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Pedometer and Human Energy Balance Applications for Science Instruction

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Abstract

Teachers can use pedometers to facilitate inquiry learning and show students the need for mathematics in scientific investigation. The authors conducted activities with secondary students that investigated intake and expenditure components of the energy balance algorithm, which led to inquiries about pedometers and related data. By investigating the accuracy of pedometers and variables that may impact reported step counts, students can better understand experimental design and statistical concepts. Students can also examine other data (distance walked, kilocalories expended) using multifunction pedometers and apply the concepts of correlation and regression. This topic fits well with thematic learning and responds to concerns about excess energy intake and insufficient physical activity in the U.S. population.

Keywords

energy; experimental design; inquiry; pedometer; technology

Pedometers have been identified as a useful tool for science teachers: they can facilitate inquiry, illustrate the need for mathematics in scientific investigation, and provide learning activities that meet most of the National Science Education Standards for content, such as *science and technology* (National Academy of Sciences 1996; Olson and Loucks-Horsley 2000; Rye et al. 2005). Pedometers relate to the output of the human energy balance equation and can be connected to the *unifying concepts and processes* of systems, equilibrium, and measurement (Tudor-Locke 2002). Energy imbalances over time produce weight loss or gain. When the body is in negative energy balance, which occurs when its energy (kilocalories or kcal) intake is less than its energy expenditure, it combusts body fat to yield kinetic or free energy to support metabolic functions and motion or work (Gropper, Smith, and Groff 2005). Positive energy balance, which occurs when energy intake is greater than energy expenditure, usually results in potential energy being stored as fat. A small positive energy balance is necessary for youth to support healthy weight gain, which includes muscle tissue. More information on energy balance and kcal is available in *The Science of Energy Balance* (Biological Sciences Curriculum Study 2005) and *Dietary Reference Intakes* (Institute of Medicine 2005).

Pedometer activities also connect to the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics 2004) for *measurement* (e.g., accuracy, precision, unit analysis), *data analysis* (variables, types of data, basic statistics), *problem*

solving, and *representation*. Pedometers are an evolving technological innovation used by researchers to measure physical activity and develop strategies for increasing physical activity (Croteau 2004; Tudor-Locke 2002). They also allow for collaboration with health and physical education teachers in the national thrust to increase physical activity opportunities and levels for youth (Corbin, Pangrazi, and Le Masurier 2004; Institute of Medicine 2005; Pangrazi, Beighle, and Sidman 2003). It is critical for schools to emphasize physical activity, given the current epidemic of overweight children and obese adults in the United States (Hill et al. 2003; Institute of Medicine 2005).

The purpose of this article is to describe five activities that examine energy intake and expenditure and that use pedometers in the context of experimental design at the high school level (Grades 9-10). The activities are informed by our experiences teaching a nutrition and energy thematic unit in the science classroom and making inquiry into human energy balance as part of a Health Sciences and Technology Academy (<http://www.wv-hsta.org>) summer institute. The activities are related to science content and standards on energy, experimental design, technology, problem solving, and personal and societal issues. The approximate time, in 90-min blocks, needed to complete these activities is (a) *energy intake*: 2 (blocks), (b) *energy expenditure*: 3, (c) *orientation* (to Pedometers): 1, (d) *relation correlation*: 1, and (e) *design your own*: 3. Cumulatively, this would be 10 blocks (or twenty 45-min class periods), which can be reduced through the use of more direct instruction.

Setting the Stage

Students may find pedometer activities more meaningful if they are placed in the broader context of human energy balance. Accordingly, we recommend first engaging students in two learning activities (energy intake and energy Expenditure) that examine the energy values of foods and physical activities.

Materials

- Food composition data, which can be found in the U.S. Department of Agriculture's database (USDA 2006) or in reference texts such as *Bowes and Church's Food Values of Portions Commonly Used* (Pennington and Douglass 2004).
- Metabolic Equivalents (MET) data for physical activity found in *The Compendium of Physical Activities Tracking Guide* (Ainsworth 2002). Abbreviated lists are published by the Institute of Medicine (2002/2005), Chapter 12, Table 12-1, and in the *President's Council on Physical Fitness and Sports Research Digest* (Ainsworth 2003).

