

ACTIVITY BRIEF

Comparing thermometers or blood pressure monitors

Many scientists need to measure temperature as a routine part of their jobs. For example, they may need to monitor the temperature of reaction mixtures, changes in the weather or human body temperatures. In doing so, they need to use the most appropriate instrument for the purpose. Today, scientists can choose from a very wide range of temperature measuring devices.

You have probably already used a variety of instruments to measure temperature yourself. These are likely to have included liquid in glass thermometers and digital probes. So you will have an appreciation of what affects whether you get good results easily - and of what may cause problems!

The picture shows a mercury in glass clinical thermometer. This was once the preferred instrument for measuring human body temperatures. If you have recently had your temperature measured by a health care professional or sports scientist, they are likely to have used a quite different type of instrument.



The same applies to the instruments used to measure blood pressure (called sphygmomanometers).



The old fashioned methods using a pressure gauge and stethoscope have mainly been replaced by a variety of modern instruments.

Are the modern techniques really better than the old fashioned methods that have been in use for many generations?

Your brief

Scientists need to choose the best instruments to use from those available. Health care professionals and sports scientists regularly monitor factors affecting human health and performance. You need to design, plan, carry out and write up an investigation to compare either two types of clinical thermometer or two types of blood pressure monitor. For a given situation, you will:

- carry out practical tests to decide which is the better device
- present evidence to justify your decision.

There are two tasks to complete. The first will allow you to decide the factors to take into account when you design your investigation. Once you have done this you will be ready to investigate and report on the two different instruments.

Task 1 Fit for its purpose: the key features needed by a clinical thermometer or blood pressure monitor

What makes a scientific instrument fit for its purpose? Your task is to decide what features make *either* clinical thermometers suitable for measuring human body temperatures *or* blood pressure monitors suitable for measuring human blood pressures.

Use *Study Sheet: Fit for its purpose: the key features needed by a clinical thermometer or blood pressure monitor*.

Task 2 Comparing two measuring devices

What makes one device better than another? Your task is to determine which of two clinical thermometers or two blood pressure monitors is more suitable for a particular purpose. You will need to prepare a report based on a practical investigation of your own design.

You will have determined what features are important in choosing a device such as a clinical thermometer.

You will apply these ideas to evaluating either two clinical thermometers or two blood pressure monitors (task 1 above)

Use *Study Sheet: Comparing two measuring devices*.

STUDY SHEET

Fit for its purpose: the key features needed by a clinical thermometer or blood pressure monitor

Which instrument to choose?

Various medical instruments are used to make measurements that allow healthcare workers to assess human health. How do they choose the most suitable instrument for a particular situation?

This activity will help you to think about the factors to consider when comparing medical instruments. You will need to be able to design an investigation to compare and evaluate one of these two types of instruments:

- two clinical thermometers
- two blood pressure monitors.

Start by considering what makes a good clinical thermometer. Alternatively, if you wish to compare blood pressure monitors, consider what makes a good blood pressure monitor.

What makes a good clinical thermometer or blood pressure monitor?

Medical professionals use clinical thermometers and blood pressure monitors. For example, a district nurse or GP checking a patient for a fever and a health and fitness trainer testing a client for hypothermia use thermometers. Work in a small group to brainstorm the question: what are the key features needed in a clinical thermometer suitable for this work? Alternatively brainstorm the question: what are the key features needed in a blood pressure monitor?

Work quickly to jot down as many ideas as possible. The ideas are for discussion, so no one should criticise any one else's idea at this stage. Record all ideas, no matter how unusual. In fact, they are welcome as fuel for debate.

You will need

- two large sheets of poster paper
- a marker pen
- some blu-tack.

What to do

- 1 Nominate one person to act as the scribe. Choose someone with large, clear handwriting.
- 2 The scribe should head one sheet of paper:

Key features needed by a clinical thermometer or blood pressure monitor

- 3 In **five minutes**, think of all the features that your group thinks makes a clinical thermometer "fit for its purpose" – in other words, good for measuring human body temperatures. To help you, think about how they might be different from other

thermometers, such as ordinary laboratory thermometers. The scribe should note your ideas down on the sheet. (Alternatively think about blood pressure monitors).

