The Chemistry of Sport Drinks: Teacher Notes

Background Information

All living cells need energy to function in order for the chemical reactions occurring in the cells to take place. In humans this energy is obtained by breaking down organic molecules such as carbohydrates, fats and proteins. When the previous substances are broken down at molecular level, bonds breaking and forming between the atoms in the molecules release or require energy. The biochemical reactions, which take place in cells when a fuel substance such as carbohydrate (e.g. glucose or fructuose) is broken down, will normally release more energy than they use. Thus energy is available for other reactions to take place and to provide the energy needed for muscle contraction.

For many years, endurance athletes such as marathon runners have been advised to eat carbohydrate-rich foods such as pasta, leading up, during and after exercise. This is because it is important for endurance athletes to maintain good levels of blood sugar so that energy can be released by both aerobic and anaerobic respiration during the event. During the 1980s carbohydrate drinks became popular in endurance sports, especially where the sporting activity lasts for more than an hour as they proved to be a good way of quickly getting carbohydrates in to the bloodstream. Sports performance is dependent on providing the energy required to contract our muscles to move our bodies. Therefore, using sports drinks could make a difference to the overall performance. Recent research evidence also suggests that consuming carbohydrates during high intensity exercise lasting less than an hour can also be beneficial to overall performance.[1][2]

Further activities and background information is available from the Wellcome Trust at www.getinthezone.org.uk.

The **Global Experiment** provides an opportunity to gather lots of primary data to test out this theory and see if sports drinks make a difference to performance during a short time of high intensity exercise.

Today there is a wide range of energy drinks, sports drinks and soft drinks on the market, which can lead to confusion. How do athletes know what to drink during exercise and does it really matter? Athletes need to remain hydrated during exercise and that extra bit of 'energy' can boost performance. So are there any real differences between the types of drinks available?

Water hydrates better than any other liquid, both before, during and after exercise. Cold water is absorbed faster by your body than water at room temperature or body temperature. However, people don't usually drink enough water.

Soft drinks contain mainly water, sugar and flavouring. They are meant to taste good, encouraging more to be drunk, resulting in better hydration. They can be high in calories.

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[1] Jeukendrup, A.E., Carbohydrate intake during exercise and performance, *Nutrition*, 20 (2004) 669-677

[2] Carter, J., Jeukendrup, A.E., Mann, C.H., Jones, D.A., The effect of glucose infusion on glucose kinetics during a 1 h time trial, *Med Sci Sports Exerc*, 36 (2004) 9

Sports drinks or **isotonic drinks** contain similar concentrations of salt and sugar as in the body. They are designed to replenish the electrolytes lost during physical activity. Sports drinks don't hydrate the body any better than water, but you are more likely to drink larger volumes, which lead to better hydration. Sports drinks usually contain fewer calories than soft drinks but will still give a carbohydrate boost.

Energy drinks contain sugar, caffeine and a variety of other ingredients such as taurine, guarana and ginseng. Manufactures claim that they are designed to 'boost' performance and increase stamina but many health experts disagree and say that any 'boost' in performance is due only to sugar and caffeine content.

Student Activities

Starter activities that could be used to introduce the Global Experiment

Ask the class what they drink before, after and during exercise. Why do they drink it? What effect do they think it has on the body?

Show the class a range of different drinks including water, a soft drink, a sports drink and an energy drink. Ask them, which they think an athlete would drink before, after and during exercise. Encourage them to give a reason for their answer.

Exploring the winning data; the Olympic 100 m sprint

Present students (14-16 or post 16) with a table of winning data and ask them to answer the questions before discussing them as a class. Depending on the ability and/or age of the group you may wish to limit the data given. This could then lead into a discussion about energy drinks, and the introduction of the global experiment in which students can make their own energy drink.

Answers to student questions

1. Many factors may be given including:
   - Improved materials for equipment and clothing
   - Training methods
   - Nutrition
   - Health of competitors
   - Psychological state of competitors
2. Some of the above factors

   Natural variation amongst competitors

   Competitors do not always perform their best at large events
3. Graph plotted by students
4. Accept any relevant correct statements, for example
   - The women's competition did not start until 1928
   - Women's time is always below men's time in the same year

- Both sets of times show an upward trend

For younger students (10-11 or 11-14) – time line activity

Student activities to get students thinking about the role of chemistry in sport drinks

1. **The Howling/Screaming Jelly Baby** (CfNS 69 & CLEAPSS SRA-01), teacher demonstration. Before carrying out this demonstration each teacher will have to carry out their own risk assessment.
   Jelly babies contain a high percentage of sugar and glucose syrup. This demonstration shows that a very exothermic reaction occurs when sugars burn in oxygen. It can be used to introduce the idea of sugar being a good source of energy, before going on to think about how this energy is released by the body during sporting activities.

2. **Powering our muscles**

   This worksheet is suitable for 14-16 year olds. Students will learn about aerobic and anaerobic respiration.

   - Insert endothermic energy level profile
   - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
   - $C_3H_6O_3$
   - pH 3-6 as it is a weak acid
   - $C_6H_{12}O_6 \rightarrow 2\ C_3H_6O_3$
   - The point at which the gradient first start to rise steeply

Faces of chemistry videos – ESPRIT

The three videos suitable for 11-14, 14-16 and post 16 students show how sport scientists are using their knowledge of chemistry to improve athletes training programmes, by monitoring their body fluids.

The 'All-in-One Sports Drink

By working through this activity students will learn more about the ingredients found in a typical sports drink. Suitable for 11-16 year old students.

Answers to the student questions

1. Sodium, calcium, potassium, magnesium
2. To replace the essential salts that are lost through sweat during exercise.
3. Hypotonic – contains a higher concentration of salt and sugar than in the body; Isotonic – contains a similar concentration of salt and sugar as in the body; Hypertonic – contains a lower concentration of salt and sugar than in the body.
4. Before exercise the body should already be reasonably well hydrated and should contain the correct balance of salts and so a lower concentration is suggested whereas

after exercise, it is suggested that a higher concentration is used to ensure that all the salts lost during exercise have been replaced.

5. Sugars
6. Accept respiration or aerobic and anaerobic respiration
7. Aerobic respiration $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$;

   Anaerobic respiration $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$
8. To help the athlete build up their stamina and immune system

Energy Drink information sheet

Many people think that energy drinks and sports drinks are the same thing but in fact they work in very different ways. This information sheet will provide further background information for junior teachers or non-specialists or they could be used with post 16 students as the basis for a discussion. It looks at how caffeine affects the body whilst the sports drink sheet focuses on respiration.

Biochemical systems information sheet

Biochemical systems answers to questions

1. ATP – PC (phosphagen) system

   Anaerobic glycolytic, or lactic acid system

   Aerobic system – comprising the glycolytic (carbohydrate) and lipolytic (fat) systems
2. ATP stands for adenosine triphosphate, and PC stands for phosphocreatine
3. Glucose + 2ADP + $2NAD^+$ + $2P_i \rightarrow$ 2 pyruvate + ATP + 2NADH + $2H^+$
4. Anaerobic
5. Aerobic system as it puts a supply of sugar into the blood stream

Biochemical systems card sort activity

This could be used as a post 16 starter or plenary activity.

Card sort activity answers

1. The starting table shows the correct answers
2. ATP-PC: 100 m sprinter and weightlifter.[3]

   Anaerobic glycolytic system: 100 m swimmer, 200 m runner, middle distance runner.

   Aerobic system: marathon runner, rower, cross country skier.

[3] http://health.howstuffworks.com/wellness/diet-fitness/exercise/sports-physiology3.html