Physiology 1 **Name**_____

Redwood High School **Class Period**_____

Muscles and Oxygen: The Physiology of Muscle Fatigue

Background

Skeletal muscles play an integral role in exercise physiology and the overall concept of "fitness." They play a major, and obvious, role in the area of strength. Strength is largely a function of muscle size. However, skeletal muscles play an equally important, but less obvious, role in the area of endurance (or aerobic fitness).

Skeletal muscles perform their function by moving. This movement is a form a kinetic energy which is generated by "burning" the chemical energy in glucose in the presence of oxygen. Endurance is largely a measure of the body's ability to effectively utilize the oxygen necessary for this chemical reaction. The skeletal muscles primarily accomplish the work of athletic competition and training. Consequently, those muscles use a large proportion of the body's total oxygen supply to breakdown glucose **with** the help of oxygen. This process is called aerobic metabolism or aerobic respiration.

The skeletal muscles can also utilize glucose **without** oxygen, in a process called anaerobic metabolism or anaerobic respiration. Anaerobic respiration can produce energy more quickly than aerobic respiration but, overall, the results are much less satisfactory. Skeletal muscles that are well supplied with oxygen exhibit different physiological responses than muscles that are not as well supplied. This produces a condition, called muscle fatigue, which is familiar to all of us as a qualitative phenomenon. In this activity we will investigate it quantitatively.

Focus Questions

- What is muscle fatigue and how does it effect muscle performance?
- What is the role of oxygen in muscle fatigue?
- What is the role of anaerobic respiration and lactic acid production in muscle fatigue?

Procedure

Part A. Pre-Lab Preparation: Muscular Anatomy of the Forearm

1. Review pages 190 - 191 in your textbook. Be sure to study both the diagrams and tables. Complete the coloring sheet "Muscles Acting on the Wrist, Hand and Fingers."
2. You must become knowledgeable about both the anatomy and physiology of the forearm muscles that are used in the following experiments. The *names* of individual muscles are less important than the understanding of their *actions*, particularly the flexion, extension, pronation and supination of the wrist. This, in turn, requires that you are comfortable with the *origins* and *insertions* of each of the involved muscles.
3. You should also perform each forearm action while palpitating the muscles. You will be able to feel the contractions of the individual muscles as they perform their various actions.

Part B. Pre–Lab Preparation: Experimental Design

1. Complete an Experimental Design Outline for this laboratory experiment. Your outline should organize the following information about this laboratory: hypothesis; independent variable; levels of the independent variable; number of trials; dependent variable and constants.

Part C: Experimental Protocols – Muscle fatigue and oxygen supply.

<u>Day 1 – Wrist Extension (dominant hand)</u>

1. Warm-up your forearm muscles by performing *each* of the important forearm/wrist movements 25 times without any weight. Your warm-up should include flexion, extension, pronation, supination, abduction and adduction. Don't forget to warm-up *both* forearms!
2. Select an appropriate amount of weight to use during the experiment. Your choice should be based on a weight that requires some work to perform a standard reverse wrist curl (this involves extension of the wrist). Record your weight in the data tables.

3. Hold the dumbbell your *dominant* hand. Place the anterior surface of your forearm against the table, with the hand and weight extending just over the edge.
4. Raise the weight as rapidly as possible, **through your entire range of motion**, using your wrist only. Your partner should hold your forearm securely to the table, to prevent all unrelated movement.
5. The tester should count and record the number of **full** repetitions for a period of (20) seconds.
6. Repeat this procedure (5) times. Stop for a (10) second rest between trials.
7. Record the results for each trial on Data Table A and on the Class Data Table on the computer.
8. Switch roles with your partner and repeat the procedure.

Day 1 – Wrist Flexion (non-dominant hand)

1. Obtain a new dumbbell to use during this experiment. Your choice should be based on a weight that requires some work to perform a standard wrist curl (this involves flexion of the wrist). It should be heavier than the weight you used for wrist extension. Record your weight in the data tables.
2. Hold the dumbbell of your *non-dominant* hand. Place the posterior surface of your forearm against the table, with the hand and weight extending just over the edge.
3. Raise the weight as rapidly as possible, **through your entire range of motion**, using your wrist only. Your partner should hold your forearm securely to the table, to prevent all unrelated movement.
4. The tester should count and record the number of **full** repetitions for a period of (20) seconds.
5. Repeat this procedure (5) times. Stop for a (10) second rest between trials.
6. Record the results for each trial on Data Table A and on the Class Data Table on the computer.
6. Switch roles with your partner and repeat the procedure.

