The heart under stress (Item No.: P1522160)

Curricular Relevance

Area of Expertise: Biology
Education Level: Age 14-16
Topic: The human being
Subtopic: Physiology: Respiration, heart and blood circulation
Experiment: The heart under stress

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

- iPad or Android tablet

Experiment Variations:

- Alternatively, use a PC with measureLAB (14580-61)

Keywords:

Electrocardiogram (ECG), Cardiac activity, Heart muscle

Overview

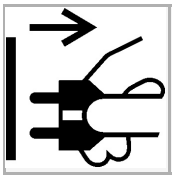
Information for teachers

Additional information

Just like the skeletal muscles, the heart muscle is assigned to the group of striated muscles although unlike the skeletal muscles it cannot be controlled at will. The electrocardiogram visualises the course of the electrical excitation during the different phases of a cardiac cycle. The heart frequency increases under physical stress in order to maintain the stability of the cardiovascular system.

On the one hand, the heart frequency at rest depends on the size of the body of a person, which is due to the size of the heart compared to the rest of the body. A relatively small heart (e.g. of a baby) must, therefore, beat more frequently in order to pump the same amount of blood through the circulatory system. On the other hand, however, the heart muscle can be trained. If a person has a relatively large and strong heart muscle (e.g. an endurance athlete), the heart needs to perform fewer contractions in order to maintain the stability of the circulatory system.
This is why endurance athletes usually have a lower heart frequency at rest than untrained persons. A resting frequency of 30 to 35 heart contractions per minute is quite possible.

Warning



Unplug when in use!
For safety reasons, the Sensor-Unit Electrophysiology must only be used if the attached Cobra4 measured data recording instrument is not connected to the mains voltage!

Please take the physical fitness of your students into consideration when asking them to exercise!
An ECG that is recorded at school should not be overinterpreted in the event of deviations from the example ECG in the illustrations. Heart disorders or damage to the heart muscle can only be diagnosed with any degree of certainty by a doctor.

Notes concerning the execution of the experiment

Please ensure that the students take care that the test person does not move during the measurement when in resting position. Even the slightest movements, e.g. the lifting of a hand, will cause the heart muscle activity to be superimposed during the measurement.

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Overview

Short description

We investigate our physical fitness

An electrocardiogram (ECG) can record the sum of the electrical activities of all of the heart muscle fibres. Under stress, cardiac activity increases in order to maintain the stability of the cardiovascular system. The heart contraction cannot be controlled at will. This experiment enables you to study how physical stress affects the respective activity of your heart.

Fig.1: Experimental set-up

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link	12601-10	1
2	Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
3	Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
4	Electrodes for ECG Sensor, 100 pcs.	12559-01	1
5	Crocodile clips for disposable electrodes, 3/pkg	12673-02	1
With disposable electrodes:			
6	Electrodes for ECG-Sensor	12559-01	1
7	Crocodile clips f. disposable electrodes, 3 pieces	12673-02	1
Or with permanent electrodes:			
8	ECG electrodes, 3 pieces	65981-01	1
9	Electrode Gel, tube	65981-06	1
Additional material:			
	Android tablet or iPad		1
	PHYWE measure App		

Android iPad

Tasks

1. Record an ECG while switching from rest to strain (20 squats).
2. Record an ECG while switching from strain to rest and calculate the time that elapses until the resting heart rate is reached again.

Set-up and procedure

Set-up

Preparatory tasks

Preparation and application of disposible electrodes

The heart, muscle, and eye activities are measured on the skin surface. You have to measure at different points depending on the organ in question.
For **getting started, disposable electrodes** are the most suitable, since you can simply stick them to the skin areas that are designated in the experiment descriptions and they also supply acceptable results. Simply fasten the crocodile clips to the ends of the colour-coded leads and clip them on the tabs of the disposable electrodes:

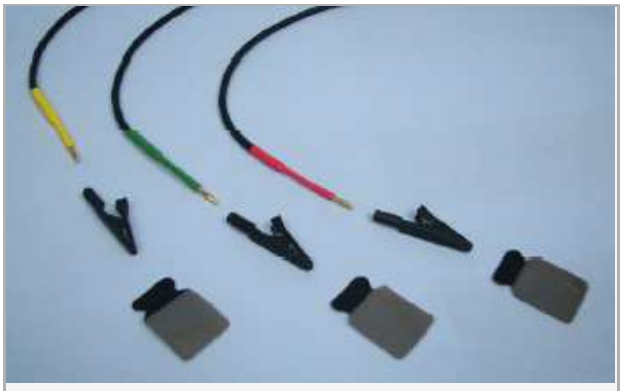


Fig.2: disposable electrodes

Preparation and application of permanent electrodes

Alternatively it is possible to use permanent electrodes aswell.

