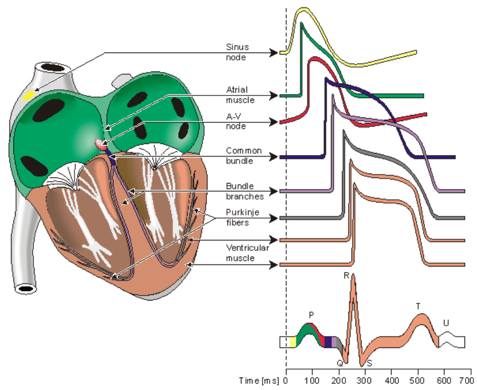
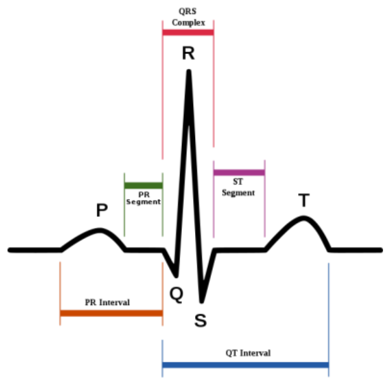
Electrocardiography

I. Background

The cyclic changes in cardiac activity generate an electrical field with varying magnitude and orientation around the heart. The electrical sequence of depolarisation and the subsequent repolarisation of the myocardium results in an uneven distribution of electrical charges on the surface of the heart. An electrical current flows from areas with negative charges towards those with positive charges. This electrical field diminishes towards the body surface, but its changes during the heart cycle can be registered by surface electrodes positioned on the skin.





The electrical signal is generated by the sinoatrial node and spreads to the ventricular muscle via particular conducting pathways:

P wave: atrial depolarisation.

PQ interval: atrio-ventricular conduction time (0.12–0.2 s)

PQ segment: the time the electrical impulse takes to travel from the sinus node through the AV node to the ventricles; in this interval, no electrical activity can be detected.

QRS complex: rapid depolarisation of the right and left ventricles. They have a large muscle mass compared to the atria, so the QRS complex usually has much greater amplitude than the P-wave (0.08 s). Atrial repolarisation also takes place in this phase.

ST segment: the period when the ventricles are depolarised. It is isoelectric.

T wave: repolarisation (or recovery) of the ventricles.

II. Measurement principle

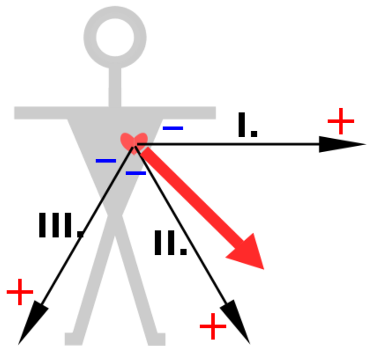
The recording of the electrocardiogram (ECG) is performed with surface electrodes positioned on particular areas of the body. A **lead** may refer to the tracing of the voltage difference between two of the electrodes and is what is actually produced by the ECG recorder. Based on the reference of the measured points, **bipolar** (*potential difference between two points*) and **unipolar** (*relative to a zero potential*) leads are distinguished.

1. Bipolar electrodes located on the limbs (one on each arm and one on the left leg) register the potential difference between the limbs. The limb leads form the vertices of what is known as **Einthoven's triangle**:

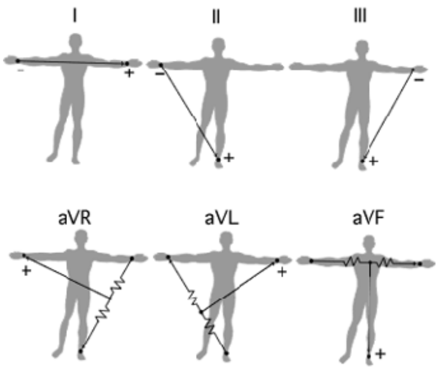
I: Right arm – left arm
II: Right arm – left leg

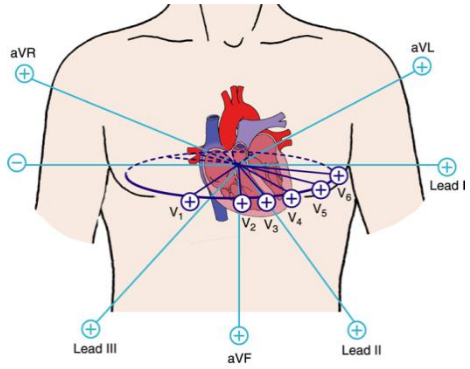
III: left arm – left leg

The three measurement points form approximately an equilateral triangle around the heart (Einthoven triangle). The electrical activity of the heart can be interpreted as a vector, so it has magnitude and direction. The bipolar leads register the projection of the main electrical axis of the heart to the corresponding three directions.



