

# INVESTIGATING HEART FAILURE

## Guide to Week 3 home practical

**Note:** You will also need to download a copy of the worksheet to fill out during the practical. You can find this in the step named 'Preparing for the heart failure practical'.

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## Introduction

This practical aims to investigate the effects of a weakened heart muscle, using a small hand pump to represent the heart and water to represent blood.

Heart failure is the progressive failing of the heart as a mechanical pump due to some sort of damage (such as having a heart attack) or due to overwork (such as long term hypertension or valvular disease). Each of these may result in a progressive weakening of the heart muscle.

As the heart starts to weaken it tries to compensate or adapt in order to maintain a sufficient flow of blood to the body. These are similar adaptations as a healthy heart makes to adapt to regular cardiovascular exercise.

There are two key terms when talking about heart failure, they are:

- Stroke volume: The volume of blood that the heart pumps with each contraction.
- Cardiac output: The volume of blood pumped per minute.

$$\text{Cardiac output} = \text{stroke volume} \times \text{heart rate}$$

# Learning Objectives

There is more to understanding a topic than just remembering facts. To really understand a topic we first learn the theory then we learn how to apply the theory through practical work.

By the end of this practical you should be able to:

- Understand the effect of heart damage or weakness on the function of the heart
- Understand the terms stroke volume and cardiac output

## Assessment

There is a worksheet for you to complete during the practical. This can be downloaded from the step named 'Preparing for the heart failure practical'. You will then be able to use the data you have collected to compare results with other learners in the discussions after the practical.

## Health and Safety

All of the practicals in this course are optional. Practical work aims to apply the theory already covered, enabling a deeper understanding of the material. If you are unable to, or do not wish to carry out the practicals, it is still recommended that you watch the videos to gain better understanding of the subject, and so that you are able to take part in discussions.

This practical involves working with water and a manual soap dispenser. There are four main risks associated with this practical:

- Risk of injury through overuse of unaccustomed muscles in the forearm and hand (STOP the practical immediately if you experience any pain).
- Risk of slipping and falling on spilt water. Water poses a slip hazard, particularly as this has potential to be a messy practical.
- Risk of water damage to your mobile device. Protect your mobile device by placing it inside a clear plastic bag and keeping it away from the immediate work area.
- Risk of injury from broken glass. Take care if using a glass measuring jug.

**People who may wish to NOT participate in the practical:**

- Those with hand or forearm weakness or injury.

As for any practical work, avoid eating, drinking, chewing gum, chewing pen lids and directly touching your computer or mobile device during the practical.

At the end of the practical, dispose of your waste responsibly. Wash all utensils (measuring jug etc.) with hot soapy water. Wipe down all surfaces with an appropriate disinfectant at the end of the practical.

Finally, wash your hands thoroughly with hot soapy water.

## Protecting your mobile device

In addition to protecting yourself it is important that you protect your surroundings and equipment.

If you plan on using a mobile device to follow the practical instructions then we strongly recommend that you place the device inside of a clear plastic bag or wrap it with plastic wrap first (and keep it away from the immediate work area). You may need to try different materials to find one that still lets your device work.

Not only will this protect the device from any small splashes but importantly it protects it from being contaminated by dirty fingers. At the end of the experiment you can simply throw away the wrapping, leaving your device clean and uncontaminated.



*Figure 1: Appropriately protecting your mobile device*

## What you will need

Before starting this practical make sure that you have the following items on a tray or plate ready to use:

- Instruction sheet
- Worksheet
- Pen / pencil to write with
- Apron
- Sink area or if not possible access to a tap and use of a washing up bowl or bucket
- 1 litre measuring jug with 100mL increments marked on it
- Pump from a manual soap dispenser (this can be returned to the soap bottle after the practical)
- Large glass or plastic cup
- Timer / clock with second hand
- Calculator

- Access to hot soapy water
- Paper towels or dish cloth
- Suitable disinfectant
- Waste bag

## Instructions

### Part 1: Determining the baseline stroke volume and cardiac output

1. Work near a sink (with draining board) if possible.
2. Check that you have all of your materials, particularly some paper towels/cloths ready to use.

