the experiment. Neither can the clothes of the subject change because this would affect the level of sweat and hence the qualitative data obtained. Another important factor that needs to be controlled is the position of the subject when taking blood pressure. The subject must remain calm and not move as this would also affect the consistency of the results. Also, the same blood pressure monitor must be used to obtain consistent results. In addition, the place of measuring the blood pressure must remain the same, either right or left hand, in order to obtain fair results.

Control:

The control will involve setting up a conical flask with water containing five drops of universal indicator. It will be put on the side to see if that there is any colour change. If there is not, then it can be said that the CO_2 reaction with water to form carbonic acid is the cause of the colour change.

Materials:

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- 13x 250mL conical flasks
- 50 mL universal indicator
- 100ml measuring cylinder
- 12x standard straws
- 2.0 L water
- striking pad
- stopwatch
- pH meter
- 0-100˚C Thermometer
- Microlife blood pressure monitor

Safety

- Ensure that the subject is able to conduct the exercise. Ensure that he/she does not have asthma or other such health issues as this would affect the subject's health.

Method for Data Processing

When processing your data, you will need to find the averages of the following:

- The time taken for the pH of the solution to decrease by one unit in seconds.
- The diastolic and systolic blood pressures (mmHg)

To do this, you add the results of trials 1, 2 and 3 and then divide them by 3 ($\frac{Trial\ 1+Trial\ 2+Trial\ 3}{3}$).

Also, the time taken for the pH to decrease by one unit should be converted into rate (s^{-1}), and this is done by dividing 1 by the average time taken. So, the rate of CO_2 expulsion will be $\frac{1}{average\ time\ taken}$ s^{-1}.

In addition, the percentage uncertainty should be calculated to account for possible uncertainties that may have risen. First however, the uncertainties of the apparatuses used must be found. Note that the apparatus used for the calculations regarding CO_2 expulsion (s^{-1}) involve the stop watch and the measuring cylinder. Therefore their uncertainties must be found. As for the blood pressure, the only uncertainty is that of the monitoring device. Obtain the uncertainty values for these apparatuses used in the experiment and record them in the table below:

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Apparatus	Uncertainty
Stop watch	
Blood pressure monitor	
100 ml measuring cylinder	

Next, the percentage uncertainty should be calculated. To do this, you divide the uncertainty of certain equipment used that may have affected your results by the data you have collected and then times it by 100 ($\boldsymbol{percentage\ uncertainty} = \frac{uncertainty}{data\ recorded} \times 100$).

<u>Figure 2:</u> The colour of the solution after the CO_2 exhalation into the flask (yellow):

Using the pH chart, the pH of this solution is 6.

<u>Diagram 2</u>: Observations in relation to the level of sweat at different intensities of exercise (ppm).

Resting Phase:
No sweat

120 (ppm):
No sweat, but face is slightly moist

140 (ppm):
Sweat becoming visible

160 (ppm):
Sweat increased, clearly more than the previous intensity

180 (ppm):
Sweat is clearly high, more than all previous trials

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Clearly from the diagram, it can be seen that as intensity of exercise increases the level of sweat also increases. The sweat was observed to be on the neck, face, and other areas, suggesting that with increased intensity, the level of sweat increases.

<u>Diagram 3</u>: Observations in relation to the level of breathing rate at different intensities of exercise (ppm).

Resting Phase:
Normal breathing rate

120 (ppm):
Breathing rate increased slightly

140 (ppm):
Breathing rate faster than the previous

160 (ppm):
Breathing rate is evidently faster with an increase in panting

180 (ppm):
Fastest breathing rate, panting faster than previous intensities.

Notably, with the increase of exercise intensity, the breathing rate also increases.

increase in diastolic blood pressure, they do support the variables – namely, the increase in the rate of CO_2 expulsion, systolic blood pressure, sweat, vasodilation and breathing rate.

Evaluation

Several limitations and sources of error might have occurred and affected experimental results. The first limitation is in relation to the breathing rate/intensity when exhaling into the straw and hence into the flask. During the time required to drop the pH by one unit, the breathing may stop, and therefore affect the time needed. Also, the intensity of breathing into the straw may have also affected the results obtained. This is a *systematic* error as it is related to a procedural limitation. This would have affected the time required to drop the pH by one unit and hence the results collected for the rate of CO_2 expulsion. In order to minimise the effect of this limitation on the results, the subject may breathe for a certain time frame and then stop. After so, the change in pH can be examined rather than it being controlled. For example, a subject can exhale for 10 seconds into the flask (controlled) and the rate of CO_2 expulsion can then be analysed by looking at the change in pH.

Another source if error is the possibility that the CO_2 exhaled into the flask might not have completely reacted in water to produce hydrogen carbonate. When blowing into the straw and hence expelling CO_2 into the flask, bubbling occurred. This bubbling might have contained undissolved carbon dioxide gases, hence affecting the pH of the solution. This is also *systematic* error and has an impact on the experimental results in relation to the rate of CO_2 expulsion. To overcome this source of error, other direct mechanisms of the homeostatic controls can be measured such as breathing rate, heart rate, and others. These do not involve breathing into a flask and are therefore are more accurate results that can be collected for the measurement of homeostatic controls.

Another limitation and a source of error is the fact that the blood pressure is not immediately taken, rather it is taken after exhaling into the conical flask. The result of this would be that the blood pressure will decrease and therefore affect the accuracy of the results. This *systematic* error is significant as it may lower the blood pressure as a result of delayed measurement of the blood pressure. Despite the fact that the blood pressure results were valid in depicting the trend with regard to homeostatic controls, waiting a few

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