Activity Description:
When undertaking a fitness program, you need to know something about your body composition (the amount of fat and fat-free mass in your body). In this activity you will use a Denso Man model to look at body composition and how the densities of “fat” and “fat-free” masses affect overall body density. The model is made of four materials to model basic human body composition: fat (wax), bone (craft stick), muscle (clay), and other tissues and air space (vinyl tube). The focus of this activity will be to see the difference in densities based on changes in the amount of “fat” and “muscle”, as might happen when a person changes diet or exercise routines. Dunk Denso Man under water, do the math, and find out how he’s doing with his fitness plan!

Activity Background:
The study of body composition has been around since the late 19th century. Body composition is a phrase used to discuss the fat and fat-free tissues of the human body. There are a variety of ways to determine body composition. The ways vary as greatly as pinching fat in various places on the body with skinfold calipers to using a Dual-Energy X-ray absorptiometry unit that is a total body scanner and is able to determine fat and fat-free tissues. Bioelectrical impedance determines body composition by looking at the resistance or impedance of electrical current in the body. The more body fat an individual has, the more bioelectrical impedance they have. Hydrodensitometry, or underwater weighing, has been considered the “gold standard” for determining body composition for decades. All new body density assessment equipment has been compared with underwater weighing.

All body composition assessment tools have strengths and limitations. In the table below you will see a comparison of the main body composition assessment methods. The cheaper, simpler methods are more easily used with large population studies but tend to not be as accurate. The very expensive methods are accurate but too cost prohibitive for large population studies.
Method | Capability Measuring Total Body Fat | Capability Measuring Fat Distribution | Applicability in large Population Studies
--- | --- | --- | ---
**Computed Tomography (CT)** | Moderate | Very High | Low
**Magnetic Resonance Imaging (MRI)** | High | Very High | Low
**Dual Energy X-Ray Absorptiometry** | Very High | High | Moderate
**Densitometry** | Very High | Very Low | Low
**Dilution Techniques** | High | Very Low | Moderate
**Bioelectric Impedance Analysis (BIA)** | Moderate | Very Low | High

**Anthropometry**

<table>
<thead>
<tr>
<th>Method</th>
<th>Capability Measuring Total Body Fat</th>
<th>Capability Measuring Fat Distribution</th>
<th>Applicability in large Population Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Mass Index (BMI)</td>
<td>Moderate</td>
<td>Very Low</td>
<td>Very High</td>
</tr>
<tr>
<td>Waist Circumference, Hip Circumference, Waist Hip Ratio, Sagittal Abdominal Diameter</td>
<td>Low</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>Skinfolds</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
</tr>
</tbody>
</table>

Table 1 adapted from: MB Snijder, RM van Dam, M Visser and JC Seidell. *What aspects of body fat are particularly hazardous and how do we measure them?* International Journal of Epidemiology 2006;35:83–92.

**Hydrodensitometry** has a very high rating for determining total body fat but is rated low as a method for large population studies. The reason for this is that the subject is submerged under water in a special tank to determine his or her body density. In a hydrodensitometry assessment, a person is first weighed in air, and then the water temperature is measured, since temperature affects the density of water. Measurements are taken to assess the amount of air in the lungs and a constant value assigned to estimate the amount of air in the intestinal tract. The subject is asked to exhale as much air as possible and his or her weight in water is measured. Calculations are done to determine the density of the test subject. The persons density is then entered into a formula that allows us to calculate the percentage of body fat in the test subject.
In this activity, your students will explore the basic concepts involved in hydrodensitometry. They will be making stick people, literally. The “Denso-Man” and “Denso-Woman” will be made of materials that are of different densities. Each of the materials used will represent the main parts of body composition: fat (wax), muscle (clay), bone (craft stick), and other tissues and air space (vinyl tube).

