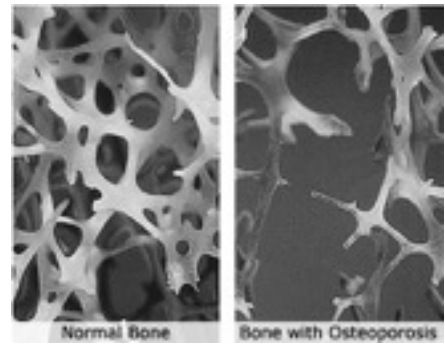# Bone Density & Osteoporosis
Calculating Density

Case Study – Background & Introduction

Your bones are constantly rebuilding themselves. As cells die, your body produces new cells to replace them. If your body cannot keep up with producing new cells, you may develop more open space within your bones. The condition associated with low bone density is called osteoporosis.

https://www.nia.nih.gov/health/publication/menopause-time-change/postmenopausal-health-concerns

There are a few reasons that people develop osteoporosis. In order to build new bone cells your body needs to absorb calcium. Taking calcium supplements or increasing your intake of calcium rich foods like dairy, certain vegetables and seafood can help you avoid bone loss. In order to absorb the calcium you need Vitamin D, which is why milk and other products are fortified by adding in vitamins.
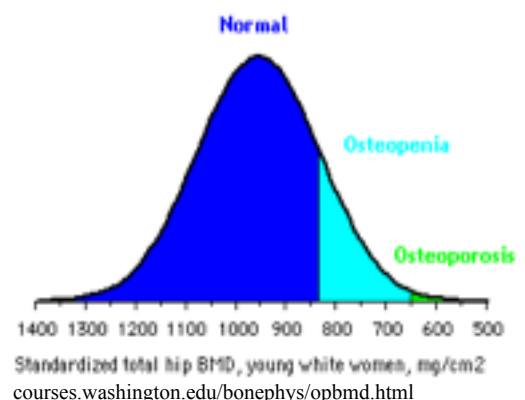

NASA.gov

Activity is also essential for building bones. If you reduce the impact felt by your bone cells there will be increased bone resorption (which means that more bone cells will begin to die) and there is reduced formation of new cells. Astronauts actually have 1.5% bone loss each month they are in space because their bone cells don't experience much impact and don't have to fight gravity. This means that if they stay for 6 months they can lose 10 percent of their bones! It can take up to 4 years for them to truly recover. This is why you might see astronauts doing a lot of exercising in space – it's not just to stay fit, but it is also to stimulate their bone cells to form.

Although not as severe as an astronaut's experience, your own inactivity can reduce your bone strength. As people age they tend to decrease their calcium intake, and also decrease their activity. In women, Estrogen helps to protect bones, so after menopause that protection ends and can greatly increase bone loss.

These combined with genetic predispositions and changes in the amount of calcium you need, can result in a severe decrease in bone density. This means that a small fall will result in severe fractures and long term recuperation.

From the age of 20 to 80, women lose 1/3rd of their bone density, and men lose 1/4th, which is why women tend to have more issues with osteoporosis. Caucasian women in particular have a genetic predisposition for bone loss so they are at the most risk.

Standardized total hip BMD, young white women, mg/cm2
courses.washington.edu/bonephys/opbmd.html

Scenario

In order to find the bone density on a living person, a radiologist takes an x-ray of the bones. The computer uses complex mathematical calculations to extrapolate the density of the bone based on the exposure levels of the x-ray. In this mathematical exercise you will use the density equation and apply it to simulated samples that you *would* have taken if you were to sample the bone directly.

Calculating Density

Density is a measurement that relates the volume of an item with its mass. Just because something weights a lot doesn't make it dense. Compare in your mind a pound of feathers and a pound of rocks. Which one weighs more? Trick question – they *weigh* the same. The difference is the volume they take up. This is because the rocks are more dense, so they take up less space based on their mass.

Use the following equation to answer the following problems: $Density = \dfrac{Mass}{Volume}$

>833 mg/cm³
Normal Bone Density

Osteopenia
833-648 mg/cm³

<648 mg/cm³
Osteoporosis

Key

Patient	Density in mg/cm³	Diagnosis
1	900	Normal
2	667	Osteopenia
3	800	Osteopenia
4	1200	Normal
5	725	Osteopenia
6	1400	Normal
7	630	Osteoporosis
8	550	Osteoporisis
9	950	Normal
10	690	Osteopenia
11	1100	Normal
12	Volume: 30.5cm³	Osteopenia
13	Mass: 47.4g	Normal
14	Volume: 67.7cm³	Osteoporosis
15	Volume: 69.27cm³ Mass:50.2g	Osteopenia

Bone Density & Osteoporosis
Calculating Density

$$Density = \frac{Mass}{Volume}$$

Directions
Find the density of each bone sample, and give a diagnosis of Normal, Osteopenia or Osteoporosis

---

Patient #1: A 1cm^3 sample was taken and it weighed 900mg
      density: diagnosis:
Work:

Patient #2: A 1.5cm^3 sample was taken and it weighed 1000mg
      density: diagnosis:
Work:

Patient #3: A 0.75cm^3 sample was taken and it weighed 600mg.
      density: diagnosis:
Work:

Patient #4: A 0.5cm^3 sample was taken and it weighed 350mg.
      density: diagnosis:
Work:

Rearranging the equation

Patient #12: This patient has a bone density of 820mg/cm^3. What is the volume of a 25g sample?
      Volume (in cm^3)   diagnosis:
Work:

Patient #13: The patient has a bone density of 1200mg/cm^3. What is the mass of a 39.5cm^3 sample?
      Mass (in grams)   diagnosis:
Work:

Patient #14: This patient has a bone density of 635mg/cm^3. What is the volume of a 43g sample?
      Volume (in cm^3)   diagnosis:
Work: