Lab #4: Cardiac Cycle

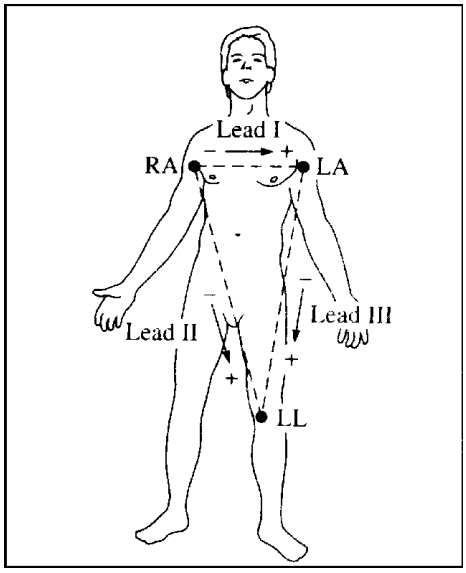
Materials Required: iWorx ETH-256 Bioamplifier with NI USB-6009 Interface; iWorx C-ISO-255 isolation amplifier; LabScribe Software; Finger pulse plethymosgraph pickup; cardiac skin electrodes.

Introduction:

The electrocardiogram, or ECG (EKG) is an important diagnostic tool for evaluating the condition of the heart. In this experiment you'll observe the Lead I signal and correlate the heart's electrical activity with observed peripheral blood pressure pulsation by using the plethysmograph pickup.

Einthoven Leads

Einthoven assumed that the electrical fields emanating from the heart originated in a relatively small area at the center of a uniform volume conductor (the body itself). The heart in Einthoven's view is an electrical *dipole*, meaning a source of an electric field. The three leads located at the left arm, right arm, and left leg form a triangle with the heart located approximately at its electrical center:



Each of the three lead configurations sees a different view of the cardiac electrical axis, and because of this, different features of the EKG will be more pronounced on each lead. For example, Lead I tends to show both atrial and ventricular electrical components equally (the measurement axis is close to a right angle with the heart electrical axis), while Leads II and III tend to emphasize ventricular signals, because the measurement axis is more in line with the effective dipole formed by the heart muscle.

Note the assumed polarities -- this has importance when interpreting the signals from the three lead configurations. In the Lead I configuration, the ground (green, reference) electrode is applied at the left leg, the negative (black) is applied at the right arm, and the positive (white) is placed on the right arm.

Lab Procedure:

1. Set up iWorx to measure the EKG and blood pressure wave. This will take a few steps:

   a) Connect the C-ISO-255 isolated amplifier to Channel 1, and the finger pulse plethysmograph pickup to Channel 2.

   b) Set the ETH-256 bioamplifier as follows (these are suggested starting settings, you may need to "tweak" as you go):

   Ch1: HPF=0.3 Hz, GAIN=X1, LPF=150 Hz
   Ch2: HPF=0.3 Hz, GAIN=X5, LPF= 50 Hz.

   c) Start LabScribe and prepare it for recording:

   * Set the default configuration (Settings → Default)
   * Set the number of channels to 2 (Edit → Preferences → Channels)
   * Set the sample rate to 200 Hz.
   * Create a new document.

2. Measure the EKG and pulse pressure wave from a subject:

   a) Apply electrodes only to clean skin. Use an alcohol pad to remove any excess oil from the electrode site, if needed.

   b) Apply the electrodes, avoiding locations with hair:

   * Negative (black) at right arm (the anterior wrist is a good surface.)
   * Reference (green) at left ankle (use the medial surface)
   * Positive (white) at left arm (anterior wrist)

   c) Place the plethysmograph pickup on the volar surface of either index finger.

   d) Make sure the subject sits VERY STILL. Allow a few seconds for settling after placing the electrodes.

   e) Start the recorder.

   f) If you don't get a strong enough EKG reading, it's okay to "cheat" a little. Place a new electrode pad at the left lateral chest wall at the 5th intercostal space, and move the positive (white) electrode there. (DO THIS ONLY IF NECESSARY. PLEASE RESPECT THE PRIVACY OF THE SUBJECT.)

3. Record several seconds of "clean" EKG & plethysmograph signal with the subject at rest, and include this in the report. Be sure to identify:

   a) Is a dicrotic notch (incisure) visible in the plethysmograph output?
   b) What is the pulse rate of the subject?
   c) What is the Q-T interval of the subject?

4. See if you can observe the normal sinus arhythmia in your subject:

   a) Have the subject breath in and out deeply several times while observing the EKG.
   b) Examine the record closely to observe the difference between inspiration and exhalation.
   c) Report this in your report.

5. Measure the effect of moderate exercise on the EKG:

   a) Carefully remove the lead connections. Place two fingers on the electrode pad to hold it in place, then gently remove the connector with the other hand. DO NOT YANK ON THE CONNECTION. YOU WILL DEGRADE THE ELECTRODE BY PULLING TOO HARD, AND IT'S ALSO EASY TO TEAR THE SUBJECT'S SKIN.

   b) Have an individual perform a medium level of exercise for two minutes. (The easiest way to achieve this is to use the stairs a few times, or briskly walk a couple of times around the perimeter of the building).

      WARNING: Persons with preexisting health problems should not do this!

   c) Quickly reconnect the leads and repeat the measurements of Step 3. Include these as as "post exercise" for this subject in your report. (Make sure to compare the results obtained between Steps 3 and 5.)

6. Repeat Steps 2-5 for everyone in your lab group:

   a) Compare the resting EKG signals for the individuals in your group. Are they homogeneous, or are there distinct differences between individuals?

   b) How does the peripheral pressure pulse time delay compare between individuals in your group?

How to Safely Remove Electrode Pads

After electrode pads have been in place a few minutes, they will generally adhere very strongly to the skin surface. RAPIDLY REMOVING THEM CAN TEAR THE SKIN. To remove them with a minimum of damage (and pain!):

a) Gently peel the leading edge of the electrode *backwards* (towards the electrode center).

b) Place a finger firmly on the skin under this edge and press down to keep the skin firm.

c) Continue peeling the electrode slowly backward, pulling *in line* with the skin surface (never at a right angle), moving your finger as needed to keep the skin from being stretched excessively.

d) Wash the site with soap and water to remove any residues from the electrodes.

Data to Include in your Report

The data from each step in the experiment should be included. For each subject in your group there should be two sets of tracings, one for pre-exercise and then post-exercise.

Document all equipment settings and measurements used in the process, as well as any troubleshooting you had to perform.

Remember that a quantitative conclusion is required in your report. This conclusion should be based on the numerical (quantitative) data recorded during the experiment.

What things might you observe quantitatively? Here are some possibilities given what you've measured:

a) How did exercise affect the pulse rate? Was the effect equal in all individuals?
b) Did the Q-T interval change with exercise -- and did it change in proportion to the rest of EKG signal components?
c) Did the time difference between the QRS and peripheral pressure wave vary between subjects? Did exercise affect this time difference?
d) Did some subjects present a larger somatic artifact than others?