# Do I Really Need Electrolyte Supplements for a Healthy Lifestyle?

Learning Outcomes:

By the end of this case study students should be able to

* + Apply the concept of aqueous solutions to different electrolyte mixtures
  + Classify substances as strong, non-electrolytes, strong/weak acids and bases, and ionic vs. molecular compounds
  + Predict the electrical conductivity of different substances in an electrolyte solution
  + Determine and write out the hydration reaction of different ionic compounds including ionic compounds with polyatomic ions
  + Differentiate and write out the dissociation reaction equation of strong and weak acids in water
  + Analyze experimental data provided

Story[1]:

In the past couple of years electrolyte supplements also known as hydration boosters have gained a lot of traction on the news and social media. Influencers have advertised electrolyte supplements as being part of a low maintenance “healthy lifestyle”. Electrolyte supplements are marketed as either drinks, powders, or tablets. Traditionally, electrolyte supplements are used by athletes to replenish fluids lost through sweat. Some electrolyte formulations are indicated for conditions such as vomiting and diarrhea which are known as oral rehydration solutions (ORS). Electrolytes can also support nerve and muscle function, maintain blood pressure, consumed by individuals on a low carbohydrate diet, contain vitamins, and even some claim it can be a part of a beauty routine to provide glow and hydration. But one question remains; do we really need electrolytes as a part of a healthy lifestyle or are there other alternative sources of electrolytes? In this case study we will examine the contents of five electrolyte supplements and look closely at their ingredients namely Gatorade™, Liquid I.V.®, LMNT, Pique®, and Pedialyte Advanced Care® Plus. We will also be analyzing experimental data to evaluate the if additives besides electrolytes are necessary. You can refer to the pre-case activity resources before your group starts working through this case study. Following the resources, you will work through a series of questions and then determine if you need to take electrolytes on regular basis or are they just limited to certain conditions.

Pre-case Activities:

Visit the websites and watch the videos (links are provide below) to learn more about electrolytes**.**

**Instructor Note: more links are provided than needed. Select 2-3.**

<https://www.today.com/health/diet-fitness/can-you-take-too-many-electrolytes-rcna204065>

<https://www.heart.org/en/news/2024/06/19/electrolytes-can-give-the-body-a-charge-but-try-not-to-overdo-it>

<https://www.theguardian.com/lifeandstyle/2024/sep/30/the-electrolytes-boom-a-wonder-supplement-or-an-unnecessary-expense>

<https://www.youtube.com/watch?v=uqEO1Xc2P64&t=800s>

<https://abcnews.go.com/GMA/Wellness/video/beneficial-electrolyte-supplements-boost-hydration-122608760>

Ingredients and Nutrition Information:

* Pedialyte Advanced Care® Plus Orange Breeze

Serving Size: 33.8 fl oz (1L)

|  |  |  |  |
| --- | --- | --- | --- |
| Ingredients | Minerals | | Nutrition Information |
| Water, Dextrose, Galactooligisaccharides. Less than 0.5% of: Salt, Citric Acid, Potassium Citrate, Natural and Artificial Flavor, Sucralose, Acesulfame Potassium, Zinc Gluconate, and Yellow 6 | Potassium | 780 mg | Calories: 100 |
| Total Fat: 0 g |
| Sodium | 1380 mg | Total Carbohydrates: 27 g |
| Zinc | 7.8 mg | Dietary Fiber: 2 g |
| Total Sugars: 19 g |
| Chloride | 1770 mg | Protein: 0 g |

* Gatorade™ Cool Blue Thirst Quencher

Serving Size: 12 fl oz (360 mL)

|  |  |  |
| --- | --- | --- |
| Ingredients | Nutrition Information | More Information |
| Water, Sugar, Dextrose, Citric Acid, Sodium Citrate, Natural and Artificial Flavor, Salt, Monopotassium Phosphate, Modified Food Starch, Glycerol Ester of Rosin, Blue 1 | Calories: 80 | % Juice: 0 |
| Total Fat: 0 g |
| Total Carbohydrates: 22 g | Caffeine: 0 mg |
| Sodium: 160 mg |
| Potassium: 50 mg | Phosphorus: 30 mg |
| Protein: 0 g |

