Haider Chaloob **ID: 0529-021**
Year 2 Pulteney Grammar School
Science Investigation Report
Oliphant Science Awards 2026

Run Jump Breathe- Repeat!

Background

Cardiorespiratory fitness is a measure of how efficiently your lungs, heart, blood vessels and muscles work together to deliver and use oxygen to produce energy for prolonged activity. Regular exercise optimises your lungs, heart, blood vessels and muscles to adapt to work more efficiently which makes your body more functional. Improved cardiorespiratory fitness reduces your risk of cardiovascular disease, cancer and diabetes as well as improving brain development and mental health. According to the World Health Organisation children should be getting at least 60 minutes of physical activity a day.

Table 1: Exercise Intensity

Sedentary **No exercise**	**Low** Slightly increases your heart and respiratory rate	**Moderate** Increases your heart and respiratory rate but you can easily talk	**High** Significantly increases your heart and respiratory rate
Sitting **Laying down** **Watching TV** **Sitting at a desk** **Reading** **Sewing**	Slow walk (shopping) Making food Stretching	Fast walk Gardening Easy bike ride Gentle swim Water aerobics	Running Fast cycling Lap swimming Tennis Soccer Basketball Boxing

Aim

To investigate how cardiorespiratory fitness affects resting heart rate, peak heart rate and how quickly heart rate and oxygen levels recover after exercise.

Hypothesis

Participants with a higher cardiorespiratory fitness level will have lower resting heart rates, higher peak heart rates and a faster heart rate recovery and higher oxygen saturation after aerobic exercise.

Materials

- Stopwatch
- Pulse oximeter
- Music beat 120 beats per minute
- Pen
- Paper
- Calculator

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Method:

1. Choose a safe area to do a star jump.
2. Each participant
    - Sit quietly for 5 minutes then record the resting heart rate and oxygen saturation
    - Complete 30 seconds of star jumps at the rate of one per second, listening to the beat of 120 beats per minute
        - Beat one- jump out and arms up
        - Beat 2- jump in and arms in
    - Participant needs to immediately sit down.
    - After 5 seconds, measure the participants pulse for 15 seconds (5-20 seconds post start jumps finishing) then multiple this by 4.
    - Record recovery heart rate and oxygen saturation.
    - Sit quietly and record
        - Heart rate at 30 seconds
        - Heart rate at 60 seconds (heart rate recovery)
        - Heart rate at 90 seconds
        - Time taken for heart rate to recover to resting heart rate.
3. Record results
4. Calculate estimated VO2max using the Queen's College Step Test Equation
    - Men: VO_{2max} ($ml/kg^{-1} . min^{-1}$)= 111.33-(0.42x recovery heart rate)
    - Women: VO_{2max} ($ml/kg^{-1} . min^{-1}$)= 65.81 – (0.18x recovery heart rate)
5. Calculate heart rate recovery at 60 seconds ÷ peak heart rate (second fitness measure)

Results

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Science Investigation Report
Oliphant Science Awards 2026

Table 2: Results 30 seconds modified VO2max

Participant	Participant F= female M= male Age in years	Self-reported fitness level	Resting oxygen level	Oxygen saturation	Resting heart rate	Recovery heart rate (5-15 sec x4)	Heart rate recovery at 30 sec	Heart rate recovery at 60 sec	Heart rate recovery at 90 sec	Time for heart rate to return to resting HR (sec)	Results method 1 Estimated VO_2 max-Queen's College Step Test Equation Men: VO_{2max} ($ml/kg^{-1} . min^{-1}$)= 111.33-(0.42xrecovery heart rate Women: VO_{2max} ($ml/kg^{-1} . min^{-1}$)= 65.81 – (0.18xreocvert heart rate)	Results method 2 My calculation Fitness Score = Recovery Time ÷ Peak Heart Rate Sec/recovery to resting heart rate
1	**40F**	**High**	**98**	**98**	**63**	144	**122**	**115**	**98**	**98**	65.81 – 25.92=39.89 **Excellent**	**0.68**
2	**22 M**	**High**	**99**	**99**	**65**	128	**111**	**90**	**79**	**189**	111.33-53.76=57.57 **Superior**	**0.68**
3	**45 F**	**High**	**98**	**98**	**72**	152	**125**	**119**	**89**	**78**	65.81 –27.36=38.45 **Excellent**	**0.51**
4	**28F**	**High**	**97**	**97**	**72**	116	**89**	**75**	**72**	**80**	65.81 –20.88= 44.93 **Excellent**	**0.69**
5	**26F**	**High**	**98**	**99**	**81**	128	**99**	**90**	**85**	**95**	65.81 –23.04= 42.77 **Good**	**0.74**
6	**7 M**	**High**	**100**	**100**	**73**	112	**76**	**73**	**70**	**56**	111.33-47.04= 64.29 **Superior**	**0.50**
7	**11 M**	**High**	**100**	**100**	**62**	120	**106**	**73**	**94**	**100**	111.33-50.4=60.93 **Superior**	**0.83**
8	**40 F**	**High**	**100**	**100**	**61**	100	**76**	**73**	**65**	**101**	65.81 –18=47.81	**1.01**

