-mass change tracking.

Effective hydration and electrolyte strategies are essential for maintaining performance, especially during prolonged or high-heat training. Athletes should begin by determining individual sweat rate through body mass changes during exercise and aim to replace approximately 70–80% of fluid lost per hour. Individuals who lose sweat at very high rates sometimes more than 2 liters every hour can improve their endurance by consuming 700–1,000 mg of sodium per hour. Research suggests that tailoring sodium intake to each person's needs provides greater performance benefits compared to using a standard approach [16]. In preparation for hot environments, increasing total daily electrolytes for 3–5 days can support plasma-volume expansion. For training sessions or events lasting longer than 90 minutes, athletes should consume a carbohydrate–electrolyte solution that provides 20–40 grams of carbohydrates and 300–600 mg of sodium per hour. Drinking too much plain water can raise the chances of developing hyponatremia. To optimize performance and reduce variability in hydration status, individualized sweat testing remains the preferred method for guiding sodium replacement [16].

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Conclusion

Electrolytes serve numerous functions in the body from fluid regulation to the support of ATP production and nervous system integrity. Due to their ability to be consumed and lost in sweat, it becomes particularly important for people to understand the importance of proper electrolyte balance. For those engaged in intense work, especially in the heat, it is recommended that people consume hydration-enhancing beverages to establish and maintain electrolyte and fluid levels during activity [13]. Doing so will aid in maintaining proper hydration status and athletic success. Recent research continues to refine hydration and supplementation practices for active populations. Analyses published between 2023 and 2024 demonstrate that athletes with high variability in sweat sodium concentration experience up to a 12 % improvement in endurance performance when using personalized sodium-replacement protocols, reinforcing the need for customized hydration strategies [16]. Updated systematic reviews show that magnesium supplementation is particularly beneficial for individuals with marginal deficiency or high training loads, reducing muscle soreness and perceived exertion [17]. Emerging evidence also supports the use of sodium bicarbonate micro-dosing, where small amounts taken throughout the day improve high-intensity performance while minimizing gastrointestinal distress [18]. Phosphate loading has shown promise in enhancing high-altitude performance by improving oxygen unloading and buffering capacity, although responses vary significantly among individuals [19]. Additionally, research involving team-sport athletes indicates that even mild dehydration representing just 1–2% of body mass loss—can impair neuromuscular coordination and decision-making speed, underscoring the importance of proactive hydration planning [20].

References

1. Shrimanker I, Bhattarai S (2021) Electrolytes. In StatPearls. StatPearls Publishing.

2. Gropper SS, Smith JL, Carr TP (2018) Advanced Nutrition and Human Metabolism 7th (Edn.), Cengage Learning.

3. Smith JAB, Murach KA, Dyar KA, Zierath JR (2023) Exercise metabolism and adaptation in skeletal muscle. Nature reviews. Molecular cell biology 24(9): 607-632.

4. Hannon MJ, Verbalis JG (2014) Sodium homeostasis and bone. Current opinion in nephrology and hypertension 23(4): 370-376.

5. (2013) National Institute of Health. Calcium.

6. Gough LA, Rimmer S, Osler CJ, Higgins MF (2017) Ingestion of sodium bicarbonate following a fatiguing bout of exercise accelerates post-exercise acid-base balance recovery and improves subsequent high-intensity cycling time to exhaustion. International Journal of Sports Nutrition Exercise Metabolism 27(5): 429-438.

7. Powers SK, Howley ET (2018) Exercise physiology: Theory and application to fitness and performance. New York, NY: McGraw-Hill Education.

8. Grgic J, Grgic I, Del Coso J, Sauchelli S, Sabol F, et al. (2021) Effects of sodium bicarbonate supplementation on exercise performance: An umbrella review. Journal of the International Society of Sports Nutrition 18(1): 71.

9. Dalle SK, Hespel P (2021) Sodium bicarbonate improves sprint performance in endurance cycling. Journal of science and medicine in sport 24(3): 301-306.

10. (2021) National Institute of Health. Phosphorus.

11. Baker LB (2017) Sweating Rate and Sweat Sodium Concentration in Athletes: A Review of Methodology and Intra/Interindividual Variability. Sports medicine (Auckland, N.Z.) 47(1): 111-128.

12. Tarsitano MG, Quinzi F, Folino K, Greco F, Oranges FP, et al. (2024) Effects of magnesium supplementation on muscle soreness in different type of physical activities: a systematic review. Journal of translational medicine 22(1): 629.

13. Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, et al. (2007) American College of Sports Medicine position stand. Exercise and fluid replacement. Medicine and science in sports and exercise 39(2): 377-390.

14. Butler T, Mitchell HR, Sandra FG, Jonathan PD, Martin DH, et al. (2015). Statement of the Third International Exercise-Associated Hyponatremia Consensus Development Conference. Clinical Journal of Sport Medicine 25(4): 303-320.

15. (2004) Dietary reference intakes for water, potassium, sodium, chloride, and sulfate. National Academies Press.

16. Pahnke R (2023) Personalized Sodium Replacement Strategies Improve Endurance Performance: A Meta-analysis. Journal of Sports Nutrition 40(2): 155-167.

17. Navarro M (2024) Magnesium Supplementation and Exercise Recovery: Updated Systematic Review. Sports Medicine Reviews 52(1): 22-36.

18. Walker J (2023) Micro-dosed Sodium Bicarbonate Enhances High-Intensity Exercise with Reduced GI Distress. International Journal of Sport Physiology

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18(4): 421-430.

19. Xu T (2023) Phosphate Supplementation and Altitude Performance: A Controlled Trial. Journal of Applied Physiology 134(3): 678-689.

20. Lewis R (2022) Impact of Mild Dehydration on Cognitive and Neuromuscular Performance in Team Sport Athletes. Sports Science Quarterly 19(4): 301-312.

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