* Liquid I.V.® Hydration Multiplier in Lemon-Lime

Serving size: one powder stick pack (16 g) in 500 mL water

**Nutrition and Ingredients:** Sugar (pure cane sugar, dextrose), Citric acid, Salt, Potassium Citrate, Sodium Citrate, Natural Flavors, Potassium Phosphate Dibasic, Silicon Dioxide, Rebiana (Stevia Leaf Extract), Ascorbic Acid (Vitamin C), Niacinamide (Vitamin B3), Pantothenic Acid (Vitamin B5), Pyridoxine Hydrochloride (Vitamin B6), Cyanocobalamin (Vitamin B12)

* LMNT in Citrus Salt

Serving size: one powder stick pack (6 g) in 32 fl oz of water

|  |  |  |  |
| --- | --- | --- | --- |
| Ingredients | Minerals | | Nutrition Information |
| Salt (Sodium Chloride), Citric Acid, Magnesium Malate, Potassium Chloride, Natural Lemon and Lime Flavors, Stevia Leaf Extract | Potassium | 200 mg | Calories: 10 |
| Total Fat: 0 g |
| Vitamin D | 0 mcg | Total Carbohydrates: 2 g |
| Magnesium | 60 mg | Sodium: 1000 mg |
| Total Sugars: 19 g |
| Calcium | 0 mg | Protein: 0 g |
| Iron | 0 mg | Cholesterol: 0 mg |

* Pique® B•T Fountain ⎜Beauty Electrolyte

Serving Size: 1 Sachet (3.75 g) in 16 fl oz of water

|  |  |
| --- | --- |
| Ingredients | Nutrition Information |
| Coconut Water Powder, Pink Himalayan Salt, Citric Acid, Yuzu Raspberry and Other Natural Flavors, Silica, Beet Juice Powder, Monk Fruit Extract | Calcium (as Calcium Malate): 30 mg |
| Magnesium (as Magnesium Glycinate): 100 mg |
| Sodium (as Sodium Citrate and Sodium Chloride): 150 mg |
| Potassium (Potassium as Potassium Citrate and Potassium Chloride): 150 mg |
| Phytoceramides (as Wheat Seed Extract): 30 mg |
| Sodium Hyaluronate (Premium Form of Hyaluronic Acid: 30 mg) |

## Part I: Background Assessment Questions

1. What type of solution best describes both Gatorade™ and Pedialyte Advanced Care® based on the solvent? Hint: look at the first ingredient on the list.

**Aqueous solution (first ingredient is water)**

1. Name any three ingredients from the five brands of electrolyte supplements that can be classified as *electrolytes* in aqueous solutions.

**Any three of the salts mentioned: sodium or potassium citrate, potassium or sodium chloride, magnesium or calcium malate, monopotassium phosphate, potassium phosphate dibasic, magnesium glycinate, or sodium hyaluronate**

1. Based on your knowledge, which substances do you expect to be *non-electrolytes*? Select any that apply.
2. **Dextrose (C6H14O7)**
3. Sodium citrate (Na3C6H5O7)
4. Monopotassium phosphate (KH2PO4)
5. **Galactooligosaccharides ((C6H10O5)n)**
6. Citric acid (C6H7O7H)
7. Potassium chloride
8. **Silicon dioxide (SiO2)**
9. Write out the dissociation equation of potassium citrate (K3C6H5O7), citric acid (C6H7O7H) and potassium chloride in water and classify them as ionic or molecular compounds.

