THE MATHEMATICAL ASSOCIATION OF VICTORIA

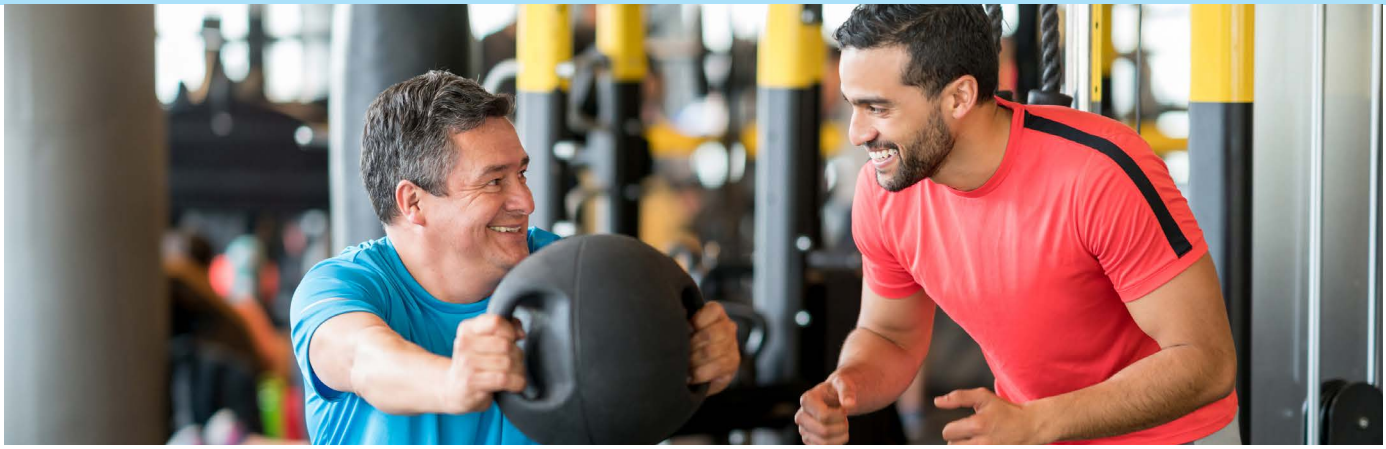
VSSEC

TEACHER NOTES

MATHEMATICS IN CAREERS

Investigation - Body Mass Index (BMI)

Key career focus for this investigation: Sport scientist, dietician, personal trainer
Related career areas: Health sciences



THINKING ABOUT CAREERS

- Brainstorm health sciences professions (such as sport scientist, personal trainer, dietician) you can think of where maths is frequently used. Use https://joboutlook.gov.au to explore health sciences related career pathways that include use of mathematics. *How is maths used in these scenarios? What maths is used in these scenarios?*
- This task focuses on how maths is used in health and fitness through investigating BMI.
- The tasks specifically looks at BMI as a determining factor of whether an individual is within a healthy weight range and asks you to identify some limitations to this.
- Explore careers such as sports scientist, dietician, personal trainer to discover how maths is used in these. For a more extensive list of careers related to this task, with a maths / science focus, refer to the table at the end of the task and explore the maths used in these jobs.

MATHEMATICS IN EVERYDAY LIFE AND CAREERS

Mathematical focus for this investigation

- Using formulas to solve problems.
- Re-arranging expressions to make a specified variable the subject.
- Using authentic data to construct scatter plots, make comparisons and draw conclusions.

Scientists including health professionals use various measurement formulas. They apply their knowledge and understanding of surface area and volume to see the relationship between volume and surface area, in various situations. In this case specifically looking at the reliability of BMI as an indicator of healthy weight range.

- Many people use various measurement formulae every day. For example, they do the area calculations in their head to calculate carpeting or tiling floor surface.
- Brainstorm and share scenarios where this mathematics may be used in health and biological sciences to solve problems.

MATHEMATICAL INVESTIGATION
BODY MASS INDEX (BMI)

STUDENT INVESTIGATION WITH TEACHER GUIDE

LINKS TO VICTORIAN CURRICULUM

Mathematics links to Victorian Curriculum Level 10	Application to work and life
Patterns and algebra Substitute values into formulas to determine an unknown and re-arrange formulas to solve for a particular term (VCMNA333) **Data representation and interpretation** Use scatter plots to investigate and comment on relationships between two numerical variables (VCMSP352)	Formulae are used in many workplaces. This may include using formulas to: • Solve problems • Investigating the relationship between variables Using authentic data to construct scatter plots, make comparisons and draw conclusions. Many people use various formulae every day. For example, in this case the BMI is used in the health industry.
Further examples of other maths used	Using samples as a representation of a population. Graphing data to show underlying trends.