Energy Intake Activity

Food energy is expressed in large calories or kcal. Thus, a nutrition label stating a food has 150 calories per serving really means 150 kcal. The energy intake activity involves computing and comparing the kcal in the same quantities of certain foods and calculating the kcal or energy density (per gram—kcal/g) for each food (Drewnowski and Specter 2004). If kilojoules (kJ) are desired, 1 kcal = 4.18 kJ.

Tell students that they will investigate which of the following four foods (use others as desired) provides the most kcal/g: chocolate candy (plain M&Ms), dry flaked cereal (Grape-Nuts Flakes), a fast food item (cheeseburger, regular single patty with condiments), and a mixed dish (chili con carne with beans). The USDA (2006) nutrient database allows the user to modify the mass (g) for each food being examined. If you are using this database to create and distribute to students printed copies of the nutrient composition for each food, set the mass of each food to a different quantity, such as 29 g for the cereal (corresponding to .75 cup) and 127 g for the

cheeseburger (corresponding to 1 regular burger with condiments). If students are using textbooks that provide food composition tables, the mass values as listed are usually different for each of these foods.

Ask students, “What must we do to compare the kcal in these foods on an equal mass basis?” They must choose the same mass for all four foods and adjust the kcal value of each food to that mass. In our work with students, we elected to use a mass of 112 g (about 4 oz). See Table 1 for an example algorithm to adjust the kcal value of each food to a 112 g mass. Lead students through the solution or have them attempt a solution on their own. Discussion should follow to ensure that students understand how to calculate and interpret the kcal values.

Ask students, “How would we calculate the kcal in foods on a per g basis, which is known as the ‘energy density’ of that food?” Table 1 shows the solution for each food. Walk students through the solution or have them attempt it, and follow with discussion to ensure understanding.

Ask students to choose a new mass (e.g., 56 g instead of 112 g) for all of the foods, determine the kcal values

Students work together on the pedometer activity.

for that mass of each food, and calculate again the energy density of each food. Students should compare the energy density (kcal/g) value for the 112 g and new mass of each food. They will discover that the energy density remains the same regardless of the mass. Discuss with students how this is also true when determining density (g/mL) as a physical property of matter.

Discuss and review with students that energy in foods comes from fat, carbohydrate, and protein, which are known as macronutrients—macromolecules that can be used by the body for energy (Mahan and Escott-Stump 2004). Discuss how the amount and distribution of fat, carbohydrate, protein, and water in each food they examined may help explain the energy-density differences they found. Carbohydrate and protein each contribute 4 kcal/g, fat has 9 kcal/g, and water contributes 0 kcal. An examination of the macronutrient and water composition of the foods reveals that the dry cereal is very low in fat but, like the chocolate candy, is nearly anhydrous (has no water). However, the percentage of water (46%) of a cheeseburger with condiments approaches half of its mass, and chili has almost three-quarters

(74%) of its mass as water. Water is an important constituent of food relative to decreasing energy density (Drewnowski and Specter 2004).

Ask each student or pair of students to calculate the energy density of an additional food or beverage. For that food, they should enter the following in a chart on the board: food name, measure (e.g., 1 cup or 1 medium), mass (g), energy (kcal), energy density (kcal/g), water (g), fat (g), protein (g), and carbohydrate (g). They should report to the class how that food's composition influences its energy density. Attempt to draw conclusions from the data about all the foods on the chart. For example, depending on the foods represented, one may conclude that high water content does not guarantee that a typical serving of the food will be low in kcal even though that food's energy density is relatively low (e.g., whole milk has a high fat content and sugar-sweetened soda has considerable added carbohydrate in the form of sugar).