K3C6H5O7:**K3C6H5O7 ⟶ 3 K+(aq) + C6H5O73-(aq), ionic**

C6H7O7H: **C6H7O7H + H2O(l) ⇌ H3O+(aq) + C6H7O7-(aq), molecular**

KCl: **KCl ⟶ K+(aq) + Cl-(aq), ionic**

1. How would the dissociation of citric acid differ from the dissociation of an acid such as nitric acid? Assume water is the solvent in both cases.

**Citric acid is an organic acid and therefore it is a weak electrolyte while nitric acid is a strong acid and a strong electrolyte. Citric acid would dissociate partially and nitric acid would dissociate completely.**

1. Based on the components of the electrolyte supplements, do you expect them to be electrically conductive or non-conductive? Explain your reasoning and assume all the supplements are in an aqueous solution.

**Yes, they would be conductive due to the presence of strong electrolytes specifically free ions such as sodium, potassium, calcium, magnesium, available to conduct charge in aqueous solution.**

1. Rank the following in order of increasing conductivity (lowest to highest conductivity): Gatorade™, distilled water and tap water. Why did you arrange them in this order?

**Distilled water < tap water < Gatorade™**

**Distilled water contains no ions, while tap water contain some ions such Na+, K+, Ca2+, Mg2+ etc. but in a lower concentration compared to Gatorade.**

1. Liquid I.V. contains a few vitamins such as vitamin C, B6, B12, etc. in addition to electrolytes. Is there a correlation between vitamins and electrolytes? Cite your sources.

**Answers may vary but must be cited. Certain vitamins such as vitamin B6 are involved in electrolyte transport, vitamin C indirectly affects the ions such as Na+, K+, and Mg2+.**

**Instructor note: this question involves outside research and may make the case study take longer than most regular class periods.**

## Part II: Case Study Questions

*Make sure to cite any references that will be included in your work to support your answers.*

1. Do you think we need to consume electrolyte supplements on regular basis or obtaining can we obtain our electrolyte needs from other sources and why do you think so? Include examples when you can.

**Not necessarily, electrolytes can be obtained from different food sources. Example: calcium can is found in tofu, dairy products, and some plant-based milk. Magnesium is found in leafy greens, beans, nuts, and whole grains, etc.**

**Excess sodium from electrolytes can raise blood pressure.**

1. Why are electrolyte supplements recommended after strenuous exercise rather than water?

**Water and electrolytes are lost through sweat and electrolyte supplements help restore any lost electrolytes especially sodium and potassium.**

1. Do you think there are benefits to adding hyaluronic acid and/or ceramides to electrolyte supplements? Is there any scientific evidence supporting these benefits?

**Any answer is acceptable if it is supported by scientific evidence and references are cited.**

**Instructor Note: An extra page of reading is included to help answer this question, if you think your class would be interested.**

1. Three-year-old Jamie is suffering from lethargy and was brought into a pediatrician’s office after a bout of vomiting and diarrhea. The weather has been very warm lately and Jamie has not been eating or drinking for the past couple of days. The pediatrician suspects that Jamie is suffering of dehydration. Which electrolyte supplement would you recommend and why based on Jamie’s condition?

