

## AP Statistics Exploration When Does Blocking Help?

Name: \_\_\_\_\_

A set of 24 dogs (6 of each of 4 breeds, each attending 1 of 4 veterinary clinics) has been randomly selected from a population of dogs older than 8 years of age whose owners have given consent for their inclusion in a study. The purpose of the study is to determine (i) whether there are different changes in bone density over the year of the study for dogs in three treatment groups; and, if so (ii) how much each treatment influences that change in bone density.

Each dog will be assigned to exactly one of three treatments. Group “Ca” will receive a dietary supplement of calcium, Group “Ex” will receive a dietary supplement of calcium and a daily exercise regimen, and Group “Co” will be a control group that receives no supplement to their ordinary diet and no additional exercise. All dogs will be given a bone density evaluation at the beginning and end of the one-year study. Bone density is measured in Houndsfield units--positive values indicate an increase in bone density and negative values represent a decrease.

### The Simulation:

We will simulate three possible design scenarios for this study -- Completely Randomized Design, Blocked by Breed, and Blocked by Clinic. Throughout the course of the simulation, YOU will be playing a particular dog who will be assigned to a treatment. Your breed and clinic will not change as we switch designs. However, your treatment may change. Your job is to calculate your change in bone density as a response to your given treatment under each design. My job is to act as the Researcher and randomly assign treatments under each design.

### Select your Dog:

You will be dealt a card indicating your dog’s name, breed, clinic, and typical dog bone density change. Record that information below. Do not reveal your information to any other dogs.

Name	Breed	Clinic	Dog Density Change

- Select a Blue card corresponding to your dog’s breed. Note the typical bone density change by breed below.
- Select a Yellow card corresponding to your dog’s clinic. Note the typical bone density change by clinic below.
- Select an Orange card representing “other” contributing factors to bone density. Follow the instructions on the card and record the bone density change below:

Breed Density Change	Clinic Density Change	Other Density Change

### Design I: Completely Randomized Design:

One way to assign treatments is to randomly allocate the dogs into three treatment groups.

Sketch a completely randomized design for this study below:

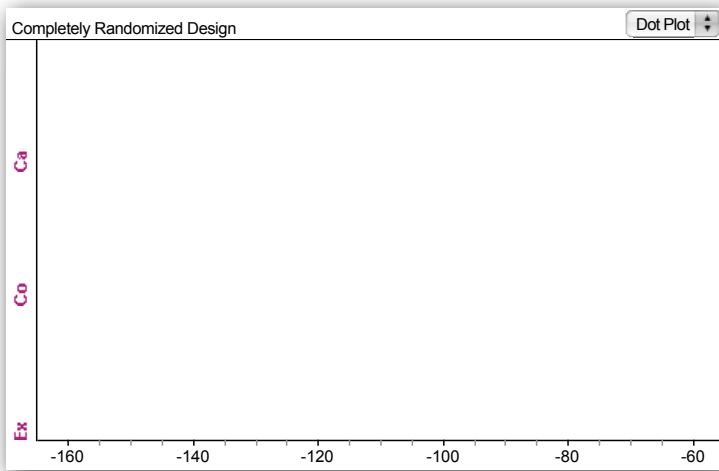
You will be dealt a card indicating your year-long treatment. Record the bone density change from your randomly assigned treatment.

Treatment	Density Change

Your total bone density change is based on a combination of your typical dog density change, breed, clinic, other contributing factors, and treatment. Calculate your total bone density change for the completely randomized year-long study and record it below.

Dog	Breed	Clinic	Other	Treatment	TOTAL

There are three stacked dotplots on the board, one for each treatment. Record your total bone density change on the appropriate dotplot and sketch all three below:



Is there a clear difference between the treatments? That is, is there a difference in the centers of the three distributions?

How does the variability within each treatment group affect our ability to see differences in overall bone density change from group to group?

Return your Treatment card to the Researcher to prepare for the next simulation.

## Design 2: Randomized Block Design, Blocked by Breed:

Another way to assign treatments is to separate the dogs by breed and then randomly allocate the dogs in each breed into three treatment groups.

Sketch a blocked by breed design for this study below:

You will be dealt a card indicating your year-long treatment. Record the bone density change from your randomly assigned treatment.

Treatment	Density Change

Your total bone density change is based on a combination of your typical dog density change, breed, clinic, other contributing factors, and treatment. Calculate your total bone density change for the blocked by breed year-long study and record it below.