PROFICIENCY FOCUS: VICTORIAN CURRICULUM

This investigation focuses on: Fluency, Understanding, Problem Solving		
Fluency describes students developing skills in choosing appropriate procedures, carrying out procedures flexibly, accurately, efficiently and appropriately, and recalling factual knowledge and concepts readily. This investigation focuses on: • Recall definitions and use these • Solving simple equations arising from formulas • Manipulate (re-arranging) expressions to make a specified variable the subject to find solutions.	**Understanding** refers to students building a robust knowledge of adaptable and transferable mathematical concepts and structures. This investigation focuses on: • Describe their mathematical thinking • Interpret mathematical information	**Problem Solving** is the ability of students to make choices, interpret, formulate, model and investigate situation, select and use technological functions and communicate solutions effectively. This investigation focuses on: • Students applying their existing strategies to seek solutions.

MATHEMATICAL INVESTIGATION
BODY MASS INDEX (BMI)

STUDENT INVESTIGATION WITH TEACHER GUIDE

INVESTIGATION BACKGROUND

The BMI or Body Mass Index is one way of trying to work out whether you are within a healthy weight range. However, it experiences some limitations that are problematic. For example, many elite athletes may be considered either obese or underweight. Examples may include AFL footballers who may be considered 'obese' according to the BMI; on the other end of the scale, healthy individuals who are shorter than average can be considered 'dangerously underweight'. It also changes for men and women, so it can be quite variable.

YOUR INVESTIGATION

Using the BMI as a jumping off point, can you create a formula that is inclusive of both the upper and lower outliers of the BMI? The general formula for BMI is given below:

$$\text{BMI} = \frac{W}{H^2}$$

W – weight in kg H – height in m

Suggestions for teachers: You may wish to start the investigation with the following discussion prompts:
You may wish to start with a sample population, such as

- Your AFL team. If you have the AFL app for your team, click on players and for each individual player record their height and weight.
- Likewise, if you have the Australian Open app, click on players and whether you choose male or female you will find heights and weights of all players
- Investigate any other group of elite sportspeople
- Your class, if permissions are granted
- Investigate any other group that has data available that you think may refute the BMI healthy weight range guide.

What is a reasonable sample population?

REFERENCE MATERIAL

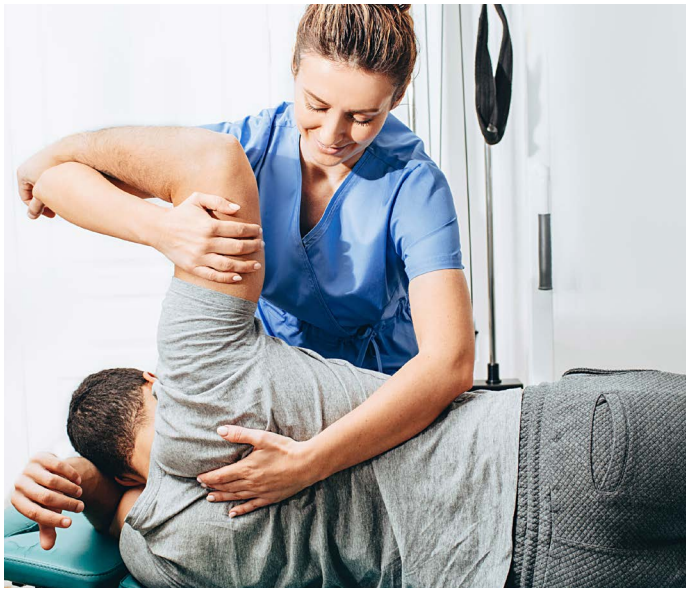
Once students have discussed their opinions on the reliability of BMI for healthy weight range you may refer them to the BMI paper By David Belk (Board Certified in Internal Medicine) at end of this document
The following weblinks may be useful.

http://healthyweight.health.gov.au/wps/portal/Home/helping-hand/bmi

http://healthyweight.health.gov.au/wps/portal/Home/get-started/are-you-a-healthy-weight/bmi/

https://caloriesburnedhq.com/bmi-calculator/

https://www.heraldsun.com.au/sport/afl/the-top-10-footballers-in-country-victoria/news-story/a2fb89d931c7be211a70a027daf8f8bd



MATHEMATICAL INVESTIGATION
BODY MASS INDEX (BMI)

ENABLING PROMPTS

Normal range is between 18.5 – 25
Provide the following suggestions to students:

- Collect your sample data as suggested above.
- Put your data in a table that includes weight, height and BMI for each person in the data sample.