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Science Investigation Report
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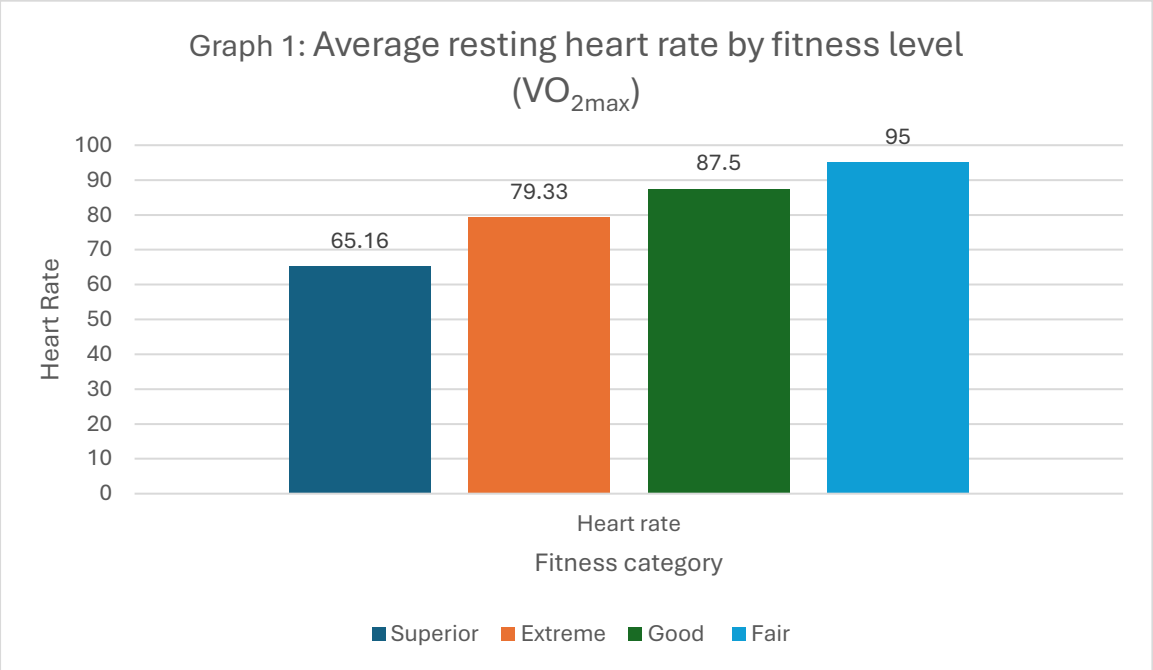
											Superior	
9	**53 M**	**High**	**100**	**100**	**54**	100	**93**	**82**	**54**	**90**	111.33-42=69.33 **Superior**	**0.90**
10	**48 M**	**Medium**	**99**	**99**	**76**	120	**117**	**98**	**92**	**338**	111.33-50.4=60.93 **Superior**	**2.82**
11	**45F**	**Medium**	**98**	**99**	**80**	132	**128**	**125**	**88**	**281**	65.81 –23.76= 42.05 **Excellent**	**2.13**
12	**35M**	**Medium**	**99**	**99**	**68**	152	**145**	**132**	**111**	**296**	111.33-63.84= 47.49 **Excellent**	**1.92**
13	**20F**	**Medium**	**100**	**100**	**59**	120	**116**	**81**	**70**	**292**	65.81 –21.6= 44.21 **Good**	**2.43**
14	**52F**	**Low**	**98**	**99**	**86**	156	**155**	**154**	**148**	**700**	65.81 –28.08= 37.73 **Excellent**	**4.49**
15	**52 F**	**Med**	**98**	**98**	**87**	168	**166**	**160**	**139**	**504**	65.81 –30.24=35.57 **Excellent**	**3.00**
16	**30F**	**Medium**	**98%**	**99**	**81**	128	**123**	**119**	**109**	**408**	65.81 –23.04=42.77 **Excellent**	**3.19**
17	**40F**	**Low**	**95**	**93**	**105**	156	**154**	**154**	**139**	**652**	65.81 –28.08=37.73 **Excellent**	**4.18**
18	**40F**	**Low**	**98**	**99**	**88**	168	**165**	**165**	**142**	**662**	65.81 –30.24=35.57 **Good**	**3.94**
19	**29 F**	**Low**	**98**	**99**	**100**	144	**144**	**144**	**115**	**612**	65.81 –25.92=39.89 **Good**	**4.25**
20	**25F**	**Low**	**98**	**95**	**100**	132	**126**	**125**	**115**	**505**	65.81 –23.76=42.05 **Good**	**3.83**
21	**25F**	**Medium**	**100**	**99**	**98**	160	**161**	**150**	**141**	**502**	65.81 –28.8=37.07 **Fair**	**3.14**
22	**27F**	**Low**	**100**	**98**	**92**	160	**155**	**151**	**149**	**610**	65.81 –28.8=37.07 **Fair**	**3.81**
23	**30F**	**Low**	**98**	**95**	**97**	148	**146**	**142**	**139**	**860**	65.81 –26.64=39.17 **Good**	**5.81**

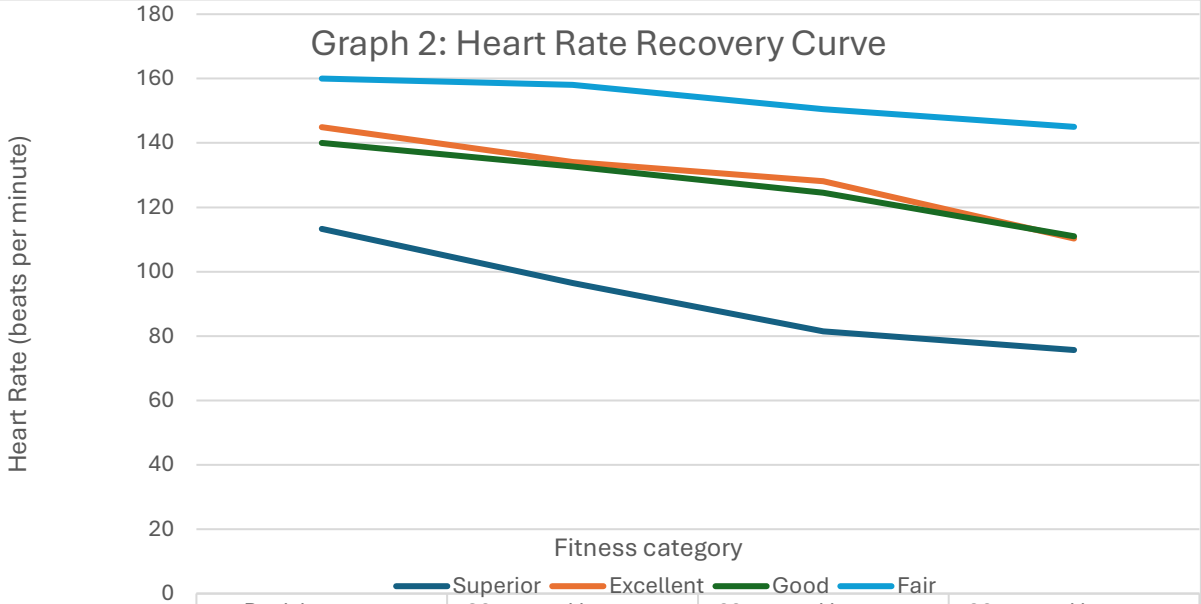
Haider Chaloob **ID: 0529-021**
Year 2 Pulteney Grammar School
Science Investigation Report
Oliphant Science Awards 2026

Table 3: Interpretation of results VO2Max for men (ml/kg/min)					
Age	**Poor fitness** -exhausted with daily activity	**Fair fitness** -below average -low daily activity -heart rate would rise lots with stairs/running/hill	**Good fitness** -Above average -moderate exercise like walking would exhaust the person	**Excellent fitness** -fine with daily activities, climbing stairs, carrying heavy loads	**Superior fitness** -endurance athletes and very active individuals
20-29	<38	38-43	44-50	51-56	57+
30-39	<34	34-39	40-46	47-52	53+
40-49	<30	30-35	36-42	43-48	49+
50-59	<26	26-31	32-38	39-44	45+
60+	<22	22-27	28-34	35-40	41+

Table 4: Interpretation of results VO2Max for women (ml/kg/min)					
Age	**Poor fitness**	**Fair fitness**	**Good fitness**	**Excellent fitness**	**Superior fitness**
20-29	<32	32-37	38-44	45-50	51+
30-39	<28	28-33	34-40	41-46	47+
40-49	<25	25-30	31-36	37-42	43+
50-59	<21	21-26	27-32	33-38	39+
60+	<18	18-23	24-30	31-36	37+



Haider Chaloob **ID: 0529-021**
Year 2 Pulteney Grammar School
Science Investigation Report
Oliphant Science Awards 2026



	Peak heart rate (recovery heart rate)	30 second heart rate recovery	60 second heart rate recovery	90 second heart rate recovery
Superior	113.3	96.5	81.5	75.66
Excellent	144.9	134.1	128.1	110.3
Good	140	132.7	124.5	111
Fair	160	158	150.5	145

Conclusion

As a submaximal test, the results show on average a lower resting heart rate and faster heart rate recovery at 90 seconds in the participants that scored higher in cardiorespiratory fitness. There was very little change in oxygen levels of the participants.

