Factors that Affect Muscle Fatigue

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Suggestions for Teachers

Purpose:

Engage students in exploring what factors may produce fatigue in the large muscle group located in the human arm. This small group (3-4 students) activity is presented as an opportunity for middle/high school students to apply their knowledge of and skills in designing experiments, recording data, and drawing conclusions. Each group will then make a presentation of its findings to the class. Each presentation will include an analysis of the experiment and any recommended changes.

If time allows, the following suggestion will extend the students' experience in designing and conducting scientific investigations. Using the information and experience acquired from the different group presentations and critiques, have the class design the **?**ultimate" investigation of a specific factor that affects muscle fatigue in the arm's large muscle group. Assign each group to conduct this class designed investigation, pool all the data collected, and have each student write up the experiment and analyze the results.

Objectives:

Part A (Introduction)

1. Students will gain an understanding of "fatigue" from observing a video and participating in a guided discussion.
2. Students will brainstorm factors that may cause (affect) muscle fatigue.
3. Students will review and list the steps/information required in a valid experimental design.

Part B (Group design/presentation)

4. Students will develop a hypothesis about a factor's affect on a large muscle group and the onset of fatigue.
5. Students will demonstrate skills required to design an experiment to test a hypothesis.
6. Students will conduct the experiment.
7. Students will draw a conclusion.
8. Students will present findings to the class.
9. Students will analyze their experiment design and recommend changes.

Part C (Class critique/design)

10. Students will critique the different experimental designs.
11. Students will use the information presented to design a class experiment to test the affect of one factor on muscle fatigue.

Part D (Group investigation/Individual write-up)

12. Students will conduct the class experiment.
13. Students will collate all the class data.
14. Each student will complete a formal write-up of the class activity, present the results, and draw a conclusion.

Materials (per group)

Weights (wrist)	Metronome(s)	Poster board/butcher paper
Stopwatch (2)	Balance (scale)	Markers/map pencils
Meter stick	Rulers	Easel/flip chart
String	Graphing paper	Transparencies/pens
Chalk	Masking tape	•other supplies as specified by the design

Procedure

Part A (Introduction)

1. **Define ?**Fatigue"(suggested class activities)**:**
   a. Video**:** locate a video clip showing an athlete experiencing muscle fatigue or exhaustion. Suggestions: a track, arm wrestling, or weight lifting tape.
   b. Questions:
      1) What do our muscles do for us? (Help us move.)
      2) Does your biceps muscle get longer or shorter when you bend your arm? **Shorter**
      • Have students feel the muscle; relate the term "contract" to the **?**shortening" of the muscle.
      3) What does a muscle require to contract? **Energy**
      • Depending on the prior knowledge, a discussion about muscle requirements may relate to oxygen, food, ATP, myosin, blood vessel supply, build up of lactic acid, amount of glycogen, etc.
      4) What is muscle fatigue? **Answers will vary**
      • The inability of a muscle to maintain a particular strength of contraction or tension over time.
   c. Write/discuss the word fatigue.
      1) Ask the class for a definition.
      2) Discuss the meaning of "fatigue" and relate it to muscles by listing examples of "muscle fatigue".

2. **Brainstorm:** List factors that may affect the rate at which a muscle may become **fatigued**.
   1. Using chalkboard/butcher paper, allow the students to list possible factors that may cause or affect fatigue. (i.e. weight of load, speed of movement, range of movement, body position, temperature, handedness, gender, physical condition, etc).
   2. Discuss ways to test the listed factors.

3. **Review:** The steps followed in most scientific investigations
    a. Identify the problem. (Does factor A affect muscle fatigue of the biceps?)
    b. State the hypothesis. (Example: If more weight is added to the load the arm is lifting, then the muscle with fatigue sooner.)
    c. Design the experiment to test the hypothesis.
    d. Conduct the experiment, collect and analyze the data.
    e. Draw a conclusion (must be supported by findings).

As noted, the above activities introducing the activity are to be done with the whole class participating and sharing information and ideas.