Weight	Height	Height^2	BMI

- Separately to the table, show your BMI calculation workings.
- In the BMI column, highlighted all people in your sample group that are either obese or underweight according to BMI.
- Graph weight (y axis) against height (x axis) in a scatter plot.

Example: rugby players are often obese according to BMI healthy weight range.
Melbourne Storm captain Dale Finucane at a weight of 1102kg and a height of 188cm (1.88m) has a BMI of 28.86 $\left(\text{BMI} = \frac{102}{1.88^2}\right)$, putting him on the obese range.

EXTENSION OR ADVANCED INVESTIGATION

Scientists have not yet found a more inclusive formula for determining healthy weight range that they agree on.
Can you find an alternative more inclusive formula? Explain why your formula is more inclusive than the BMI.

CAREERS RELATED TO THIS INVESTIGATION

Refer to the student investigation, it provides:

- An extensive table of careers related to this investigation
- Further career references

CAREERS ACTIVITIES

Refer to the student investigation, it provides:

- A table of the top 10 rated jobs of 2021. This data comes from careercast.com. Have students investigate the jobs specific to this investigation.

INDUSTRY PARTNER

This project was produced collaboratively between The Mathematical Association of Victoria (MAV) and the Victorian Space Science Centre (VSSEC).

The Victorian Space Science Education Centre (VSSEC) is a specialist STEM learning facility, one of six established by the Victorian State Government. Since its official opening in 2006, VSSEC has used the context of space to enhance the learning experiences in Mathematics, Science, Technology and Engineering for both teachers and students.
VSSEC is located in the grounds of Strathmore Secondary College. The spiral galaxy shaped building provides a stimulating environment which encourages students to be fully engaged in problem-solving and scenario-based learning.
www.vssec.vic.edu.au

MATHEMATICAL INVESTIGATION
BODY MASS INDEX (BMI)

APPENDIX: BMI PAPER

BMI: Why Body Mass Index Is Wrong for So Many People

By David Belk (Board Certified in Internal Medicine)

We've all heard that there's an obesity epidemic in the U.S. And if you're one of the many people who has been told that you're "overweight," you've probably had at least one talk with a doctor about your Body Mass Index (BMI).

So what is BMI? Supposedly, it's an index that allows us to find the healthy weight for our height. You can even check your BMI by typing your height and weight into one of the many BMI calculators on the web. We've been told that if it's 25 or above, we'd better cut the calories and hit the gym or we're likely to pay for it with health problems later in life.

Now the risks of obesity are real. But can we rely on a single number to tell us if someone is overweight? How reliable is BMI really?

The answer is that BMI works reasonably well at what it was first designed for: looking at broad trends in the health of large groups — to see if there's an obesity epidemic. It was never designed to assess the "healthy weight" of an individual, so it really only sort-of works at that.

How can something work for a group of people but not for a person in that group? The answer is that as long as it works for most people (say 2/3 of the population), the errors will tend to cancel out so the trend will be valid. When BMI was first used to track obesity in groups, it was shown to work about as well as the more difficult process of calculating body fat percentage. But the current BMI formula makes a very strange assumption. It assumes that the best way to guess how much fat you carry is to divide your weight by the square of your height (your height, multiplied by itself).

How well does BMI work in practice? Well, if you're between about 5'5" and 5'9", it's not bad. On the other hand, an NFL quarterback in top condition might be 6'2", 220 pounds and so have a BMI of 28. His doctor might tell him he's overweight, but this person doesn't carry a lot of fat. A standard BMI chart also shows us that a person who is 6'8" is considered "overweight" at 230 pounds and "normal" at 170 pounds. That can't be right.