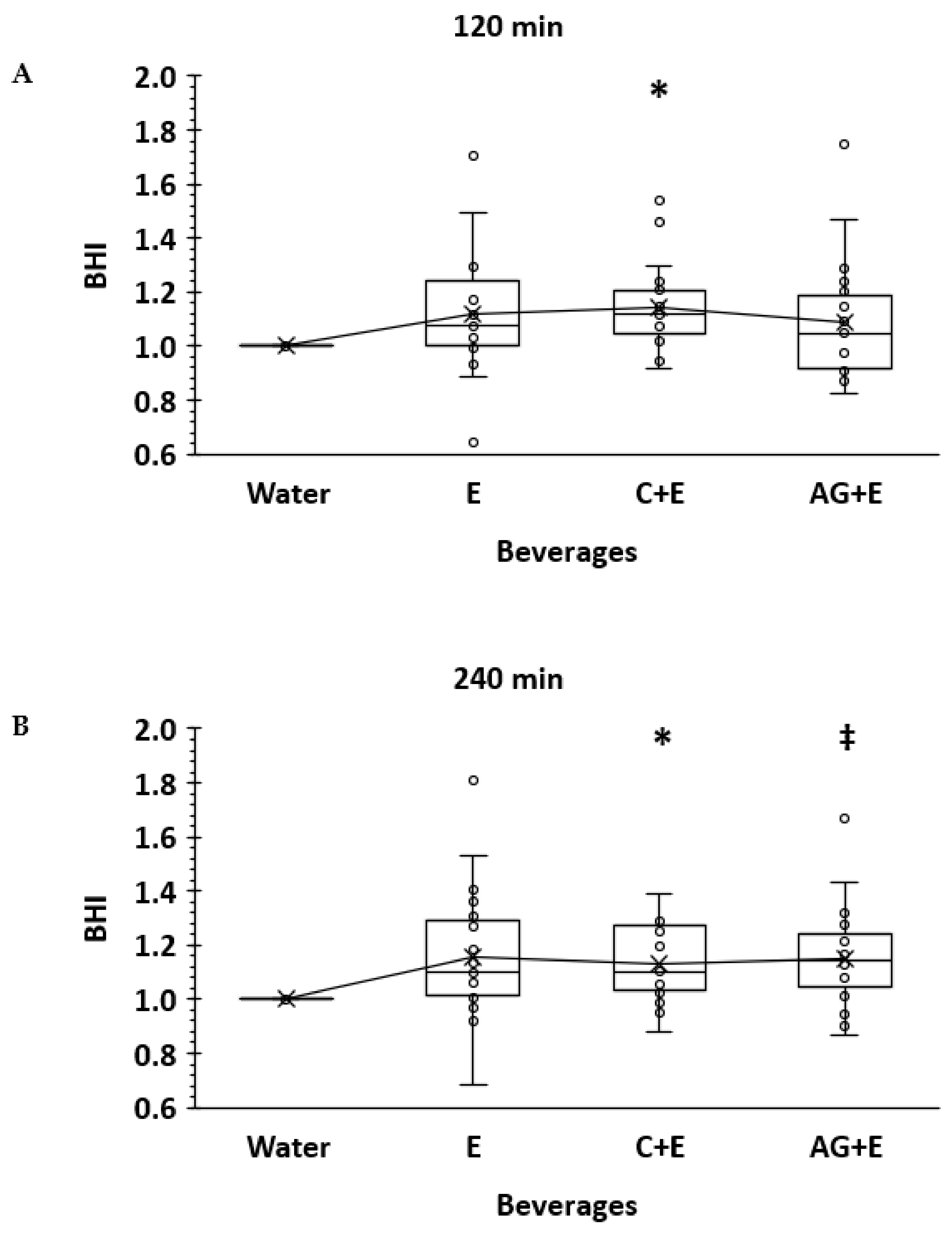
**Answers may vary, but generally Pedialyte Advanced Care® Plus has the best balance of sugars and electrolytes. Sports drinks and other supplements may contain too many sugars which may draw water to the intestine worsening the diarrhea or may not contain enough electrolytes for rehydration. Other answers may be acceptable depending on scientific reasoning.**

1. If you were to design your own electrolyte supplement, what ingredients would you use and why? How would you test the effectiveness of your electrolyte supplement?

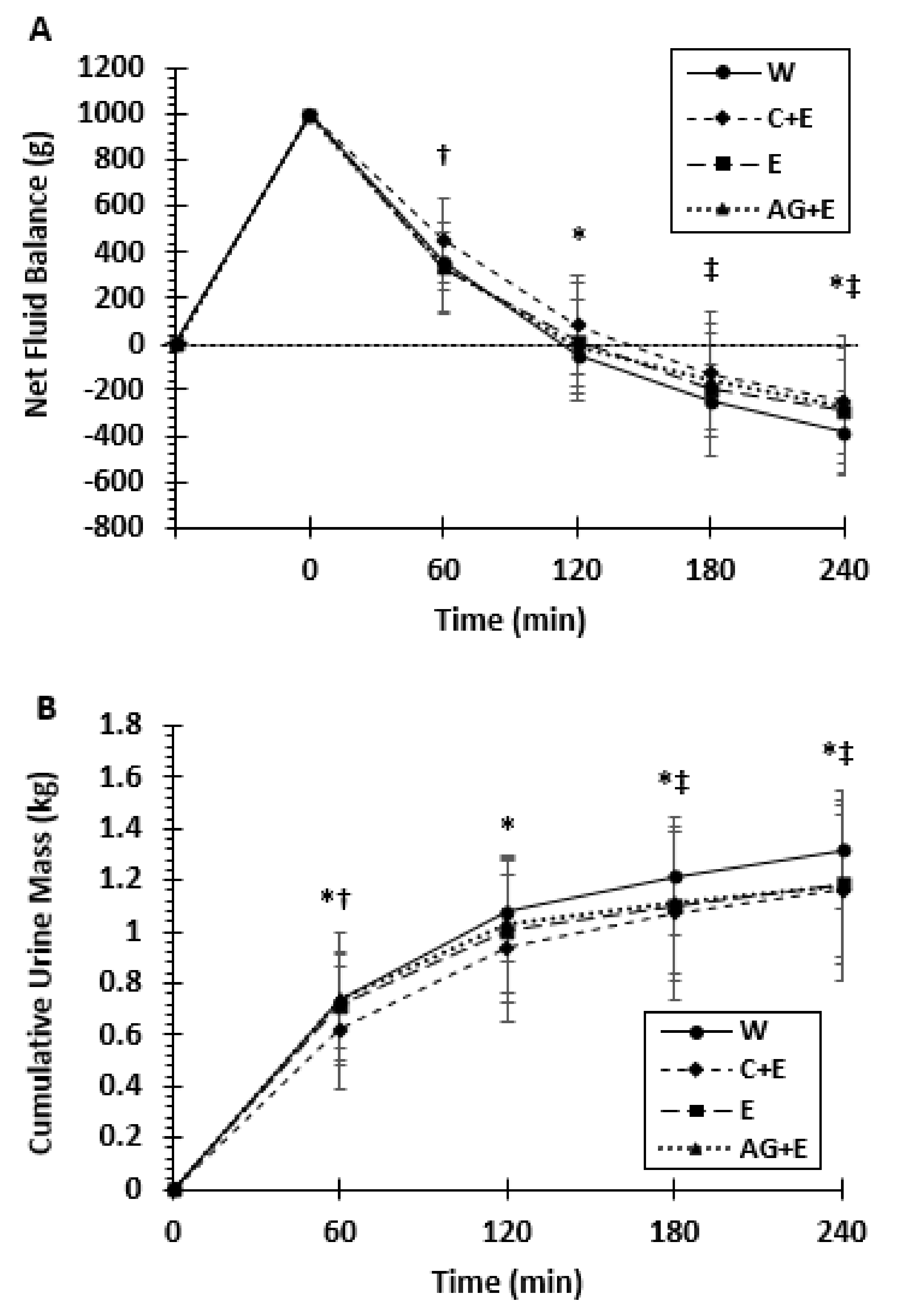
**Answer may vary and are acceptable as long as scientific reasoning and references supporting answers are provided.**

## Part III: Analyzing Experimental Data

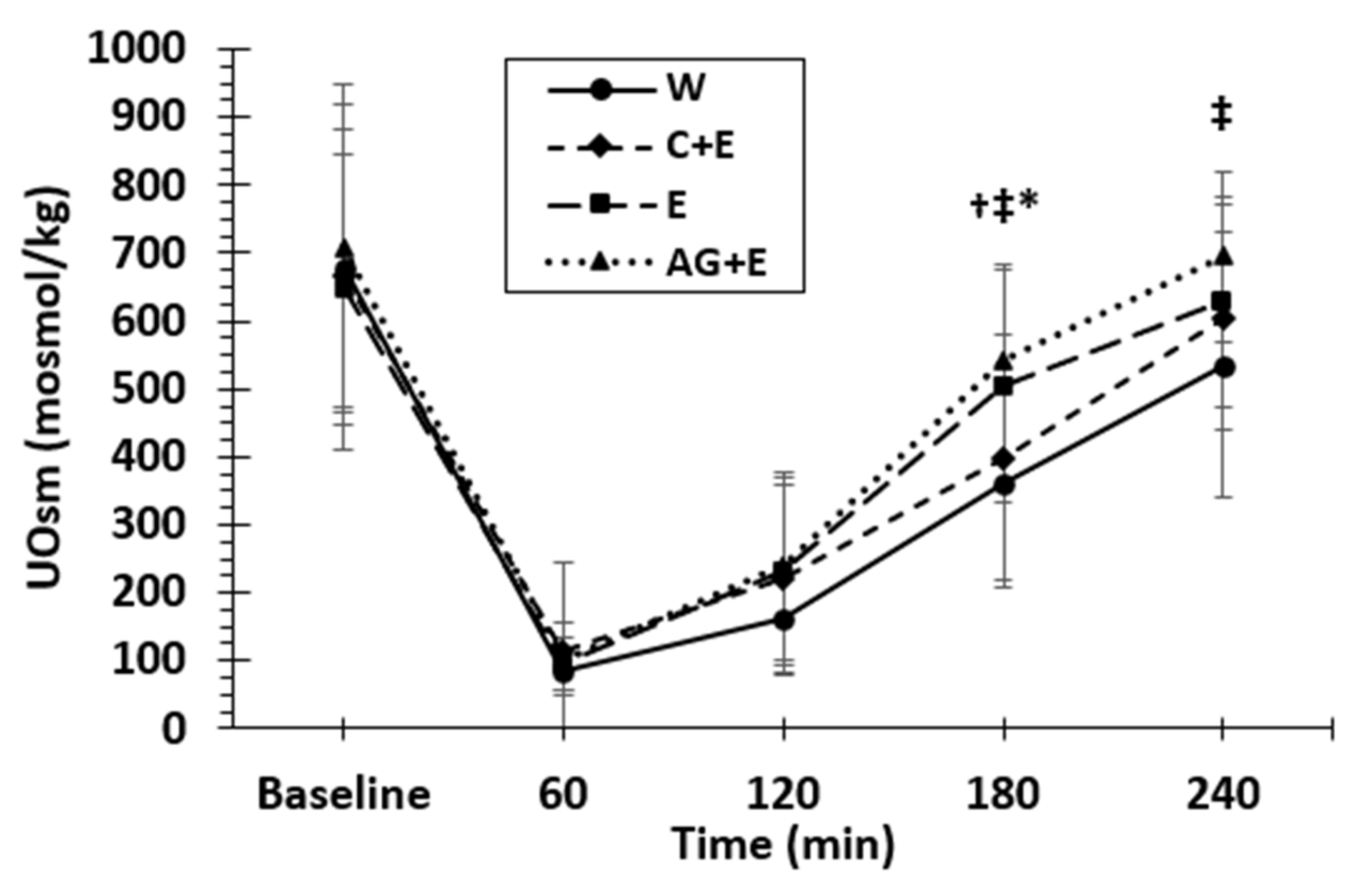
Studies have been conducted in the past few years to measure and compare the short-term hydration properties of drinks including electrolyte supplements using a scale known as beverage hydration index (BHI).[2] BHI simply measures the ability of an electrolyte supplement for fluid retention compared to water.[3] A few of the evidence to evaluate the BHI index of electrolyte supplements is the urine mass measured in kilograms and urine concentration measured in milliosmoles. In the plots below, water (W), a supplement containing electrolytes (E), a supplement containing carbohydrates (fructose and sucrose) plus electrolytes (C+E), and a supplement containing alanyl- glutamine dipeptide (AG+E) which shows supporting evidence of rehydration following exercise.[4] Using this information coupled with the plots below answer the following questions.