**Basic Activity Materials per group:**

**Activity Materials:**

- 1 Bin of materials provided by your teacher (per group)
- 1 Bag of Materials to Assemble Denso Man or Denso Woman; See Table 2.
- 1 Triple Beam Balance (per group, although groups can share if needed)
- 1 Copy of the Student Information Page (from class set)
- 1 Copy of the Student Data Page (per student)

**Table 2 Basic List of Materials for Denso Man and Denso Woman**

<table>
<thead>
<tr>
<th>Material List</th>
<th>Denso Man</th>
<th>Denso Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Craft Sticks</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Clay</td>
<td>30 g</td>
<td>22 g</td>
</tr>
<tr>
<td>Wax</td>
<td>10 g</td>
<td>12 g</td>
</tr>
<tr>
<td>Vinyl Tube</td>
<td>4 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Total Body Mass</td>
<td>55 g</td>
<td>45 g</td>
</tr>
</tbody>
</table>

For the Denso Bags, you will need:

- craft sticks—often come in bags of 200-300 or more; find at a craft store; you will need @ 80/class of 32 students
- modeling clay—you will need about 1.25 packs of modeling clay per/period; the 16oz (1 lb.) (454g) Permoplast® Modeling Clay or any clay that is non-toxic/odorless/non-hardening—it is not recommended to get the colored modeling clay because students will be submerging the clay in water; colored clay bleeds—everywhere!
- dental wax—ask your dentist to donate sheets of dental wax; it would be great to have about 5 sheets/class of 32 students
- identity tags—these are included in the Teacher Information Pages
- 10 ft—7/8” (outside diameter) X 5/8” (inside diameter) clear vinyl tubing
- WATTS 42143912; found in plumbing section at hardware store
- tape to label the bags
- dull metal knife and a cutting board to cut the clay
- scissors to cut vinyl tubing and wax
- dry erase marker
- metric ruler
- zip type of sandwich size plastic bags
Activity Instructions:

Denso-Woman coming to a class near you!

1. Lay out all the materials in front of you. It is easier if you do all the Denso Women at the same time and all the Denso Men at the same time.

2. Cut out the labels and tape one on each bag.


4. Open all the bags for the Denso Women.

5. Place 4 craft sticks in each of their plastic zip bags.

6. Cut the vinyl tubing into 3cm pieces; use a dry erase marker to mark 3cm marks on the vinyl tubing and then cut a class set at one time. Place a 3cm vinyl tube in each Denso Woman plastic bag.

7. Take the clay and make 22g clay lumps needed for your class. (3-4 students/groups) Place each lump outside the labeled bags.

8. Measure out 12g of wax/group. Lay each by a Denso Woman bag.

9. Have fun. In this step you get to trade off wax mass for clay mass. You are going to actually have bags with varying amount of wax (fat) and clay (muscle), but each will total 45 g. This simulates how two people can have the same mass, but very different body composition.

10. Measure the mass of wax from one Denso exchanged for an equal mass of clay from another Denso.

11. Re-measure each Denso Woman to make sure they all have an approximate mass of 45g by placing the 4 crafts sticks, 3cm vinyl tube, 12g of wax and 22g of clay on the balance at the same time.

12. Once you are sure that the materials for a Denso Woman are approximately 45g (± .2g) put them in a bag and zip it up. Repeat for the remaining Denso Women. Place each bag in a separate bin.

Time for Denso-Man!

1. Cut out the labels and tape them to the plastic bags for the Denso Men.

2. Open all the bags for the Denso-Men.

3. Place 6 craft sticks in each of their plastic zip bags.

4. Cut the vinyl tubing into 4cm pieces; use the ruler and a dry erase marker to mark the 4cm marks and then cut a class set at one time. Place a 4cm vinyl tube in plastic bag.
5. Take the clay and make **22g clay lumps** needed for your class. (3-4 students/groups) Place each lump outside the labeled bags.

6. Measure out **10g of wax**/group. Lay each by a group bag.

7. In this step you trade off *wax mass for clay mass*. You will have bags with varying amounts of wax (fat) and clay (muscle)—just to have fun with the kids. Once again, this will help prove the point that people can have the same mass but varying amounts of fat.

