**SOP for Isometric Muscle Contractions**

**October 1, 2012**

## Purpose

The purpose of this SOP is to ensure that isometric force production measurements are obtained in a safe, valid, and reproducible manner.

## Materials

*Equipment List*

1. Isometric exercise apparatus
2. T-type Allen wrench
3. Omega DMD-465WB bridge amplifier
4. NI cDAQ-9174 w/module NI 9205
5. Dell laptop with external monitor for lab studies or goggle system for MRI studies.
6. LabVIEW and LabVIEW vi's as needed – see below.

*Hardware Configuration*

For lab studies, the cable leading from the load cell is connected to the bridge amplifier via a dedicated cable. The amplifier is connected into the DAQ module.

For MR studies, the cable leading from the load cell is connected to the RF filter panel via a dedicated cable. A second cable connects this to the bridge amplifer. The amplifier is connected into the DAQ module.

For the pin diagram in the cables, see the end of the SOP.

In addition, the extra monitor or goggle system should be connected to the laptop via the VGA connector. The goggle system needs to be turned on and may need to be repeatedly toggled to produce a binocular view of the screen.

## Safety Issues/Risks

1. Excessive changes in blood pressure: Isometric contractions induce a pressor response (an increase in blood pressure associated with muscle contraction, occurring as a result of feedforward and feedback cardiovascular control mechanisms). Holding one's breath and straining can produce a Valsalva maneuver, which can exacerbate these changes and produce a dangerously high response in some subjects.
2. Other cardiovascular event: There is a very small risk of other cardiovascular complications (angina, poor peripheral perfusion, heart attack, or stroke) during isometric contractions, particularly in compromised populations or as a result of certain lifestyle behaviors.
3. Local muscle pain or soreness: During intense and prolonged contractions, the subject may feel local muscle discomfort ("burning"). The subject may notice some delayed-onset muscle soreness following the exercise.

4. Other discomfort: The subject may feel some local orthopedic or other discomfort.
5. Terminals 6 and 7 on the amplifier are connected to 120V AC.

**Risk Reduction**

*General Risk Reduction Procedures*

1. Two or three people should be present during all testing procedures. At least one of those present should be certified in CPR.
2. In the event of an adverse consequence of testing, the following emergency plan should be implemented:
    - The most medically qualified person present will provide care to the subject;
    - The person will assess environment for hazards to self or subject (running treadmill, electrical hazard, etc);
    - If unconscious, that person should assess the subject for Airway, Breathing, Circulation, and Deadly injuries; and
    - That person will communicate information to second research team member.

    In the case of emergent conditions, the second research team member will call the resuscitation team at 1-1111 and

    - Communicate his/her name, location, the subject's condition, and other requested information to the resuscitation team;
    - Communicate instructions from resuscitation team to the other researcher;
    - Meet the resuscitation team and escort to lab; and
    - Transfer care to the resuscitation team when they arrive.

    In the case of urgent conditions, the second research team member will call the Clinical Radiology MRI Center at 2-2394 and

    - Communicate his/her name, location, the subject's condition, and other requested information to the MRI Center;
    - Request assistance from an MRI Center physician;
    - Communicate instructions from MRI Center to the other researcher;
    - Meet the answering physician and escort to lab; and
    - Transfer care to the physician when s/he arrives.

    Resuscitation carts are permanently located in B160 VUH and AA0117 MCN (in the imaging facilities).

*Specific Risks Reduction Procedures for Isometric Exercise Testing*

1. The subject should be instructed to exhale during the initial effort and continue to breathe during the contraction.
2. The subject should be properly screened for health conditions that may enhance the risks associated with contraction using the Health History Questionnaire. Subjects should be

excluded from participation or receive physician consent prior to performing exercise procedures, as per the IRB protocol. Lifestyle activities should be restricted as follows during the pre-testing period:

- The subject should not take over the counter medications during the 48 hours prior to testing.
- The subject should continue prescribed medications.
- The subject should not consume alcohol within 24 hours of testing.
- The subject should not perform any strenuous physical activity within 24 hours of testing.
- The subject should not consume caffeine within 6 hours of testing.
- The subject should not use any tobacco produce within 6 hours of testing.
- The subject should have eaten a full meal 3-6 hours prior to testing.

Data concerning these activities can be acquired using the 48 Hour Inventory Form.

3. Local pain during contractions is a typical, but temporary, consequence of intense exercise and should begin to resolve when the exercise concludes. The subject should be allowed to voluntarily end the exercise should the pain become unbearable. Post-exercise discomfort is a rare consequence of isometric contractions. If it does not begin to improve within 2-3 days, the subject should be referred for medical care.
4. The subject should be instructed in proper contraction technique so as to limit the involvement of other muscle groups. Straps may be used to limit bulk motion, but should not be tightened excessively.

