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STEM Project

Chapter 7: Surviving

Pages 115–138

Bone density

Density is the amount of matter in a given space. It is a measure of how compact a material is.

Bone density is the mass of bone per cubic centimetre (the mass per unit volume). It is measure that tells us about how strong a bone is – the more mass in each cubic centimetre, the less likely it is for the bone to break.

Bone density in humans tends to peak when they are young adults and then starts to decline. However, bone density is positively affected by weight bearing activities. These are activities where a person uses their muscles to push against the force of gravity. Walking, tennis and weight lifting are all weight bearing activities. Engaging in weight bearing forms of exercise will slow down the loss of bone density as a person ages. It will also reduce the chances of developing a medical condition called 'osteoporosis', which occurs when bones lose too much density. Osteoporosis is typically associated with age as well as hormonal changes or a deficiency of calcium or vitamin D.

In this task, you will investigate how much force is required to break the bones of different animals with different bone densities.

Bone Density experiment

Aim: To measure the relationship between bone density and the force required to break a bone.

Materials:

- Chicken rib bone
- Lamb or pig rib bone
- Fish rib bone
- Kitchen scales
- A beaker
- Water
- Hanging weights secured with fishing line
- Retort stands or clamps

Method:

1 Measure the mass in *kilograms* of each bone with the kitchen scales and record it in the table in the Data and Results section. Be careful to record it in kilograms, not grams.

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2 Fill up the beaker to a chosen volume that will provide enough water to submerge your bones.

3 Submerge each bone, one by one, into the water. Note by how much the volume measurement of the water in the beaker increases when the bone is fully submerged. This is the volume of the bone in millilitres (mL).

4 In the table, record the volume of each bone in cm^3 (note that 1mL = 1 cm^3).

5 Use the results to calculate the density of each bone and write it in the table. The density is the mass (kg) divided by the volume (cm^3).

6 Use the clamps to secure the bones horizontally to the table.

7 Attach hanging weights to the centre of the secured bone with fishing line. Slowly increase the amount of weight hanging from the bone until the bone breaks.

8 In the Data and Results section, record the mass of the weights (in kilograms) required to break each bone.

9 Use these results to calculate the force that was required to break the bones. Force is the mass multiplied by the acceleration due to gravity (which is approximately 9.8m/s^2).

10 Underneath your results tables, graph the bone density against the force required to break the bone.

Data and results

Animal rib	Mass (kg)	Volume (cm^3)	Density mass/volume (kg/cm^3)
Chicken			
Lamb/Pig			
Fish			

Animal Bone	Mass that broke the bone (kg)	Acceleration due to gravity (m/s^2)	Force to break bone mass X acceleration (Newtons, N)
Chicken		9.8	
Lamb/Pig		9.8	
Fish		9.8	

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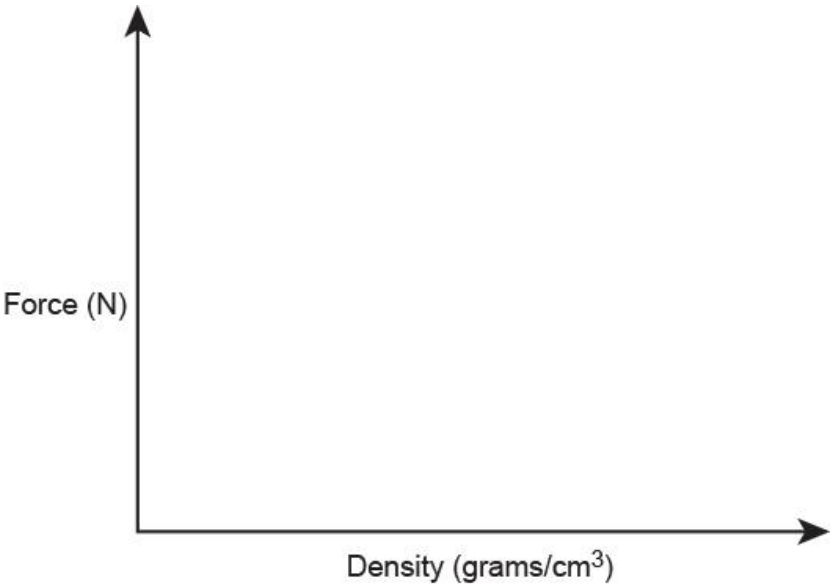
Bone density vs Force required to break the bone



Discussion and reflection

1 Describe the relationship between the density of the bones and the force required to break them. Is this what you expected?

2 What possible uncontrolled variables may have affected your results?

3 If each of the animal bones you tested had osteoporosis, which reduced the bone density you measured by 20%, predict the force that would have been required to break them.

Chicken:

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Lamb/Pig:

Fish:

Extension activity

The acceleration due to gravity on Earth is 9.8 m/s^2.

The acceleration due to gravity on Mars is 3.7 m/s^2.

Would bones be more or less likely to break on Mars than on Earth? _____

How could you work out the hanging mass required to break the bones you tested on Mars? Calculate this mass for each bone.

Chicken:

Lamb/Pig:

Fish:

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Astronauts in an orbit in space experience zero gravity. Is it possible to break a bone at zero gravity? Explain your answer.

At zero gravity, it is very difficult to do weight-bearing exercise. What are the implications of spending long periods in space for the bone density of astronauts? How could this be overcome?

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