Energy Expenditure Activity

We engaged students in computing and comparing energy-expenditure values of activities listed in the *Compendium of Physical Activities Tracking Guide* (Ainsworth 2002). These energy values will mean more to students if you first acquaint them with the estimated daily energy requirements (EER). For moderately active 14- to 18-year-old individuals, the EER are 2000 kcal for girls and 2400-2800 kcal for boys (see Table 3 in the *Dietary Guidelines for Americans*; U.S. Department of Health and Human Services [USDHHS] 2005). Detailed information on energy requirements, including factors (e.g., body size, gender, growth) that influence these requirements, is available in *Dietary Reference Intakes* (Institute of Medicine 2002/2005).

We introduced students to the MET concept, which is the approximate kcal expenditure by adults per kg of body weight per hr (kcal/kg/hr). For example, 1 MET = 1 kcal/kg/hr. Ainsworth (2002, 2003) provides a more detailed explanation of the *Compendium* and MET concept. Table 2 provides examples of the information found in the *Compendium*: headings, descriptions, and METs for activities referred to in this article.

The MET value for any physical activity includes the kcal needed to maintain life at rest, which is 1 MET. Thus, an activity with a MET value of 3 (e.g., general housecleaning) includes the 1 MET that an individual would burn just to rest (i.e., doing no physical activity). Note that the MET value for sitting quietly and watching television is only 1, which means that this activity does not expend any more kcal than are needed to rest.

1. Our introduction included practice converting sample body weights from pounds (lb) to kg (1 kg = 2.2 lb). Students' own body weights should be treated with respect and as confidential information; they should never be asked to volunteer their personal body weights for class examples. Students can perform such calculations privately as desired.
2. For several physical activities, we asked students to calculate the energy expenditure from MET values using sample body weights and durations of engagement, holding body weight and engagement constant for some of the activities to facilitate comparisons. You can assign students to specific activities or let them choose. If you let them choose, know that the *Compendium* (Ainsworth 2002) is fairly comprehensive and includes MET values for self-care (e.g., sitting on the toilet) and sexual activity (passive, general, and active), so you may want to constrain the choices to relevant and age-appropriate activities.
3. Students should compare and discuss the kcal expenditures, especially for activities for which the body weight and duration of engagement have been held constant. See

the following example: $\text{MET} = 1$ (1 kcal/kg/hr) for riding in a car or truck. For a 60 kg (132 lb) individual, the energy expended riding in a car for 45 min (0.75 hr) is

$$1 \text{ kcal} \times 60 \times 0.75 = 45 \text{ kcal.}$$

Ask students to contrast this energy expenditure with the expenditure for a more vigorous physical activity, such as bicycling at 10-11.9 mph ($\text{MET} = 6.0$) for 0.75 hr. Students can use unit (dimensional) analysis to compute the energy expenditure of bicycling. The algorithm also converts body weight from lb to kg:

$$\frac{6.0 \text{ kcal} \times 1 \times 132 \times 0.75}{1 \times 2.2} = 270 \text{ kcal}$$

Therefore, bicycling at 10-11.9 mph as opposed to riding in a car for the same length of time (0.75 hr) expends an additional 225 kcal (270 kcal - 45 kcal).

4. To increase complexity, students can solve problems that require the calculation and comparison of kcal intake from a meal or an entire day to the kcal expenditure from various activities or during a 24-hour period. For each comparison, they should calculate the energy balance and answer the question, "If this comparison was reflective of an individual's everyday diet and activity level, what would result?"
5. You can end the segment on calculating energy expenditures using MET values by focusing on walking, which relates directly to the use of pedometers. The *Compendium* (Ainsworth 2002) categorizes 42 activities as walking and includes many additional activities that involve walking, such as fishing, hunting, and gardening.