- 4 After the five minutes, take no more than **10 minutes** to discuss each idea in turn and refine it or reject it. The scribe should write a summarising list of your ideas on the second sheet of paper.
- 5 Join in a class discussion. Take it in turns to report your best ideas to the other groups. Keep your own individual set of notes.
- 6 Fix your poster where it can be seen by other groups.
- 7 Make yourself a checklist of what you would look for to make a comparison of two clinical thermometers or two blood pressure monitors.
- 8 Add to or alter your checklist by matching it against the posters of ideas. Remember that not all the ideas will necessarily be good ones!
- 9 In your group, discuss which features are the most important to take into account when choosing a clinical thermometer/blood pressure monitor. Refine your checklist into its final form: decide which ideas to use and place them in rough order of priority.
- 10 You are now ready to design and carry out an investigation to compare two measuring instruments. Ask your teacher what to do next.

STUDY SHEET

Comparing two measuring devices

Your teacher will ask you to compare either two clinical thermometers or two blood pressure monitors. You will need to decide which of the instruments you are given will be better for a particular purpose. In this case, consider use by a medical professional, such as a district nurse making home visits, or a sports scientist testing a client in a gym or sports field.

You will need to work with one or two other students to:

- design, plan, carry out and write up your investigation in the time available
- carry out practical tests to decide which is the better device
- present evidence to justify your decision.

This follows on from *Study Sheet: Fit for its purpose: the key features needed by a clinical thermometer or blood pressure monitor*.

The investigation

Discuss with your teacher:

- laboratory and class time available for collecting evidence
- the deadline for reporting and sharing your evidence
- how you should keep records of your work and report your findings.

You will need to work with one or two other students to:

- design, plan, carry out and write up your investigation in the time available
- carry out practical tests to decide which is the better device
- present evidence to justify your decision.

Method

Collect the two instruments that you will be evaluating. Read any accompanying instructions.

- 1 Review your checklist for evaluating a clinical thermometer or blood pressure monitor. (See *Study Sheet: Fit for its purpose: the key features needed by a clinical thermometer or blood pressure monitor*).
- 2 Decide how you will assess each factor on your checklist. Prioritise and consider those that are most important. Make a list of what you plan to do.
- 3 Check that the materials and apparatus you need are available. Follow your normal laboratory procedures to request any additional items. Modify your request or plan if necessary.
- 4 Carry out a risk assessment for the investigations you are planning. What are the hazards and how will you reduce the risks to acceptable levels? Use a table with the headings below or a risk assessment form that your teacher provides:

Initial risk assessment			
Hazard	Risk	Action to reduce risk (with references, e.g. HAZCARDS)	Acceptable?

5 Make a rough estimate for the time needed for each investigation. Quickly sketch out a plan to fit the remaining time available. Your plan should include assigning tasks to carry out the work efficiently.

6 Collect and record your data.

Note:

- you will probably have to modify your approach as you progress
- keep an eye on the clock
- if you need to, change your plan to suit the time remaining
- control or keep factors constant to make fair comparisons.

7 Analyse your data and observations and record your findings in whatever form is suitable for your report. You will all need to write your own report.

8 Did you get all the evidence you wanted?

Make a note of any other information that you think might have been useful.

Make sure you record which professional you are choosing the thermometer/blood pressure monitor for.

9 Share your findings with the other groups.

Decide who:

- presented the best evidence
- presented evidence in the best way.

Teacher notes

This activity links to **AQA A2 Unit 8 Medical physics**. Note: aspects of this unit lead on from Unit 2 Energy Transfer Systems.

This practical investigation could be developed into a project suitable for:

- **AQA Unit 7 Planning and carrying out a scientific investigation**
- **OCR Unit 8 Investigating the scientist's work**

Students interested in this line of enquiry could compare a wider range of instruments for specific purpose and might be asked to work alone from the onset, in order to start accumulating credit for the unit. Other measuring instruments could be considered, as the principles have general application. Care should be taken to allow them the opportunity to meet all the assessment criteria.

Specification content related to the activities:

17.2 How you will be assessed

In this unit you will be required to complete an external examination of 1½ hours duration. The examination will consist of a series of compulsory short answer, structured questions and will be marked out of 80.

You will be assessed on your knowledge, understanding and skills relating to medical physics. You should ensure that you have a detailed knowledge and understanding of all the information in Section 17:3.