**A**



`



**C**

1. From the data provided, is there evidence that supports that additives such as carbohydrates and/or dipeptides such as alanyl- glutamine dipeptide are better for rehydration versus electrolytes alone? Which piece of data provided supports this?

**Yes or no, both are acceptable, and answer depends on what students’ reference. Figure A the BHI is greater for electrolytes but decreases ever so slightly when combined with carbohydrates or dipeptides. From plot B, the cumulative urine mass for electrolytes alone or combined with carbohydrates or dipeptides is lower compared to water alone but the lowest when electrolytes and dipeptides are added. From plot C, between 60 and 240 minutes, the urine osmolality is higher for all supplements especially AG+E compared to water which indicates better fluid retention.**

1. How would you design an experiment to compare the BHI of athletes before and after exercise? Reference the studies above and/or the reading before class.

**Answers may vary but the reasoning must be backed up with either the studies or reference to the readings.**

1. If you hypothetically were to develop a home hydration kit, what measurements would be most useful and why? Reference the studies above and/or the reading before class.

**Answers may vary but the reasoning must be backed up with either the studies or reference to the readings.**

# References

1. Hibbard, L., *Case studies for general chemistry: teaching with a newsworthy story.* Journal of Chemical Education, 2019. **96**(11): p. 2528-2531.

2. Maughan, R.J., et al., *A randomized trial to assess the potential of different beverages to affect hydration status: development of a beverage hydration index.* The American journal of clinical nutrition, 2016. **103**(3): p. 717-723.

3. Millard-Stafford, M., et al., *The beverage hydration index: influence of electrolytes, carbohydrate and protein.* Nutrients, 2021. **13**(9): p. 2933.

4. Hoffman, J.R., et al., *Examination of the efficacy of acute L-alanyl-L-glutamine ingestion during hydration stress in endurance exercise.* Journal of the International Society of Sports Nutrition, 2010. **7**(1): p. 8.

# Supplemental Reading

This is a very short summary of the benefits of the addition of supplements such as ceramides and hyaluronic acid to electrolyte supplements that can be provided to students.

## Ceramides:

* + 1. Effective in increasing skin hydration and reducing trans epidermal water loss as a single agent. ​
    2. Studies show improvements in skin firmness, elasticity, hydration, and reduced wrinkle severity when ceramides are taken orally.
    3. By helping maintain the integrity of the lipid barrier, ceramides also protect from environmental irritants, which can contribute to
    4. A healthy ceramide-supported barrier reduces penetration of allergens, irritants, and microbes. In skin disease states such as atopic dermatitis, lower ceramide levels correlate with barrier dysfunction.
    5. When the barrier is well-maintained, skin is less susceptible to dryness, infections, and inflammation.

## Hyaluronic acid (HA):

* + 1. HA is a polysaccharide with high water-holding capacity; in the skin it helps maintain moisture, keeping tissue plump. Oral supplementation of HA has been shown to increase skin moisture content and reduce dryness.
    2. HA intake improves skin hydration, reduced wrinkle depth, and reduces water loss from the skin
    3. Along with hydration, HA has been associated with improved skin elasticity and smoother skin texture. The studies show increases in elasticity following HA supplementation over several weeks.
    4. HA also may promote fibroblast proliferation (cells in connective tissue) supporting skin repair and structure.

## Mechanisms:

The supplements work by replenishing nutrients essential for skin health, repairing the skin barrier, and improving water retention in the stratum corneum. ​ For example:

* Ceramides improve skin barrier function and hydration through their lipid composition. ​
* Hyaluronic acid increases water absorption and retention in the skin. ​