

# The Vitruvian theory—does it apply to you?



## Preparation

### Time required

Allow at least two lessons for this activity. Students may complete it for homework or continue with it in the next class.

### Students will

- carry out a statistical investigation as a statistician would
- strengthen their measurement skills.

### Introduction

Talk to your class about Leonardo da Vinci as you pass out copies of the student worksheet.

For more information on Leonardo and his ideas about body proportion, try searching the Internet using the words 'vitruvian man.'

## Student worksheet

### Problem



Discuss the question—**Is the Vitruvian theory that height is equal to arm span true for Canadian students today?**—so that students understand what they are investigating.

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### Plan



Encourage students to make a prediction and test it using Census at School data.

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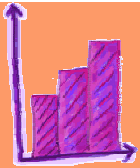
### Data



1. Have students enter the data for all the students in the class, using the Census at School class dataset.
  2. Have them work out the ratios of arm span to height and enter them in the table as both
    - an unsimplified fraction (e.g., 170/160, not 17/16), and
    - as a decimal (e.g., 1.06). (This will allow comparisons with Leonardo's perfect ratio of 1. Values above 1 (e.g. 1.03) mean that arm span is greater than height, and vice-versa for values below 1 (e.g. 0.97).)
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### Analysis

1. When students look at the data table, they should notice features like largest or smallest measurements, which columns show most variation, whether height tends to be greater than arm span, etc.



2. It is possible that there will be no students whose ratios match Leonardo's theory exactly. Ask students why this might be.
3. A student fits this theory if their height equals their arm span.
4. Graph 1:
  - Shape: Younger students should describe clumps and bumps; older students should use words like 'normal' and 'skewed.' It depends on the type of graph drawn.
  - Spread: bunched, evenly spaced, etc.
  - Interesting: varies with students.
- Graphs 2, 3 and 4:
  - Line of best fit: This will depend on the data used.
  - Shape: diagonal clump with a gradient of about 1.
  - Spread: This will depend on data used. Students of similar ages will have a grouping around the middle and fewer points at the extremes.
  - Interesting: This will depend on the sample. Are the data clustered close together or evenly spaced? Any outliers are interesting.
5. Students should be able to notice slight differences among the graphs. Teenage boys may have slightly different proportions as their bodies rapidly change during puberty. There should not be significant differences between younger boys and girls. Students should use evidence from their own graphs to support their claims.
6. They will find that most of the students' heights do not exactly equal their arm spans. This is because the students are real and so vary slightly. Some students may also have stretched their arms more than others or stood taller rather than slouched. One of the key aims of statistics is to deal with the variation in data and say whether it is natural, random, or caused by something else.
7. Answers will vary. Babies have different body proportions from children and adults and are growing very fast. Seniors get shorter in height as they grow older.

## Conclusion



Students' conclusions should relate back to the opening question and explain any difference with their original prediction. They should also mention any features they had noticed or wondered about and investigated.

If all your body measurements were exactly related to each other, you could draw someone from just one measurement. Forensic scientists would know the height and other body measurements of a thief from just one footprint. Fashion designers could also design clothes for you from just one measurement.

Who would be interested? media; school uniform or clothing manufacturer; school architects; manufacturers of school desks and chairs.

## Enrichment activity

The Vitruvian theory contains a total of 10 ratios between different parts of the body.

See a translation of Vitruvius' original roman text at

[http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/3\\*.html](http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/3*.html)

(Vitruvius, De architectura, Book III, Chapter 1)

Four of these ratios can be verified using data from Census at School:

1. Height is equal to arm span.
2. Length from the elbow to the end of the hand is equal to one quarter of height.
3. Length of the hand is one tenth of height.
4. Length of the foot is one seventh of height.

## Mathematical concepts

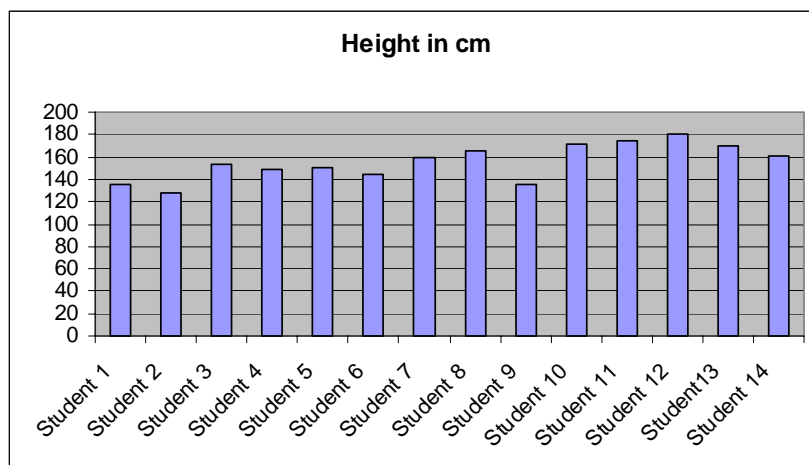
**Ratio:** The relation between two values. (For example, the ratio of 8 to 5 can be written 8:5 or  $8/5$ .)

For this particular activity, students should write the ratio as a fraction. DO NOT let students simplify the fraction (e.g.,  $170/160$  reduced to  $17/16$  will affect the axis scale). Students should also represent the ratio of arm span to height as a decimal value ( $170/160 = 1.06$ ) to show how it compares with Leonardo's perfect proportion ( $170/170 = 1$ ).