2. The unipolar leads with electrodes positioned on the limbs (aVL, aVR, aVF) and on the chest (V_1-V_6) measure the electrical potential of the given point with reference to a practically zero potential.



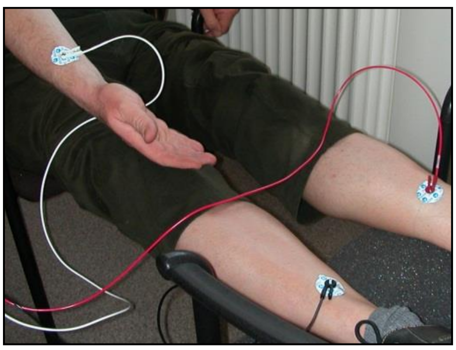


III. Aims of the measurement

- To get acquainted with the measurement of the electrocardiogram using bipolar (Einthoven II.) leads.
- To determine the typical intervals and waves of the ECG (times and amplitudes) at rest and after exercise.
- To follow heart rate changes following exercise.

IV. Measurement protocol

1. Start 'BSL Lessons 3.7' on the measuring computer and choose 'Lesson 5 (ECG-1)'.
2. Give the ETR code of the patient as the file name.
3. Position electrodes on the limbs:
   - Red: left ankle
   - Black: right ankle
   - White: right wrist
4. Calibrate the system.
5. Register normal ECG in sitting position (1 minute).