**Proper Testing Procedures**

*General Issues*

1. Pre-testing for maximal voluntary contraction (MVC) force should typically occur 1-3 days prior to the testing session. If submaximal contractions are to be performed, the subject should be allowed to rehearse these in advance also.
2. For multi-day studies, all testing should occur at about the same time of day and similar lifestyle restrictions should be practiced prior to each day of pre-testing or testing. Also, the project personnel present during testing procedures should be consistent for all study days.
3. Perform the following procedures prior to subject arrival. Secure the exercise device to the grid plate on the exercise bench (lab) or patient bed (MRI studies). For lab studies, the exercise bench should always be used. The exerciser should be placed on the same side as the subject's dominant leg. For MRI studies, the exerciser should be placed as close to the center of the patient bed as possible. *Note that the T-handle wrench is magnetic and so for MR studies, adjustments to the exerciser position on the grid plate must always be done outside of the magnet room. Before entering the magnet room, double check to ensure that the wrench has been removed from the patient bed/gurney*.
4. Make all physical connections between the components of the force measurement system, start the software, and ensure the proper function of the system. Clear lab space of extra materials and ensure that all data recording instruments are prepared. Allow extra time to debug the

system or handle unexpected problems, if needed. Review the experimental protocol with all study personnel.

5. Testing will typically occur using the subject's dominant foot (preferred leg for kicking or the weight-bearing leg when the subject begins to walk).
6. Subject positioning for plantar- and dorsi- flexion: Position the subject supine on the imager's patient bed or the exercise table. The foot should be strapped tightly into the exercise device. Adjust the heel position so that the straps are placed proximal to the base of the fifth digit. Any discomfort may inhibit maximal efforts, so padding may be added between the foot and the strap. Padding may be introduced under the knees to provide strain relief for the back. Rigid supports under the knee should be avoided as they may occlude flow through the popliteal artery. The arms should be folded across the chest or placed lightly to the side.
7. The subject should be instructed to isolate the contraction to the muscle group of interest. The subject's technique should be carefully examined to ensure that s/he is not making extraneous movements of other body parts that would tend enhance force production or otherwise alter the physiological response. Coached practice is very helpful.
8. The subject should be continuously monitored visually and verbally during contractions for signs of inappropriate responses to contractions, such as lack of responsiveness, cyanosis, or pallor. Also, proper breathing patterns should be ensured.
9. Force data are sampled at 1000 Hz. The LabVIEW force analysis programs apply a 25 Hz, $10^{th}$ order lowpass Butterworth filter.

*Testing Protocol for MVC Force Measurements*

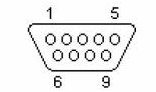
1. Position the subject on the table.
2. Open the MVC_Dorsiflexion.vi or MVC_Plantarflexion.vi program, as appropriate (the two programs are the same except that the applied calibration is opposite in sign). Supply information concerning expected MVC force, contraction duration, etc. When specifying the file name, be sure to add the .lvm extension. Typical forces are from 100-500 N, depending on body weight and muscle group. Typically we use a 3 sec. contraction for MVC measurements.
3. Instruct the subject in proper form, breathing, etc. The subject should be instructed to pull as hard and as fast as possible, exhaling during the initial effort and continuing to breathe afterwards. Also, explain the use of the LED panel at the top of the screen; it is typically helpful to tell the subject to light as many of the LED's as possible. Have the subject perform several contractions, focusing on giving a high effort and gradually correcting aspects of technique.
4. Run the vi. There will be a 15 sec. preparatory period prior to the contraction. Give the subject notice with 10 sec. prior to the contraction and then a 5-4-3-2-1 countdown. Give the subject the command to start the contraction. Monitor and strongly verbally encourage the subject during the contraction. Ensure that proper form is used. Typically, force production is maximized if the subject is provided with verbal encouragement during the contraction.
5. Close the vi and open the ReadMVC.vi program. When prompted, select the file of interest. Adjust the sliders so that the window includes a small period of baseline right before the contraction and the maximum force produced during the contraction. Select the "Measure Now" button and read the MVC force as the largest force range.

6. After a ~5 min. rest, repeat the contraction. For a valid MVC, the forces must be within 5% of each other. Repeat it a third time if necessary and use the higher of the two contractions that are within 5% of each other. Occasionally, a fourth contraction is necessary.