8. Measure the amount of wax from one *Denso Man* exchanged for clay of the other *Denso Man*.

9. Re-measure each *Denso Man* to make sure they all have an approximate mass of 55g by placing the 6 crafts sticks, 4cm vinyl tube, 10g of wax, and 30g of clay on the balance at the same time.

10. Once you are sure that the materials for a *Denso Man* are approximately 55g (± .2g) put them in a bag and zip it up. Repeat for the remaining *Denso Men*.

11. Place each bag in a separate bin with the remainder of the equipment each student will need.

**Activity Management Suggestions:**

**Modifications:**
Choose student groups so that all students can participate fully in the activity.

**Extensions:**

Student groups write a personal history of a *Denso Man* or *Denso Woman*. The personal history should include information on activity level and caloric intake, along with plans to improve the body composition of the *Denso Person*.

Student groups write a personal history of a *Denso Man* or *Denso Woman*. Based upon the current body composition of *Denso*, what kind of health future might he or she face? What should the Denso character do to improve his or her future?
OPTIONAL: It’s a Stick! It’s Clay! No, it’s Denso-Man! Identity Tags for Denso Materials

Larry Lumberjack  Fitzgerald Fixer  Tommy Teacher  Attorney Al  Jimmy Journalist

Penny Principal  Sally Secretary  Coffee Carry  Jumping Jill  Chef Cheryl

Larry Lumberjack  Fitzgerald Fixer  Tommy Teacher  Attorney Al  Jimmy Journalist

Penny Principal  Sally Secretary  Coffee Carry  Jumping Jill  Chef Cheryl

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**Activity Description:**

Everyday people pass by us—teachers, lawyers, librarians, truck drivers, chefs, farmers, multitudes of people. Little do we know their true identity. Today you will meet one.

Slower than a speeding bullet. Lighter than the average man. Bullets pass through him. Legs like sticks. Hollow inside. Is he a superhero? Yes! Does he stop crime? No! But he is Denso Man, she is Denso Woman! You will use model Denso Men and Denso Women to look at body composition. The model is made of four materials to model basic human body composition: fat (wax), bone (craft sticks), muscle (clay) and other tissues & air space (vinyl tube).

**Activity Background:**

The study of body composition has been around since the late 19th century. Body composition is the phrase used to discuss the fat and fat-free masses of the human body. As you know, the human body is made of a variety of tissues, and is thus a heterogeneous body. Each tissue type has a unique mass and density. You may recall that mass is the amount of matter that makes up something. The more you have of that something the greater the mass. Not only do body tissues have mass, they also have density. Density is the amount of mass per volume of an object. Volume is the amount of space, three-dimensionally, that an object takes up. Body composition assessment involves measuring the total body density of a person. Since muscle is denser than fat, a person with more muscle and less fat will have a greater density than a person of the same mass with more fat and less muscle.

You may be wondering why you are studying body composition. The simple answer: overall health. It has been known for years that an individual with too much fat or too little fat will have a higher risk of health problems over their lifetime. Although muscle is denser than fat it also has the capacity to metabolize, or use food more quickly. That means that fuel from food is used more efficiently. Conversely, a person with less muscle mass and more fat mass will metabolize food slower and less efficiently.

There are a variety of ways to determine body composition. Hydrodensitometry (under water weighing) has been considered the “gold standard” method of assessment for a number of decades. This means that hydrodensitometry has been considered the best standard of assessment. The accuracy of all other body composition assessment methods is compared to hydrodensitometry. The pre-fix: “hydro” means water. Remember that density is the amount of mass in relation to volume of an object. The suffix “-metry” comes from the word meter referring to an instrument used to
measure something. Thus hydrodensitometry measures the density of something while in water! It is a useful skill to be able to break big words into easily understood concepts!

