# Responses to Static (Isometric) Exercise

## Suggestions for Teachers

### Background

Static exercise involves the contraction of skeletal muscle without a change in muscle length, hence the alternative term, isometric (*iso* = same, *meter* = length) exercise. Static exercise produces a cardiovascular response that differs significantly from that observed during dynamic exercise. Typical examples of static exercise include athletic events such as weight lifting, shot put, hammer throw, and everyday activities such as lifting heavy boxes or carrying a heavy briefcase.

Prolonged continuous contraction of skeletal muscles inhibits regional blood flow as muscle fibers compress blood vessels. The decrease in blood flow is partially offset by local arterial vasodilation, however if the muscle is contracted to 70% of its maximal voluntary contraction, blood flow may be completely occluded. This reduction in blood flow allows the accumulation of acidic metabolic byproducts that stimulate chemoreceptors within the muscle itself. In combination with mechanoreceptors, these ascending afferents provide feedback to cardiovascular control areas in the brainstem.

A second system also serves to regulate cardiac response to static exercise. This central neural mechanism originates in higher centers in the CNS and responds to increased motor output by activating cardiovascular and respiratory control areas. The combined action of this central neural mechanism and the feedback mechanism described above both serve to increase heart rate. However, this system does not result in a concomitant increase in stroke volume as is exhibited in dynamic exercise, and any increase in cardiac output is due almost entirely to increases in heart rate. In addition, as muscular exertion is relatively localized with static exercise, there is little systemic vasodilation, hence increased stroke volume is not compensated in the peripheral circulation as during dynamic exercise. This condition leads to increases in mean arterial pressures proportional to increases in cardiac output.

In this activity volunteers will perform a prolonged static contraction using a grip dynamometer (or other device) as blood pressure and heart rate are monitored over a period of time. A second blood pressure cuff will then be used on the exercised arm to demonstrate the effects of the two separate neural components of the response.

### Materials

- Grip dynamometer or grip exerciser, spring clamp (available at hardware stores), or rubber ball
- Stopwatch or clock
- 2 blood pressure cuffs
- Stethoscope

**Procedure**

1. You will need groups of at least four students, five is better.
2. This works best if students have experience taking blood pressure.  Groups should choose the person with the best technique to monitor blood pressure during this activity.
3. A few “dry runs” are suggested before beginning, as all members of the group must work closely under time constraints to gather data.
4. As with the first part of this module, quiet in the classroom is essential.
5. The subject should try to maintain about 30% of their full grip strength during a full three minutes.  Choose subjects carefully, as this activity will be fatiguing and somewhat uncomfortable.

**Safety**

1. Students should be careful to not leave the blood pressure cuff on any longer than necessary. Dry runs should only mock the occlusion at the end of the activity.
2. Group members should change roles if this activity becomes too uncomfortable for the participant.
3. Students should be warned to not drop the dynamometer.

**Suggestions for Assessment**

Students can answer analysis questions or make this a part of a full lab report along with the first part of this module.

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## Student Activity

### Background

Static exercise occurs when muscles exert a force, but do not change in length. As we saw in the previous activity, a number of changes take place in the cardiovascular system to compensate for increased demands of exercising muscles. However, the response to static exercise is somewhat different than it is to dynamic exercise. In static exercise there is very little vasodilation that takes place in the periphery, hence the heart must work harder to pump blood than during dynamic exercise. In this activity you will investigate the effects of static exercise on cardiovascular response and relate this response to the underlying neural mechanisms at work.

There are (at least) two neural systems at work when muscles are exercised. The first, the "Central Command," is located in the higher centers in the brain. It monitors the nerve signals sent out to the muscles and responds by stimulating areas in the brainstem responsible for heart rate and strength of contraction. The second is a feedback system that detects work in the muscle by monitoring contraction and the buildup of cellular wastes. It then signals the brainstem to increase cardiac output to compensate for increased muscular activity.

This activity has two components. In the first, you will measure the blood pressure of a volunteer who is performing static (isometric) exercise over a three-minute period. Then you will use a second cuff to block blood flow to the exercising arm as the volunteer stops exercising and continue to monitor blood pressure.

### Materials

- Grip dynamometer (or grip exerciser, spring clamp, or rubber ball)
- Stopwatch or clock
- 2 blood pressure cuffs
- Stethoscope

### Procedure

1. This activity works best with a group of 5 students. Choose one person for each of the following jobs: subject, blood pressure monitor, pulse monitor, timer/recorder, and someone to inflate second (occlusion) cuff.
2. Read over the entire procedure, making note of the timing of the measurements. Practice the procedure at least once with all participants. Do not inflate the occlusion cuff during practice runs.

3. Have the volunteer sit in a chair. If a grip dynamometer is available, determine the maximum force that the volunteer can exert with their dominant hand. Their target force for this activity will be about 30% of that value. If a rubber ball or spring exerciser is used, the subject should try to estimate the grip force to be in this range.
4. Place the blood pressure cuff on the other arm. Take an initial reading. Record the systolic and diastolic pressures in the data table. Leave the cuff on the volunteer's arm.
5. Determine the volunteer's resting heart rate by taking their radial pulse. Record the heart rate in the data table.
6. Place the occlusion cuff on the upper part of the exercising arm. Do not inflate.
7. The volunteer will then exert a force on the dynamometer approximately 30% of their maximum and maintain it for three minutes.
8. At one minute the blood pressure will be taken. The monitor will have to anticipate this reading and inflate the cuff prior to the time mark so that the reading is as close to one minute as possible.
9. A pulse reading should be taken at immediately following the blood pressure reading.
10. Repeat the readings of blood pressure and pulse rate at the two- and three-minute marks.
11. Just following the three-minute reading, the occlusion cuff should be inflated to 200 $mm_{Hg}$. This will cut off all blood flow to the arm. As soon as the pressure reaches 200, the volunteer should stop exercising.
12. At four minutes, check blood pressure and pulse. Deflate the occlusion cuff immediately.
13. Take a final blood pressure reading and pulse at 5 minutes.
14. Calculate MAP as you did in the first part of this activity. Record these values in the table.
15. Make a line graph of your results. You should have one line for each of the three values, systolic pressure, diastolic pressure, and MAP.

**Data**

| | **Initial** | **1 Minute** | **2 Minutes** | **3 Minutes** | **4 Minutes** | **5 Minutes** |
|---|---|---|---|---|---|---|
| **Systolic** | | | | | | |
| **Diastolic** | | | | | | |
| **MAP** | | | | | | |
| **Heart Rate** | | | | | | |

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**Analysis**

1. Describe what happened to the volunteer's MAP and heart rate during static exercise. How do these compare to values you obtained for dynamic exercise in the first part of this activity? How can you account for any differences?
2. How did heart rate and blood pressure change during the time the blood flow was occluded? Which of the two systems, Central Control or Feedback was most active at this time? Relate this information to your observations.
3. What was happening during the last minute? How do the data show this?