You should be able to plan and evaluate investigations ensuring that they are valid and reliable. This is for investigations both in the laboratory context, and from the point of view of professionals working in a scientific environment.

17.3 You need to know, understand and be able to demonstrate

You should learn how to measure the following: body temperature and blood pressure.

For body temperature measurements you should know about commonly used thermometers (liquid-in-glass clinical thermometers and thermistor thermometers) in terms of how they work and the advantages and disadvantages of each type of thermometer for measuring and monitoring core body temperature. You should also be able to evaluate the choice of thermometer and blood pressure monitor to perform a specified function.

You should know the following and be able to apply this knowledge to a range of appropriate medical situations:

- *the value of normal core body temperature and the range of core temperatures over which the body can survive, noting the effects on the body as the temperature moves from normal towards the lower and upper limits of this range. This should include the symptoms of*
- *hyperthermia and hypothermia*
- *the range of body temperatures measured in the mouth: normal - 36.8 °C (range 36.5-37.2 °C); death - below 25 °C; hypothermia - 32 °C; fever above - 37.2 °C; heat*

exhaustion or heat stroke - likely if above 38 °C in absence of infection; high temperatures that would lead to death - above 43 °C

- *the structure of a sphygmomanometer, how it works, how it is used and why blood pressure readings are taken at the upper arm*
- *the terms systolic pressure and diastolic pressure, and be able to explain them and describe how the person using a sphygmomanometer can record these values of blood pressure*
- *the difference between invasive and non-invasive methods of measuring blood pressure, and comment on the advantages and disadvantages of each evaluating their use in a variety of situations*
- *the normal values of blood pressure for healthy young adult males (125/80 mm Hg) and healthy young adult females (123/80 mm Hg) and be able to explain what each figure represents and relates to.*

Aims and teaching strategies

The main purpose of this activity is to familiarise students with factors that need to be considered when measuring human body temperatures and blood pressures.

Activity brief: Comparing clinical thermometers or blood pressure monitors introduces the problem of having a range of instruments to choose from. This can be used as an opportunity to consider the specification content on human body temperatures and blood pressures and their measurement. This might be introduced in a formal lesson or students might be given research tasks and report their findings. If students are unfamiliar with blood pressure monitors you may need to give a brief overview of the purpose of blood pressure monitors and discuss details such as what systolic and diastolic means.

Study Sheet: Fit for its purpose: the key features needed by a clinical thermometer or blood pressure monitor uses an ideas pool and discussion to consider those factors that should be taken into account when selecting a clinical thermometer or blood pressure monitor. Students construct a checklist to use in the design and implementation of a follow up investigation, outlined in the *Study Sheet: Comparing two measuring devices*.

The student brief and the first study sheet can form the basis of a single lesson, but more time is necessary if they are to be integrated with the theoretical background to human body temperatures and blood pressures. Students need to be aware of the range and precision of the measurements to be made. Students can be asked to plan their investigations before the follow-up practical session.

You should decide whether students consider clinical thermometers or blood pressure monitors. The class could be divided according to the instruments available, with groups investigating either thermometers or blood pressure monitors. Findings can then be shared in a class discussion. If time and resources allow, students can investigate both types of instrument. When assigning tasks you should consider that comparing blood pressure monitors is probably a higher level task than comparing thermometers. If a student is going to compare blood pressure monitors it might be useful from them to complete the activity *Using blood pressure monitors* before commencing this activity.

A double session will give time for slower groups to complete the practical tasks. Faster groups can begin analysing and writing up their findings. Students can complete their reports in their own time to use in a follow-up session. The study sheet leaves the form of reporting open. As this is an examined unit, there is no requirement for students to write formal

reports. However, the activity requires them to provide conclusions supported by evidence for a class discussion. Groups could be asked to prepare presentations of their findings.

Study sheet: Fit for its purpose: the key features needed by a clinical thermometer or blood pressure monitor

Groups are asked to prepare their own checklists for assessing and comparing two clinical thermometers or blood pressure monitors. For weaker groups you may prefer to use a class discussion and prepare a definitive checklist to be used by everyone. Practical approaches may also be discussed. However, much is to be gained by making students think for themselves and their checklists and practical investigations can be modified during the course of their implementation. Different approaches will add more fuel to the plenary discussion.