When determining the body composition of an individual using hydrodensitometry, you are comparing the proportion of body fat and fat-free body mass. In other words, the percentage of your body that is fat and the percentage that is not fat. The greater your body density the more muscle and less fat you have. The lower the body density the more fat and less muscle you have. This activity is not an exact representation of a hydrodensitometry assessment, but allows you to explore the concepts involved in such assessments.

Let’s put Denso in the tub!

**Activity Materials:**

- ▼ 1 Bin of materials provided by your teacher (per group)
- ▼ 1 Bag of Materials to Assemble Denso Man or Denso Woman
- ▼ 1 Triple Beam Balance (per group, although groups can share if needed)
- ▼ 1 Copy of the Student Information Page (from class set)
- ▼ 1 Copy of the Student Data Page (per student)
- ▼ Sink or access to water
- ▼ Paper towels

**Activity Instructions:**

**Building Denso!**

1. Gather your materials.

2. Clear your working space of everything except your materials.


4. Remove the materials you were given in the plastic bag. If you have a:
   - "Denso-Woman" you will have only 4 craft sticks, a 3cm vinyl tube, wax, clay, and a total mass of about 45g or
   - "Denso-Man" you will have 6 craft sticks, a 4cm vinyl tube, wax, clay, and a total mass of about 55g.

5. Place all your materials on the balance. Again if you have Denso Woman the total mass of all four materials should be about 45g. Denso Man should have a total mass of about 55g. Due to the fact that all materials were cut and measured your Denso’s total mass may be ± 0.2g from the desired mass. Record the actual mass on Table 1 of your Student Data Page.
6. Look at the diagram on the right. You need to place flat pieces of clay over the openings on the vinyl. As shown in Figure 1, place a little clay on the sides of the vinyl.

**Building Your Denso – Step 1**

![Figure 1 Step 1](image)

- Vinyl Tube-place a flat piece of clay over both ends of the vinyl to prevent water from entering the tube.

7. Begin building your Denso! Notice in Figure 2 only 2 craft sticks are placed on each side (total of 4 sticks). This diagram shows the basic start for building your Denso. *(If you have a male, you will have 3 craft sticks on each side, or a total of 6 sticks).* Place all the sticks in a stack with one on top of the other. Take half the stack, flat side to flat side and press against the vinyl. Repeat with the other stack.

**Building Your Denso – Step 2**

![Figure 2 Step 2](image)

- Craft Sticks-lay the sticks so that the flat sides touch; make a stack of them. Divide stack into two stacks. Lay one stack onto a side of the vinyl tube. Hold with a little clay. Repeat with the other stack on the other side of the tube.

- Clay-place some of the clay over the openings of the vinyl tube to insure Denso has air! Use the rest of the clay to wrap around the sticks to hold your Denso together. Try to make it like a Denso on legs with arms up – ready to jump in the pool!
8. Look at Figure 3. Follow the instructions to complete your “Denso-Woman” or “Denso-Man”!

Building Your Denso –
Step 3

Craft Sticks
Vinyl Tube
Clay-use the remainder of the clay to wrap around the vinyl and sticks; try to make it look like Denso has a body; if there is enough clay left give him/her a head, muscles, etc.
Wax-tear into strips to wrap around the belly of Denso Man; chest and hips for Denso-Woman.

Figure 3 Step 3

Denso Takes the Plunge!
1. Use the triple beam balance to determine the mass of your Denso. Remember that Denso Woman should be approximately 45g; Denso Man should be approximately 55g. Record the mass on the Student Data Page.

2. Place the aluminum pie pan under the plastic cup on a flat table top.

3. Fill the plastic cup with water; about three-fourths full. Use the graduated cylinder to slowly pour water in the cup until it is filled to the brim but NOT overflowed. The Aluminum pie pan should be dry.

4. Gently lower Denso into the cup filled with water. Without allowing your finger to be submerged, press on Denso Man or Denso Woman until the model is completely submerged in the water. The water will overflow into the pie pan.
5. In order to remove water from the cup, lower a drinking straw into the cup. Put your finger over the top opening and withdraw the straw. You have drawn some of the water out of the cup so you can pick it up without spilling. Allow the water in the straw to empty into the sink. Repeat until your group thinks it can safely lift the cup without spilling water into the pie pan. This helps to make sure you get a more accurate reading of the volume of water your Denso displaced.