Discussion

Individuals with high cardiorespiratory fitness have a higher cardiovascular fitness score (VO_{2max}) because their bodies have already adjusted to high workloads and can easily respond. Fitter individuals have lungs that take deeper breaths (higher tidal volume) which means they get in more oxygen, and the lungs also move the oxygen from the lung sacs (alveoli) into the blood faster with more rapid gas exchange. The heart is already much stronger and with every contraction it pushes a higher volume of blood out (stroke volume) into the blood vessels. The heart can beat slower at rest and only needs to slightly increase the heart rate when fit individuals exercise. The heart will beat much faster if a person exercises at their maximum effort or to exhaustion, but star jumps at 30 per 30 seconds is a submaximal test. Fit people have more blood vessels due to a process known as angiogenesis and these vessels relax more and become wider letting more blood flow through so more oxygenated blood gets to the muscle faster. Fit people also have more blood cells to carry the oxygen. As a result, the muscles are getting more oxygen from the lungs, transported in larger volumes to the muscle and the muscle has more power cells (mitochondria)

to make energy from the oxygen. As a result, a fit person is expected to have a lower resting heart rate, a lower peak heart rate at a submaximal effort activity, and their heart rate will recover quicker.

The results were limited by a small study size with a range of age participants. This affected the average results for each fitness category particularly when testing resting heart rate and recovery heart rate because the VO_{2max} score was adjusted for age. This made the data interpretation challenging. Overall, the results were consistent with those having superior fitness having lower resting and recover heart rates overall than those with good fitness. The heart rate recovery time at one minute was much closer to resting heart rate in the superior fitness group compared to those with good fitness. The lowest fitness level was classified good despite participants self-recording low fitness levels. However good fitness is classified as a person who would become out of breath climbing stairs or carry heavy loads, while superior fitness is someone that regularly runs or is very active.

A submaximal field fitness test was used to test cardiorespiratory fitness and the VO_{2max} was calculated using the Queen's College Step Test Equation to evaluate participants fitness levels. Most participants either rated their fitness at or below the actual calculated results which showed that people assessing their own fitness is not accurate which is why we need scientific testing. Due to the number of participants rating lower or medium fitness the test needed to be modified so more participants could complete the task which is why 30 seconds of star jumps was the requirement. Keeping the star jumps at a set beat controlled the workload of the exercise which made it a modified test. If participants jumped at their own rate this would have affected the results with some participants performing higher amounts of jumps than others.

As a submaximal test, the results are consisted with a lower resting heart rate and recovery heart rate in the participants that scored superior and excellent group compared to the good fitness group. There was very little change in oxygen levels in all participants.

My method of testing fitness by dividing recovery time over maximal heart rate was similar to the VO_{2max} results in indicating fitness, with most superior fitness participants getting less than one. The results became less accurate in the excellent to good category with a range of three to four. I would like to repeat this study with a maximal fitness test as this would allow maximum heart rates to be recorded which would be higher in very fit people rather than the current test design.

Word count 1056

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Acknowledgements

1. My mum did my bibliography, but we did talk about what a bibliography is and why it is important to look at where you get your information and to also acknowledge who shared the information.
2. This topic required lots of reading and understanding scientific principles. This was difficult at the start but the more I read and talked about it with my parents the easier it was to understand. We talked about this lots- in the car, on runs, at the dinner table! I felt very confident when it became time to do my experiment and my report. I like thinking of

physical fitness in terms of cars and people, V4 vs V12 engines and raceways. I thought of this and it helps me remember (and I love cars).

3. My mum helped with getting me to think about what I was reading and asked some questions to make me think about fitness and health (like asking about exercise guidelines). Dad gave me the idea to draw diagrams to help me understand.
4. The results were very hard to understand because there were all scrambled, so I rewrote them up in categories to make it easier. Drawing the graphs made it much easier to understand the results and I enjoyed learning how to charts in Word after I drew my graphs on paper.
5. My mum helped with some of the typing of questions, and I also used voice to text then edited it. Rechecking my report and logbook took a long time.

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Science Investigation
Oliphant Science Awards 2026
Work book

Run Jump Breath, Repeat!

Log Book

10/5/2026

This is my third year doing the Oliphant Science Awards. This year I want to do a science investigation on fitness. My reasons are:

- I want to be able to measure how fit I am and learn how to improve and track my fitness.
- I want to do an investigation that combines my three favourite subjects- science, maths and PE.
- I want to show my parents I am ready to run the Victor Harbor half marathon in December. They thought I was too young last year and I did the 5km. Since then, I have competed in many 5-10km running races and even trail runs. I did the 6km city to bay in 26 minutes and the Myponga 7km trail run with a 65m elevation in 36 minutes!

When I think of fitness, I think of what happens when I run. My heart beats faster, my breathing increases, my body gets hot and I get sweaty, my muscles warm up and I run faster. At the end of a run, I feel amazing. You would think I feel tired, but I don't!

I have also been observing other people at running events. Some run fast and make it look easy, some run fast but look really hot and tired, some walk and some collapse to the ground at the end. I think they are all doing a great job. There are also lots of spectators that do not join the race. This made me wonder what fitness is and how can I improve my fitness.

11/5/2026

I have come up with a list of questions that I will need to investigate before I plan my experiment.

1. **What is fitness**
2. **Are there different types of fitness?**
3. **What fitness do I want to investigate?**
4. **How do you measure fitness?**
5. **Why do some people get tired after exercise?**
6. **Can you improve fitness? What affects fitness?**
7. **What is heart rate?**
8. **How do we measure heart rate?**
9. **What affects heart rate?**
10. **Why do we breathe faster when we exercise?**
11. **Why does your heart rate increase when you exercise?**
12. **What do I think happens when you are fit and you run 5km?**
13. **What do you think would happen when you are unfit and ran 5km?**
14. **How am I going to design an experiment to measure physical fitness?**
    a. **Aim**

   b. **Method**
      i. **What will be constants in the experiment (thing that are the same)?**
      ii. **What will be a variable (what changes)?**
   c. **Results- how will I measure these**
   d. **Conclusion**
   e. **Discussion**

15. **Why is fitness important**
16. **Have I met all the criteria for Oliphant Science Investigation**
17. **What did I find challenging in my research and experiment?**
18. **What would I change about your experiment?**
19. **What will I add to my experiment next time?**

12/6/2026

1. **What is fitness?**

Physical fitness is the ability for your body to do normal daily activities without becoming exhausted. Running, jumping, star jumps and all kinds of exercise require fitness. It you are very fit; you can do any exercise and be able to do it for a long time without getting tired and can continue to play the rest of the day even after a PE class.

CDC (1985). *Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research*. [online] stacks.cdc.gov. Available at: https://stacks.cdc.gov/view/cdc/66195.

