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Day 3 Handout: Experimental Design

DO NOW: Read the following passage from Physiopedia (https://www.physio-pedia.com/Muscle_Fatigue) and highlight important information pertaining to muscle fatigue.

Exercise and Muscle Fatigue

Physical exercise affects the biochemical equilibrium within the exercising muscle cells. E.g., inorganic phosphate (in ATP), protons, lactate (see anaerobic capacity) and free Mg2+ (an electrolyte) accumulate within these cells. These biochemical products directly affect the mechanical machinery of the muscle cell e.g. mitochondria. Furthermore, they negatively affect the different muscle cell organelles that are involved in the transmission of neuronal signals. The muscle metabolites produced, and the generated heat of muscle contraction, are released into the internal environment, putting stress on its steady state.

- The tremendous increase in muscle metabolism compared with rest conditions induces an immense increase in muscle blood supply, causing an increase in the blood circulatory system and gas exchange. Nutrients have to be supplied to the exercising muscle, emptying the energy stocks elsewhere in the body. Furthermore, the contracting muscle fibers release cytokines, which in their turn create many effects in other organs, including the brain.
- All these different mechanisms sooner or later create sensations of fatigue and exhaustion in the mind of the exercising subject. The final effect is a reduction or complete cessation of the exercise.
- Many diseases speed up the depletion of the energy stocks within the body. So diseases amplify the effect of energy stock depletion that accompanies exercise [4] (e.g., multiple sclerosis).

Do you think muscle fatigue is different between athletes and non-athletes when doing the same exercise? Please provide biological reasoning.

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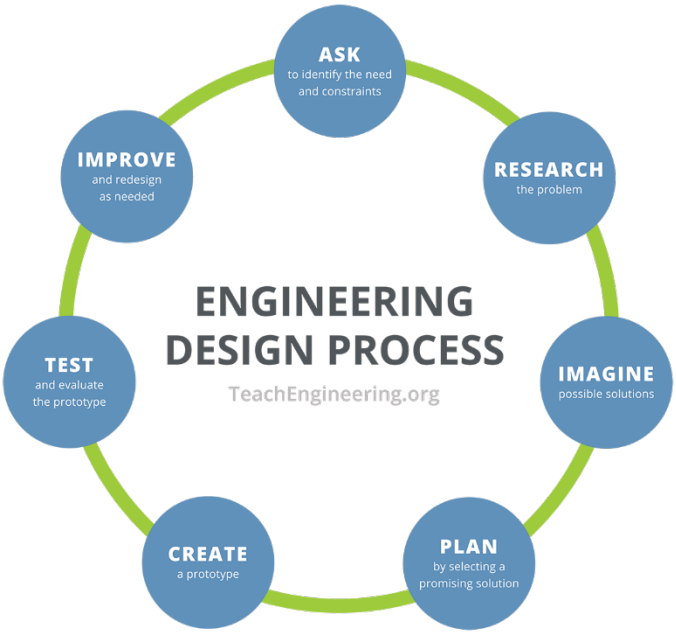
Engineering Design Challenge

Introduction

You have already learned about motor units, muscle fibers, ATP, and both central and peripheral muscle fatigue through videos, readings, and diagrams. You also have experience using the micro:bit and completing simple coding tasks. Now, it's time to apply all of that knowledge in a real-world, hands-on design challenge. Working in small groups, you will use the engineering design process to answer the following question: **How can we measure changes in muscle activity (biopotential signals) to determine the effect of muscle fatigue?**



Start by working with your group to understand the challenge and define the problem you want to solve. Think about what you've already learned that can help you, and decide what you want your design to do. Talk through different ideas and explore a variety of possible solutions. Consider what materials, tools, or technology you might use, and sketch or describe your ideas to help guide your thinking. Once your group agrees on a direction, plan how you will build and test your prototype.

Next, create your design and set up a simple procedure to test it. Think about what information you'll need to collect, and how you'll know if your design is working well. As you test, observe carefully and record what happens. Use feedback from your group members, teacher, and results to make changes and improve your design. After refining and retesting, prepare a short presentation to share your process, what you learned, and how your work could relate to real-world problems or solutions.

