Basic Statistics for the Clinician

Matthew S. Briggs PT, DPT, PhD, SCS, AT

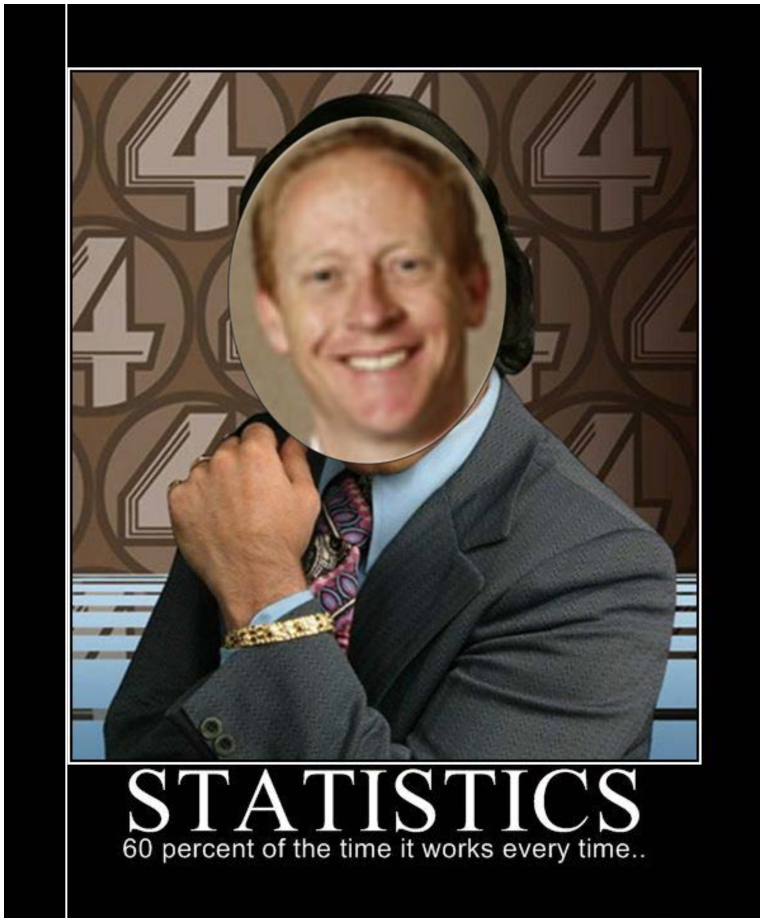
THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