Day 2–Wrist Extension (dominant hand)

1. Warm-up your forearm muscles by performing *each* of the important forearm/wrist movements 25 times without any weight. Your warm-up should include flexion, extension, pronation, supination, abduction and adduction. Don't forget to warm-up *both* forearms!
2. Place a blood pressure cuff around the upper arm of your dominant hand. Inflate the cuff above the testee's systolic pressure (until the radial pulse cannot be felt), indicating that the blood supply to the hand has been cut off.
3. Using the *same weight as Day 1*, perform the reverse wrist curl (wrist extension). Raise the weight as rapidly as possible, through your entire range of motion, for a 20-second trial. Your partner should hold your forearm securely to the table, to prevent all movement except from the wrist.
4. Repeat this procedure (5) times. Stop for a (10) second rest between trials**, but do not remove/deflate the cuff between trials.** Immediately remove the pressure cuff when the trials are complete. Once you stop, all subsequent trials that cannot be completed should be recorded as '0' repetitions.
5. Record the results for these trials on Data Table B and on the Class Data Table on the computer.
6. Switch roles with your partner and repeat the procedure.

Day 2 – Wrist Flexion (non-dominant hand)

1. After your partner has finished, place a blood pressure cuff around the upper arm of your non-dominant hand. Inflate the cuff above the testee's systolic pressure (until the radial pulse cannot be felt), indicating that the blood supply to the hand has been cut off.
2. Using the *same weight as Day 1*, perform the wrist curl (wrist flexion). Raise the weight as rapidly as possible, through your entire range of motion, for a 20-second trial. Your partner should hold your forearm securely to the table, to prevent all movement except from the wrist.
3. Repeat this procedure (5) times. Stop for a (10) second rest between trials**, but do not remove/deflate the cuff between trials.** Immediately remove the pressure cuff when the trials are complete. Once you stop, all subsequent trials that cannot be completed should be recorded as '0' repetitions (which, of course, will equal '0' work).
4. Record the results for these trials on Data Table B and on the Class Data Table on the computer.
5. Switch roles with your partner and repeat the procedure.

Data Analysis

Use your period's data set to answer the following.

1. Construct an experimental design outline/organizer for this experiment. Your organizer must convey the following: title; hypothesis; independent variable; levels of independent variable and experimental trials for each level; dependent variable; experimental constants. Your hypothesis statement must be absolutely clear.
2. Select the *specific* data you will analyze to evaluate your hypothesis. List the data you have selected and provide a brief explanation for why you made that selection.

3. Calculate the appropriate statistics for the data you will analyze. Report your statistics in a statistical data table.
4. Construct a *graph* that effectively displays your experimental results. (Remember: you must include both dependent and independent variables that are relevant to your hypothesis).

Discussion/Conclusions

Use your period's data set and the data analysis you conducted to answer the following:

1. Evaluate your hypothesis statement. What is your conclusion to this statement? Cite *specific* data/statistics that you have used to draw your conclusion.
2. Evaluate the overall design and procedures used to conduct this experiment. What parts were effective and why were they effective? What aspects could be improved upon and why were these aspects not effective? What specific improvements should be made?
3. What does muscle metabolism mean? Briefly explain the concept of muscle fatigue as an aspect of muscle metabolism.
4. What is the relationship between the experimental results and the physiology of muscle fatigue?

Data Table A.
Repetitions – With Oxygen

Wrist Extension				Wrist Flexion			
Trial	Wt (lb)	Reps	Wt x Reps	Trial	Wt (lb)	Reps	Wt x Reps
1				1			
2				2			
3				3			
4				4			
5				5			

Data Table B.
Repetitions – Without Oxygen

Wrist Extension				Wrist Flexion			
Trial	Wt (lb)	Reps	Wt x Reps	Trial	Wt (lb)	Reps	Wt x Reps
1				1			
2				2			
3				3			
4				4			
5				5			

Physiology of Muscle Fatigue Laboratory
Individual Data Summary **Name:**_____

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Extension - O2					
Flexion –O2					
Record your data as work (reps x wt)!					
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
Extension- No O2					
Flexion -No O2					

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Flexion –O2					
Record your data as work (reps x wt)!					
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