At the other extreme, my daughter is 4'4" and 70 pounds That's a very average height and weight for a 9-year-old girl. But pediatricians will say she's overweight because her BMI is 18. Huh?! What happened to 25? Well, BMI has to be adjusted for age in children and, the truth is my daughter is not 9 years old, she's only 6. A BMI of 18 is fine if you're 9, but it's too high for a 6-year-old (even if that 6-year-old is as tall as an average 9-year-old). How does any of that make any sense at all?

Now this chart shouldn't be used as an absolute indicator of whether a person's weight is ideal for their height. Other factors such as a person's body habitus and how much muscle and fat they have should always be considered.

Refer to the standard BMI chart included on page 6.

MATHEMATICAL INVESTIGATION
BODY MASS INDEX (BMI)

Body Mass Index (BMI) Charts

https://www.vertex42.com/ExcelTemplates/bmi-chart.html

Body Mass Index (BMI) Table for Adults

Obese (>30) | Overweight (25-30) | Normal (18.5-25) | Underweight (<18.5)

HEIGHT in feet/inches and centimeters

WEIGHT		4'8"	4'9"	4'10"	4'11"	5'0"	5'1"	5'2"	5'3"	5'4"	5'5"	5'6"	5'7"	5'8"	5'9"	5'10"	5'11"	6'0"	6'1"	6'2"	6'3"	6'4"	6'5"
lbs	(kg)	142cm		147	150	152	155	157	160	163	165	168	170	173	175	178	180	183	185	188	191	193	196
260	**(117.9)**	**58**	**56**	**54**	**53**	**51**	**49**	**48**	**46**	**45**	**43**	**42**	**41**	**40**	**38**	**37**	**36**	**35**	**34**	**33**	**32**	**32**	**31**
255	(115.7)	57	55	53	51	50	48	47	45	44	42	41	40	39	38	37	36	35	34	33	32	31	30
250	**(113.4)**	**56**	**54**	**52**	**50**	**49**	**47**	**46**	**44**	**43**	**42**	**40**	**39**	**38**	**37**	**36**	**35**	**34**	**33**	**32**	**31**	**30**	**30**
245	(111.1)	55	53	51	49	48	46	45	43	42	41	40	38	37	36	35	34	33	32	31	31	30	29
240	**(108.9)**	**54**	**52**	**50**	**48**	**47**	**45**	**44**	**43**	**41**	**40**	**39**	**38**	**36**	**35**	**34**	**33**	**33**	**32**	**31**	**30**	**29**	**28**
235	(106.6)	53	51	49	47	46	44	43	42	40	39	38	37	36	35	34	33	32	31	30	29	29	28
230	**(104.3)**	**52**	**50**	**48**	**46**	**45**	**43**	**42**	**41**	**39**	**38**	**37**	**36**	**35**	**34**	**33**	**32**	**31**	**30**	**30**	**29**	**28**	**27**
225	(102.1)	50	49	47	45	44	43	41	40	39	37	36	35	34	33	32	31	31	30	29	28	27	27
220	**(99.8)**	**49**	**48**	**46**	**44**	**43**	**42**	**40**	**39**	**38**	**37**	**36**	**34**	**33**	**32**	**32**	**31**	**30**	**29**	**28**	**27**	**27**	**26**
215	(97.5)	48	47	45	43	42	41	39	38	37	36	35	34	33	32	31	30	29	28	28	27	26	25
210	**(95.3)**	**47**	**45**	**44**	**42**	**41**	**40**	**38**	**37**	**36**	**35**	**34**	**33**	**32**	**31**	**30**	**29**	**28**	**28**	**27**	**26**	**26**	**25**
205	(93.0)	46	44	43	41	40	39	37	36	35	34	33	32	31	30	29	29	28	27	26	26	25	24
200	**(90.7)**	**45**	**43**	**42**	**40**	**39**	**38**	**37**	**35**	**34**	**33**	**32**	**31**	**30**	**30**	**29**	**28**	**27**	**26**	**26**	**25**	**24**	**24**
195	(88.5)	44	42	41	39	38	37	36	35	33	32	31	31	30	29	28	27	26	26	25	24	24	23