2. **Are there different types of fitness?**

There are different types of fitness. Some people are very fast at swimming, running and athletics. This requires speed, agility and the ability to move. Some people are very strong and can lift heavy weights but are not good at running. Physical fitness can be divided into different categories:

a. **Body composition**- this compares how much fat, water and other tissue (fat free tissue- muscles, bones and organs) there is in your body. This is done with a body composition scan and can show us if there is too much or not enough muscle and fat.
b. **Cardiorespiratory endurance (aerobic)**- this is how well you heart, lungs and muscles work together to produce energy for physical activity. It requires healthy lungs to breath in oxygen that goes into the blood, a strong heart to pump the oxygenated blood to the muscles, and muscle cells that can make energy for the muscle to use.
c. **Flexibility**- this is how well you can move your joints and stretch your muscles.
d. **Muscular fitness**- is how well you can use your muscles repeatedly without fatigue. It is also how much maximal force your muscles can make to resist a force

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Science Investigation

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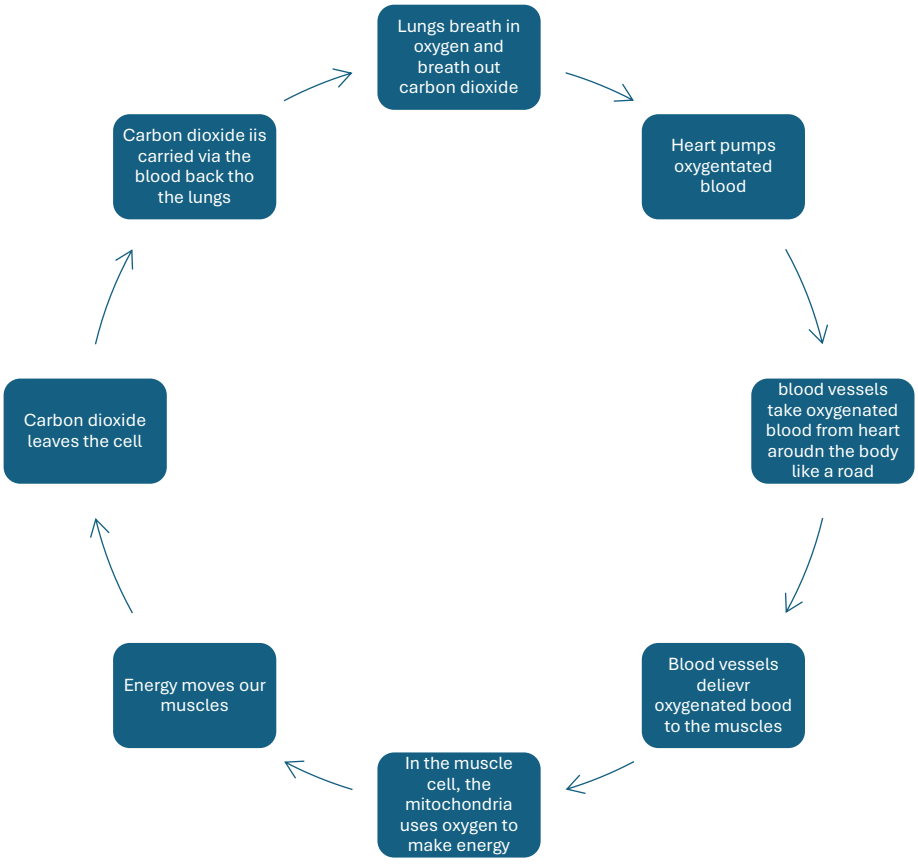
and for how long without the muscles getting tired. For example how many squats you can do or how long you can hold up a heavy weight without dropping it.

CORBIN, C. and LE MASURIER, G. (2022). *What Is Physical Fitness?* [online] Human Kinetics. Available at: https://us.humankinetics.com/blogs/excerpt/what-is-physical-fitness.

3. What type of fitness do I want to investigate?

I want to test cardiorespiratory fitness.



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Work book

14/5/2026

4. **Are aerobic and cardiorespiratory fitness the same?**

Yes, it's how efficiently (well) your lungs, heart and muscles work together to allow you to do an activity.

When you exercise, you breath in the oxygen through your lung, this goes to your blood, the heart pumps the blood around the body in blood vessels, the oxygen goes into the muscle cells. In the muscle cell, a part of the cell called a mitochondria uses the oxygen and glucose (from food) to make energy. The energy then is used by the muscle to make muscle movement. Then the muscle cell makes carbon dioxide which is returned to the blood and back the lungs, breathed out and new oxygen is breathed in again.

Raghuveer, G., Hartz, J., Lubans, D.R., Takken, T., Wiltz, J.L., Mietus-Snyder, M., Perak, A.M., Baker-Smith, C., Pietris, N. and Edwards, N.M. (2020). Cardiorespiratory Fitness in Youth: An Important Marker of Health: A Scientific Statement From the American Heart Association. Circulation, [online] 142(7). doi:https://doi.org/10.1161/cir.0000000000000866.

5. **What happens if you can't get enough oxygen in when you are exercising?**

This was a cool fact I learnt.

Aerobic respiration is when a cell in the body uses **glucose** from food you eat + **oxygen** from the air you breath and circulate through the blood to the cell→ this produces **energy** for the cell as well as waste products of **water** and **carbon dioxide**. The carbon dioxide is returned to the blood and back the lungs, breathed out and new oxygen is breathed in again.

Glucose + oxygen→energy + water + carbon dioxide

But when you exercise and use up all the oxygen in the cell because you cannot breath fast enough or transport the oxygenated blood fast enough, the cell must use **anaerobic respiration**, which is making energy without oxygen (<u>an</u>aerobic). When the cell uses anaerobic respiration it produces **lactic acid** which is what causes the burning in your muscles! This might happen if you are using lots of energy at once like in a fast running sprint or if you have something wrong with your heart or lungs or bloods vessels and can't deliver oxygen to the muscle cells or if you are not as fit.

Glucose→energy + lactic acid

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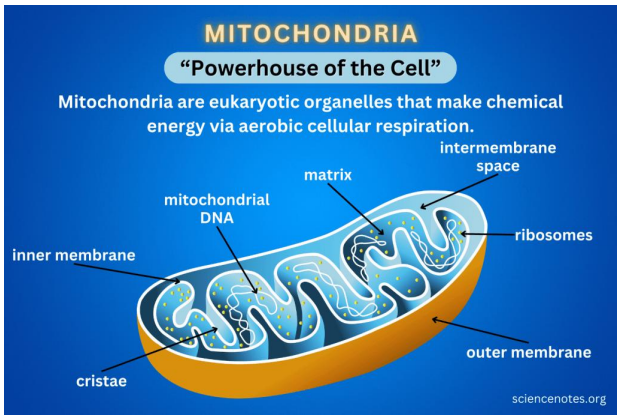
6. **What are mitochondria?**

Our body is made up of billions of cells. Most cells have a nucleus which holds DNA (deoxyribonucleic acid). These are eukaryotic cells. They all have mitochondria within the cell, the role of the mitochondria is to use oxygen, delivered to the cell from bloods vessels to produce energy for the cell. Glucose + oxygen→energy + water + carbon dioxide



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16/5/2026

7. **Why is cardiorespiratory fitness important**

- It is an important indicator of risk of cardiovascular disease and death from heart disease.
- Improved cardiorespiratory fitness has improvement in cardiovascular, cerebrovascular (brain), cognitive and mental health.
- It reduces the risk of cardiovascular disease, cancer, diabetes and reduces the symptoms of depression, anxiety and improves overall wellbeing.
- In children and adolescents, physical activity promotes bone health, healthy growth and development of muscles and improves physical and brain development.
- According to the World Health Organisation, 31% of adults and 80% of adolescents do not meet the recommended levels of physical activity. The health impacts of this are predicted to cost the world $300 billion US dollars from 2020 to 20230 from disease and poor health.

World Health Organization (2024b). *Physical activity*. [online] World Health Organization. Available at: https://www.who.int/news-room/fact-sheets/detail/physical-activity.