Requirements

Each group will need two sheets of poster paper, a marker pen and some blu-tack

Ideas for constructing the checklist

The main factors affecting choice can be considered under four headings:

1 Health and Safety

Safety is the prior consideration. Even if mercury thermometers or BP manometers are not investigated, there should be some discussion of their use. Some countries have banned the use of mercury column sphygmomanometers (e.g. Sweden and Holland). This is not simply for the risk presented by mercury to users, but also because of its environmental impact. Oral thermometers are not suitable for small children and mercury in glass thermometers should not be used for them. Avoiding the use of glass is a useful property in a portable instrument that may need to be used outdoors.

2 Validity of measurements

How close to the correct values are the measurements?

Reliability can be checked by repeated measurements. The specification quotes values to the nearest 0.1 °C, requiring precision to 0.05 °C to distinguish temperatures above and below the critical values.

Accuracy at this level of precision can only be checked by comparing measurements with a standardised thermometer.

Range is also important if the critical values are to be measurable.

Cuff size is an important factor affecting accuracy of BP measurements (should relate to wrist size).

The specifications require: "...why blood pressure readings are taken at the upper arm." Radial artery readings tend to be higher than brachial artery readings. Various explanations are given for this, including that it is due to the narrowness of the radial artery. See

<http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ijanp/vol9n1/bp.xml>. Aortic arteries give a better estimation of ventricular pressure than peripheral arteries. Raising or lowering a limb to a different level to the heart will also affect measurements.

3 Ease of use

A trained person should be able to use a device to obtain accurate measurements quickly, safely and healthily while maintaining patient comfort. The ease with which an

accurate reading can be made is crucial. Reliability and a good response time are also important. Accuracy may also relate to the ability to check/recalibrate the instrument and the frequency with which this is necessary. For example, aneroid BP meters tend to become inaccurate after a period of time and have to be recalibrated. Easy to follow instructions are less important than the complexity of the technique involved. Health and Safety issues include consideration of the likelihood of spread of infection. Portability is important, including robustness and, where relevant, battery life.

Ease of recording results is also a factor. A useful feature of many automatic digital devices is the ability to store previous measurements. Some can be connected to printers to obtain reliable hard copy results.

Some comparison of patient comfort could be assessed (subjectively) by asking for a score on a scale of 1 to 5.

It may be noted that there is considerable concern that even doctors and nurses do not use stethoscope methods correctly to measure BP. This could be discussed with more able or interested students. See

<http://www.bmj.com/cgi/content/full/322/7293/1043#B7> (British Medical Journal article) and http://highbloodpressure.about.com/od/highbloodpressure101/ss/measure_sbs.htm.

4 Cost

Students should be aware that this is a factor affecting choice, even if information is not available for the devices they are comparing. For examples of the range of prices of sphygmomanometers, see <http://www.valuemed.co.uk/acatalog/Sphyg.html>. Running costs are also important, including life expectancy and maintenance costs such as disposable probes, battery or cuff replacement (cost and frequency). Does a battery powered device have an automatic cut-off?

Study sheet: Comparing two measuring devices

Students should relate their decisions to the context provided: "You will need to decide which will be better for use by a medical professional, such as a district nurse making home visits, or a sports scientist testing a client in a gym or sports field." Devices need to be portable, safe, healthy, easy to use, robust and reliable. Students are asked to design and implement their own investigations. Basic planning can be done before the practical session. Some trial and error may be necessary.

Students should be familiar with risk assessment procedures and adhere to local requirements. Their risk assessments should be checked by the teacher/lecturer before they start a procedure.

Requirements

Each group will need either two contrasting clinical thermometers or blood pressure monitors, with associated instructions. If apparatus is in short supply, groups could be asked to compare a clinical thermometer with an ordinary laboratory thermometer. Cheap digital thermometers are available from supermarkets and discount stores such as Poundland. Newer methods for measuring body temperature also include infrared ear probes and temperature strips that change colour when placed on the forehead. Aneroid upper arm and digital wrist sphygmomanometers can be obtained for under £20. Standard procedures and guidance for measuring blood pressures can be found in the activity *Using blood pressure monitors*.

Basic laboratory apparatus should be made available for student use, including water baths and, if possible, standardised laboratory thermometers. Water from a hot water tap

(adjusted with water at room temperature) can be used to obtain temperatures in the range required by clinical thermometers. Provision should be made for supplying reasonable additional student requests.

