3 Edexcel A Biology A-Level

Core Practical 17

Investigate the effects of exercise on tidal volume, breathing rate, respiratory minute ventilation and oxygen consumption using data from spirometer traces.

A spirometer is a device which **measures breathing and respiration**. It can measure **breathing rate** (number of breaths per minute), **tidal volume** (volume of gas of one normal breath), **respiratory minute ventilation** (volume of gas inhaled per minute), and **vital capacity** (volume of gas of one forced deep breath).

A spirometer consists of a **chamber filled with air**, connected by tubes and suspended in a tank of water. When the volume of gas changes, the **lid of the chamber moves** up and down. The chamber contains **soda lime** to absorb the exhaled carbon dioxide, so changes in the position of the lid are due to changes in the volume of oxygen inhaled/exhaled by the person breathing into the tubes. The person wears a nose clip so that all breathing occurs through the mouth. The graph produced by a spirometer is called a spirograph or **spirometer trace**.

Equipment

- Spirometer
- Datalogger/computer/kymograph
- Soda lime
- Disinfectant
- Nose clip

Method

1. Find the **vertical scale** by emptying the chamber, starting the kymograph and then forcing a known volume of air into the chamber. This measures the volume of gas in the chamber, and by reading the trace, the movement of the pen on the **kymograph** can be calibrated to the actual volume of air.
2. Find the **horizontal scale** by setting it to 1 mm per second, using the switch (or as close to 1 mm per second as possible). This is the speed at which the **drum turns.**
3. A trained member of staff can fill the spirometer with **medical grade oxygen**.
4. **Disinfect the mouthpiece** and attach it to the tube. Turn the tap so the tube is not attached to the spirometer..
5. Subject attaches the nose clip and breathes into the tube for a while to practice. When they are comfortable, start the datalogger/kymograph and turn the tap to attach the tube to the spirometer.
6. Subject takes **one forced deep breath** and then **breathes normally** into the spirometer for a duration of **5 minutes maximum**.

Risk Assessment

Hazard	Risk	Safety Precaution	In emergency	Risk Level
Disinfectant	Flammable	Keep away from naked flame	Put out fire; seek assistance	Low
Soda Lime	Corrosive	Wear eye protection; avoid contact with skin, keep away from edge of desk	Wash off skin immediately; flood eye/cuts with cold water	Low
Spirometer	Breathing/circulatory problems	Read manufacturer's notes before using; only use spirometer supervised; don't use with breathing/circulatory issues	Stop using spirometer immediately; seek medical attention if necessary	Medium

Conclusion

- From the calibration of the kymograph, volume of air can be linked to the movement (e.g. in number of squares) of the pen on the kymograph. Therefore, **distance can be linked to volume**.
- Interpreting the spirometer trace:
    - The **tidal volume** is the **distance from peak to trough**, when the subject is breathing normally.
    - The **vital capacity** is the **distance from peak to trough,** when the subject takes a forced deep breath.
    - **Breathing rate** is the number of **peaks in a time corresponding to a minute** (e.g. total peaks divided by 5).
    - **Respiratory minute ventilation** is calculated by **multiplying breathing rate by tidal volume**.
- If the experiment is repeated after exercise (although not during exercise, because a spirometer can create resistance to breathing and therefore isn't safe for use during exercise):

    - Tidal volume increases.
    - Vital capacity remains the same (although can be impacted long-term by regular aerobic exercise).
    - Breathing rate increases.
    - Respiratory minute ventilation increases.
- This is because **respiration increases during exercise** because of increased **muscle contraction**. Therefore, **more oxygen is required** and **more carbon dioxide is produced**, so breathing rate, tidal volume and therefore respiratory minute ventilation increases to cope with this demand up to the **maximum aerobic rate**. After this point, minute ventilation will **plateau to a maximum** and further respiration will be anaerobic.

NB: **informed consent** should be obtained before anyone uses the spirometer, as they are a participant in scientific research. Anyone should be allowed to refrain from participating or contributing their data, and can stop at any time during the practical.