Permanent electrodes are more time-consuming and costly, but have the following advantages apart from lower follow-up costs:
-EMG permanent electrodes: reduced footprint on the skin and, thereby, more precise measurements
-ECG permanent electrodes: increased footprint on the skin and, as a consequence, stronger signals

In order to establish contact, cut a paper handkerchief or similar to the size of the ECG electrode and moisten it with a 1% potassium chloride solution. Place it between the electrode and skin when fastening the electrode to the arm or leg with the rubber belt. After the positioning of the electrode, connect the colour-coded leads to the corresponding electrodes:

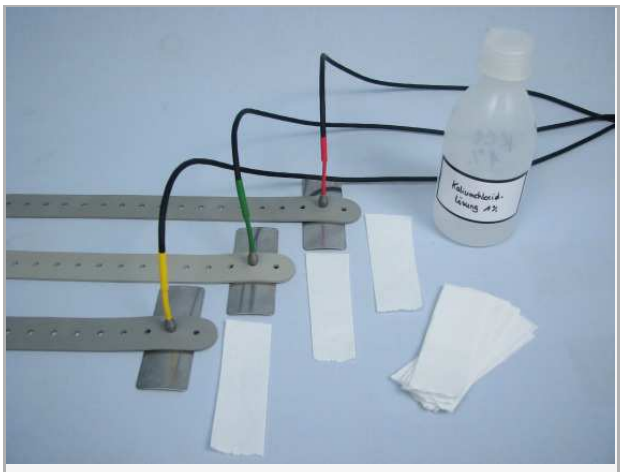


Fig.3: Permanent electrodes

Set-up

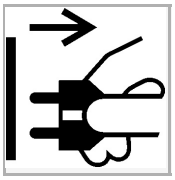
- The experiment requires at least two persons wherein one test person is to be connected to the electrodes and another person will operate the tablet/computer.
- Fasten one disposable ECG electrode each with the adhesive surface to the inner side of the right and left wrists as well as to the left ankle. The test person who is connected to the electrodes should be seated in a relaxed position.
- Now, connect the colour-coded leads with the crocodile clips to the electrodes: the red crocodile clip to the electrode of the

right wrist, the yellow clip to the electrode of the left wrist, and the green clip to the electrode at the left ankle.

- You can now connect the electrode cables to the Cobra4 Sensor-Unit Electrophysiology. Plug the red plug into the socket that is marked with (+), the yellow plug into the socket that is marked with (-), and the green plug into the socket that is marked with (Ref).

Procedure

Fig. 4



Unplug when in use!
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- Connect the sensor-unit Electrophysiology with the Wireless/USB-link and switch it on.
- Connect your tablet via WiFi with the Wireless/USB-link.
- Open the PHYWE measure App and select the sensor "Electrophysiology". Select the sensor-mode "ECG".
- Select a sampling rate of your choice. The higher your sampling rate the more accurate the measurement will be. In addition to this there is also a possibility to mulitply your values by a factor to get an even clearer result.
- Start the measurement data recording process once the voltage has levelled out. It is very important for the test person to remain absolutely still throughout the measurement, since otherwise the system will also record other muscle activities.

Measurement 1:

- Start the measurement data recording process once the test person is at rest. 20 seconds after the start of the measurement, the test person starts to exercise (e.g. 20 squats). Then, the test person must rest again (sit down on a chair).
- Save the data of this measurement and continue with the next measurement.

Measurement 2:

- Set a countdown of 300 seconds. Therefor you can use the integrated stoppwatch of the PHYWE measure App or any other stoppwatch. Let the test person complete 20 squats and start the measurement instantly afterwards.
- When the 300 seconds are over, stop the measurement and save it.