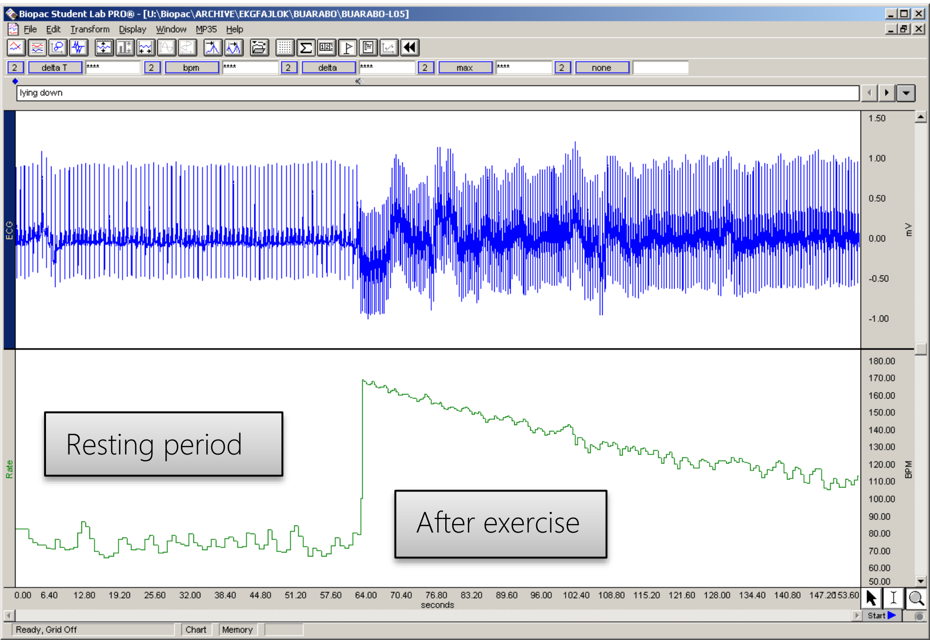


- Start measurement: *Record*
- Pause measurement: *Suspend*

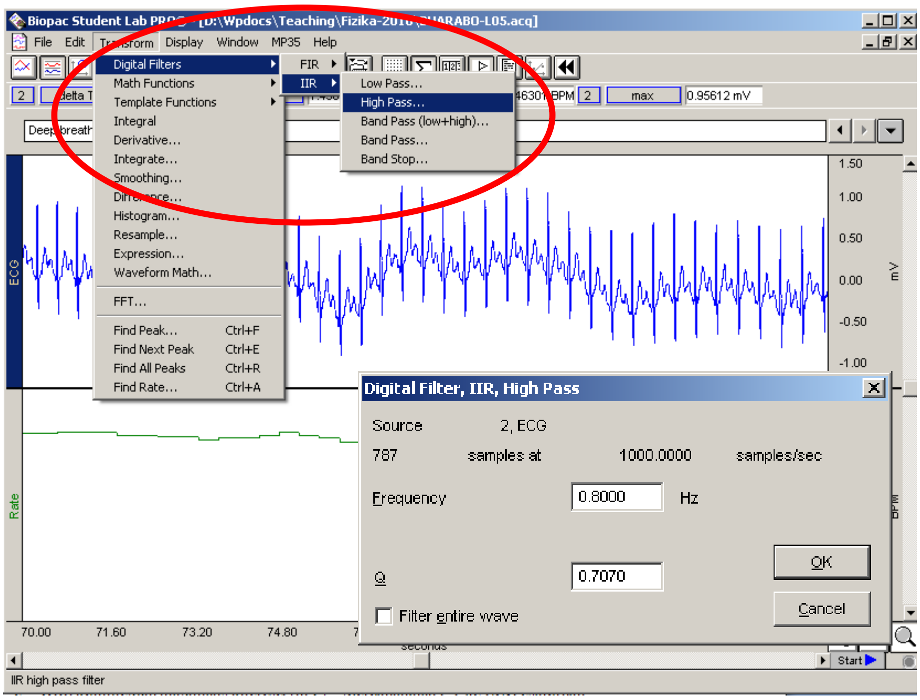
6. Record the ECG after exercise (2 minutes)
   - Continue measurement: *Resume*
   - Pause measurement: *Suspend*
   - Terminate recording: *Done*
7. Perform measurements on another patient *(Record from another subject)* or end the measurement *(Quit)*.
8. Notify the instructor when you are finished with all measurement tasks.

V. Signal processing and data analysis

1. Launch the program 'BSL Pro 3.7' and open an ECG recording from the folder C:\TEMP\MEASURE (file type LDD, name: ETR code-L05)
2. Open the Excel laboratory report file from the folder C:\TEMP\MEASURE (Jkv_Report_Bericht.xls)
3. Hide journal (*Hide journal* button on the toolbar).

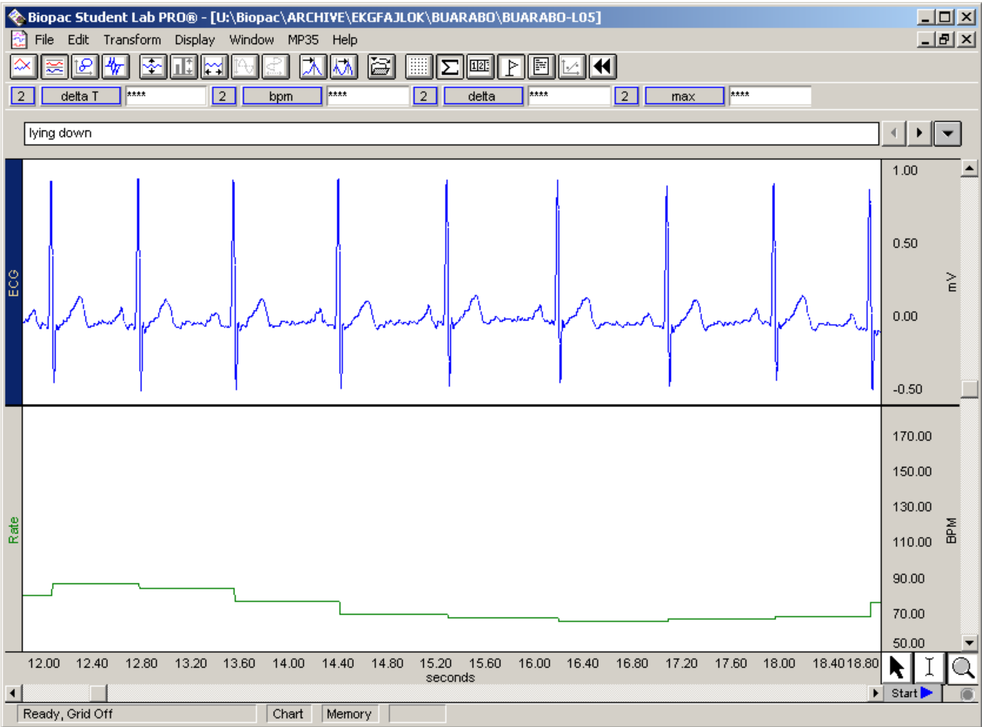


4.
   a. The undulation of the baseline of the ECG curve can be decreased applying a high-pass filter (eg, 0.5 Hz)



b. If the ECG recording is contaminated with high-frequency noise, it can be eliminated using a low-pass filter (25 Hz).