Pedometer Orientation and Investigations

You and your students should become familiar with the functions of the pedometers you are using before conducting these investigations. By doing an Internet search for "pedometers" or "pedometer accuracy," you can locate a variety of vendors and related product information. Other sources of information on pedometers include local physical education teachers and the physical education division of a local college or your state Department of Education. Pedometers range considerably in price depending on quality and variety of functions. If you cannot borrow a set from a local source and you need to order only a few of them, expect to spend approximately \$10 to \$30 per pedometer. We used Accusplit Eagle (AE) models 170 and 140s (<http://www.accusplit.com>) in our orientation and many of the investigations. It is a good idea to ascertain that the pedometers are functioning properly prior to using them with students: Pangrazi et al. (2003) provide procedures for testing them. The materials required for the orientation and investigations are outlined below and include the need for a safe place to walk. An additional safety precaution is to be knowledgeable of any students for whom walking, for health or mobility reasons, would be difficult; involve those students in other important tasks (e.g., helping to record data). We recommend that science teachers who plan to conduct these pedometer investigations talk with their health, physical education, and math teacher colleagues about opportunities to coordinate and collaborate. For instance, students can use an experimental design to collect step-count data in physical education classes (see Pangrazi et al.).

Materials

Per student:

1. Pedometer (same brand)
2. Index card

3. Handout with research questions about pedometers (You can select or adapt these questions from http://www.wv-hsta.org/cdc_chc/pedometer_questions.htm or design your own.)
4. Computer with Microsoft Excel or another software program that allows the student to enter, analyze, and graph data and perform simple statistical calculations (Directions provided in this article are for the 2003 version of Microsoft Excel.)

Per small group:

1. Clipboard
2. If the pedometer given to each student has only a step-count feature, then a few other pedometers are needed with additional features to allow small groups to make inquiry about other variables, such as distance traveled and kcal expended.
3. Several other brands or models of pedometers so groups can check the variation, accuracy, and precision in step counts across brands
4. Two rolls of masking tape and linear measuring devices, such as a measurement wheel (the athletic department

Students walk while wearing pedometers.

may have one) or long measuring tape, so students can accurately determine and mark off distances. A global positioning system (GPS) unit also will work for measuring distances outdoors.

5. A safe place to walk, away from motor vehicle traffic (e.g., inside the school building, around the school track, or on grassy fields or sidewalks on school property)

Orientation Activity

Orient students to a pedometer; its functions; how to read the display; what data to enter, if any (e.g., stride length); and where to position it on the body. Refer to the instructional literature that accompanies the pedometer. Additional literature we developed for orientation to two of the pedometers that we used can be found at http://www.wv-hsta.org/cdc_chc/project_resources.htm (see Pedometer Illustrated Guides for AE 140s and 170).

This orientation can be done via direct instruction or as an exploratory activity, in which students examine and test the pedometers on their own, followed by a group discussion of what they discovered about the functions. All brands of pedometers record and report steps taken while walking (step-count data). The AE 140s and 170 also calculate distance walked based on a stride length that the user enters.

The AE 140s also tracks time spent walking, and the AE 170 calculates kcal expenditure using an entered body weight. Pedometer-determined distance walked and kcal expended may differ from actual values and should be considered approximate. Students can compare these values to those obtained through other measures (e.g., kcal expenditure of walking as calculated from MET values; Ainsworth 2002).

If the pedometer that you are using has a distance feature, ask students to determine their own stride length and enter the stride length into the pedometer. One method for determining stride length is to ask each student to follow these steps:

1. Walk a pre-measured linear distance (e.g., 30.5 m, 100 ft) and count the number of steps from start (toes of both shoes on starting line) to end (last step or fraction thereof as the first foot crosses the finish line).
2. Divide that distance by the number of steps taken (e.g., $100 \text{ ft} / 40.5 \text{ steps} = 2.47 \text{ ft per step}$). Some rounding may be necessary when entering stride length into the pedometer.

Investigation Activities

We present two investigations: relation correlation and design your own. The latter is dependent on student knowledge of experimental design setup. The book *Students and Research* (Cothron, Giese, and Rezba 1993) is an excellent tool for such instruction and provides a template for experimental designs.

Prior to carrying out these investigations, review with students the different types of variables: independent (IV), dependent (DV), and constant (CV; see Table 3). The data collection portion of the correlation relation activity can be an extension of the pedometer orientation in which students try out the pedometer.

