

Nutrition & Food



Milk as an Exercise Recovery Drink

Description of Event: Race results/data demonstrate that collegiate swimmers at Indiana University who added chocolate milk to their regular post-training routine swam faster than they had used carbohydrate sports drinks or calorie-free beverages.	Stimuli: How will students experience and/or observe the phenomenon/problem? Video and accompanying case study text. https://youtu.be/Z7E4IzRiYuA 0:21 - 1:25
Essential Question(s): How does chocolate milk contribute to swim performance? Why did swimmers recover quicker with chocolate milk vs a traditional sports drink or calorie-free beverage? (Optional)	Case Study https://www.eurekalert.org/news-releases/702637
Related Phenomena/Problems: • Plant cells or tissues deprived of nutrients, minerals, or hydration cannot survive. • Plants exposed to extreme temperatures are not able to survive. • A weightlifter's performance varies based on his diet leading up to competition. • The body uses more calories during and after a bout of exercise. • Breathing rate increases during exercise. • More ambulances are required during high intensity sporting events if temperatures are high. • A triathlete collapses before the finish line of an Iron Man competition. • A marathoner monitors their heart rate closely during training.	
Considerations for Instructional Design: • Students can study this in connection with the role of nutrients in recovering from strenuous physical training. • Students can study this in connection to metabolism and energy consumption in the body, and how the body converts various proteins, carbohydrates, and calories into energy. • Students can investigate the role of signals from the nervous system traveling along an axon as it pertains to moving skeletal muscles. • Students can investigate the neurotransmitters associated with the synapses between axons and skeletal muscle fibers. • Students can investigate the roles of actin and myosin in the context of skeletal muscle contraction.	
Explanation: <i>"Indiana University researchers found that when collegiate, trained swimmers recovered with chocolate milk after an exhaustive swim, they swam faster in time trials later that same day. On average, they shaved off 2.1 seconds per 200-yard swim and 0.5</i>	

seconds per 75-yard sprint, compared to when they recovered with a traditional carbohydrate sports drink or calorie-free beverage."

This phenomenon highlights concepts related to homeostasis. Exercise requires muscle contractions and movement. For muscles to maintain these activities, they require energy. Generating energy requires nutrients, water, and oxygen. Expending energy also generates heat. Several body systems are affected directly or indirectly. To survive, they must maintain within thresholds temperature, oxygen levels, carbon dioxide levels, blood sugar levels, fluid levels, and electrolyte levels. Our nervous system utilizes feedback loops to sense and trigger responses to help our body maintain homeostasis.

Feedback Loops

Homeostasis refers to the ability of an organism to maintain stable internal conditions in response to changes in the external environment. During strenuous exercise, the internal and external environment cause several changes that our bodies must compensate for. These are things like: external temperature, internal body temperature, the need for more oxygen and sugar to generate energy, and changes in blood pH. Our bodies use several feedback mechanisms to help cells maintain a steady enough environment to live. Feedback mechanisms are a loop system in which the system senses and responds to a changing condition in the body. The body can either speed up or slow down certain processes in response to the stimulus. The purpose of a feedback loop is to help the body maintain homeostasis. For every feedback loop, there is a sensor, a receptor, and effectors. There are several feedback mechanisms that help to regulate homeostasis, including negative, positive, and feed forward loops. (HS-LS1-3)

Energy Sources

When a muscle contracts, it requires a large amount of energy to fuel the process. This energy is provided by the breakdown of glucose and fatty acids, which are the primary energy sources for muscles. The energy required for muscle contraction is derived from the metabolic breakdown of glucose and fatty acids, which produce adenosine triphosphate (ATP). ATP is the main source of energy for cells, and when it is hydrolyzed (broken down), it releases energy that is used by the muscle to contract.

During a high intensity workout, the fastest sources of energy are already located within the muscle cells. First, there is always a very small amount of free ATP ready to be broken down for instant energy. Second, there is a substance in muscle cells that is able to help recycle the ADP formed (via ATP) that is able to donate a phosphate group to reform ATP. Third, muscle cells have their own stores of muscle glycogen. Glycogen is composed of glucose molecules. It can be considered an efficient way to pack and store glucose. The glucose already located in the muscle cell can be used for cellular respiration. During high intensity exercise, the muscle glycogen undergoes anaerobic respiration because it is quicker and does not rely on the delivery of oxygen in the bloodstream.

As the fuel sources in the muscle cell itself are depleted, the body primarily relies on the glucose and oxygen available in the bloodstream to supply the muscle cells and allow for aerobic cellular respiration. As blood glucose levels begin to lower (due to use), it begins to release some of its glycogen stored as glucose in an effort to stabilize blood glucose levels.