6. Lift the cup out of the pan without spilling water.

7. Use your fingers and gently make a pour spout on one edge of the pie pan by crimping the edge.

8. Carefully pour the water out of the pie pan into the graduated cylinder.

9. Look at the bottom of the meniscus and determine the volume of water displaced by Denso. This volume of water equals the volume of Denso. Record the volume of your Denso on the Student Data Page.

10. Repeat steps 1-9 for Trial 2. Record data in Table 2 on your Student Data Page. Find the average of your two trials.

11. Determine the density of your Denso by dividing the mass of your Denso by its volume. Record on the Student Data Page.

12. Place your fingers over the opening of the cup and slowly pour the water out into the sink. Remove your Denso and place it on the paper towel to dry.

13. Dry off all your equipment. Place your equipment, except your Denso wrapped in its paper bath towel, back in the bin.


15. Clean up according to your teacher’s instruction.
Hy-Density: It’s a Stick! It’s Clay! No, It’s Denso-Man!

Student Data Page Activity 3B Part 6

Name of Denso: ______________________________________
Job/Hobby: ______________________________________
Female/Male: __________________ Age: _____________

Mass: __________
Volume: __________
Density (mass/volume):

Observations:
(Does your Denso sink, float or hang suspended in water? Other observations?)

QUESTIONS ???

LESSON 3
ACTIVITY 3B PART 6
Calculate the density of your Denso Model and record in Table 1.

**Table 1 Density of Denso**

<table>
<thead>
<tr>
<th>Denso Name</th>
<th>Total Mass (g)</th>
<th>Volume (ml)</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
<td>Average</td>
</tr>
</tbody>
</table>

Write the Data for each Denso Model in your Class and record the information in Table 2.

**Table 2 Class Data Table**

<table>
<thead>
<tr>
<th>Denso Man</th>
<th>Denso Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Name</td>
</tr>
<tr>
<td>Mass (g)</td>
<td>Mass (g)</td>
</tr>
<tr>
<td>Volume (ml)</td>
<td>Volume (ml)</td>
</tr>
<tr>
<td>Density (g/ml)</td>
<td>Density (g/ml)</td>
</tr>
</tbody>
</table>
1. Define:
   a. Mass: ______________________________________________________
      ____________________________________________________________
      ____________________________________________________________
   b. Volume: ____________________________________________________
      ____________________________________________________________
      ____________________________________________________________
   c. Density: ____________________________________________________
      ____________________________________________________________
      ____________________________________________________________

2. Look at the Table 2 Class Data. Look at the data for all the Denso Women, you will notice they all have about the same mass. Are their densities the same?
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________

3. If the densities are not exactly the same, what could explain the difference?
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________

4. In what way does Denso model basic human body composition?
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________

5. What are some of the limitations of the Denso model in comparison to basic human body composition?
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________
   ________________________________________________________________________________
6. *Denso Woman* went to the doctor eight months ago. Her doctor ordered her to get a body composition assessment using hydrodensitometry. *Denso Woman’s* results showed she had a higher percentage of fat than in previous tests.

*Denso Woman* began to watch her diet and exercise more. She has her yearly check-up with her doctor in three months. *Denso Woman* has noticed that her jeans are getting looser and she is looking more buff.

If *Denso Woman* continues watching her diet and exercising, what do you predict her hydrodensitometry assessment results will be?

_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

Explain the reasons for your prediction.

_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

7. *Denso Man* injured a leg 6 months ago and is not running around like he used to. *Denso Man* has his yearly check-up next week. If his doctor orders a hydrodensitometry assessment, what do you predict his results will be compared to the assessment done when he was running every day and watching his calorie intake carefully?

_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

Explain the reasons for your prediction.

_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________