At this time the students should be assigned to groups of 3 or 4.
For each group:

- make them aware of the location/instructions for supplies.
- instruct them on expectations (valid experimental design).
- identify any restrictions (safety to avoid injury).
- time frame (relates to age and prior learning).

Part B (Group design/presentation)

4. Each group needs to select a testable factor that may affect arm muscle fatigue.
    a. establish an **operational definition** of fatigue.
    b. each group needs to state the hypothesis.
5. Students will demonstrate skills required to design an experiment that will test the hypothesis:
    a. state variables to be tested/controlled
    b. lists factors that must stay constant
    c. write the protocol (be sure to include repetitions)
    d. acquire teacher's approval (or edit as suggested).
6. Conduct the experiment:
    a. collect and record data in table/chart
    b. present data in graphic/pictorial form
7. Analyze data and draw conclusion
8. Group presentation (include all members):
    a. oral report
    b. display (poster with key information/graphs)
9. Critique experimental design and recommend improvements

Part C (Class critique/design)

10. Class session to design the **ultimate** experiment:
    a. All group posters/data will be on display for reference.
    b. Identify/select the most testable **factor** which affect fatigue.
    c. Select/design the protocol for the experiment (discuss changes or improvements if an existing design is used).
    d. Discuss all aspects that this experiment should include.

2. The final design must be supported by a class consensus.

Part D (Group investigation/Individual write-up)

12. Each group will conduct the class experiment.
    a. collate the data from all the groups
    b. graph and analyze the data
    c. draw a conclusion.
13. Acknowledge/address the increased validity/accuracy of the conclusion resulting from more data.
14. Each student will complete a write-up of the class experiment.

Safety

One concern is to prevent the students from designing/creating a situation that may lead to muscle strain. It is recommended that the procedure defines fatigue at an early point when a particular motion cannot be completed (i.e., when the hand cannot touch the shoulder).

Where to Go From Here

In the best of situations, this lab could be used during a study of striated/voluntary muscles or the study of human movement. It is also a vehicle to incorporate physiology in general study that focuses on the structure/process of scientific investigations (see brief vocabulary below). The students are always interested in their bodies and here teachers can use that curiosity to explore.

Vocabulary/Terms:

Skeletal Muscle-

- attaches to the bones of the skeleton;
- their contractions exert force to move the bones;
- is a *voluntary muscle* - its contractions are normally under the conscious control of the individual;
- when viewed under a microscope it appears to have light and dark bands which makes it look striped (striated).

Smooth Muscle-

- found in the walls of hollow organs and tubes (stomach, intestines, blood vessels, lymphatic vessel);
- contractions move materials through these structures;
- is an *involuntary muscle* - contractions are not normally under the conscious control of the individual;
- contractions are regulated by factors inside (intrinsic) the muscle, hormones, and nerve

signals from the brain.

Cardiac Muscle-

- forms the wall of the heart;
- is an *involuntary muscle* (see above);
- contractions are regulated by intrinsic factors, hormones, and nerve signals.

Muscle Fatigue: **the inability of a muscle to maintain a particular strength of contraction or tension over time.**

1. factors will vary with type of muscle and/or exercise
   - blood vessel supply;
   - amount of myoglobin;
   - myosin molecules that splits ATP at a rapid rate;
   - speed of contraction.

2. inability of a muscle to generate energy at a rate sufficient to meet its requirements
   1. depletion of metabolic reserves - glycogen;
   - geared to utilize the anaerobic metabolic processes;
   - build up of lactic acid - inhibits enzymes.

3. Psychological fatigue (related to feelings, not muscles)

Cramps: **painful, involuntary muscle contractions that are slow to relax** (precise cause not known)

- intrinsic causes in the muscle (low oxygen supply);
- stimulation from the nervous system;
- low blood levels of sodium and chloride ions (due to sweating);
- low levels of salt work on the muscle and/or nerve (which?).

References

Spence, Alexander P., Mason, Elliott B., (1987). *Human Anatomy and Physiology*. Menlo Park, California: The Benjamin/Cummings Publishing Company, Inc.

The Incredible Machine. (1992). Washington D.C.: The National Geographic Society.

Wong, Ovid K. Ph.D., (1986). *Your Body and How It Works*. Chicago: Regensteiner Publishing Enterprises, Inc.