The investigations that follow provide examples of data analysis and representation using Microsoft Excel. Students will need to be familiar with a spreadsheet program that has data analysis and graphing capabilities. Our procedures assume that the teacher is familiar with basic operations in Excel and has some experience with the graphing, equation, and statistics

functions (this software includes a “Help” drag-down menu). If you use Excel to perform statistics, have the “Add-In” (under “Tools” drag-down menu) called “Analysis ToolPak” installed. This will permit access to “Data Analysis” through the “Tools” drag-down menu. Use “Data Analysis” to choose the statistic of interest.

Relation Correlation

In this activity, students identify research questions and conduct an experiment investigating the relationships between individuals’ heights and their step counts from walking a predetermined distance at normal pace. Mark the starting and stopping points of the distance to be walked (e.g., the inside lane of a track in the school gymnasium or outdoor athletic field), and ensure that the route is a safe distance from motor vehicle traffic.

1. Invite students to test the pedometers by taking a short walk during which each student walks the same distance at his or her normal pace. Tell students that you will use the data collected to pose and answer research questions. Tell students to walk by themselves and not talk to each other, because walking with someone may cause them to alter their normal pace. Instruct them not to compete, and announce any safety precautions.
 - a. Remind students that they need to reset their pedometer step count to 0 immediately before taking the first step of their walk.
 - b. Each student needs to have an index card and pencil on which to write the pedometer step count at the end of the walk, before they take another step beyond the end. Tell students to keep their data private.
 - c. Stagger the start of each walker to leave sufficient space so that one walker does not overtake another (e.g., first walker leaves the starting point, followed 10 s later by second walker, and so forth).
2. Review or introduce the concept of a relationship between two variables. The two variables can have a direct relationship (as one goes up or down, the other does the same), an inverse relationship (as one goes up or down, the other does the opposite), or no relationship (there is no pattern). Ask students what variables they think may have a relationship with step count. Lead students to height as an answer.
 - a. Students should privately write on their index card their known or estimated height in ft and in. (round to the nearest 0.5 in.) and convert that measure to cm; 1 in. = 2.54 cm, round to nearest 0.5 cm). In case a student has no idea of his or her height or wants to know the exact measurement, you may make arrangements in advance with the nurse’s office to measure the heights of students who are interested. Remind students again about keeping their data private: When scientists conduct investigations that use measurements about people, they keep the data as confidential as possible. Thus, tell students not to write their names on the cards, although they may write code names of up to several characters in length that contains at least one number (e.g., strider13).
 - b. If you have a heterogeneous group by gender, students can write “M” or “F” on their card; this increases future possibilities for data analysis.
3. Students should pose a research question about step count and height and a corresponding hypothesis to test the question. For instance, students might ask, “What is the relationship between adolescents’ step counts to walk 500 m (0.5 km) and their heights?” A corresponding hypothesis would be, “There is a direct relationship between the height of adolescents and their step counts to walk a specified distance.”

4. Complete an experimental design that identifies the IV (height), DV (step count), and CVs (e.g., all students might walk the same distance or use the same brand of pedometer to measure their step counts). Collect students' cards and compile a master list of the data to subsequently distribute to students for use in data analysis. Alternatively, you can jump directly to Step 5 and ask students to create their own Excel files of the data by copying you as you build via projection an emerging spreadsheet of the data.
5. Analyze the data. Each student should enter the class-height and step-count data into two columns in an Excel spreadsheet, create a scatter plot to represent that data, and conduct a statistical analysis to determine the correlation between the two variables.
 - a. Scatter plot. Cothron, Giese, and Rezba (1993) illustrate the use of scatter plots of two variables to look for a relationship. You can ask the students to first manually plot the data points on graph paper and then compare their manual plot to a scatter plot graph they create in Excel. Figure 1 shows a scatter plot generated in Excel from example data. Discuss with students what the general pattern of data suggests about the relationship between these two variables. Descending dots, left to right, depict an inverse relationship; ascending dots, left to right, depict a direct relationship; randomly scattered dots suggest little to no relationship.
 - b. Correlation. *Correlation* is a statistical term used to label and quantify the relationship between variables. A direct relationship will have a positive correlation and yield a number between 0 and 1; an inverse relationship will have a negative correlation and yield a number between 0 and -1; no relationship will yield a correlation very close or equal to 0. The technical term for this correlation value is the Pearson productmoment correlation coefficient, designated by the symbol r (Mendenhall, Beaver, and Beaver 1999). The correlation value also describes the strength of the relationship: Larger numbers indicate stronger correlations (e.g., $-.52$ is a stronger negative correlation than $-.25$). In the "Data Analysis" pop-up window, which is accessed by choosing "Data Analysis" from the "Tools" drag-down menu in Excel, choose the statistical test "Correlation." Select the two columns of data and perform the correlation. Note that the columns must be side by side. Discuss the correlation values with the students, including their ideas about IVs that may have a weaker or stronger negative correlation with step count.