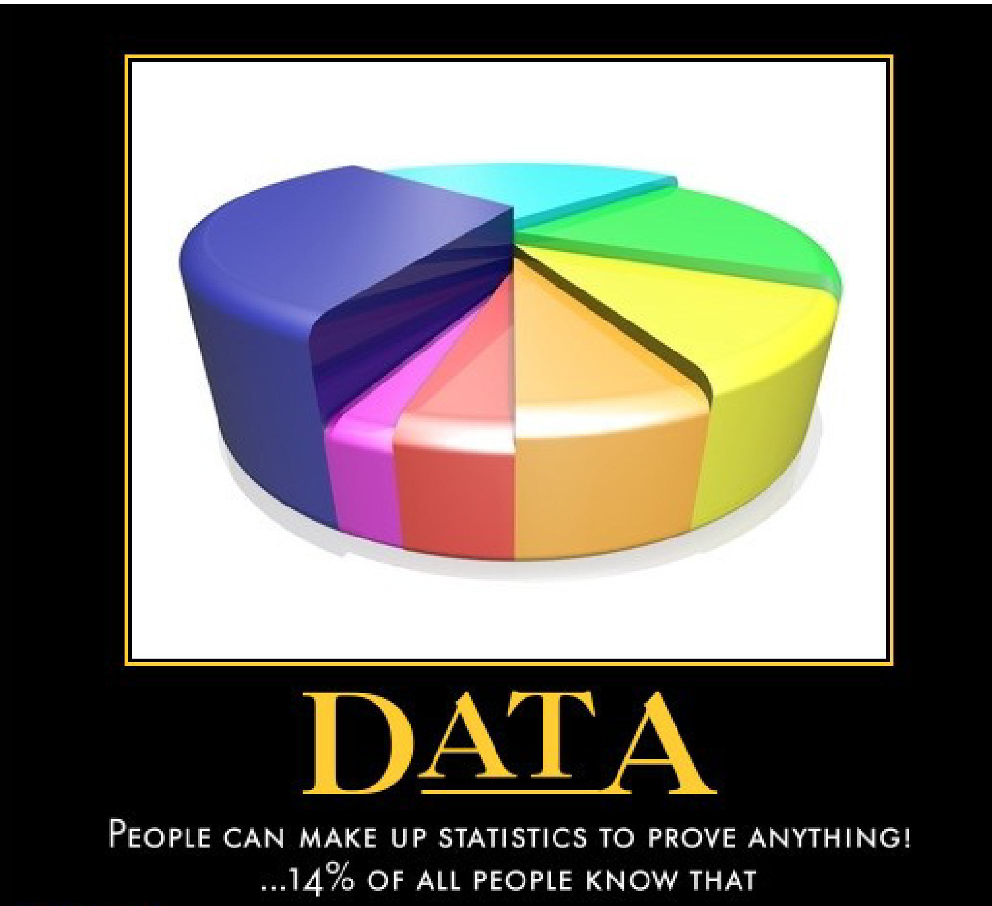
OSU Sports Medicine

Disclosure

Nothing to disclose

Why do I need to know statistics…?





…and for any other reason…

THEY WILL BE ON YOUR SPECIALTY BOARD EXAM!!!