If blood glucose depletes to certain levels, the body is then able to use free fatty acids as a fuel source. The free fatty acids are digested lipids in the bloodstream. Additionally, free fatty acids can be accessed and released into the bloodstream from adipose tissue if needed.

Nutrient Replenishment Post-Exercise

Milk works well as a recovery drink because it naturally contains the right ratios of carbohydrates, high-quality proteins, and lipids. The carbohydrates are used to refill the glycogen stores of the muscle cells, liver, and replenish blood glucose levels. Amino acids are delivered to muscles and can help speed up recovery. With strenuous resistance exercise, microscopic tears in the muscles occur. The proteins in milk help to stimulate muscle protein synthesis, which is essential for muscle recovery and growth. The repair of these tears builds stronger and larger muscles over time. (HS-LS1-6) Specifically, the casein and whey protein ratio in milk helps slow absorption and maintain elevations of blood amino concentrations. The whey proteins in milk can also help with muscle metabolism and protein synthesis. (HS-LS1-7)



Low-fat milk contains a similar amount of carbohydrates to sports drinks. Additionally, a further study has looked at whole milk as compared to low-fat milks. It is important to replace the electrolytes that are lost during exercise; milk naturally contains a high concentration of these electrolytes (Roy, 2008).

How are nutrients digested and absorbed in our bodies?

Breakdown of the food we eat into absorbable nutrients begins in the mouth with chewing and enzymes in our saliva. The process continues in the stomach which has muscles that churn the food alongside acids and enzymes that further break down food. Nutrients are absorbed into the bloodstream in the small intestine. The small intestine has specialized tissue and cells that allow nutrients to pass through their membranes to the bloodstream. The tissue is arranged with lots of tiny folds which increase the surface area. More surface area allows the maximum amount of food making its way through the small intestine to come in contact with the epithelial cells making up the walls of the small intestine. Some of the cells along the folds have channels in their membranes that allow certain nutrients to pass through them. Lactose is a carbohydrate and carbohydrates are nutrients. However, lactose is too large of a molecule to pass through these channels. When lactose is broken down into its smaller parts of glucose and galactose, those carbohydrates are then small enough to pass into the bloodstream and be carried off to where they are needed for cellular respiration or to be stored for later. (Kong, S. 2018.) (MS-LS1-3)

Student questions about this phenomenon/problem that could be instructionally productive:

- How does milk help make you feel less sore after exercising?
- What are the ingredients in a typical sports drink? How do those compare to chocolate milk?
- Would milk still benefit you if you drank it before exercising?
- Does it have to be low-fat chocolate milk?
- Would consuming other dairy products have the same effect?
- How does recovering faster make you perform better?
- What do they mean by recovery?
- How does the milk get to our muscles?
- How does eating food give us energy?
- Why do people get sore after a hard workout?
- Does this only apply to swimming?
- How does our body decide what food to use and what to pass as waste?
- How does the water I drink get spread throughout the body?
- Does milk have electrolytes like sports drinks?

Explaining the phenomenon/problem or related phenomena could lead students toward developing the following DCIs:

LS1.A: Structure & Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1) Built toward an understanding of sweat, diffusion of oxygen into the bloodstream, the transport of oxygen via hemoglobin in red blood cells, nutrient absorption in intestine and to other cells in the body.
- Built toward as students consider the body at different levels ranging from organism to organ systems, tissues, cells, and in some cases, to the molecular level of activity within a cell.
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3) Built toward as students begin to recognize the physical and visual effects of exercise are often a result of a body system looking to maintain homeostasis. Several feedback loops are at play in this phenomenon.

LS1.C: Organization for Matter & Energy Flow in Organisms

- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), forming new cells. (HS-LS1-6) *Built toward as students make sense of how nutrients from food are broken down and utilized by our cells for cellular respiration.*
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6) (HS-LS1-7) *Built toward the reference to the reactants and products of cellular respiration, enzyme activity, digestion, etc..*
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another and releases energy to the surrounding environment and to maintain body temperature. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. (HS-LS1-7) *Built toward sensemaking related to feedback loops related to maintaining temperature, and how muscles access the products needed for cellular respiration.*

Notes about relevance and authenticity (funds of knowledge, interests, identity) *Why might students be engaged?*
Students who are active (exercise, in a sport, etc.) could relate.

- Many students have participated in or know others who participate in athletics.
- Some students have been exposed to swimming by participating, competing, or viewing competitions, such as the Olympic Summer Games.
- Chocolate milk is simple, accessible, and affordable to nearly all students attending school.
- Students may be familiar with other recovery drinks or energy drinks.
- Most students have, at some point, experienced physical exhaustion and/or sore muscles after a workout.

Resources/References

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