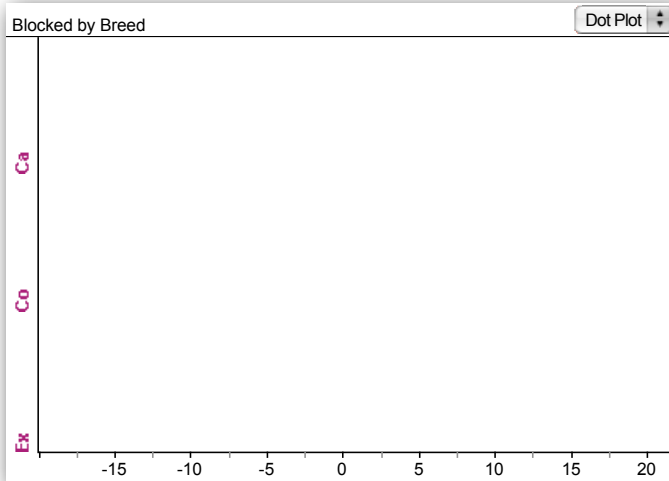
Dog	Breed	Clinic	Other	Treatment	TOTAL

Locate the other 5 dogs from your breed. Record each dog's bone density change based on treatment below. Then, calculate the overall average bone density change for your breed.

Finally, calculate the effect of the treatment on the average bone density change by subtracting the breed average from each dog's observed response. Why do we do this?

	Observed Changes				Observed-Average		
Exercise				Breed Average	Exercise		
Calcium					Calcium		
Control					Control		

There are three stacked dotplots on the board, one for each treatment. Record your "Observed-Average" differences on the appropriate dotplots and sketch all three below:



Is there a clear difference between the treatments? That is, is there a difference in the centers of the three distributions?

Can you estimate the average amounts by which the treatments improve bone density?

Return your Treatment card to the Researcher to prepare for the next simulation.

### Design 3: Randomized Block Design, Blocked by Clinic:

Another way to assign treatments is to separate the dogs by clinic and then randomly allocate the dogs from each clinic into three treatment groups.

Sketch a blocked by clinic design for this study below:

You will be dealt a card indicating your year-long treatment. Record the bone density change from your randomly assigned treatment.

Treatment		Density Change	
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Your total bone density change is based on a combination of your typical dog density change, breed, clinic, other contributing factors, and treatment. Calculate your total bone density change for the blocked by clinic year-long study and record it below.

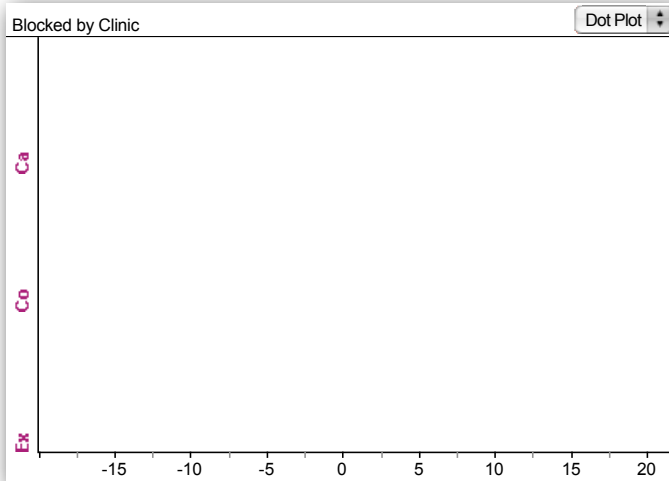
Dog	Breed	Clinic	Other	Treatment	TOTAL

Locate the other 5 dogs from your clinic. Record each dog's bone density change based on treatment below. Then, calculate the overall average bone density change for your clinic.

Finally, calculate the effect of the treatment on the average bone density change by subtracting the clinic average from each dog's observed response.

	Observed Changes				Observed-Average		
Exercise				Clinic Average	Exercise		
Calcium					Calcium		
Control					Control		

There are three stacked dotplots on the board, one for each treatment. Record your "Observed-Average" differences on the appropriate dotplots and sketch all three below:



Is there a clear difference between the treatments? That is, is there a difference in the centers of the three distributions?

In which simulation/design was it easiest to discern the effects of the three treatments?