8. **What can be the effects of low cardiorespiratory fitness?**

- **Adults:** increase risk of death from all diseases, cardiovascular disease and death (heart attacks, strokes), cancer and type two diabetes.
- **Children and adolescents:** increased obesity, heart disease, reduced fitness, social and emotional poor health, reduced and disrupted sleep.

World Health Organization (2024b). *Physical activity*. [online] World Health Organization. Available at: https://www.who.int/news-room/fact-sheets/detail/physical-activity.

9. **How can you improve cardiorespiratory fitness?**

You need to exercise regularly, go to the gym or do push ups, star jumps, running, swimming, athletics or any other sport you enjoy. You should track your fitness and make sure you are improving.

10. **How much should you exercise each day? Are there any guidelines?**

The World Health Organisation recommends 150 minutes of moderate intensity or 75 minutes of vigorous intensity aerobic exercise each week for adults. Children should be getting at least 60 minutes of physical activity a day.

Exercise Intensity			
Sedentary No exercise	**Low** Slightly increase your heart and respiratory rate	**Moderate** Increase your heart and respiratory rate but you can easily talk	**High** (Vigorous) Significant increase in your heart and respiratory rate
Sitting Laying down Watching TV Sitting at a desk Reading Sewing	Slow walk (shopping) Making food Stretching	Fast walk Gardening Calm bike ride Gentle swim Water aerobics	Running Fast cycling Lap swimming Tennis Soccer Basketball Boxing

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Year 2 Pulteney Grammar School
Science Investigation
Oliphant Science Awards 2026
Work book

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18/5/2026

11. How does exercise improve cardiorespiratory fitness?

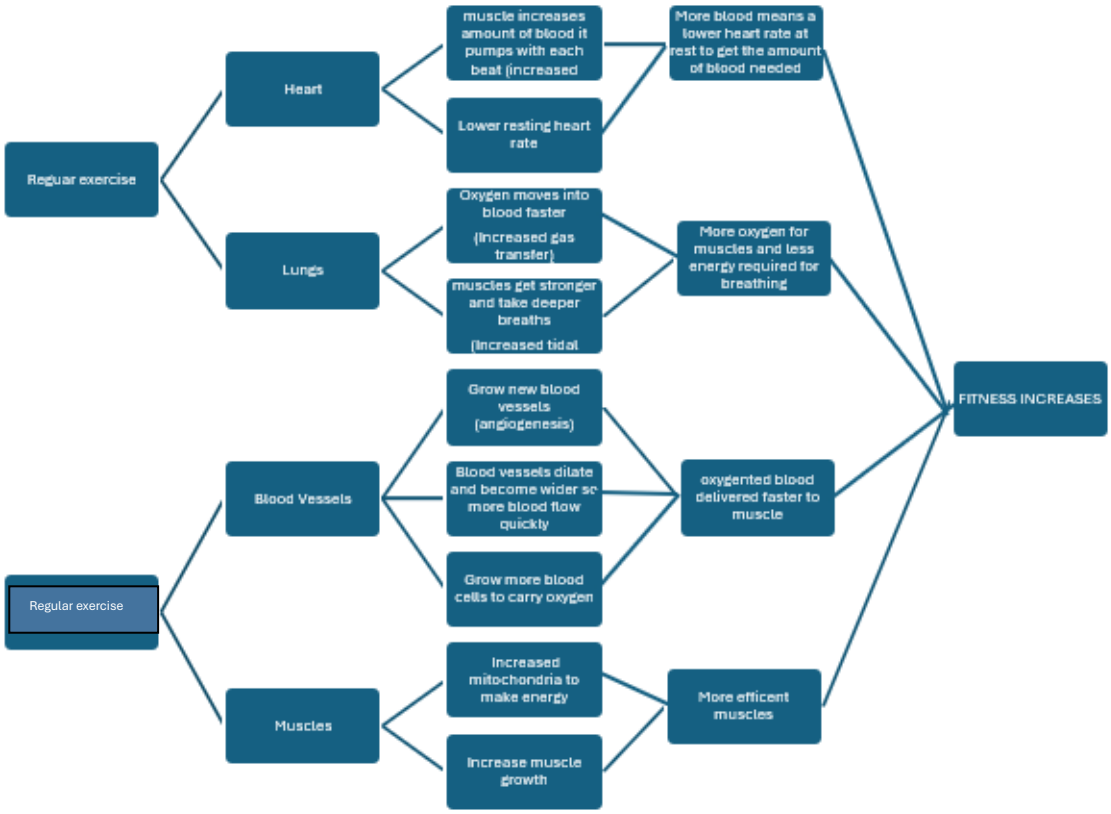
Exercise causes your muscles, heart, lungs and blood vessels to work harder. If you regularly exercise the muscles, heart, lungs and bloods vessels change and adapt to work more efficiently (better) which makes your body more functional and more conditioned (ready) for the exercise. I love cars so I will use that to help explain cardiorespiratory fitness.

- **Lungs**: your respiratory (breathing) muscles become stronger, making it easier to take deep breaths. This allows your lungs to move air in and out more easily with bigger breaths (this is also called tidal volume and is the amount or air moved in and out in a single breath) which makes breathing more efficient. Your lungs also get faster at moving the

oxygen into the blood vessels from the air sacs (alveoli of the lungs) in a process called gas exchange. With increased air moving in and faster gas exchange, you are able to get more oxygen in which is carried to your cells.

- **Heart**: with repetitive exercise, your muscles also adapt by increasing in size and strength of the heart muscle. When it pumps blood with each heartbeat (contraction), it is more powerful so pumps out more blood. The heart adapts by having a lower resting heart rate because it is so good at pumping blood. The amount of blood it pumps per contraction (beat) is called stroke volume. When you exercise the heart beats faster with a larger stroke volume so you can pump more oxygenated blood quickly around the body to the muscles to make energy.
    - **The best way to remember this is to think of a bus and a car**
        - **Blood cells which carry oxygen are like people**
        - **Buses are bigger with bigger engines and carry more people, so more blood gets to the place. Fit people have a heart like a bus.**
        - **Cars are small and can sometimes only fit 2 people, so less people get to the place.**
- **Blood vessels:** with repetitive exercise, your body grows more blood vessels to get the blood quicker to the muscles (this is called angiogenesis), your blood vessels also dilate more so more blood can quickly flow down the blood vessel and you also make more blood cells which is how oxygen is carried to the cell. So you have more blood vessels that are wider and carrying more blood which means a lot more oxygen getting to the muscles a lot quicker.
    - **The best way to remember this is to think of a road and you need to get to a rack track.**
        - **The blood vessel is the road**
        - **The cars are the red blood cells**
        - **The people in the car are oxygen.**
        - **When you are fit, your body has 3 lane freeways which can transport lots of cars with lots of people inside quickly to the get to race track.**
        - **When you are unfit, your body has a small narrow road that can only take a few cars one behind the other, which means it takes longer to get to the race track and not many people arrive by the time the race starts.**
- **Muscles:** when you regularly exercise you make more mitochondria so you can convert more oxygen into energy. Your cells also get better as using the oxygen.
    - **When you are fit you have a better engine with more cylinders in your car. Fit people's muscle are like driving a V12, unfit people have muscles like a 4 cylinder car and can't produce as much energy.**
- All your muscles (skeletal, heart and respiratory) are bigger and have more blood vessels (angiogenesis) which increases the amount and speed of oxygen delivery to muscles making them more efficient (work better). So, when you breath in air, you get more air into your lungs, which quickly goes to the blood vessels, the heart pumps the blood quickly, forcing it along the wider and more blood vessels and delivers it to the skeletal muscles which also has more mitochondria to make energy. So, you can exercise more easily with less fatigue, and this is how exercise improves fitness.