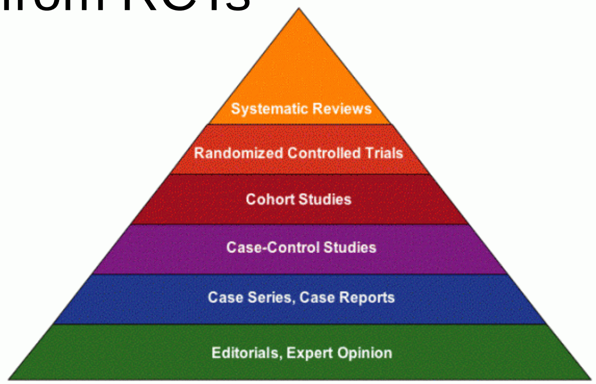
Learning Objectives

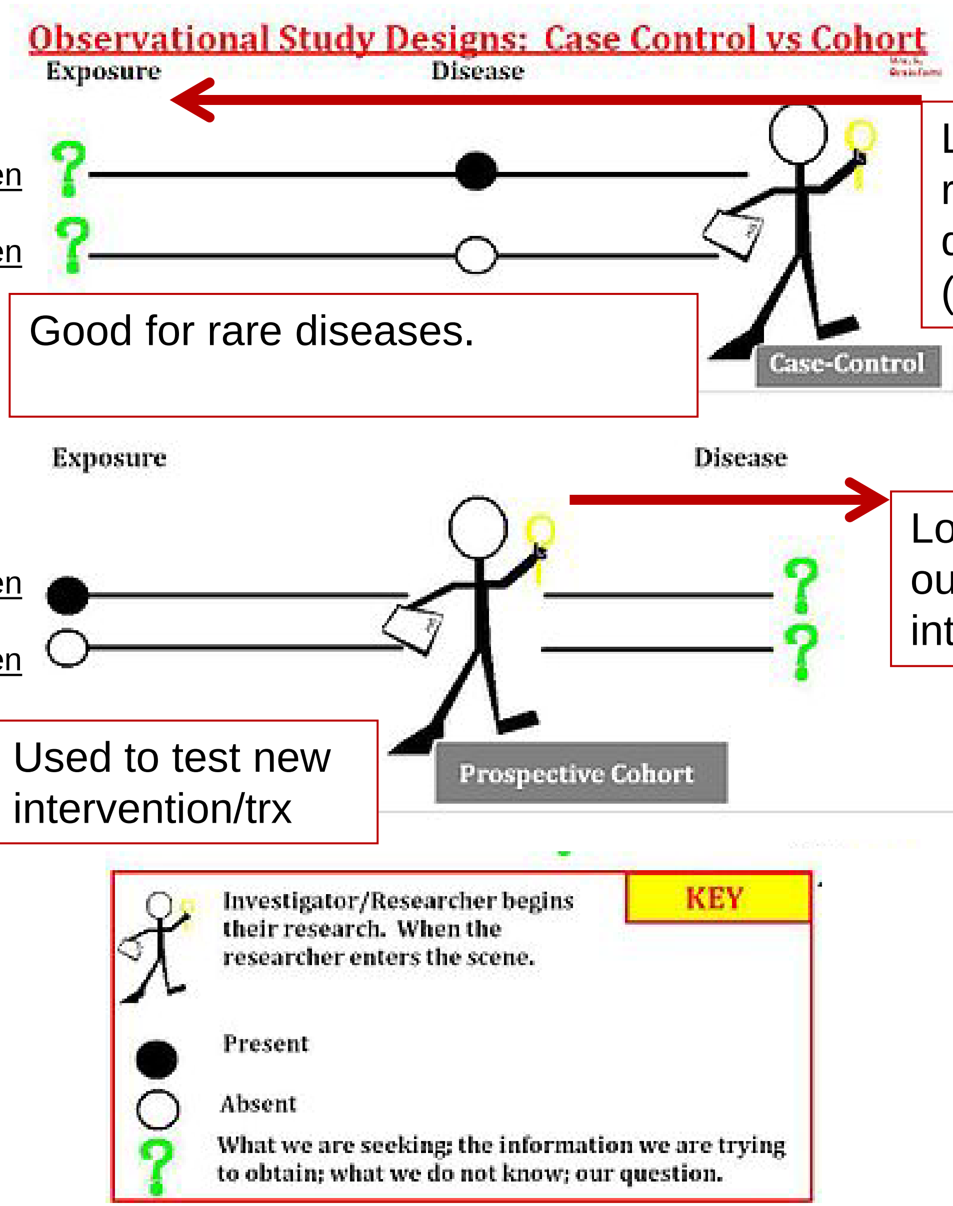
- Review basic study design & levels of evidence common to clinical research
- Review basic applications of hypothesis testing:
  - purpose of *p*-value
  - tests for determining difference b/w groups
    - (eg. t- test & ANOVA, etc.)
  - tests for determining relationships
    - (eg. Correlation analysis, regression, etc.)
- Understand difference between prevalence & incidence
- Review & understand results of basic statistical analysis commonly used in clinical diagnostic research:
  - Sensitivity, Specificity
  - Positive Predictive Value, Negative Predictive Value

Common Clinical Research Design Types Study

"…how did dey do dat?"

- **Systematic Reviews/Meta-Analysis**
  - Focused review and synthesis of results from RCTs
- **Randomized Controlled Trial**:
  - Subject randomized into different groups
- **Cohort**:
  - Examine 2 or more groups over time
- **Case Control**:
  - Patients with condition are matched to a control group
- **Cross-Sectional**:
  - Data is collected at a single point in time (prevalence)
- **Case Reports/Case Series**:
  - Medical histories in one or more patients with condition or treatment





No Sunscreen

Sunscreen

Look back at exposures related to groups that did/didn't have condition (retrospective)

Good for rare diseases.

Lotion Sunscreen

Spray Sunscreen

Look forward at outcomes related to intervention (longitudinal)

Used to test new intervention/trx

http://en.wikipedia.org/wiki/Case-control_study


STATISTICS
THE DISCIPLINE THAT PROVES
THE AVERAGE HUMAN HAS
ONE TESTICLE

What are these?

- P – value
- T-test
- Analysis of Variance (ANOVA)
- Pearsons Correlation (r)
- Regression (r^2)

Error?