How did the characteristics of the variables and the design of the allocation work together to make that particular design scheme work best?

<p><b>You are “Elmer”</b>  <b>Breed: Akita</b>  <b>Clinic: Treehouse</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Bernie”</b>  <b>Breed: Akita</b>  <b>Clinic: Barking Lot</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Queenie”</b>  <b>Breed: Akita</b>  <b>Clinic: Pooch Palace</b>  <b>Your Annual Bone Density Change: -105</b></p>
<p><b>You are “Sugar”</b>  <b>Breed: Akita</b>  <b>Clinic: Paw Prince</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Jock”</b>  <b>Breed: Akita</b>  <b>Clinic: Pooch Palace</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Curly”</b>  <b>Breed: Akita</b>  <b>Clinic: Treehouse</b>  <b>Your Annual Bone Density Change: -105</b></p>
<p><b>You are “Rocky”</b>  <b>Breed: Beagle</b>  <b>Clinic: Paw Prince</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Happy”</b>  <b>Breed: Beagle</b>  <b>Clinic: Pooch Palace</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Nico”</b>  <b>Breed: Beagle</b>  <b>Clinic: Barking Lot</b>  <b>Your Annual Bone Density Change: -105</b></p>
<p><b>You are “Alex”</b>  <b>Breed: Beagle</b>  <b>Clinic: Treehouse</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Pepper”</b>  <b>Breed: Beagle</b>  <b>Clinic: Paw Prince</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Snickers”</b>  <b>Breed: Beagle</b>  <b>Clinic: Paw Prince</b>  <b>Your Annual Bone Density Change: -105</b></p>
<p><b>You are “Buster”</b>  <b>Breed: Collie</b>  <b>Clinic: Barking Lot</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Newton”</b>  <b>Breed: Collie</b>  <b>Clinic: Pooch Palace</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Sparky”</b>  <b>Breed: Collie</b>  <b>Clinic: Treehouse</b>  <b>Your Annual Bone Density Change: -105</b></p>
<p><b>You are “Lad”</b>  <b>Breed: Collie</b>  <b>Clinic: Treehouse</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Julius”</b>  <b>Breed: Collie</b>  <b>Clinic: Paw Prince</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Cinnamon”</b>  <b>Breed: Collie</b>  <b>Clinic: Barking Lot</b>  <b>Your Annual Bone Density Change: -105</b></p>
<p><b>You are “Rex”</b>  <b>Breed: Dalmation</b>  <b>Clinic: Pooch Palace</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Euclid”</b>  <b>Breed: Dalmation</b>  <b>Clinic: Pooch Palace</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Spot”</b>  <b>Breed: Dalmation</b>  <b>Clinic: Barking Lot</b>  <b>Your Annual Bone Density Change: -105</b></p>
<p><b>You are “Archie”</b>  <b>Breed: Dalmation</b>  <b>Clinic: Barking Lot</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Euler”</b>  <b>Breed: Dalmation</b>  <b>Clinic: Paw Prince</b>  <b>Your Annual Bone Density Change: -105</b></p>	<p><b>You are “Lucy”</b>  <b>Breed: Dalmation</b>  <b>Clinic: Treehouse</b>  <b>Your Annual Bone Density Change: -105</b></p>