In this experiment the pump from the soap dispenser represents the heart and the water represents blood.

3. Fill a measuring jug to 1000mL (1 litre).



*Figure 2: Measuring the water*

4. Rinse the manual soap dispenser pump through to remove any residual soap.

Place the pump into the measuring jug of water and an empty large glass or cup next to it.

5. Hold the pump with three fingers, placing your index and 4<sup>th</sup> fingers under each side of the pump and your middle finger hooked onto the back and the palm of your hand over the top, with the squirty bit facing you.

Try to hold the pump in this way so that we can compare it to other ways of holding it later.



*Figure 3: Using the pump with three fingers*

6. To obtain the baseline readings you are going to depress the pump once every second to pump 300mL of water from the measuring jug into the empty glass.

Note the elapsed time (in seconds) on the worksheet when the volume in the measuring jug reaches 900mL, 800mL and 700mL (ie After transferring 100mL, 200mL and 300mL).

You may need to stop and start your timer to note the values, or it may be easier to have another person note the times for you.

Try to pump once per second, but if you feel any pain, stop immediately.

7. Calculate the transfer time for each 100mL increment and record this on the worksheet.
8. The stroke volume is the volume of blood the heart can pump with each contraction.

Calculate the baseline stroke volume for your pump by dividing 100mL by the number of times you depressed the pump (as you depressed the pump once per second, the number of pumps it took to transfer each 100mL is the same as the transfer time).

Record this on the worksheet.

9. Cardiac output is the volume of blood the heart can pump in 1 minute.

Calculate the baseline cardiac output for your pump by dividing 100mL by the transfer time (in seconds), and multiplying by 60 seconds.

Record this on the worksheet.

10. Calculate the average baseline cardiac output and record this on the worksheet.

## **Part 2: Investigating what happens during exercise by carrying out a rapid transfer**

1. During exercise the body's muscles need more oxygen, so the heart has to work faster and harder to pump blood around the body.

Fill the measuring jug to 1000mL again.

Holding the pump with three fingers, as described above (step 5), transfer 300mL from the measuring jug to the large glass or cup as fast as you can, noting the elapsed time (in seconds) when the volume in the measuring jug reaches 900mL, 800mL and 700mL.

You may need to stop and start your timer to note the values.

If your hand feels tired slow down. If you feel any pain, stop immediately.

2. Whilst you take a short break in order for your hand/forearm muscles to recover, calculate the stroke volume, cardiac output and % baseline cardiac output for each 100mL of your rapid transfer.

### **Part 3: Investigating what happens if we ask a weakened or damaged heart to do the rapid transfer**

1. After a sufficient rest period, you are going to repeat the rapid transfer of up to 300mL, but this time only using one finger (your middle finger) to work the pump.

Using only one finger mimics a heart that has lost some of its muscle through damage, for example by a heart attack.



*Figure 4: Using the pump with one finger*

2. Fill the measuring jug to 1000mL again. Holding the pump with one finger, as described above, transfer 300mL from the measuring jug to the large glass or cup as fast as you can.

Note the elapsed time (in seconds) when the volume in the measuring jug reaches 900mL, 800mL and 700mL.

If your hand feels tired slow down, but try not to stop even if you are pumping very slowly. If you feel pain, stop immediately.

3. Again calculate the stroke volume, cardiac output and the percentage baseline cardiac output for each 100mL of your weakened rapid transfer.
4. Complete the questions on the worksheet, ready to collate and discuss the group data.
5. Once you have finished the worksheet, clear away any spilt water. Wash all utensils with hot soapy water. Clean the work surface with a suitable disinfectant or hot soapy water. Check that there is no spilt water on the floor that may be a slip hazard to others.