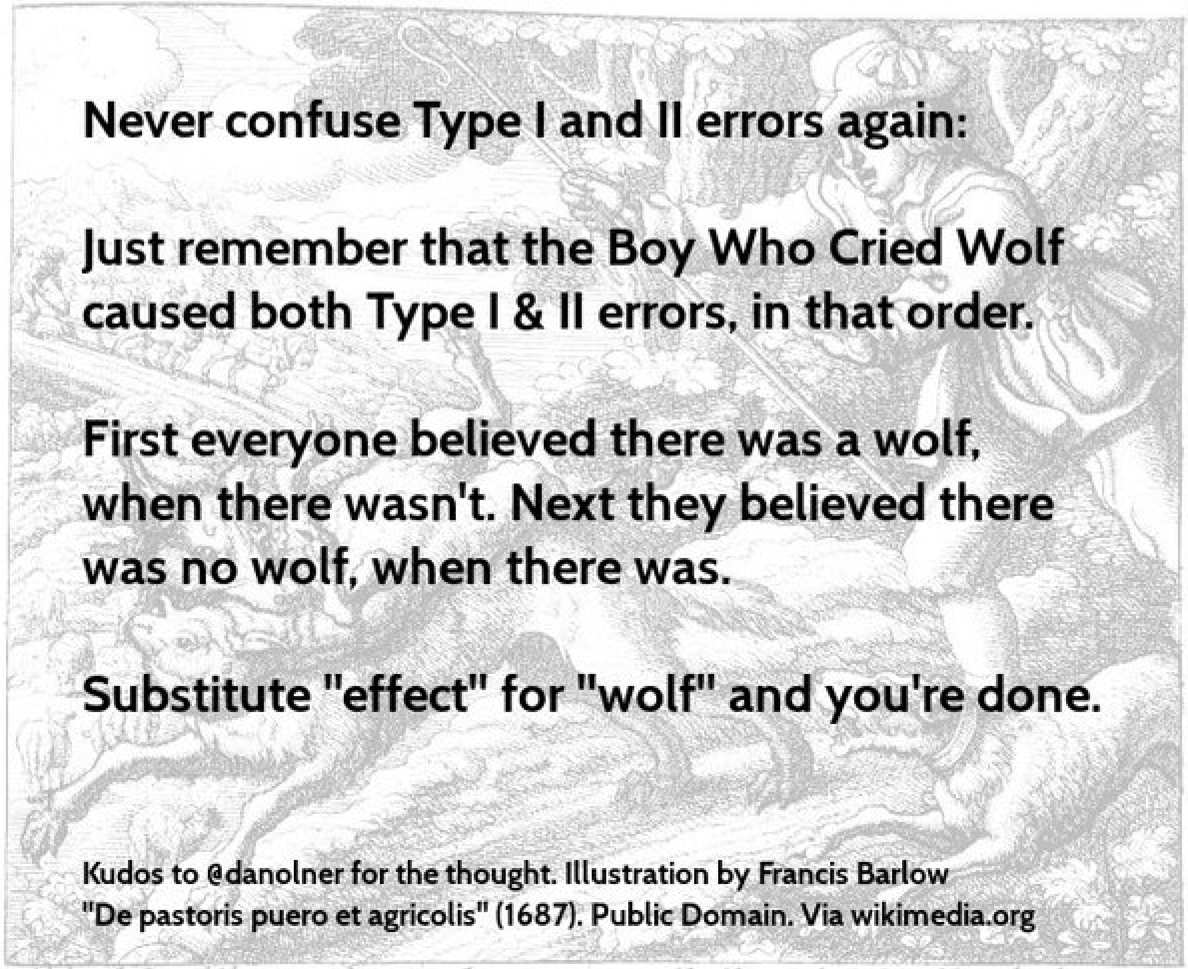
- **Type I:** (false ‘+’)
  Concluding there **IS** a difference between groups when there really isn’t…
- **Type II:** (false ‘-’)
  Concluding there is **NO** difference between groups when there actually is…

α

β

Reality

Measured / Perceived	Reality: True	Reality: False
True	Correct ☺	Type I False Positive
False	Type II False Negative	Correct ☺