<p><b>Breed: Akita</b></p> <p><b>Annual Bone Density Change for your Breed: -2</b></p>	<p><b>Breed: Akita</b></p> <p><b>Annual Bone Density Change for your Breed: -2</b></p>	<p><b>Breed: Akita</b></p> <p><b>Annual Bone Density Change for your Breed: -2</b></p>
<p><b>Breed: Akita</b></p> <p><b>Annual Bone Density Change for your Breed: -2</b></p>	<p><b>Breed: Akita</b></p> <p><b>Annual Bone Density Change for your Breed: -2</b></p>	<p><b>Breed: Akita</b></p> <p><b>Annual Bone Density Change for your Breed: -2</b></p>
<p><b>Breed: Beagle</b></p> <p><b>Annual Bone Density Change for your Breed: 9</b></p>	<p><b>Breed: Beagle</b></p> <p><b>Annual Bone Density Change for your Breed: 9</b></p>	<p><b>Breed: Beagle</b></p> <p><b>Annual Bone Density Change for your Breed: 9</b></p>
<p><b>Breed: Beagle</b></p> <p><b>Annual Bone Density Change for your Breed: 9</b></p>	<p><b>Breed: Beagle</b></p> <p><b>Annual Bone Density Change for your Breed: 9</b></p>	<p><b>Breed: Beagle</b></p> <p><b>Annual Bone Density Change for your Breed: 9</b></p>
<p><b>Breed: Collie</b></p> <p><b>Annual Bone Density Change for your Breed: 32</b></p>	<p><b>Breed: Collie</b></p> <p><b>Annual Bone Density Change for your Breed: 32</b></p>	<p><b>Breed: Collie</b></p> <p><b>Annual Bone Density Change for your Breed: 32</b></p>
<p><b>Breed: Collie</b></p> <p><b>Annual Bone Density Change for your Breed: 32</b></p>	<p><b>Breed: Collie</b></p> <p><b>Annual Bone Density Change for your Breed: 32</b></p>	<p><b>Breed: Collie</b></p> <p><b>Annual Bone Density Change for your Breed: 32</b></p>
<p><b>Breed: Dalmation</b></p> <p><b>Annual Bone Density Change for your Breed: -39</b></p>	<p><b>Breed: Dalmation</b></p> <p><b>Annual Bone Density Change for your Breed: -39</b></p>	<p><b>Breed: Dalmation</b></p> <p><b>Annual Bone Density Change for your Breed: -39</b></p>
<p><b>Breed: Dalmation</b></p> <p><b>Annual Bone Density Change for your Breed: -39</b></p>	<p><b>Breed: Dalmation</b></p> <p><b>Annual Bone Density Change for your Breed: -39</b></p>	<p><b>Breed: Dalmation</b></p> <p><b>Annual Bone Density Change for your Breed: -39</b></p>

<p><b>Clinic: Treehouse</b></p> <p><b>Annual Bone Density Change for your Clinic: 1</b></p>	<p><b>Clinic: Treehouse</b></p> <p><b>Annual Bone Density Change for your Clinic: 1</b></p>	<p><b>Clinic: Treehouse</b></p> <p><b>Annual Bone Density Change for your Clinic: 1</b></p>
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<p><b>Clinic: Barking Lot</b></p> <p><b>Annual Bone Density Change for your Clinic: 2</b></p>	<p><b>Clinic: Barking Lot</b></p> <p><b>Annual Bone Density Change for your Clinic: 2</b></p>	<p><b>Clinic: Barking Lot</b></p> <p><b>Annual Bone Density Change for your Clinic: 2</b></p>
<p><b>Clinic: Barking Lot</b></p> <p><b>Annual Bone Density Change for your Clinic: 2</b></p>	<p><b>Clinic: Barking Lot</b></p> <p><b>Annual Bone Density Change for your Clinic: 2</b></p>	<p><b>Clinic: Barking Lot</b></p> <p><b>Annual Bone Density Change for your Clinic: 2</b></p>
<p><b>Clinic: Pooch Palace</b></p> <p><b>Annual Bone Density Change for your Clinic: 0</b></p>	<p><b>Clinic: Pooch Palace</b></p> <p><b>Annual Bone Density Change for your Clinic: 0</b></p>	<p><b>Clinic: Pooch Palace</b></p> <p><b>Annual Bone Density Change for your Clinic: 0</b></p>
<p><b>Clinic: Pooch Palace</b></p> <p><b>Annual Bone Density Change for your Clinic: 0</b></p>	<p><b>Clinic: Pooch Palace</b></p> <p><b>Annual Bone Density Change for your Clinic: 0</b></p>	<p><b>Clinic: Pooch Palace</b></p> <p><b>Annual Bone Density Change for your Clinic: 0</b></p>
<p><b>Clinic: Paw Prince</b></p> <p><b>Annual Bone Density Change for your Clinic: -3</b></p>	<p><b>Clinic: Paw Prince</b></p> <p><b>Annual Bone Density Change for your Clinic: -3</b></p>	<p><b>Clinic: Paw Prince</b></p> <p><b>Annual Bone Density Change for your Clinic: -3</b></p>
<p><b>Clinic: Paw Prince</b></p> <p><b>Annual Bone Density Change for your Clinic: -3</b></p>	<p><b>Clinic: Paw Prince</b></p> <p><b>Annual Bone Density Change for your Clinic: -3</b></p>	<p><b>Clinic: Paw Prince</b></p> <p><b>Annual Bone Density Change for your Clinic: -3</b></p>



