Teacher Notes - Muscle Fatigue

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Introduction:

The systems of the body are interrelated to the extent that no system can work on its own without the cooperation of the other systems. They all work together in harmony and the final product is a healthy body that can do both muscular and mental activities.

In this experiment, students will learn about the skeletal muscular system and correlate its functions to the respiratory system. In each cell in the body there is a powerhouse which supplies the body with the energy required to do its functions. This powerhouse is called the mitochondria. An important process happens inside the mitochondria called cellular respiration, where nutrients are broken down in the presence of oxygen giving carbon dioxide, water and energy. Because oxygen is part of this process, this cellular respiration is defined as aerobic respiration. However, if the oxygen supply is not sufficient, the cell undergoes another type of respiration called anaerobic respiration which creates lactic acid and much less energy than aerobic respiration, leading to muscle fatigue.

A lack of oxygen can occur due to vigorous exercise. This is dependent on the VO2 max of the individual. In this experiment, students will investigate muscle fatigue in more detail.

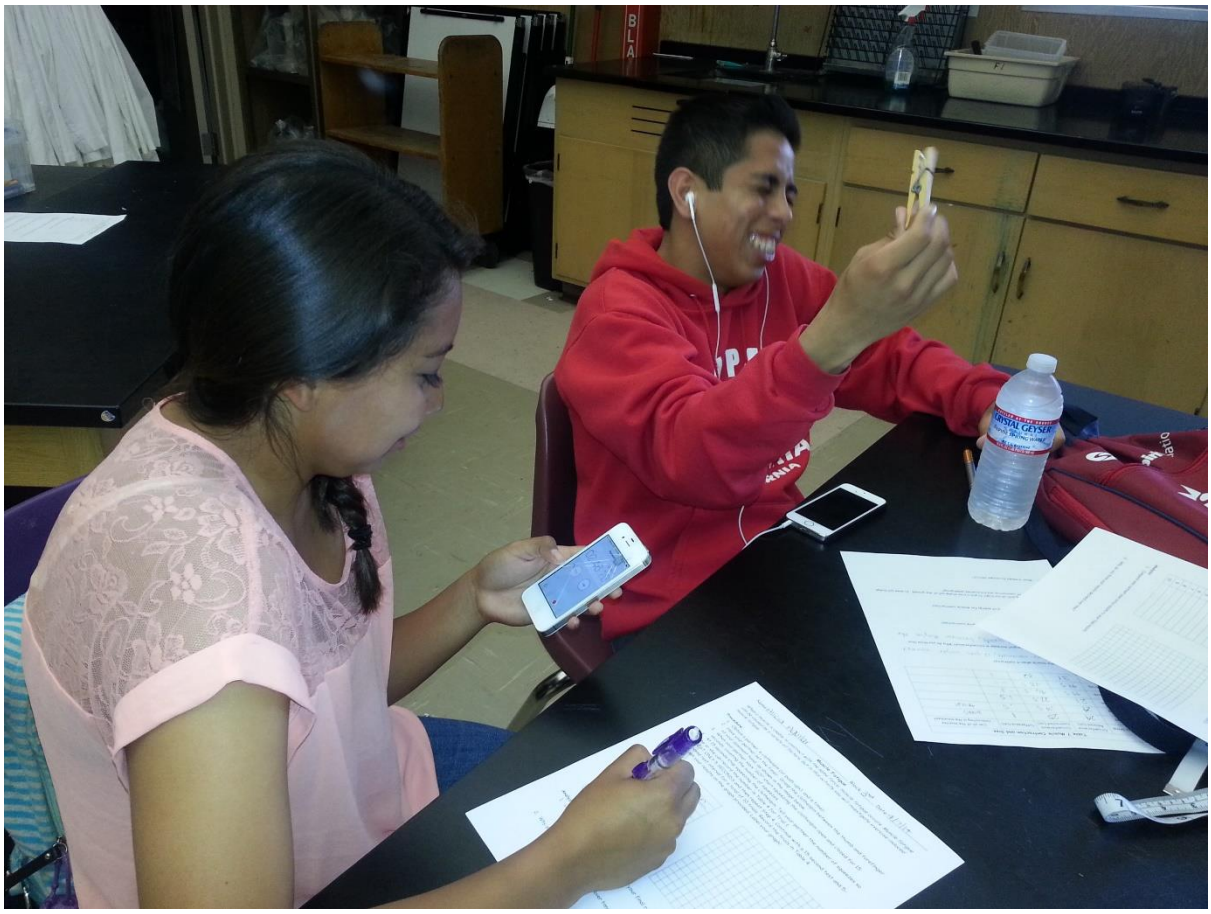

Figure 1: Practicing muscle fatigue

Questions:

This is a structured level of inquiry as students are able to choose their question from a list of questions. You can open it up more by giving them a chance to create their own question. The rest of the experiment is more open as students are required to determine the plan, conduct the experiment and record their measurements and observations. They will also analyse the data, make conclusions and communicate their findings.