Haider Chaloob **ID: 0529-021**
Year 2 Pulteney Grammar School
Science Investigation
Oliphant Science Awards 2026
Work book



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Year 2 Pulteney Grammar School
Science Investigation
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20/5/2026

These were very hard questions, and I talked lots with my parents to make them easier to understand.

12. How do we measure cardiorespiratory fitness?

- You need to measure how much oxygen the body can use with maximal performance, this is known as VO_{2max}. It is a scientifically proven test that measuring how much oxygen your body uses when you are doing maximal exercise, this can indicate how well your body can make energy to allow you to do the exercise.
- Measurement
    - The best way to measure cardiorespiratory fitness is with gas analysis in a laboratory setting in a test called Cardiopulmonary Exercise Testing. They connect a closed face mask to your face like a fighter pilots mask, then they get you to run or cycle as fast as you can until you are exhausted. This measures the amount of oxygen you used and carbon dioxide you made. Then they calculate the maximum amount of oxygen your body can beath in, transport to your muscles and use in one minute of intensive exercise. The more oxygen you can get in shows the more fit you are.
    - Field based performance tests are used if you don't have a laboratory.
        - There are calculations to use that can give an estimated VO2max.
            - Measure performance against time, distance or heart rate.
            - Field test (maximum exercise effort)
                - The time to complete 800—1500m runs
                - 12 minute distance walk or run
                - 2km walk test
                - 20m shuttle run test
                - 3 minute step test
            - There is also a submaximal test you can use. The calculations are changed to allow for a test like star jumps that does not require maximum effort.

I wanted to do an 800m run but lots of my participants could not run 800m or even do a 3 minute step test. So, I changed to use star jumps for 30 seconds. I found a calculation for a modified result.

I found an online calculator to test VO2max but it is more maximal effort tests- https://www.formbeat.com/tools/vo2-max-calculator.

I also found a formula to submaximal tests- **Star jump Estimated VO_2 max**

- Men: VO_{2max} ($ml/kg^{-1} . min^{-1}$)= $111.33-(0.42 \times HR_{rec})$
- Women: VO_{2max} ($ml/kg^{-1} . min^{-1}$)= $65.81 – (0.18 \times HR_{rec})$
- I will use the provided charts to determine level of fitness

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Year 2 Pulteney Grammar School
Science Investigation
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VO2 Max Chart for Men (ml/kg/min)

Age	Poor	Fair	Good	Excellent	Superior
20-29	<38	38-43	44-50	51-56	57+
30-39	<34	34-39	40-46	47-52	53+
40-49	<30	30-35	36-42	43-48	49+
50-59	<26	26-31	32-38	39-44	45+
60+	<22	22-27	28-34	35-40	41+

VO2 Max Chart for Women (ml/kg/min)

Age	Poor	Fair	Good	Excellent	Superior
20-29	<32	32-37	38-44	45-50	51+
30-39	<28	28-33	34-40	41-46	47+
40-49	<25	25-30	31-36	37-42	43+
50-59	<21	21-26	27-32	33-38	39+
60+	<18	18-23	24-30	31-36	37+

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Science Investigation
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22/5/2026

13. What is heart rate?

Heart rate is the number of times your heart beats in one minute. You can measure it with a pulse oximeter, an electrocardiograph, listening to your heartbeat with a stethoscope or by feeling your pulse.

- Normal heart rate at rest (when you are relaxed)
    - New born 0-3 months: 100-150 beats per minutes
    - 3-12 months: 100-160 beats per minutes
    - Toddlers (1—3 years):
    - Preschoolers (3-5years): 80-120 beats per minutes
    - School age (6—12 years): 60-105 beats per minutes
    - Adolescents 12+: 60-100 beats per minutes
    - Adult: 60-110 beats per minute
    - Adult athletes: can be as low as 40-50 beats per minute as their hearts are more efficient.

To feel your pulse you need to apply pressure to once of your arteries and you will feel a beat. This is the heart contracting. I was surprised that kids heart rates are higher than adults heart rates.

Health Direct (2024). *Resting heart rate*. [online] Healthdirect.gov.au. Available at: https://www.healthdirect.gov.au/resting-heart-rate.

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23/05/2026

14. What affects heart rate?

- **Being active and exercise:** you need to get more oxygen to your muscles when you are exercising so you breathe faster, then your heart beats faster to move more oxygenated blood to the muscles, for conversion to energy in your mitochondria. Your heart rate takes time to recover post exercise but the more you exercise and become fit the faster your heart rate recovers and your heart rate slows.
- **Emotions:** feeling worried or scared or excites can increase your heart rate because your body releases the fight or flight hormone adrenaline.
- **Environment:** when it is hot, your blood vessels dilate to help you to sweat, this reduces your blood pressure, so your heart speeds up to help keep your blood pressure dropping too low.
- Food/drinks and other medications that act to speed or slow down your heart.
- Age
- Medical conditions
-

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Year 2 Pulteney Grammar School
Science Investigation
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24/05/2026

15. What is oxygen saturation?

It measures how much oxygen your red blood cells are carrying, compared to how much they can carry. It is a percentage.

16. What is recovery? What is heart rate recovery?

Recovery measures how quickly your body returns to its normal resting level post exercise. you can measure a recovery heart rate by measuring your peak (highest) heart rate while exercising then measure your heart rate after 1 minute of rest. This is your recovery heart rate. Fit people heart rate recovery is faster because their bodies are used to exercise and already conditioned to exercise and recovery.

26/5/2026

17. How does the heart beat and what is a heart rate?

The heart beats on an electrical rhythm by cells in the heart, the nervous system plays a role in the heart rate. The heart rate is how may times the heart contracts to push blood out in 1 minute.

18. What is the basic circulatory system?

I watched a great video on this at https://www.visiblebody.com/learn/circulatory/circulatory-pulmonary-systemic-circulation.

27-28/5/2026

1. How are you going to design your experiment? How will you measure fitness?

I wanted to do running but when asking people most people could not do most activities and my friends fingers don't work with a pulse oximeter because they are too small and cold, so I changed to star jumps.

- I am going to ask the participant to rate their fitness level low/medium/high and then compare it to my results
- Activity

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Year 2 Pulteney Grammar School
Science Investigation
Oliphant Science Awards 2026
Work book

- Star jumps for 1 minute
- So as everyone does the same activity, I am setting a beat of 120 beats a minute
- Beat one- jump out and arms up
- Beat 2- jump in and arms in

- Results
  - I will measure the resting heart rate and oxygen saturation with my pulse oximeter
  - Then they do 60 star jumps in 1 minute
  - Then they sit and I immediately measure the peak recovery heart rate from 5—20 seconds rest and multiply it by 4 and record
  - I am also going to measure the time for the heart rate to return to the resting heart rate (heart rate recovery)
  - I am also going to measure the resting and initial post recovery oxygen level.
- Calculating results
  - Method 1: There is well developed formula for field test VO2 max, the website https://www.formbeat.com/tools/vo2-max-calculator uses a calculator based on a 3 minute step test which I will use. This is based on a maximal test not submaximal but the comparison will be interesting.
  - Method 2: There is also an estimated way that can be used for star jumps which I will also compare- **Estimated VO_2 max**
    - Men: VO_{2max} ($ml/kg^{-1} . min^{-1}$)= 111.33-(0.42xHR_{rec})
    - Women: VO_{2max} ($ml/kg^{-1} . min^{-1}$)= 65.81 – (0.18xHR_{rec})
  - Method 3: I also made my own fitness calculator of recovery time ÷ peak heart rate, as I believe based on research the more fit you are the faster recovery time you should have to reach resting heart rate and the small change in heart rate peaks you should be able to achieve as their body should be conditioned to exercise.
- Discussion
  - I will compare if my fitness calculator (method 3) has similar outcomes at the more well-known calculators of method 1 and 2.