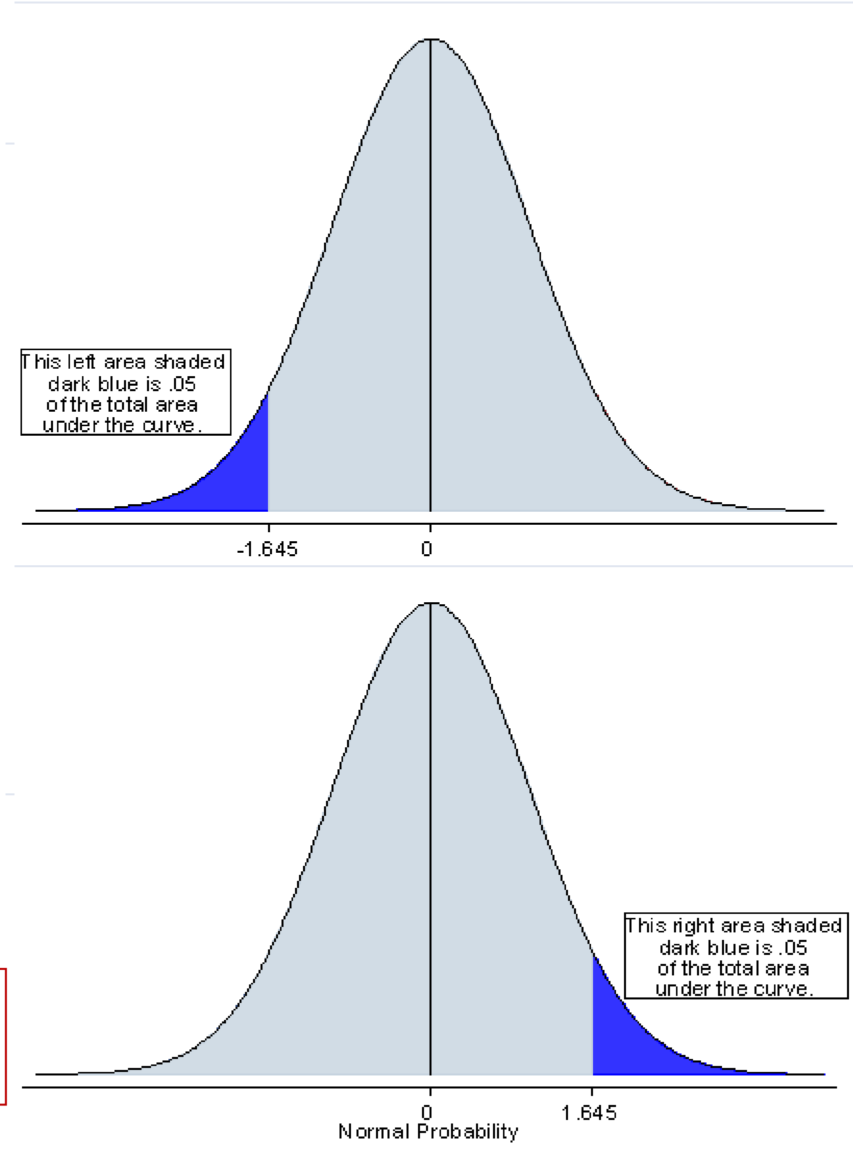

Never confuse Type I and II errors again:
Just remember that the Boy Who Cried Wolf caused both Type I & II errors, in that order.
First everyone believed there was a wolf, when there wasn't. Next they believed there was no wolf, when there was.
Substitute "effect" for "wolf" and you're done.
Kudos to @danolner for the thought. Illustration by Francis Barlow "De pastoris puero et agricolis" (1687). Public Domain. Via wikimedia.org

Significance…?
It's all about P for "percentage"

***p*-value**:

- Probability of committing a type I error
- *p*=.05
  - 5% probability that the difference b/w means/groups occurred by chance
  - 5% chance of type I error

Roll a 20-sided die and you'll notice that any given number comes up pretty often!



How do I know if there is a difference?

