Lab 1: The metric system – measurement of length and weight

Introduction

The scientific community and the majority of nations throughout the world use the metric system to record quantities such as length, volume, mass (weight), and time. The metric system is based on units of 10, and conversion to higher or lower values is relatively easy when compared to using the English system customarily used in the United States.

In this laboratory you will become familiar with the use of the metric system in measuring quantities of length and weight, and with the basic processes of graphing, reporting, and interpreting a simple set of data.

Objectives

- use of metric system in measurement of length and height
- convert metric base units of length and mass to multiples or fractions
- understand and use basic descriptive statistics – mean, median, standard deviation
- use Microsoft Excel for calculation of basic descriptive statistics and graphing

Materials

A meter stick, metric tape, scale.

Procedure

The base units and English equivalents for measurement of length and weight are shown in Table 1.

Table 1: Metric system and Equivalents

Quantity	**Base Unit**	**English Equivalent**
Length	Meter (m)	1.09 yard (39.4 inches)
Weight	Gram (g)	0.036 ounces

As mentioned above the metric system is based on units of 10, and prefixes are used to denote the scale of measurement relative to the base unit – these prefixes are shown in Table 2.

Table 2: Decimals of the metric system

Prefix	Definition	Multiple/fraction
kilo- (k-)	One thousand times greater	1000 fold of base unit
deci- (d-)	One-tenth as much	0.1 of base unit
centi- (c-)	One-hundredth as much	0.01 of base unit
milli- (m-)	One-thousandth as much	0.001 of base unit
micro- (μ-)	One-millionth as much	0.000001 of base unit

For example, the meter stick (1 m) you will be working with is composed of 100 cm or 1000 mm. If you use the stick to measure your lab partner's height and determine that she is 175 cm tall, you can equally report that her height is 1.75 m.
Likewise if a student uses a metric scale to determine that he weighs 67.5 kilograms (kg), he can also report that his weigh is 67,500 grams, although the kg unit is more appropriate to denote weights in this range. In another example a pill contains 250 mg of ibuprofen – this is equivalent to 0.25 g or 0.00025 kg – however reporting the weight in milligrams (mg) is more appropriate for the quantity involved.

1. Measurement of lower leg length and height

In this part of the exercise you will measure lower leg length and body height of your lab partner.

To measure lower leg length have your lab partner kneel on a chair with the thigh vertical and the back of the calf at a 90 degree angle to the thigh. Place a meter stick or tape along the outside (lateral) edge of the back of his/her calf. You should feel the tendon of the biceps femoris muscle behind and on the lateral side of the knee. Make sure that the meter stick is just at the edge of the tendon, and record the distance in centimeters (cm) from this tendon to the bottom of his/her heel.

To measure height have your partner take off his/her shoes and stand completely upright against a wall. Place a hard cover book on top of his/her head and make a light mark on the wall representing the top of the head – measure this distance in centimeters (cm) and convert it to meters (m).

Have your partner repeat the above procedures using you as a subject. When finished enter the data for leg length (cm) and height (m) on the chalkboard or on a chart provided by your lab instructor.

2. Descriptive statistics for class leg length and height

Using Microsoft Excel you will determine the mean, median, and standard deviation for the class leg length and height data collected above.

The mean is simply the mathematical average of the data. The mean provides you with a quick way of describing your data, and is probably the most used measure of central tendency. However, the mean is greatly influenced by outliers. An outlier is an observation in a data set which is far removed in value from the others in the data set. It is an unusually large or an unusually small value compared to the others. For example, consider the following data set: 1, 1, 2, 4, 5, 5, 6, 6, 7, 150.

While the mean for this data set is 18.7, it is obvious that nine out of ten of the observation lie below the mean because of the large final observation. Consequently, the mean is not always the best measure of central tendency.

The median is the middle observation in a data set. That is, 50% of the observation are above the median and 50% are below the median (for sets with an even number of observation, the median is the average of the middle two observation). The median is often used when a data set includes outliers. In the example above the median is 5 – in this example the median is a better measure of central tendency than the mean, due to the presence of an outlier.

Standard deviation is a measure of the spread or dispersion of a set of data. The more widely the values are spread out, the larger the standard deviation. For example, say we have two separate lists of exam results from a class of 30 students; one ranges from 31% to 98%, the other from 82% to 93%, then the standard deviation would be larger for the results of the first exam.

a. Open MS Excel by double clicking on the respective icon on the desktop of your computer. The program will open and a window showing Workbook 1 will appear. The workbook is a spreadsheet with columns and rows that you will use to enter data. Each individual "rectangle" in the workbook is referred to as a "cell".

Columns are denoted alphabetically – A, B, C – and rows are identified numerically – 1, 2, 3, etc. The location of a cell is indicated by its column and row coordinates – for example, the cell located at the very top left of your screen is cell "A1".

b. Highlight cell B1 and type in "Height" – this is the title for the column where you will enter the data for class height you collected above. Highlight cell D1 and type in "Leg length" – this is the title for the column where you will enter the data for class leg length you collected earlier.

Get the data from the chalkboard and enter each individual data point in a cell – hit the "Enter" key or use the mouse to move the cursor to the next cell in the column.

c. Descriptive statistics

Go to a cell below the last data point you entered in the column entitled "Height". Highlight this cell and then click on the "=" sign on the upper left corner of the Excel toolbar – a dialog box will appear.