Results and evaluation

Use the "zoom" function to select the suitable measurement sections and evaluate them. The "survey" button is particularly suitable for this purpose (compare Fig. 5).

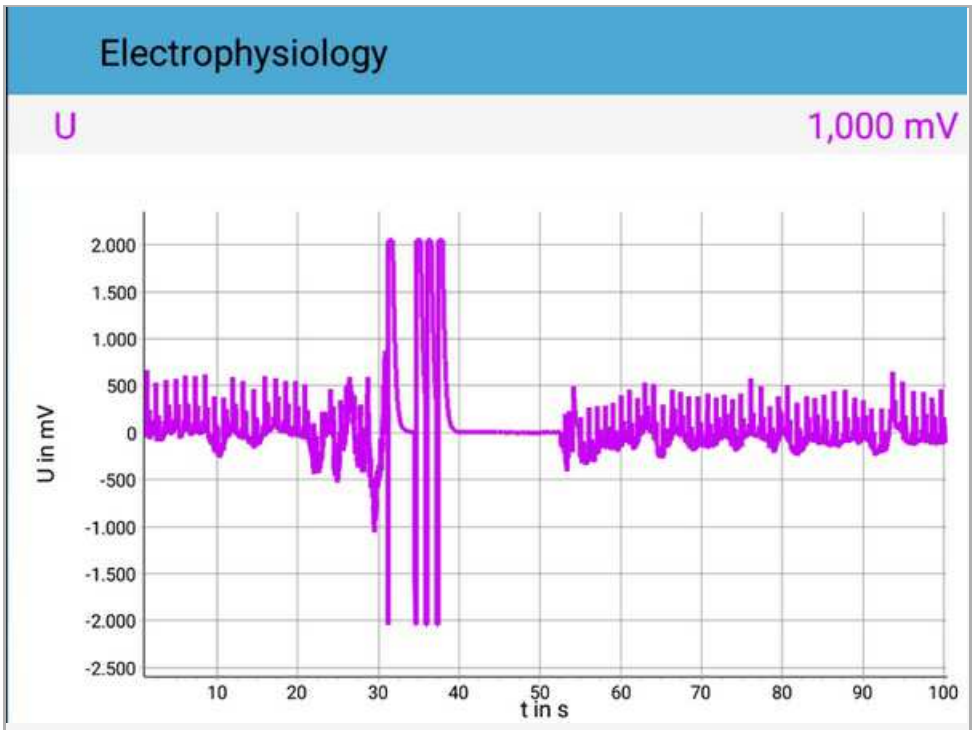

Fig. 5: ECG under strain

Go to the report, analyse the ECG sections and answer the questions.

Report: The heart under stress

Evaluation - Question 1

Measurement 1:

1. How long is the interval between two heart contractions at rest?
2. What is the heart frequency at rest in f/min?

Evaluation - Question 2

Measurement 1:

How does the cardiac activity change under strain compared to the cardiac activity at rest? Determine the average number of heart contractions per minute under strain and calculate how the heart rate has increased. Calculate the heart frequency by averaging an approximately 10 to 15 seconds long section of the ECG immediately after the end of the physical stress.

1. Heart frequency shortly after the physical strain (f/min)
2. Difference between the heart frequency at rest and the heart frequency shortly after the physical stress in (f/min)

Evaluation - Question 3

Measurement 2:

How quickly does the cardiac activity change after the end of physical strain? Calculate the time that elapses until the resting heart rate is reached again. To do so, look at the three sections of the ECG and determine the heart frequency (f/min):

1. directly after the end of physical stress
2. after 100 seconds
3. after 250 seconds

Note also approximated regeneration time (s):

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Evaluation - Question 4

Table 1: Comparison of the regeneration rate of the heart muscle after physical strain

Heart frequency (f/min)	Max	Lukas
At rest	62	68
Immediately after strain	106	128
100 seconds after strain	83	99
250 seconds after strain	64	78

Look at the measurements concerning the regeneration rate of the heart muscles of the two persons Max and Lukas in Table 1. The two have nearly the same age and height. What factors may have caused the differences in the measurement results?

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Evaluation - Question 5

How quickly does physical stress affect cardiac activity? Why is it so important for the heart to react quickly to physical stress?

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