Parametric

- **T-Test**: →

  means of **2** groups

- **Analysis of Variance (ANOVA)**: →

  means of **>2** groups

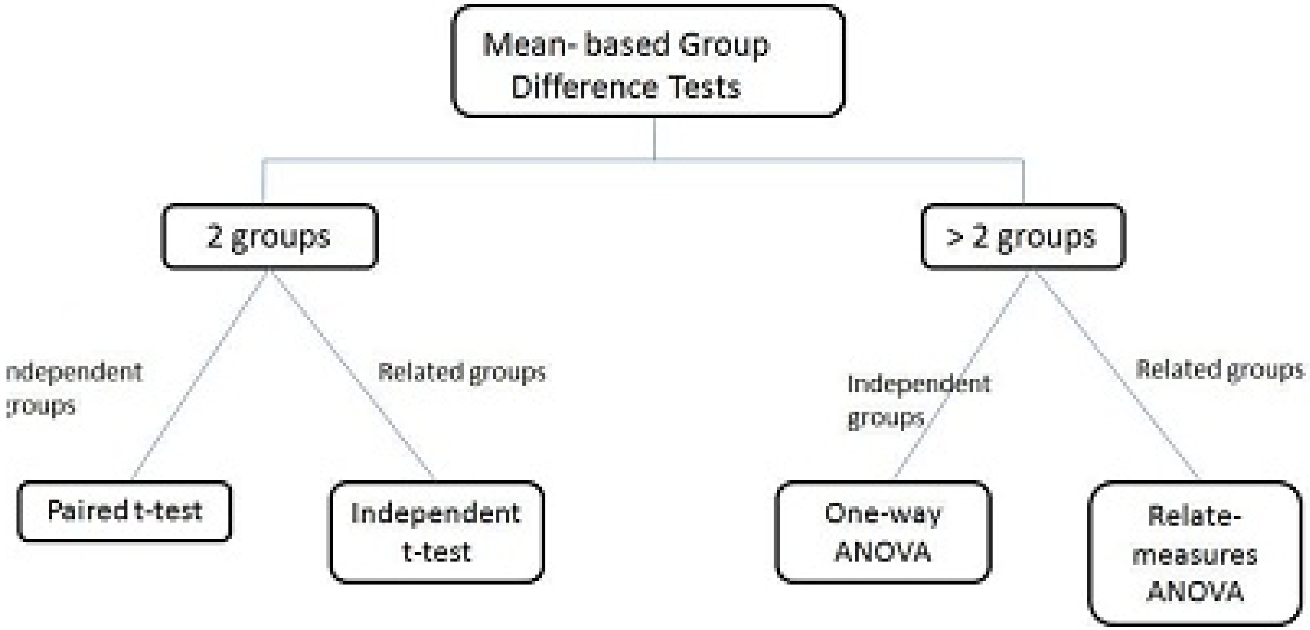
Non-Parametric

- **Mann-Whitney U-Test**:

  means of **2** groups

- **Kruskal-Wallis ANOVA by ranks** (*H* or $_{X}{}^{2}$):

  means of **>2** groups



Scenario

- Aim 1: To determine the optimal exercise intervention (volitional quad set or electrical stimulation) in improving quad strength 1 week following ACLR.