Students are provided with three questions from which they will select one to investigate. They are allowed to pose other questions and decide whether it is possible to find an answer to them through experimentation.

Plan:

Students will choose the question they want to answer; accordingly, they will design their own experiment and write a full list of the equipment they will use. They will write a detailed method on how they are going to conduct the experiment and what they are going to measure.

Students will form groups of three and will write a hypothesis stating what they expect to find. They will also state their independent, dependent and control variables.

Discuss with students the risks of the experiment depending on what they choose to do. In all cases, they have to know that overexercising after feeling tired can have its unwanted consequences. The muscles can tear and require a long time to heal. This means that once they feel tired, they should take a break.

A useful link about muscle fatigue can be viewed on this link
https://www.youtube.com/watch?v=OcNOXBv3Bcc

Discuss with students the importance of trying to practice the exercise before they start the measurement. The reason why is to get experience with what can go wrong while doing the real experiment, for example, how to hold the peg in a way so that it does not fall in the middle of the experiment.

Planning multiple trials of the experiment may be one way that the students try and improve the fairness of the test. However they will soon find out that the second time they try it they can't go for as long as the first try, even after a rest. This ongoing fatigue needs to be accounted for in the analysis section.

Conduct

Before starting the experiment discuss with students the advantage of having each student in the group conduct their own test. They can then take an average of their results to improve their reliability.

Question 1

The first question they are given is "Can all fingers on a person's hand exercise at the same rate before they become fatigued?" This question allows one to find the fastest and slowest finger to get fatigued. An interesting application of this would be to correlate the position of the finger with how often this finger is used in daily life. This can show how exercise training over time affects the rate of muscle fatigue. For this experiment, students can use a peg and count how many times they can open and close it in a certain amount of time. Another way to conduct this experiment is to start a stopwatch and count the number of times a student can open and close the peg before feeling tired.

Students have to record the time. It does not matter which way they are going to do it as long as they are consistent.

Question 2

"Does a short period of rest, say 10 seconds, between periods of exercise affect the time it takes for muscles to become fatigued?" To answer this question, students will design their experiment in a way to include breaks in the middle of the exercise. Again, they can set a time period to see how many times they can open and close the peg or set the stopwatch as a counter and find how many times they can open and close the peg until they get tired. It is a good idea to use the same peg for this experiment and compare the results with results from the group doing question 1.

It is also possible to extend this question by testing the effect of a resting period. How does a 30 second rest compare to a 10 second rest? How long does it take to fully recover? When comparing recovery, students can control different levels of fitness by only comparing the performance before and after recovery time for each student individually.

It is also possible to do some other activities such as push ups or lifting a certain weight. Discuss with students what they want to do and the safety issues with each experiment.

More questions

Students can test for the difference in muscle fatigue between their left hand and right hand and state if they are right-handed or left-handed. This will help them find the effect of exercise on muscle fatigue.

Another question that they can examine is the effect of a warm-up exercise on muscle fatigue. According to the design of their experiment they can search what is the most suitable warm up exercise. This will allow them to decide whether a warm-up is useful or not.

Different groups doing the same question may like to co-operate and design their experiments together with the view of finding the best solution for the question. Different groups will come up with different ideas, or they might choose to conduct the experiment exactly the same like other groups in order to have a big number of data and get the average.

Analyse

It is up to students how to analyse their results. Depending on the number of groups and how they chose to conduct the experiment, they can tabulate their results and include all sets of data to plot a graph. Graphs allow data to be easily visualised, an example is a bar graph as shown in figure 2.