Health and safety

Students should carry out risk assessments and these should be checked by the teacher/lecturer before they start any activity.

If devices containing mercury are used, students should be aware of the necessary safety precautions and spillage kits should be on hand. Clinical thermometers will require appropriate hygiene procedures for multiple uses.

Do not allow students to carry out blood pressure measurements unsupervised. Sometimes students experience dizziness or fainting if the cuff pressure is too high for too long. The bulb operated cuff type in particular can be over inflated and cause pain. Readings should not be interpreted as indicators of a student's health as there are too many variables.

Other considerations

- Body temperature can be measured under the tongue (oral), under the armpit (axillary), in the ear canal (tympanic) or in the rectum (rectal). Students should be advised not to attempt rectal measurements, but the advantages of using this method in certain circumstances could be discussed. Disposable probes are available for use with ear canal thermometers.
- Mercury thermometers are being phased out because they are dangerous if broken. Mercury is toxic if swallowed or if it comes in contact with the skin. They should be used for adults only, because children are more likely to bite and break the glass. The infrared ear probe is the preferred method used for children. Other advantages include that it is fast and gives a close reading to the true body core temperature.
- The armpit temperature is the lowest, because this has a cooler blood supply nearer the surface of the body than either the rectum or eardrum which give readings closer to core temperature. Under the tongue gives a value in between.
- Body temperature is not constant but subject to change through the day and according to activity. Blood pressure is sensitive to changes in activity (even standing from sitting) and mood. Comparisons of devices and checks for reliability should therefore take these effects into account and measurements should be taken as close together as possible.
- There is considerable disagreement concerning critical human body temperatures. NHS Direct state: 'For guidance, a 'normal' temperature is in the range 36-36.8°C' which contrasts with the specification (normal 36.8 °C, range 36.5-37.2 °C)
(see www.nhsdirect.nhs.uk/articles/article.aspx?articleId=1065).
- In part this derives from the original 37 °C being stated to the nearest whole degree and to different methods being preferred in different countries (e.g. axillary temperature was the norm in Russia). See Yahoo Health <http://health.yahoo.com/hearing-resources/rectal-ear-oral-and-axillary-temperature-comparison/healthwise--tw9223.html>
- A more accurate blood pressure reading can often be obtained at home compared to when taken by a medical professional. This is because many people can become anxious in medical environments (white coat syndrome).

Some guidelines

Feature	Notes
Health and Safety	<p>The use of glass and devices using mercury can be discussed. Mercury thermometers continue to have good response times and mercury manometers do not need calibrating/recalibrating.</p> <p>Single use clinical thermometers are available which can be used to reduce the risk of cross infection.</p> <p>Problems associated with young children can be discussed.</p>
Accuracy/validity	<p>Comparison with a standardised thermometer is necessary*. Laboratory thermometers tend to show significant variation, but can be tested with the bulb just above boiling distilled water at 100 °C (if necessary adjusting for barometric pressure) and in distilled water containing melting distilled water ice at 0 °C. An accurate thermometer can then be matched in a water bath with other thermometers to select the best.</p>
Precision	<p>Students should be aware of the techniques which can be applied to estimate fractions of the smallest divisions on a scale. Clinical thermometers need to be accurate and precise to 0.05 °C to validly distinguish "normal" from "fever" using the criteria given in the specification.</p> <p>Liquid-in-glass thermometers must be immersed to the correct depth (marked on the stem). Mercury thermometers are more forgiving.</p>
Costs and ease of use	<p>Students can be supplied with information on maintenance and battery life expectancy/costs or given additional time to research these if they are accessible. Otherwise, these are factors which can still be discussed without having the facts to hand.</p> <p>The use suggested in the study sheet (home visits or in gym or sports field) requires a portable, robust instrument that is unlikely to fail (for example because batteries run out frequently) or break easily.</p>
Reliability	<p>Students will need to decide how precisely repeated measurements should match. The differences in values obtained in different sites of the body should emerge during this investigation (e.g. oral vs axillary).</p>

*Standardisation of thermometers at the National Physical Laboratory is shown in a video clip in the Scientists at Work package (see <http://www.4science.org/products-science-enhancement.htm>)

Further information and illustrations of devices can be found at:

http://en.wikipedia.org/wiki/Medical_thermometer

http://en.wikipedia.org/wiki/Blood_pressure