Design Your Own

In this activity, small groups of students conduct an experiment about the precision or accuracy of the pedometer or factors that may affect step count (or distance or kcal) data.

1. Brainstorm with students some topic areas and corresponding research questions for inquiring into the accuracy or variability of the data (e.g., step count) provided by the pedometers. Discuss what factors may affect that data, such as pedometer location while walking or walking on level ground as opposed to ascending and descending stairs. Alternatively, give them a handout with a predetermined list of topics and corresponding research questions (available at http://www.wv-hsta.org/cdc_chc/pedometer_questions.htm). Four sample questions adapted from this Web site are:
 - a. What percent error in step count data is associated with the Brand X pedometer when the actual (i.e., manually counted) step count is compared with the pedometerderived (digital) step count?

- b. To what extent does rate of walking impact the percent error in Brand X?
 - c. How much does the step-count data vary across three brands of pedometers?
 - d. How much does the step-count data vary when an individual walks alone as opposed to with a partner?
2. Ask each student to identify a research question that he or she is interested in answering and to draft a corresponding experimental design.
3. Form small groups based on similar student interests. Tell each small group to finalize their experimental design, draft procedures (including safety precautions, which should be checked by the teacher before conducting the experiment), and conduct the experiment. You may wish to assign roles to students (e.g., principal investigator, recorder).
4. After the groups have completed their experiments and analyzed the results, ask students from each group to present their design, procedures, and results (including their research question, hypotheses, data table, and graphics).
5. Discuss with students problems they encountered in conducting their experiments and how they would change their designs and procedures if they were to conduct the experiments again. You may want to focus on variables that were not held constant but should have been and would have led to a fairer test of the hypotheses and more valid results.

Findings and Discussion

Our students were thoroughly engaged in the kcal density activity, willingly completing the calculations involving proportions and clearly demonstrating their understanding of the underlying mathematics. They were surprised to find that the dry cereal actually had a higher energy density than did either the cheeseburger or chili. We found that students initially had trouble interpreting the table key for food composition data, so it is worthwhile to spend extra time at the start explaining how to use it. For activities that required calculating energy expenditures using MET values and comparing those expenditures to energy intake, all students demonstrated their ability to do the mathematics. This was a dramatic improvement over past experiences in which students had considerable difficulty with foundational concepts.

For the relation correlation activity, it is a challenge to get the students to walk alone to collect their step-count data (you may tell students that in the upcoming design your own activity, they can investigate “Walking with someone vs. alone—Does this impact step count?”). In our experiences conducting this relationship investigation, the correlation between height and step count is usually negative. In discussing variables that may produce a stronger negative correlation with step count, leg or stride length may surface.

For the design your own activity, some students volunteered that they had selected their topic based on their perception of what would be easy. A few students had difficulty identifying their IV and DV; for example, some students who chose to examine the “easy” topic of the accuracy of a single brand of pedometer incorrectly identified the IV as the pedometer when the pedometer was a constant (as was the distance to be walked, rate of walking, and the walker). A small group of students who were deemed excellent from past performance examined variance in step count across brands of pedometer. They correctly identified their IV (the brand of pedometer), DV (Step Count), and CVs. However, their report revealed that they used a different walker to test each brand of pedometer, and, accordingly, they had two IVs. They also performed only one trial for each pedometer.