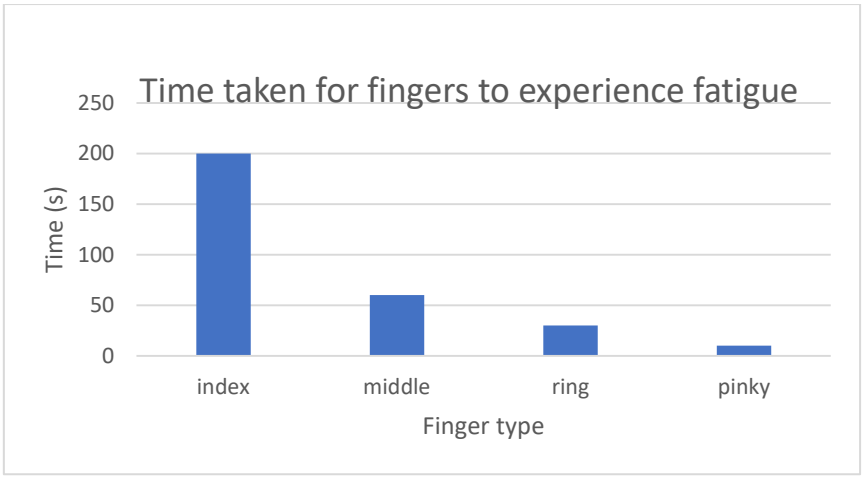

Figure 2: A bar graph showing the relation between the time taken for each finger to get fatigued and the finger type.

Students can choose the type of graph they want to plot to represent their data, another example is the pie graph as shown in figure 3.

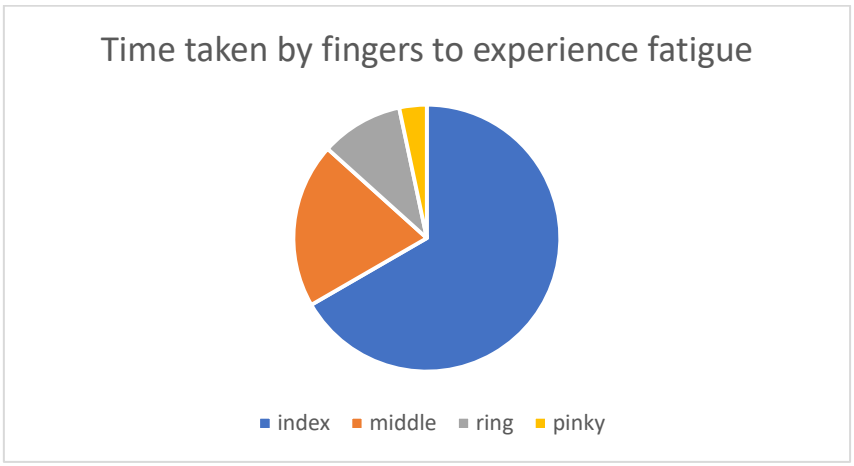

Figure 3: A pie chart showing the time taken by different fingers to experience fatigue

Problem solving and discussion

At this stage, students will discuss what their results mean. Do their results agree with the hypothesis they made? Or is it different? What was their hypothesis based on? If the results agree, does this necessarily mean that their hypothesis was right? Did they choose the correct independent and dependent variables? Were all the control variables kept constant? Do the results agree with other groups' results? Do their results agree with what is published in reviews about the question they chose?

Here is some useful information on what is expected according to published information: Muscle fatigue happens when a muscle can no longer contract in response to a stimulus.[(2)]

Females are expected to tolerate effort longer than males as their muscles are more fatigue resistant and recover faster[(3)].This is due to the hormone estrogen, however, with children this might not be the case if year 7 or 8 students are doing the experiment.

There are two main causes of muscle fatigue, neural and metabolic [(4)]. The neural fatigue can be reduced by training and exercise whereas the metabolic fatigue depends mainly on the nutrients

present in the body (can either be insufficient or in excess). Accordingly, it is expected that muscles which undergo more exercise in daily life are able to tolerate effort longer before experiencing fatigue. This is valid for two different muscles in the same body, for example, right hand versus left hand (dominant hand versus recessive hand). However, it is very hard to compare between different bodies because the fatigue process is complex and it involves a number of factors which is impossible to control in a school environment.

In the experiment involving taking a break, the idea is to allow the muscles to recover and get the required oxygen required for aerobic respiration.

It is important that students understand what is involved in muscle fatigue in order to make a valid discussion.

Some variables that students need to keep as a control include: the type of peg, all pegs have to be similar. It is better to buy a new set of pegs in order to have the same spring strength and same size. The environment and posture, so all students undergoing the same experiment should either be sitting or standing similarly. All experiments should be done at the same time to ensure that the students involved are equally exhausted or relaxed.

Conclusion

This experiment is an excellent practice for students to experience critical thinking. They will formulate the questions and design their experiments. They will also use their scientific knowledge to evaluate their results and reflect on the method used to investigate the question.

References

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