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1. **Ask** - Identify the need and constraints of the problem.
   Work with your group to clearly define the challenge and understand the limits of your project. Consider the following questions to guide your thinking:
   a. What problem are you trying to solve?
   b. What does muscle fatigue look like when measured with EMG signals?
   c. What kind of data do you need to collect to detect fatigue?
   d. Which muscle group and physical task will help you get clear, measurable results?
   e. What materials, tools, and technology are available for your design?

2. **Research –** What do you know about measuring muscle fatigue using EMG sensors? (Hint: What did you learn from Handouts 1 and 2?)

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3. **Imagine** – Individually brainstorm FOUR different solutions/ways to set up your prototype and testing experiment. Think about:
    a. Which muscle group should you target? (e.g., biceps, forearm, calf)
    b. What physical task will best induce fatigue? (e.g., repeated squeezing, holding a weight)
    c. How and where will you position the EMG sensors for clean signals?
    d. What features should your micro:bit code include?

a	b
c	d

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4. **Plan** – Have each team member share their ideas. As a team, select ONE prototype and testing procedure. This can be one specific solution or a mixture of ideas.

   Prototype Sketch: Draw your team's agreed-upon prototype solution in the box below.

   Materials: List all the materials needed to create your prototype and conduct your testing procedure.

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Which muscles and movements will be tested? Where will the sensors be placed?

How will you test your device? (Hint: What is the independent variable to be tested? What is the control variable?) You must provide a detailed step-by-step procedure for both experimental and control groups.