2. What can I keep the same so as results are not affected?

- Same exercise
- Same number of star jumps per minute
- Same time for exercise
- Same environment
- Same testing- heart rate, oxygen saturation, recovery time (10 seconds), formula for VO2max

3. What will be a variable (what changes)?

- Participant's fitness level
- Age
- Gender

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Year 2 Pulteney Grammar School
Science Investigation
Oliphant Science Awards 2026
Work book
1/6/2026-14-6/2026

- Collecting my results took a lot of time
- Finding people to participate was hard
- I wanted to use my friends but their hand were too cold and small and the pulse oximeter did not work, so I ended up having to go to a few workplaces to get adults that were willing to try.
- There were so many things to write down and so many calculations
- It was hard to interpret the results as they were all jumbled so I ended up growing the fitness levels together on my final table to help interpret the results which helped.

Participant	Participant F= female M= male Age in years	Self-reported fitness level	Resting oxygen level	Oxygen saturation	Resting heart rate	Peak heart rate (peak within 10 seconds completion)	Recovery heart rate at 30 seconds	Recovery heart rate at 60 seconds	Recovery heart rate at 90 seconds	Time for heart rate to return to resting HR (sec)
1	40F	H	98	98	63	144	122	115	98	98
2	22M	H	99	99	65	128	111	90	79	189
3	45F	H	98	98	72	152	125	119	89	78
4	28F	H	97	97	72	116	89	75	72	80
5	26F	H	98	99	81	128	99	90	85	95
6	7M	H	100	100	73	112	76	73	70	56
7	11m	H	100	100	62	150	106	73	94	100
8	53M	H	100	100	54	100	93	82	54	90
9	48M	H	99	99	76	129	117	98	92	338
10	45F	M	98	99	80	132	128	125	88	281
11	35M	M	99	99	68	152	145	132	111	296
12	10F	H	100	100	61	100	76	73	65	101
13	20F	M	100	100	59	120	116	81	71	292
14	32F	L	98	99	86	156	155	154	148	700
15	52F	M	98	98	87	168	166	160	139	504
16	30F	M	98	99	81	128	123	119	109	408
17	40F	L	95	93	105	156	154	154	139	652
18	46F	L	98	99	88	166	165	165	142	662
19	29F	L	98	99	100	145	144	144	115	612
20	25F	L	98	96	100	132	126	125	115	505
21	25F	M	100	99	98	164	161	150	141	502
22	27F	L	100	98	92	160	155	151	149	610
23	30F	L	98	95	97	148	146	142	139	860

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Year 2 Pulteney Grammar School
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Table 3: Interpretation of results VO2Max for men (ml/kg/min)					
Age	**Poor fitness** -exhausted with daily activity	**Fair fitness** -below average -low daily activity -heart rate would rise lots with stairs/running/hill	**Good fitness** -Above average -moderate exercise like walking would exhaust the person	**Excellent fitness** -fine with daily activities, climbing stairs, carrying heavy loads	**Superior fitness** -endurance athletes and very active individuals
20-29	<38	38-43	44-50	51-56	57+
30-39	<34	34-39	40-46	47-52	53+
40-49	<30	30-35	36-42	43-48	49+
50-59	<26	26-31	32-38	39-44	45+
60+	<22	22-27	28-34	35-40	41+

Table 4: Interpretation of results VO2Max for women (ml/kg/min)					
Age	**Poor fitness** -exhausted with daily activity	**Fair fitness** -below average -low daily activity -heart rate would rise lots with stairs/running/hill	**Good fitness** -Above average -moderate exercise like walking would exhaust the person	**Excellent fitness** -fine with daily activities, climbing stairs, carrying heavy loads	**Superior fitness** -endurance athletes and very active individuals
20-29	<32	32-37	38-44	45-50	51+
30-39	<28	28-33	34-40	41-46	47+
40-49	<25	25-30	31-36	37-42	43+
50-59	<21	21-26	27-32	33-38	39+
60+	<18	18-23	24-30	31-36	37+

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Year 2 Pulteney Grammar School
Science Investigation
Oliphant Science Awards 2026
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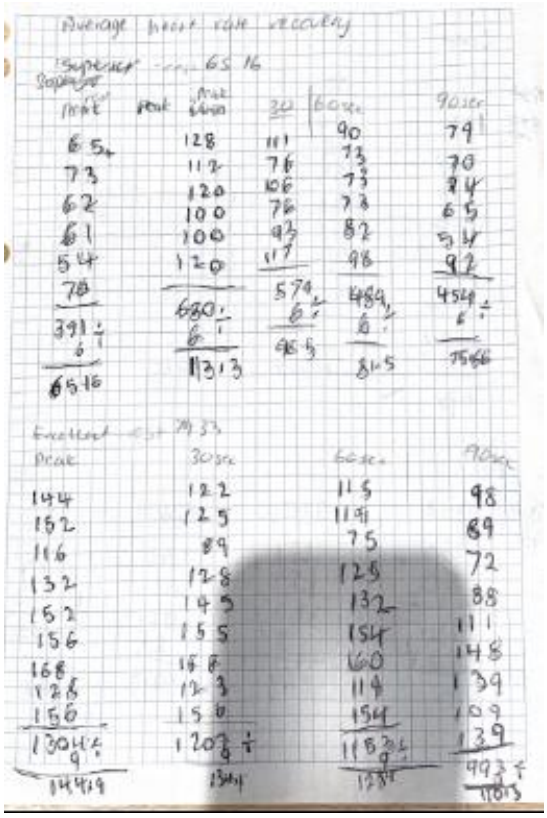

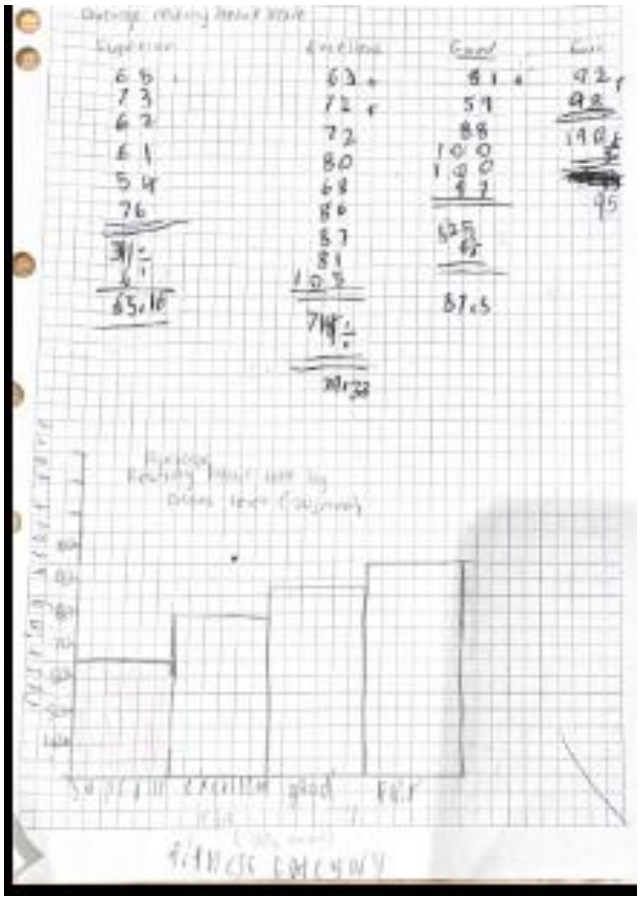

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Year 2 Pulteney Grammar School
Science Investigation
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What do the results mean?