Select the AVERAGE function from the scroll box on the left of this dialog box – a second dialog box will open. In the text box following "Number 1" make sure that you list the range of cells that you want to use to compute the average. For example, if "B2:B12" is listed in this text box, the function will compute an average using values present in cells B2 – B12. Select OK. The function will now compute the average or mean for selected cells.

Go to another cell below the "Height" column. Highlight this cell and then click on the "=" sign on the upper left corner of the Excel toolbar – a dialog box will appear.

This time select the MEDIAN function from the scroll box on the left of this dialog box. Repeat the procedure outlined above to calculate the median for the height data.
Go to another cell below the "Height" column. Highlight this cell and then click on the "=" sign on the upper left corner of the Excel toolbar – a dialog box will appear.

This time select the STDEV function from the scroll box on the left of this dialog box. Repeat the procedure outlined above to calculate the standard deviation for the height data.

Using the procedure outlined above determine the mean, median, and standard deviation for the leg length data. Label cells so it is clear what the descriptive statistics refer to. Save the workbook to a folder indicated by your instructor.

3. Relationship between leg length and height

Using the class data collected above and Microsoft Excel, produce a graph that illustrates the relationship between leg length and overall height of an individual. Plot the length of the leg (cm) on the x-axis and the overall height of the individual on the y-axis. Use the scatter plot feature of MS Excel and fit a line to the data. Print a copy of the graph and give it to your instructor at the end of class (one copy per group). Save your work. A general procedure for making scatter plots using MS Excel is outlined below.

- Highlight all cells containing information. Then click **Insert** (in the main menu), then **Chart**.
- Choose **XY (Scatter)** as a chart type. Then click **Next**.
- On the next screen, click **Next.**
- Fill in the **Chart, X-axis, and Y-axis** titles – include the units of measurement in parentheses.
- Click the tab labeled **Legend**. Uncheck the box labeled **Show legend**.
- Click **Next**.
- Click **Finish**

At this point you may note that the y-axis scale for your graph includes a range where there are no data points present. For example the shortest individual in the class was 1.58 meters, yet the y-axis starts at zero. To correct this do the following:

- Double-click on the y-axis.
- On the dialog box that opens click the tab labeled **Scale**.
- Change the minimum value to an appropriate number – in the above example 1.50 meters would be appropriate.
- Click OK
- You may also have to adjust the scale of the x-axis in similar fashion.

To add the **line of best fit (trend line):**

- Choose ***Chart*** from the top menu bar. (Make sure that the graph is highlighted/selected by box bullets on the perimeter. You can do this by clicking anywhere on the graph.)
- Click **Add Trendline**.
- The Linear type of trend line should already be selected. This is what you need.
- To get the R-Square value to print on your graph, click the tab labeled **Options**. Then check the box titled **Display R-Squared Value on Chart.**
- Click **OK**.

Note that R^2 indicates the strength of the relationship between the two variables. Values of R^2 ranges from 0 to 1.0. As the value of R^2 increases, the relationship is getting stronger, with a value of 1.00 indicating a perfect correlation. Conversely, as R^2 approaches 0, the correlation is weaker, with a score of 0 indicating the absence of any linear relationship between the variables.

4. Measurement of weight

Weigh yourself either using a metric scale or a English scale. Enter your weight in kilograms (1 kg = 2.2 lb.) on the chalkboard or on a chart provided by your lab instructor.

5. Descriptive statistics for class weight

Using the same MS Excel workbook you started earlier, create a new column for weight and enter the class values. Determine the mean, median, and standard deviation for this variable. Save your work. Print a copy of the Workbook and give it in to your instructor at the end of class (one copy per group).

6. Relationship between overall height and weight

Using the class data collected above and Microsoft Excel produce a graph that illustrates the relationship between overall height and weight of an individual. Plot the overall height (m) on the x-axis and the body weight (kg) of the individual on the y-axis. Use the scatter plot feature of MS Excel and fit a line to the data. Determine R^2. Print a copy of the graph and give it to your instructor at the end of class (one copy per group). Save your work.

Assignment

1. Conversions:

1.76 m = _________ cm

250 g = __________ kg

375 mm = __________ m

550 mg = _________ g

2. Refer to the graph illustrating the relationship between leg length and height.

a. Is there a correlation between leg length and height?

b. For every 5 cm change in leg length what is the approximate change in height?

c. According to your graph, predict how tall a person would be if his or her leg length was 0.37 m. How tall do you predict they would be if the individual had a leg length of 0.48 m?

3. Refer to the graph illustrating a relationship between overall height and weight.

a. Is there a correlation between height and weight?

b. For every 2 cm change in height what is the approximate change in weight?

c. According to your graph predict the weight of the individuals with the following heights: (i) 185 cm; (ii) 140 cm

4. Which shows a higher degree of correlation, leg length and height or height and body weight? Explain your answer.

5. If you were to do a new experiment examining the relationship between arm length and overall height, which of the two individuals below would you expect to be taller?

Individual A: arm length = 65 cm

Individual B: arm length = 0.85 m