Case File 1

Tracks of a Killer: Using footprints to estimate height

Analyze the relationships between shoe size, stride length, and height, and then use that information to identify the likely killer.

The body of famous pop music producer Jonathan Wallace was found in his bathtub. It is our hypothesis that an intruder surprised the victim and drowned him. The only clue at the crime scene was a set of muddy footprints leading from a nearby window to the bathroom and back again. The footprints were smeared, so their exact size could not be determined. The soles of the shoes had no pattern. It will be difficult to match the footprints to any particular pair of shoes.

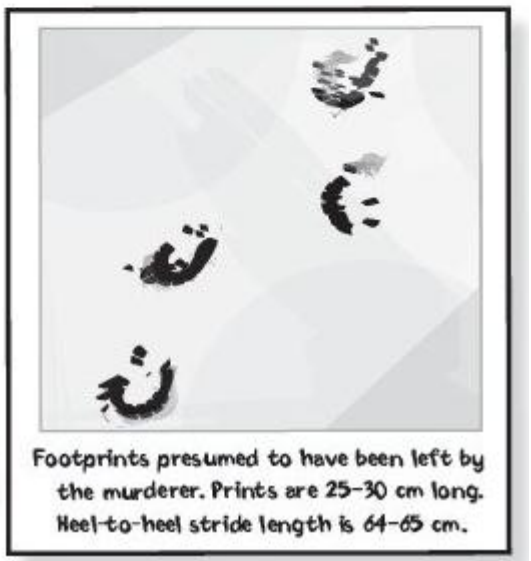
Three suspects were questioned immediately following the murder:

Penelope Paige, pop star: 5'4"/green eyes/blond hair
Possible motive: She is suing Wallace over the failure of her last album.

Rex Chapman, rock guitarist: 5'8"/brown eyes/brown hair
Possible motive: He accused Wallace of stealing profits from his hit single "Walk It Off."

Dirty Dawg, rapper: 6'0"/brown eyes/black hair
Possible motive: He wants out of a record contract with Wallace.

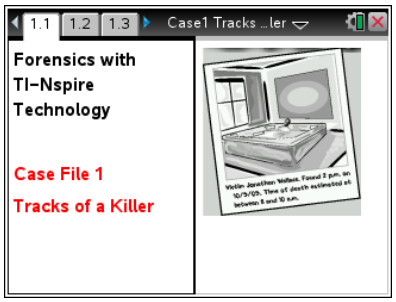
Victim Jonathan Wallace. Found 2 p.m. on 10/5/05. Time of death estimated at between 8 and 10 a.m.



Footprints presumed to have been left by the murderer. Prints are 25–30 cm long. Heel-to-heel stride length is 64–65 cm.

About the Lesson

- This lab introduces the concepts of linear regression and correlation coefficient values through an analysis of the relationship between stride length, shoe size, and height.
- Teaching time: one 45 minute class period



Science Objectives

- Determine if there is a relationship between the length of a person's stride and his or her height.
- Determine if there is a relationship between the size of a person's shoes and his or her height.
- Efficiently gather data to test for correlations between height, shoe size, and stride length.
- Use a linear regression model of the data to predict height based on stride length.

Activity Materials

- TI-Nspire™ technology
- *Case_1_Tracks_of_a_Killer.tns* file
- *Case_1_Tracks_of_a_Killer _Student.doc* student activity sheet
- metric tape measure or meter stick
- chalk or tap

TI-Nspire™ Navigator™

- Send out *Case1Tracks_of_a_killer.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Teacher Notes and Teaching Tips

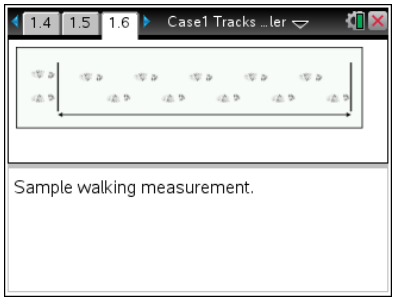
- The student activity sheet and .tns file contain the complete instructions for data collection. All assessment questions are also included in both places giving you the flexibility to either collect the .tns files with student data/answers (using TI-Nspire Navigator) or the student activity sheet.
- Setting up students for data collection:
  - Option 1: Break up the class into groups of three or four students; each group will make all three measurements, using one TI-Nspire handheld to record the data.
  - Option 2: Set up three stations and have pairs of students travel to each station—one person to collect data, and one person to record data.
- If using TI-Navigator, collect all data, combine it, and redistribute it to the class.
- If time is short or students are less advanced, eliminate the process of measuring shoe length and determining if there is a relationship between height and shoe length. If you choose this option, case Analysis questions 3 and 4 should be removed.

Allow students to read the forensics scenario on the first page of their student activity sheet.

Procedure

Part 1 – Collecting Data

Move to page 1.3–1.6.



Students measure the height of each person, shoe length, and stride length and record the data in the Evidence Record. There is an example of how to mark the start and finish line on page 1.6. Students need to record the data from the entire class in the Evidence Record on the activity sheet.