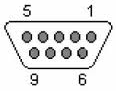
*Testing Protocol for Submaximal Contractions*

1. Position the subject on the table.
2. Open the Submax_WithRamp_Dorsiflexion.vi or Submax_WithRamp_Plantarflexion.vi program. Supply information concerning the MVC force, contraction duration, desired contraction intensity, etc.
3. Instruct the subject in proper form, breathing, etc. The subject should be instructed to ramp up slowly to the target intensity, exhaling during the initial effort and continuing to breathe afterwards. Also, explain the use of the LED panel at the top of the screen; yellow means that the subject needs to pull harder; the large green LED in the center is the target force, and red means that the subject is pulling too hard.
4. Run the vi. There will be a 15 sec. preparatory period prior to the contraction. Give the subject notice with 10 sec. prior to the contraction and then a 5-4-3-2-1 countdown. The ramp time is 6 s. Give the subject the command to start the contraction by following the lower light panel. Monitor and encourage the subject during the contraction. Ensure that proper form is used.
5. Close the vi and open the Read_Submaximal.vi program. When prompted, select the file of interest. As desired, adjust the sliders so that the window includes a period of interest. Select the “Measure Now” button and read the descriptive characteristics for the force production during that window.

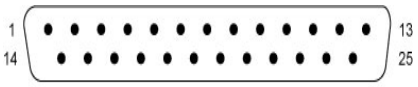
# Diagrams and Pin Assignments for Force System



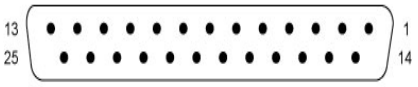

DB-9 Male



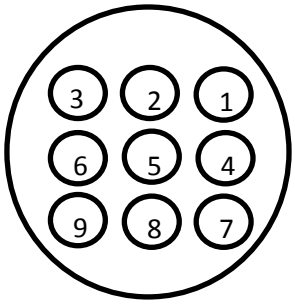

DB-9 Female




DB-25P (Male Plug Front View)




DB-25S (Female Socket Front View)




Round 9-pin

*Pin Connector for Cable #1 (from force transducer)*

**9 Pin Female Round Connector**

Pin 1: RED

Pin 4: BLACK

Pin 7: GREEN

Pin 8: WHITE

*Pin Connector Diagram for Cable #2*

| **9 Pin Male Round Connector** | **9 Pin Female Connector** |
|---|---|
| Pin 1: RED | Pin 2: BLACK |
| Pin 4: BLACK | Pin 5: RED |
| Pin 7: GREEN | Pin 7: WHITE |
| Pin 8: WHITE | Pin 8: GREEN |

*Pin Assignment for Cable #3*

| **9 pin Male connector** | **25 pin Female connector** |
|---|---|
| Pin 2: BLACK | Pin 2: BLACK |
| Pin 5: RED | Pin 4: WHITE |
| Pin 7: WHITE | Pin 10: RED |
| Pin 8: GREEN | Pin 12: GREEN |

*Pin Assignment for Cable #4 (to transformer)*

**25 pin Male connector**

Pin 2: BLACK

Pin 4: WHITE

Pin 10: RED

Pin 12: GREEN

*Cable #5 connects amplifier (OMEGA DMD-465WB) to A/D converter (NI cDAQ-9174 w/ module NI 9205)*

**Amplifier (Omega DMD-465WB)**

Pin 2: RED (from cable #4)

Pin 4: BLACK (from cable #4)

Pin 5: GREEN/YELLOW (from 3-prong)

Pin 6: BLUE (from 3-prong)

Pin 7: BROWN (from 3-prong)

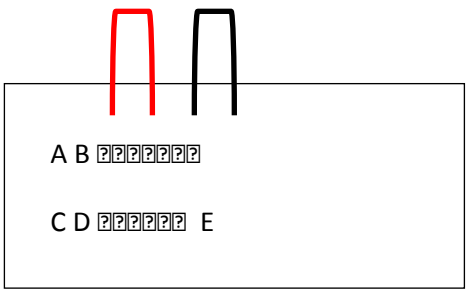
Pin 8: GREEN (from cable #4)

Pin 9: WHITE (from cable #4)

Pin 10: BLACK (from cable #5)

Pin 11: RED (from cable #5)

Jumpers (1 to 2, 3 to 4)




**A/D converter NI9205**

Pin AI0: RED (from cable #5)

Pin AI18: BLACK (from cable #5)

Jumper (AI18 to COM)

| Channel | Signal+ | Signal- | Channel | Signal+ | Signal- |
|---|---|---|---|---|---|
| 0 | AI0 | AI8 | 16 | AI16 | AI24 |
| 1 | AI1 | AI9 | 17 | AI17 | AI25 |
| 2 | AI2 | AI10 | 18 | AI18 | AI26 |
| 3 | AI3 | AI11 | 19 | AI19 | AI27 |
| 4 | AI4 | AI12 | 20 | AI20 | AI28 |
| 5 | AI5 | AI13 | 21 | AI21 | AI29 |
| 6 | AI6 | AI14 | 22 | AI22 | AI30 |
| 7 | AI7 | AI15 | 23 | AI23 | AI31 |

**Training Log**

| Name | Instructor | Date |
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