  - H_1 :
- Aim 2: To characterize the relationship between quad strength and knee effusion following ACLR.
  - H_2:

Which statistical tests should be used?

Patients s/p

p A

T-Test

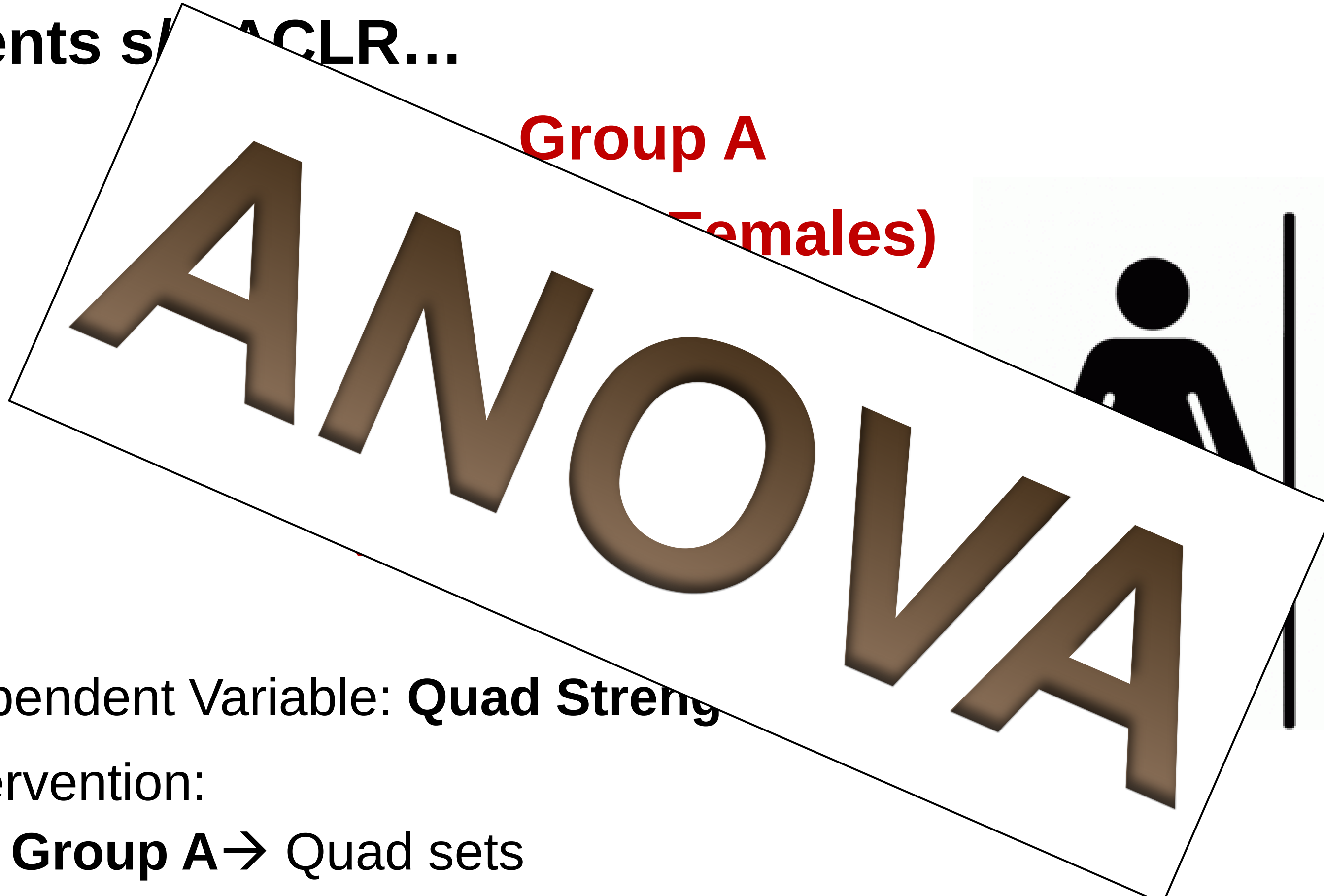
- Dependent Variable: **Qu**
- Intervention:
  - **Group A**→ Quad sets
  - **Group B** → Electrical Stimulation
- What test would you use to determine if quad strength was different between the groups A & B following the interventions?