Part 2 – Entering the Data into TI-Nspire

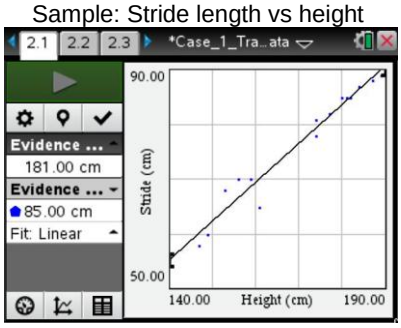
Move to page 2.1.

Students enter the data from the Evidence Record on the activity sheet into the table on page 2.1. They should enter the heights in the Height Column, the shoe lengths in the ShoeL column, and the stride lengths in the Stride column. Each row represents one student's data.

Part 3 – Analyzing the Data

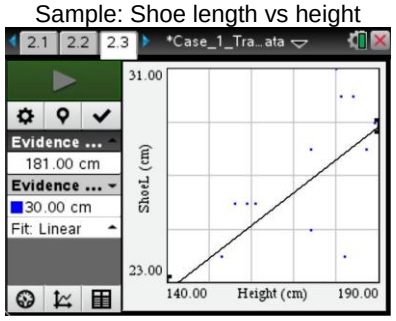
Pages 2.1–2.4.

Sample: Stride length vs height



Students switch to "Graph View" tab on page 2.1, and will see a graph of stride length vs. height. Students then perform a linear regression of the data they have graphed. They need to record both the equation and the correlation value in the Evidence Record on page 2.5 of the .tns file, the activity sheet, or both.

Sample: Shoe length vs height



Students change the variable graphed on the y-axis to shoe length and find the linear regression of the data. Students use their results from the data collection and regression to answer the questions in the Case Analysis.

Evidence Record

SAMPLE DATA

Student Name	Measurement 1 Height (cm)	Measurement 2 Shoe Length (cm)	Measurement 3 Stride Length (cm)
Student 1/Group 1	147	23	58
Student 2/Group 2	159	26	70
Student 3/Group 3	187	28	88
Student 4/Group 4	177	23	82
Student 5/Group 5	180	31	85
Student 6/Group 6	161	26	65
Student 7/Group 7	174	28	78
Student 8/Group 8	189	29	89
Student 9/Group 9	182	24	85
Student 10/Group 10	184	30	87
Student 11/Group 11	149	23	60
Student 12/Group 12	153	24	68
Student 13/Group 13	156	26	70
Student 14/Group 14	174	25	81
Student 15/Group 15	181	30	85

Graph	Equation	Correlation Value (r^2)
Stride Length vs. Height	$y = 71x - 44$	0.98
Shoe Size vs. Height	$y = 12x + 5$	0.65

Case Analysis

Move to pages 3.1 – 4.1.

Have students answer the following questions either on the handheld, the activity sheet, or both.

Q1. Should a linear model be used to best represent you data? Explain why or why not.

Answer: A linear model should be used to best represent the data because there is a linear relationship between height and stride length. The data points fall on a fairly straight line.

Q2. What is the correlation value for the straight line that best describes your data for student stride *vs*. height? Do you think the straight line fits the data well?

Answer: The correlation values should be close to 1 (0.95 or 0.90 is acceptable). If the values are significantly lower than this, it is possible that the students entered incorrect data or that their measurements were inaccurate.

Q3. Based on your data, is there a linear relationship between student height and shoe length?

Answer: There should not be a clearly linear relationship between height and shoe size.

Q4. Do you think that it is possible to infer a person's height from his or her shoe size? Explain your answer.

Answer: No, it is generally not possible to predict a person's height from his or her shoe size.

Q5. Using the relationship between height and stride length that you calculated, determine the approximate heights of people with the following stride lengths:

a. 0.75 m

b. 0.45 m

c. 0.50 m

Answer: Answers will vary depending on calculated height–stride-length equations.

Q6. Using the relationship between height and stride length that you calculated, predict the stride length of a person who is not a student in your class (for example, your teacher, your principal, or a student in a different class) based on his or her height. Then measure the person's actual stride length. How close was your prediction to the actual stride length?

Answer: (Answers will vary.)

Q7. Suppose you measure the stride length of a set of footprints, and you predict that the person who made the footprints is 1.75 m tall. Later, you find out that the person who made the footprints is actually only 1.52 m tall. Give possible reasons why your prediction was incorrect.

Answer: Possible reasons for incorrect predictions of height include the following:

- The person was running or was taking larger or smaller steps than usual.
- The person's normal stride does not follow the trend.
- The stride length was measured incorrectly.

Q8. Using the relationships that you calculated, determine which of the three suspects most likely left the footprints to and from Jonathan Wallace's bathroom. Show all your calculations. (**Hint**: In the equation that you wrote down, *x* is stride length and *y* is height.)

Answer: Answers will vary; based on the sample data here, Penelope Paige most likely left the footprints (her height is closest to the calculated height of 1.54 m).

stride length = 0.71 (height) – 0.44

$$\text{height} = \frac{\text{stride length} + 0.44}{0.71} = \frac{0.65 + 0.44}{0.71} = 1.54\text{m}$$