190	**(86.2)**	**43**	**41**	**40**	**38**	**37**	**36**	**35**	**34**	**33**	**32**	**31**	**30**	**29**	**28**	**27**	**26**	**26**	**25**	**24**	**24**	**23**	**23**
185	(83.9)	41	40	39	37	36	35	34	33	32	31	30	29	28	27	27	26	25	24	24	23	23	22
180	**(81.6)**	**40**	**39**	**38**	**36**	**35**	**34**	**33**	**32**	**31**	**30**	**29**	**28**	**27**	**27**	**26**	**25**	**24**	**24**	**23**	**22**	**22**	**21**
175	(79.4)	39	38	37	35	34	33	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21	21
170	**(77.1)**	**38**	**37**	**36**	**34**	**33**	**32**	**31**	**30**	**29**	**28**	**27**	**27**	**26**	**25**	**24**	**24**	**23**	**22**	**22**	**21**	**21**	**20**
165	(74.8)	37	36	34	33	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21	21	20	20
160	**(72.6)**	**36**	**35**	**33**	**32**	**31**	**30**	**29**	**28**	**27**	**27**	**26**	**25**	**24**	**24**	**23**	**22**	**22**	**21**	**21**	**20**	**19**	**19**
155	(70.3)	35	34	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21	20	20	19	19	18
150	**(68.0)**	**34**	**32**	**31**	**30**	**29**	**28**	**27**	**27**	**26**	**25**	**24**	**23**	**23**	**22**	**22**	**21**	**20**	**20**	**19**	**19**	**18**	**18**
145	(65.8)	33	31	30	29	28	27	27	26	25	24	23	23	22	21	21	20	20	19	19	18	18	17
140	**(63.5)**	**31**	**30**	**29**	**28**	**27**	**26**	**26**	**25**	**24**	**23**	**23**	**22**	**21**	**21**	**20**	**20**	**19**	**18**	**18**	**17**	**17**	**17**
135	(61.2)	30	29	28	27	26	26	25	24	23	22	22	21	21	20	19	19	18	18	17	17	16	16
130	**(59.0)**	**29**	**28**	**27**	**26**	**25**	**25**	**24**	**23**	**22**	**22**	**21**	**20**	**20**	**19**	**19**	**18**	**18**	**17**	**17**	**16**	**16**	**15**
125	(56.7)	28	27	26	25	24	24	23	22	21	21	20	20	19	18	18	17	17	16	16	16	15	15
120	**(54.4)**	**27**	**26**	**25**	**24**	**23**	**23**	**22**	**21**	**21**	**20**	**19**	**19**	**18**	**18**	**17**	**17**	**16**	**16**	**15**	**15**	**15**	**14**
115	(52.2)	26	25	24	23	22	22	21	20	20	19	19	18	17	17	16	16	16	15	15	14	14	14
110	**(49.9)**	**25**	**24**	**23**	**22**	**21**	**21**	**20**	**19**	**19**	**18**	**18**	**17**	**17**	**16**	**16**	**15**	**15**	**15**	**14**	**14**	**13**	**13**
105	(47.6)	24	23	22	21	21	20	19	19	18	17	17	16	16	16	15	15	14	14	13	13	13	12
100	**(45.4)**	**22**	**22**	**21**	**20**	**20**	**19**	**18**	**18**	**17**	**17**	**16**	**16**	**15**	**15**	**14**	**14**	**14**	**13**	**13**	**12**	**12**	**12**
95	(43.1)	21	21	20	19	19	18	17	17	16	16	15	15	14	14	14	13	13	13	12	12	12	11
90	**(40.8)**	**20**	**19**	**19**	**18**	**18**	**17**	**16**	**16**	**15**	**15**	**15**	**14**	**14**	**13**	**13**	**13**	**12**	**12**	**12**	**11**	**11**	**11**
85	(38.6)	19	18	18	17	17	16	16	15	15	14	14	13	13	13	12	12	12	11	11	11	10	10
80	**(36.3)**	**18**	**17**	**17**	**16**	**16**	**15**	**15**	**14**	**14**	**13**	**13**	**13**	**12**	**12**	**11**	**11**	**11**	**11**	**10**	**10**	**10**	**9**

Note: BMI values rounded to the nearest whole number. BMI categories based on CDC (Centers for Disease Control and Prevention) criteria.

https://www.vertex42.com BMI = Weight[kg] / (Height[m] x Height[m]) = 703 x Weight[lb] / (Height[in] x Height[in])