

STRONGMAN COMPETITION LAB

Purpose:

To investigate the power produced by different muscles in the human body to do various athletic exercises.

Background:

The muscles in the human body are capable of applying **forces** through different **distances**, so the body is capable of doing **work**.

An applied force only does work if it is in the same direction as the resulting displacement. For example, if a person runs up the stairs, the **work** done is lifting the person's **weight** up. So the **distance** the **weight** is lifted is just the **vertical height** the person climbs – not the distance along the stairs (this is ignoring friction).

If the **time** it takes to get up the stairs is measured, the **power** output of the body can be determined. Power is the **rate** of work performed. **POWER = WORK / TIME.**

NEEDED EQUATIONS:

Work = Force * displacement ($W = F*d$)

Power = Work / time ($P = W / t$)

1 pound = 4.45 Newtons

Materials:

- Stairs
- Stopwatch
- Meterstick or tape measure
- Weights
- Rope
- Spring scale or Vernier LabQuest2 and Dual-Force Sensor

Procedure:

1. In this lab, the following activities will be tested and compared.

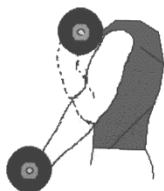
Doing push ups



Running up stairs



Curling a Mass



Dragging a weight



2. Decide which member will be performing the activities. The same member should perform all of them.
3. Decide how each activity can be tested, and what is actually being tested. Several values must be known in order to find the **power** of an activity.
 - What is the **force** being applied?
 - Over what **displacement** is it being applied?
 - Are the **force** and **displacement** in the same direction?
 - How **long** does it take for the force to produce the displacement?

Write down your final process in the space provided under Testing Procedures.

4. **Write down your hypothesis concerning which activity will require the most power.** Rank the activities from least powerful to most.
5. Test each activity. **Measure the applied force, displacement, and time for each activity** and record this data in the data table.
6. Use the force, displacement and time data to **calculate the work performed and the power supplied by the human body to complete each activity.**

Testing Procedures:

PUSHUPS	Force = Displacement = Time =
STAIRS	Force = Displacement = Time =

NAMES: _____ DATE: _____

CURLING	Force = Displacement = Time =
DRAGGING	Force = Displacement = Time =

Hypothesis (Rank the activities from least power required to most power required, 1 – 4):

Exercise	Rank (1-4, 1 being least powerful)
Pushups	
Stairs	
Curling	
Dragging	

Data:

<i>Exercise</i>	Pushups	Stairs	Curling	Dragging
<i>Force (N)</i>				
<i>Distance (m)</i>				
<i>Time (s)</i>				
<i>Work (J)</i>				
<i>Power (W)</i>				

Calculations: Show on a separate piece of paper.

NAMES: _____ DATE: _____

Analysis: (answer the following questions in your lab report)

1. In which activity was the **most power** produced? Which muscle group(s) was used primarily in this activity? **Support your answer with specific data.**

2. Which activity produced the **least power**? Which muscle group(s) were used in this activity? **Support your answer with specific data.**

3. How did your answers to 1 and 2 compare to your hypothesis? Explain your results.

4. Did the activity that used the **smallest force** result in the **smallest power** produced? Support your answer with specific data.

5. Explain
 - a. how a **large force** can result in a **small power** output using your data.

 - b. how a **small force** can result in a **large power** output using your data.

6. There is something called electrical power which uses the same units as mechanical power. Could any of the performances light a 60-Watt light-bulb. If so, how many light-bulbs could it light? Hint: A 60 Watt activity could produce enough power to light up one 60 Watt light-bulb.

NOTES TO TEACHERS

ESTIMATED TIME: 1 class period (40-60 min depending on the size of the lab groups)

WHEN IN UNIT

I usually do this lab right after I introduce students to the concepts of WORK and POWER, usually the next class.

DISCLAIMER

As you can see, the data taken in the lab is not going to be perfect. These ways are not completely accurate ways to measure power and work. For example doing curls and pushups we just count the work done pulling/pushing up but the time is the total time up and down so that is not completely correct, but the purpose is not to get perfect numbers, but rather to do a fun lab where students can practically use and understand work and power, and see how it manifests itself through our muscles, and then learn techniques to compare and contrast the data. The results usually do rank in the correct order: legs, back, triceps, biceps however, giving them some qualitative validity.