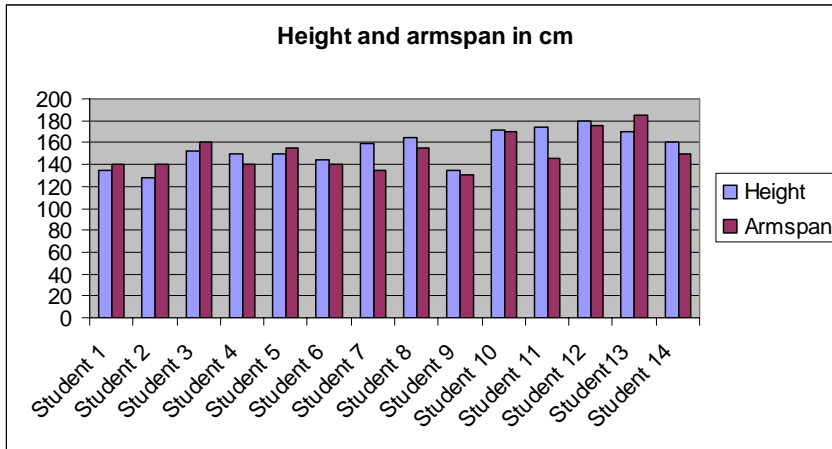
**Variable:** A characteristic being measured. The two variables in this activity are 'arm span' and 'height.'

**Bivariate:** Analysis involving two variables. This activity is bivariate as it measures two variables for each individual (height and arm span).

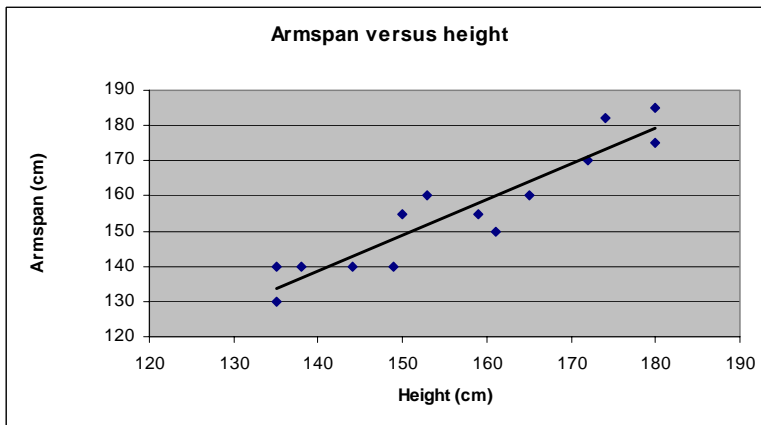
**Bar graph:** Used for discrete (countable) data for a single variable for each individual. Each bar represents an individual and there are spaces between the bars.



**Composite bar graph:** Used for discrete (countable) bivariate data for each individual. The two bars representing the variables for each individual are touching and there are spaces between these double bars. The same data could also be presented in a scatterplot, but a composite bar graph is a better starting point for students who have not previously worked with bivariate data.



**Scatterplot:** Two variables are plotted against each other, one on each axis (e.g., ‘arm span’ on the y-axis and ‘height’ on the x-axis). Each individual is represented as a point on the graph. The data could also be graphed using a composite bar graph.

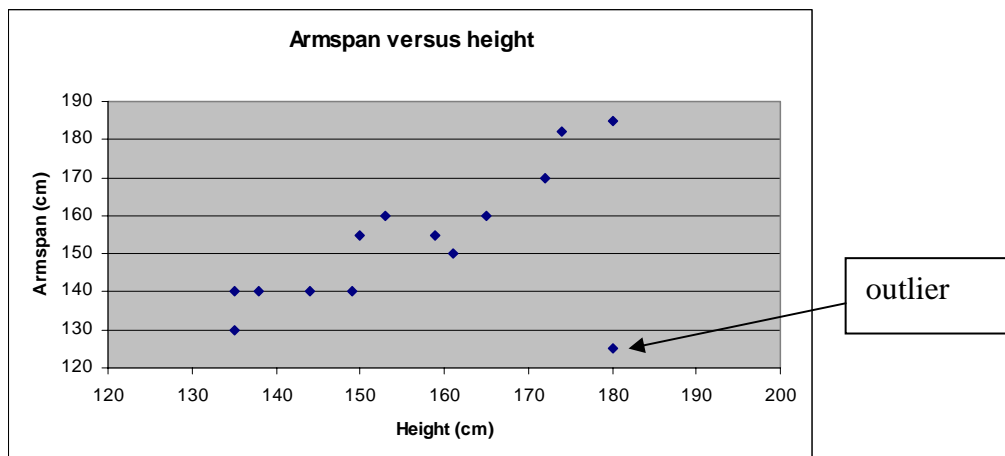


**Line of best fit:** A line drawn through the data on a scatterplot, where approximately half the points are above the line and half below. Higher-level students could discuss aspects of the gradients and their meanings, such as positive and negative relationships.

**Units:** The measure used for the variable(s). In this activity, centimetres are used rather than metres in order to avoid awkward decimals.

**'Bumps,' 'clumps,' etc.:** Words such as 'bumps' (for bar graphs) and 'clumps' (for scatterplots) can be used to describe what younger students can see from the graphs.

**Outlier:** A point in a scatterplot that is a long way from the rest. Outliers can be caused by incorrect measuring.



**Range:** In a dataset, the largest value minus the smallest value. For example, if the tallest student is 180 cm and the shortest 150 cm, the range is 30 cm. The range can help students select an appropriate scale for the graph.