Experimental Group Procedure	Control Group Procedure

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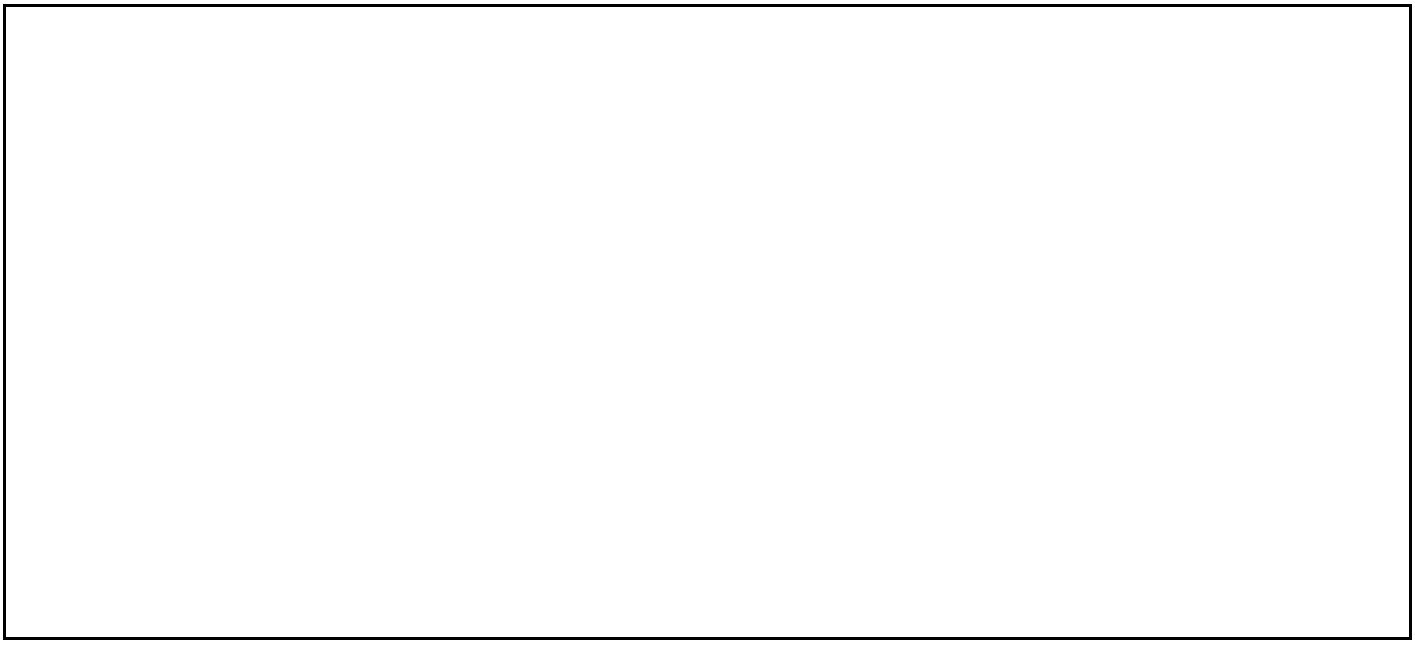
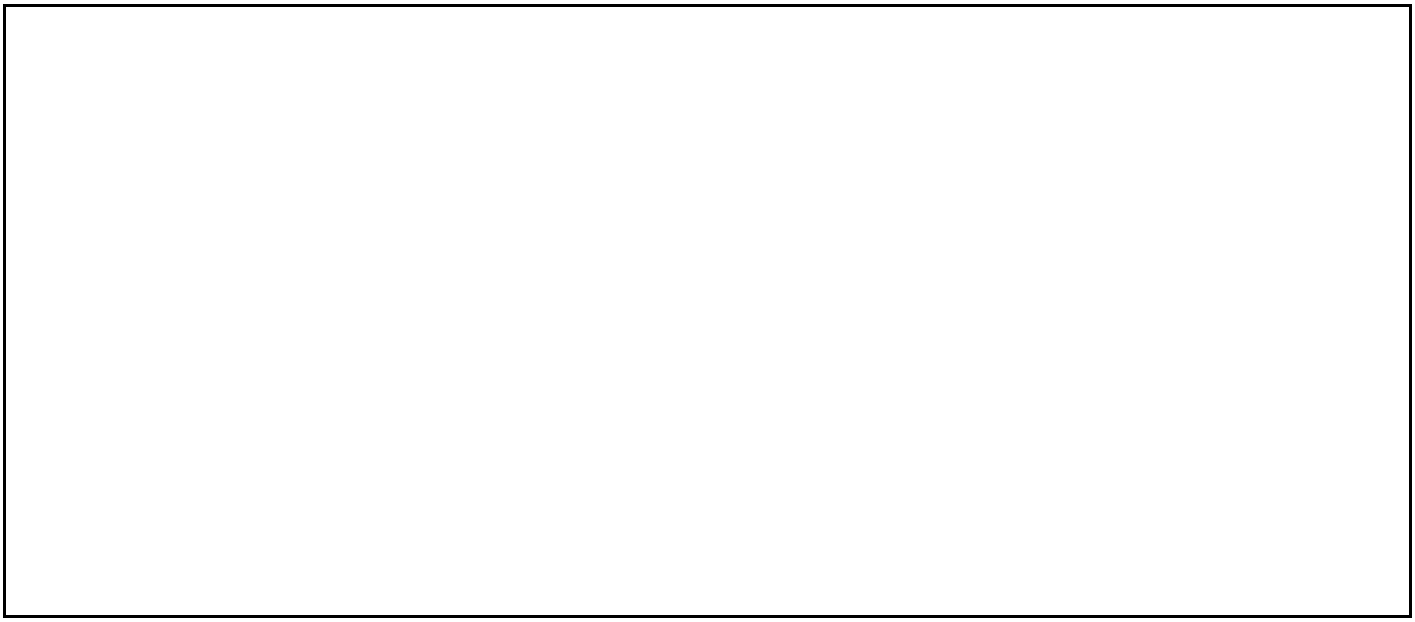
5. **Create** – Build your prototype as shown in your group's drawings.

6. **Test** – Test your design using your testing procedures above on your group's chosen muscle group.
   a. Collect data for three trials of the experimental procedure.
   b. Collect data for three trials of the control procedure.
   c. Graph each set of data, making sure to label your data correctly.
   d. Put a screenshot of your experimental procedure data here: (Note: Organize by trials 1, 2, & 3.):



   e. Put a screenshot of your control procedure data here: (Note: Organize by trials 1, 2, & 3.):



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What worked in your design, and why?

What did not work in your design, and why?

7. **Improve** – Based on your testing and results, how would you improve your design? Why?

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Conclusion:

After collecting your data, you will write a conclusion using the claim, evidence, and reasoning (CER) format. Your claim should summarize what your data shows about muscle fatigue. Support this with specific evidence from your experiment, such as patterns or trends in the EMG signals. In the reasoning section, explain how your evidence connects to neuroscience concepts—such as motor and sensory units, how fatigue affects muscle function, and the role of the technology used to measure these changes. Be sure to identify at least one potential source of error in your experiment. Finally, reflect on what you learned and connect your findings to a real-world application, such as sports performance, rehabilitation, or wearable technology.