DOING THE LAB

As you can see, this lab involves physical activity. I usually do not make every student physically compete in every event if they do not feel comfortable. Some students do not want to do push-up, or run, and many students do not like others knowing their weight. Therefore I usually make lab groups where each group will have at least one student who will do all the exercises, and the others will do the ones they feel comfortable with. It also helps to let the students know what day the lab will take place on so they can wear appropriate clothing. The results of this lab may not be extremely precise, but they should be good enough to compare the power output of different muscle groups, as well as give the student practice on determining WORK and POWER for real life situations in a fun and relaxed way.

PROCEDURES

This lab is designed to have students come up with their own procedures for determining the WORK and POWER of each exercise. There are three ways that I have accomplished this – depending on the level of class.

HARD (Honors level):

Have students come up with the procedures all by themselves in their lab groups or as a pre-lab exercise. Have them check their procedures with the teacher to make sure they will give correct results. Different lab groups may have different procedures. If done during class, this may take up to 20 minutes. You could also give them the materials they can use to create their procedures to make sure you would have everything they need.

MEDIUM (college prep level):

Hold a class discussion in which the class and teacher decide on the procedures to determine the WORK and POWER of each exercise. Here the students will write down the procedures and all use the same ones.

EASY (college prep level):

Simply give the students the procedures that they should use to determine the WORK and POWER of each exercise.

EXTENSIONS

At the end you could also have the students get data from other groups and analyze all of the data from the class, where they could calculate overall averages, high, lows, etc.

Procedures that I have used are summarized on the next page.

=====

A) Push-Ups

- The muscles doing the applying in this case are your pectorals (chest) and your triceps.
- The force to do a pushup is due to gravity, but it is not the entire weight of the student. To figure out how much the arms and chest have to push up we can use a bathroom scale.
- Get down in the push-up position, and place hands on top of a bathroom scale, rather than the floor.
- The reading on the scale is the size of the force that the arms must apply when doing a push-up (pushup weight).
- To measure the distance traveled while doing a push-up, measure the shoulder height of the student in the "up" pushup position.
- Then measure the height in the "down position." This position is when your upper arms are parallel with the ground, or when the chest is on the ground depending on how the pushup is being done.
- The difference between these two values is the displacement of your body during a push-up. Since we are doing 10 push-ups, the total displacement will be 10 times this value.
- To measure the time of doing the push-ups, just time how long it takes to do 10 push-ups.
- Again this is not perfect, it does not take into account the time going back down, so if you would like to add a fudge factor (maybe -30% of total time) that would be OK.

B) Stair Climbing

- For the stair climbing part, we will be climbing 1 floor worth of stairs.
- Here the force being applied in the direction of motion is just equal to the weight of the student. This can be measured using a bathroom scale.
- The distance traveled is a little tricky. Gravity acts straight down, so the displacement that is parallel to motion is actually just the height of the stairs climbed. We can find this by measuring the height of one stair, and then multiplying it by the total number of stairs climbed.
- Again, a stopwatch can measure the time.

C) Curling a Mass

- Curling is lifting a weight using only your biceps. The weight starts at your hip with your arm parallel to your body. It is then "curled" up until it is next to your shoulder, again parallel to your body.
- The force that is being applied here to produce motion has to be equal to the weight of the mass.
- The displacement is going to be just the change in height of the mass as you lift it. To do this, hold the mass in the start position and measure how high it is off the ground. Measure it again in the finish position. The difference between the two is the displacement of the mass. We will do 10 curls, so the total displacement is 10 times this displacement.
- The time can be measured using a stopwatch.
- Again this is not perfect, it does not take into account the time going back down, so if you would like to add a fudge factor (maybe -30% of total time) that would be OK.

D) Dragging a Mass

- Do not use your legs. This should be done from a stationary, seated position on the floor (may want to use a blanket or towel to sit on depending on the state of your school floors).
- The muscles used to drag a mass are your shoulders back and upper arms.
- To set up this experiment,
 - Tape off a 7-meter course.
 - Tie a rope to a backpack and place about 40 pounds of weights inside it.
 - Place the backpack at one end of the course, and lay the rope out until it reaches the other side of the course.
 - The participant should sit at the end where the rope is, about 1 meter behind the tape mark.
 - Pull in the rope hand over hand until the bag crosses the finish line.
 - A timer should measure the time from the beginning of the first pull until the front of the bag crosses the finish line.
- The displacement here is 7 meters, but can be anything.
- The force needed to move the mass is equal to the kinetic frictional force between the mass and the floor. To find this, attach a spring scale(s) to the bag and drag it. When it is dragged at a constant speed, a force should measure on the scale(s). This force is equal to the kinetic frictional force. *Due to time considerations, I may measure this value for the students and give it to them in advance.*
- The time is again the time on the stopwatch.