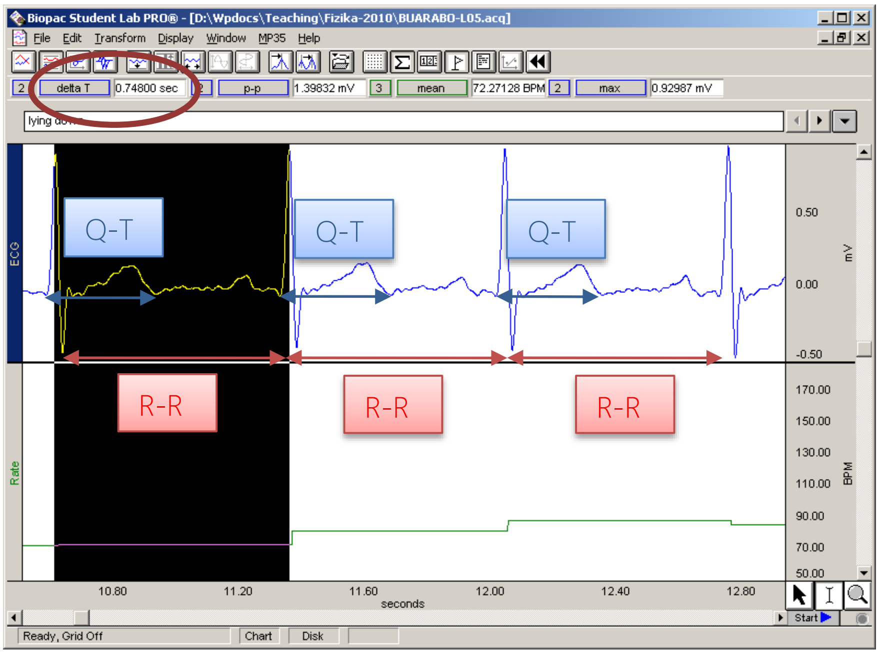
5. Zoom in on the ECG signal recorded at rest:



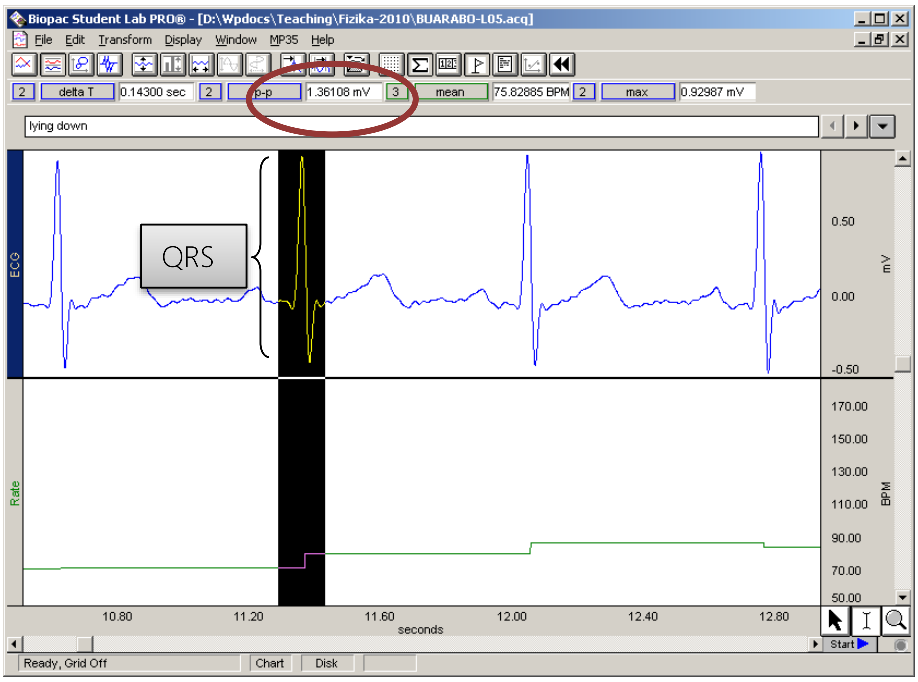
6. Measure the following in 6 consecutive heart cycles:

   a. the time between two neighbouring R waves (R-R distance) – use a measurement window set to *Delta T* on the ECG channel;

b. the duration of the Q-T intervals – use a measurement window set to *Delta T* on the ECG channel;



c. the amplitude of the QRS complex (in mV) – *P-P* in the measurement window on the ECG channel;



d. the pulse rate in the 6 cycles examined – *Mean* in the measurement window on the Rate channel.

7. Zoom in on the ECG signal collected ***after*** the exercise and repeat the points 5. a, b, c, d
   a. in the first seconds after the exercise (6 heart cycles);
   b. in the last 10 seconds after the exercise (6 heart cycles).