Several groups investigated the impact on step count of walking with someone as opposed to alone. They produced accurate designs but manipulated more than one variable in conducting the experiment (e.g., they walked different distances). These students reflected one of our observations made over the past five years when implementing inquiry-based learning: Students will typically perform well on a multiple-choice or short answer test about the scientific method, but they demonstrate weaknesses in applying what they have learned to an authentic problem. At best, they do not collect data unless the teacher provides them with a data-collection form. At worst, they change the IV haphazardly, creating confusion and anxiety when they try to analyze the data.

Overall, student response to the design your own activity was outstanding, despite the fact that most, if not all, had difficulty explaining their results and what the results proved. Analysis often was limited to a raw data table. Discussion with students about past science learning experiences suggested that they were used to more of a “canned lab” approach, in which they followed and filled out lab sheets. We plan to employ a guided inquiry approach to start all our science projects, transitioning to more open-ended inquiry as students gain confidence and proficiency with this type of learning.

Extensions and Cross-Curricular Applications

In these activities, mathematics is inherently a cross-curricular application. An additional math application for energy-intake data is to ask students to analyze and create a pie graph of the percentage of kcal derived from the energy providing macronutrients (carbohydrate, fat, protein) in each food in their favorite meal or an entire day's worth of meals. They can subsequently modify that meal's or day's intake as needed to reach some recommendation (e.g., 25-35% of kcal coming from fat [USDHHS 2005]). Computer software is used in data analysis and representation, contributing to students' competence in the use of technology.

Our activities also present opportunities for connection with health and physical education classes. For example, Pangrazi, Beighle, and Sidman (2003) suggest hypotheses that students may test about step counts in various physical activities. Students can collect the data to test these hypotheses during physical education class and analyze them in science class. Additionally, students' writing skills can be assessed through the written reports on their pedometer investigations.

To elaborate on energy expenditure, provide students with a problem scenario in which an individual wants to increase his daily expenditure by some specified amount of kcal by making three or more changes in his daily lifestyle. Students can inspect a 24-hr physical activity log typical for this individual and subsequently make modifications to that log to achieve the desired increase. Additionally, the energy expenditure data provided by some pedometers can be explored by comparing that information with the values calculated using the *Compendium* MET values (Ainsworth 2002; e.g., 3.3 MET for walking on a level and firm surface at 5 km/hr [$\sim$ 3 mph]). In making these comparisons, use fictitious body weights and distances. For walking, the *Compendium* provides rates up to 10 km/hr (6 mph; speed walking) and different slopes (e.g., uphill, upstairs, downstairs); you also can inspect jogging and running. How much do the data calculated from the *Compendium* (METs) and shown by the pedometer differ? What might one conclude about pedometer-derived kcal data?

The scatter plot can be taken to another level by asking students to choose “Regression” from the “Data Analysis” menu in Excel and perform the analysis (Excel performs a linear or bivariate regression). Here, we regress the DV (step count, y-axis) on the IV (height, x-axis). In generating the statistical output of the regression table, place a check in the box to the left of “Line Fit Plots” and click “OK.” This results in a scatter plot diagram to the right of the

regression table. Right click on the predicted value data points in the scatter plot and choose “Add Trendline.” Select the “Linear” option and click “OK.” Finally, right click on the trendline, choose “Options” from the “Format Trendline” pop-up window, and check the box to the left of “Display equation on chart” (this is the regression equation, $y = mx + b$, used to calculate the predicted y values). This diagram (regression table plus graph, latter illustrated as Figure 1) can be used to help students learn regression concepts.