Fit individuals have a higher cardiovascular fitness score because their bodies already have adjusted to high work loads and can easily respond. They have:

- Lungs that take deeper breaths (higher tidal volume) which means they get more oxygen in and the lungs also move the oxygen from the lung sacs (alveoli) into the blood faster. So you get more oxygen delivered quicker.
- The heart is already much stronger and with every contraction it pushes a higher volume of blood out (stroke volume) into the blood vessels. So the heart can beat slower at rest and only needs to slightly increase the heart rate when you exercise. it will beat much faster if you exercise at your maximum but star jumps at 30 per 30 seconds is a submaximal test.
- The blood vessels: fit people have more blood vessels that relax more and become wider letting more blood flow through so more oxygenated blood gets to the muscle. Fit people also have more blood cells.
- The muscles are getting more oxygen from the lungs, transported in larger volumes to the muscle and the muscle has more power cells (mitochondria) to make energy from the oxygen.
- A fit person is expected to have a lower resting heart rate, a lower peak heart rate at a submaximal effort activity, and there heart rate will recover quicker.

16/6/2026

What difficulties have I found?

- Some of the science was difficult
- I broke it down into small questions
- I made maps to help me remember things, like for what is fitness and how does exercise change our body and make us more fit
- I made a list of words that kept getting used in my research and learnt what they meant. I used an easy word and the scientific word. Some examples are:
    - Cardiorespiratory- cardio means heart, respiratory is your lungs and how you get oxygen to cells.
    - Stroke volume- is just how much blood your heart pumps out with each contraction.
    - Contraction- is when a muscle squeezes, like the heart or the skeletal muscle
    - Cardiac output- is how much blood your heart can pump out usually in one minute. Cardiac output= heart rate x stroke volume.
    - Angiogenesis- is when the body makes new blood vessels.
    - Filtration- is when you separate a substance from another substance, like when you remove the carbon dioxide from the blood back into the lung air sacs to breath out.
    - Recovery heart rate- immediate heart rate after exercise calculated from 5—15 seconds post exercise x4 to get a minute.
    - Heart rate recovery- is you heart rate at certain intervals post exercise.

Haider Chaloob **ID: 0529-021**
Year 2 Pulteney Grammar School
Science Investigation
Oliphant Science Awards 2026
Work book

- I wanted to best recovery after an 800m run. However not all participants could do these exercises. I found it very hard to get most people to do more than 30 seconds of star jumps so I chose this.
- I wanted lots of my friends to do the activities, but their fingers were very small and cold, so the pulse oximetry did not work well and I can to change to participants with larger fingers. These were mainly adults, but this did give me a greater range of participants as I think all my friends would have been fit.
- It took a really long time to type up my results
- I felt a bit disappointed that everyone had good to superior fitness, I think I would have more range with a maximal test.

What have I enjoyed?

- I really liked learning the science, I actually think this was the best part and I have a much better understanding of how exercise improves my body which has inspired me to keep running and swimming.
- I really enjoyed the actual experiment.
- Know with all my knowledge I am looking forward to building a heart.

18/6/2026

Report writing

For my report I used a lot of the information I had already made in my workbook. My brother taught me this trick, so I took extra care when doing my workbook.

18/62026- Report writing background

19/6/2026- aim, hypothesis

20/6/2026- materials and method

21/6/2026- results

22/6/2026- conclusion and discussion

23/6/2026- discussion

24-26/6/2026- final check

25/6/2026 Bibliography

Acknowledgements and my reflection

1. My mum did my bibliography but we did talk about what a bibliography is and why it is important to look at where you get your information and to also acknowledge who shared the information.

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Year 2 Pulteney Grammar School
Science Investigation
Oliphant Science Awards 2026
Work book

2. This topic required lots of reading and understanding scientific principles. This was difficult at the start but the more I read and talked about it with my parents the easier it was to understand. We talked about this lots- in the car, on runs, at the dinner table! I felt very confident when it became time to do my experiment and my report. I like thinking of physical fitness in terms of cars and people, V4 vs V12 engines and raceways. I thought of this and it helps me remember (and I love cars).
3. My mum helped with getting me to think about what I was reading and asked some questions to make me think about fitness and health (like asking about exercise guidelines). Dad gave me the idea to draw diagrams to help me understand.
4. The results were very hard to understand because there were all scrambled, so I rewrote them up in categories to make it easier. Drawing the graphs made it much easier to understand the results and I enjoyed learning how to charts in Word after I drew my graphs on paper.
5. My mum helped with some of the typing of questions and I also used voice to text then edited it. Rechecking my report and log book took a long time.
6. I set up my logbook with the same heading of last year.

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OSA RISK ASSESSMENT FORM

for all entries in (✓) ☐ Models & Inventions and ☑ Scientific Inquiry

This must be included with your report, logbook or entry. One form per entry.

STUDENT(S) NAME: Haider Chaloob ID: 0529-021

SCHOOL: Pulteney Grammar School 10

Activity: Give a brief outline of what you are planning to do.

I am really interested in fitness and improving fitness. I want to investigate fitness, what is it? How can we measure it? I know already from some research that I want to ~~investigate aerobic fitness and this requires doing a few different activities, testing heart~~ rate, oxygen levels and recovery. I am getting a group of people of different fitness levels to complete a group of exercises.

Are there possible risks? Consider the following:

- Chemical risks: Are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal risks: Are you heating things? Could you be burnt?
- Biological risks: Are you working with micro-organisms such as mould and bacteria?
- Sharps risks: Are you cutting things, and is there a risk of injury from sharp objects?
- Electrical risks: Are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead? **Only batteries can be used for Models & Inventions entries*
- Radiation risks: Does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards.

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

Risks	How I will control / manage the risk
1. Health risks- falls, excess physical activity, over heating	1. I will make an information sheet for participants that asks how often they exercise? State what I would like them to do in the experiment and if they feel they can do this. I will also explain that if they feel unwell or not able to complete the exercise then they can stop. 2. I will have a medically trained person with me in case of an emergency. 3. I will conduct exercises where possible in a stable flat ground.

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

RISK ASSESSMENT COMPLETED BY (student name(s)): Haider Chaloob

SIGNATURE(S): Haider

☒ By ticking this box, I/we state that my/our project adheres to the listed criteria for this Category.

TEACHER'S NAME: Tom Mildren

SIGNATURE: DATE: 12/6/26