Suggestions for Assessment

1. Teacher approval of experimental design (before conducting)
2. Group presentation (see 2 rubrics on the following pages):

    - The EXPERIMENTAL DESIGN RUBRIC is quite detailed. I feel that this is one way to provide the students with the criteria that will be used to evaluate their presentations.

    - The POSTER AND PRESENTATION GRADING SHEET is appropriate for investigations that are assessing a more general process with less detail.

3. Each student will submit a formal write-up of investigation (see official guidelines for **?**a controlled experiment")

Investigation: _____

Members: _____ _____

_____ _____

Experimental Design Rubric
(Poster and Presentation Evaluation)

Topic	Criteria For Assessment (circle the points earned)	Possible Points=100
Problem	Clearly stated as a question Clearly stated, but not a question Stated as a question, but not clearly Not stated	12 8 4 0
Background Research	Research attached, addresses problem, leads to hypothesis Research addresses problem, does not lead to hypothesis Research does not address problem Research not attached	12 8 4 0
Hypothesis	Hypothesis stated and attempts to answer problem Hypothesis stated, but does not address the problem Hypothesis not stated	4 2 0
Materials	Supplies needed and their quantities listed Supplies listed, but not their quantities Supplies not listed	4 2 0
Procedure	Written clearly, step by step, at least 3 repetitions, could be duplicated Written clearly, step by step, not 3 repetitions, could be duplicated Written clearly, not step by step, at least 3 repetitions, can't duplicate Not written clearly	16 12 8 0
Data Recorded (chart/table)	Data recorded, variables labeled, metric measures Data recorded, variables labeled, not metric measures Data recorded, variables not labeled, not metric measures Data not recorded in chart/table	12 8 4 0
Data Display	Graph complete: labels, legend, all data present, clear relationships Graph complete: labels, legend, all data present, relationships not clear Graph complete: labels, legend, data incomplete Graph not complete: labels, legend, or some data missing No graph	16 12 8 4 0
Analysis/ Conclusion	Analysis addresses hypothesis, is complete, data supports, logical Analysis is complete, data supports, but does not address hypothesis Analysis addresses the hypothesis, but is not supported by data Analysis is incomplete	12 8 4 0
Presentation to Class	All members participate, visuals are clear and neat, organized All members participate, visuals organized but not clear and neat All members do not participate, but visuals are clear and neat No criterion is met	12 8 4 0
	Total Points	

A Controlled Experiment

Directions:
Use the format below to help you design the experiment, identify factors, and develop your procedure. You will not use/address all the conditions listed in every investigation.

1. Identify the Problem (?):

2. Gather Information about the Problem (evidence):

3. Form a Hypothesis (educated guess):

4. Experiment (procedure to test the hypothesis):
   A. Identify Factors-
      Constants: 1._____ 4._____ 7._____
      2._____ 5._____ 8._____
      3._____ 6._____ 9._____

      Variables:
      Manipulated:_____
      Responding:_____

   B. Identify Setups:
      Control(s):_____
      Experimental(s):_____

   C. Operational Definition:_____
      _____

   D. Record Data: 1._____ 2._____
      3._____ 4._____
      5._____

5. Analyze Data:

6. Draw Conclusion

Names: _____ _____

_____ _____

Poster and Presentation
Grading Sheet

Investigation: _____
_____

		Possible Points	Points Earned
Problem	• Stated • Stated as a question	10	_____
Research	• Attached • Addresses problem	10	_____
Hypothesis	• Is supported by research	5	_____
Experimental Design	• Lists materials and amounts • Procedure is step by step in logical order • Identifies variables • Includes 3 repetitions	20	_____
Recorded Data	• In chart or table • Correctly labeled	10	_____
Display Data	• Appropriate type graph or chart • X and Y axes labeled correctly • Equal Intervals	15	_____
Analyze Data	• State Conclusion • Supported by collected/displayed data	10	_____
Communicate Results	• Poster displays above items • Attractive and neat	10	_____
Presentation to Class	• All group members participate • Shows organization / planning	10	_____
	Total Points	100	