Conclusion

The activities presented in this article illustrate the degree to which science and mathematics are interconnected and how technologies such as pedometers and computer spreadsheet and data analysis programs are vehicles to help make those connections. Students enjoy learning with these technologies, and the learning outcomes cut across science education content standards, including science in personal and social perspectives. Greater collaboration among science, mathematics, and health and physical education teachers on energy-balance issues will facilitate integrated, inquiry-based learning that can have a long-term impact on America’s economic well-being, given that the current estimated annual cost of physical inactivity and excess weight in U.S. adults is more than \$507 billion (Chenoweth and Leutzinger 2006).

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FIGURE 1. Scatter plot of actual and predicted step counts and trend line for predicted step counts based on linear regression (regression equation: $y = -3.9418x + 1306.5$).

Table 1

Data on Foods Used in the Energy Intake Activity

Food and measure	Mass (g)	Energy (kcal)	Calculation of kcal per 112 g of food ^a	Calculation of energy density (kcal/g) of food
Chili con carne with beans, 1 cup	246	298	$\frac{112 \text{ g}}{246 \text{ g}} \times 298 \text{ kcal} = 136$	$\frac{136 \text{ kcal}}{112 \text{ g}} = 1.21$
Cheeseburger, 1 regular patty with condiments	127	343	$\frac{112 \text{ g}}{127 \text{ g}} \times 343 \text{ kcal} = 302$	$\frac{302 \text{ kcal}}{112 \text{ g}} = 2.70$
Grape-Nuts Flakes cereal, $\frac{3}{4}$ cup	29	106	$\frac{112 \text{ g}}{29 \text{ g}} \times 106 \text{ kcal} = 409$	$\frac{409 \text{ kcal}}{112 \text{ g}} = 3.65$
M&M's plain chocolate candy, 1.7 oz package	48	236	$\frac{112 \text{ g}}{48 \text{ g}} \times 236 \text{ kcal} = 551$	$\frac{551 \text{ kcal}}{112 \text{ g}} = 4.92$

Note. Mass and kilocalorie data are from U.S. Department of Agriculture (USDA). 2006. *USDA National Nutrient Database for Standard Reference, Release 19*. Agricultural Research Service, Nutrient Data Laboratory Home Page. <http://www.ars.usda.gov/ba/bhnrc/ndl> (accessed July 1, 2006). Data from other sources may differ slightly.

^a Other algorithms or approaches, such as unit (dimensional) analysis, may be used to calculate the kcal value.

Table 2

Example Headings, Descriptions, and Metabolic Equivalent (MET) Values for Five Activities from *The Compendium of Physical Activities Tracking Guide*

Heading	Description	MET
Bicycling	Bicycling, 10-11.9 mph, leisure, slow, light effort	6.0
Home activities	Cleaning, house or cabin, general	3.0
Inactivity quiet	Sitting quietly and watching television	1.0
Transportation	Riding in a car or truck	1.0
Walking	Walking, 3.0 mph, level, moderate pace, firm surface	3.3

Source: Ainsworth B. E. (2002, January). *The compendium of physical activities tracking guide*. Prevention Research Center, Norman J. Arnold School of Public Health, University of South Carolina. http://prevention.sph.sc.edu/tools/docs/documents_compendium.pdf (accessed July 1, 2006). MET values listed above are from year 2000 calculations.

Table 3

Types of Variables in an Experimental Design

Type of variable	Description
Independent	The variable that investigators intentionally change or manipulate. For example, if someone is examining how the step count reported by a pedometer changes when the pedometer is positioned at different places on the body, the independent variable is the location of the pedometer.
Dependent	The variable that may or may not be impacted by changes in the independent variable (e.g., step count in the example above). The dependent variable may be referred to as the <i>responding</i> variable.
Constant	Also known as the control variable, this variable is held constant so all conditions remain the same except for changes in the independent variable. For example, in the step-count investigations described above, if the same walker and same pedometer are used in each trial, they are constant variables.

Note. Variable descriptions are adapted from A. A., Carin, J. E. Bass, and T. L. Contant. 2005. *Teaching science as inquiry*. Upper Saddle River, NJ: Pearson.