Which statistical tests should be used?

Patients s/ ACLR…

Group A

Females)



- Dependent Variable: **Quad Streng**
- Intervention:
  - **Group A→** Quad sets
  - **Group B →** Electrical Stimulation
- What test would you use to determine if quad strength was different between groups A, B, males, & females following the interventions?

Which statistical tests should be used?

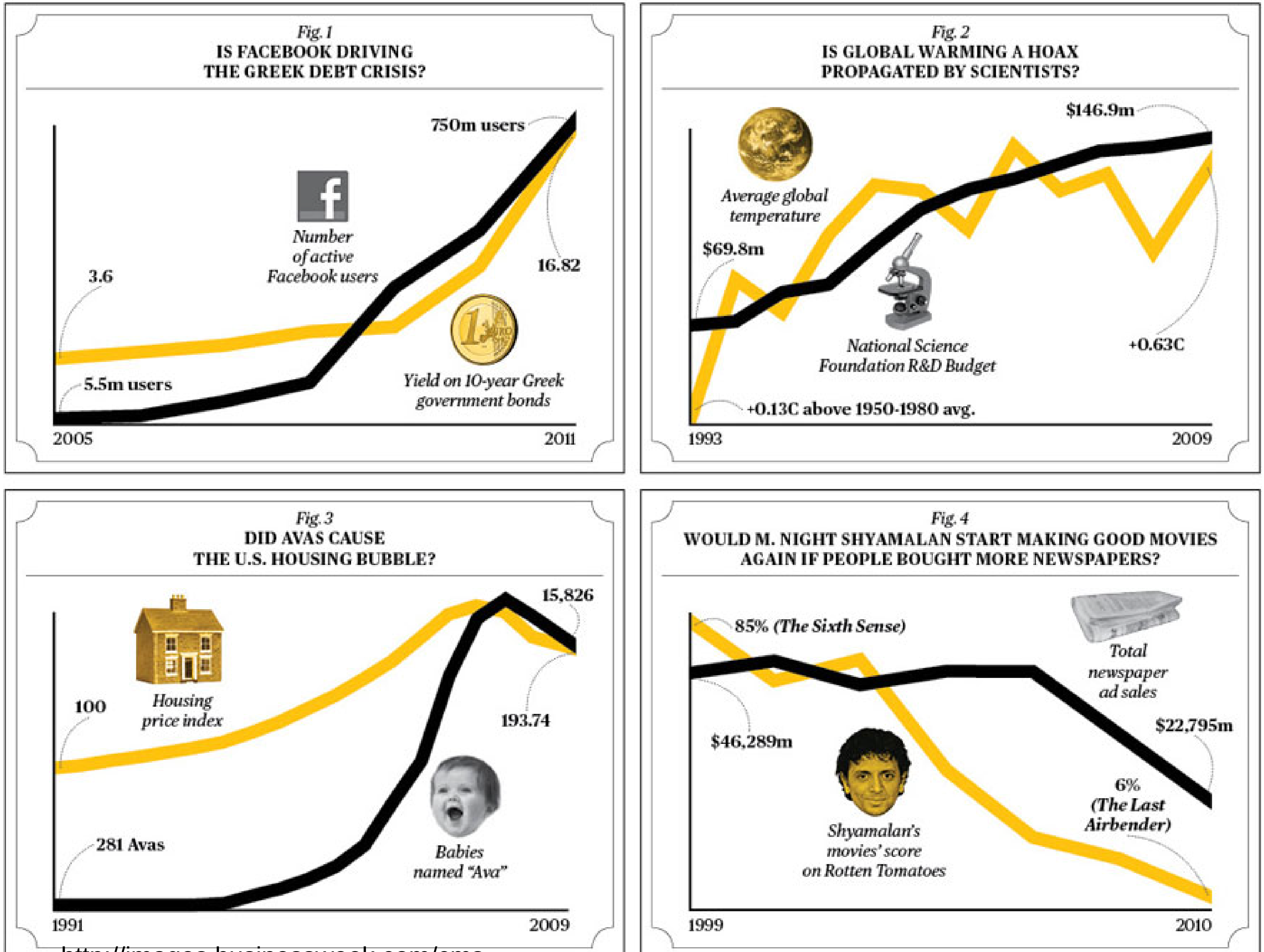
Patients s/

- De
- Interventi
  - **Group A→**
  - **Group B →** Electr

- What test would you use to determine ... ociation between quad strength and knee effusion p...

Pearson's Correlation (r)

Pearson's Correlation (r)



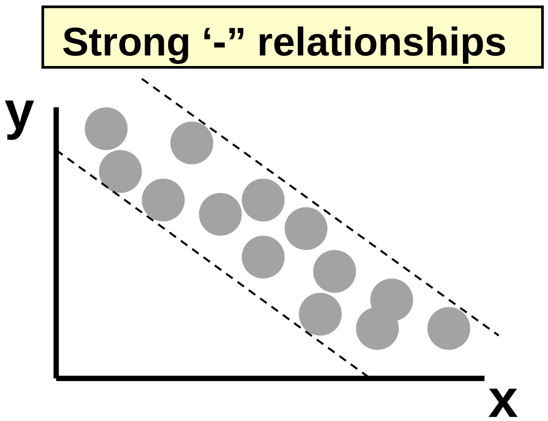
http://images.businessweek.com/cms

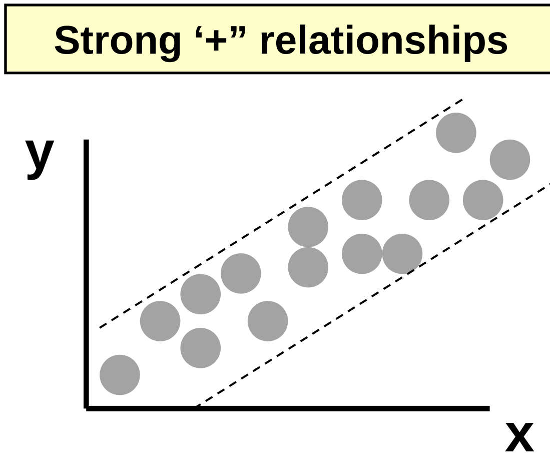
Pearson's Correlation (r)

- Direction & strength of linear **relationships**
- Not causative

Negative					Positive				
< .70	.40-.69	.30-.39	.20-.29	.01-.19	.01-.19	.20-.29	30-.39	.40-.69	≥ .70
Very Strong	Strong	Moderate	Weak	None	None	Weak	Moderate	Strong	Very Strong

Pearson's Correlation (r)





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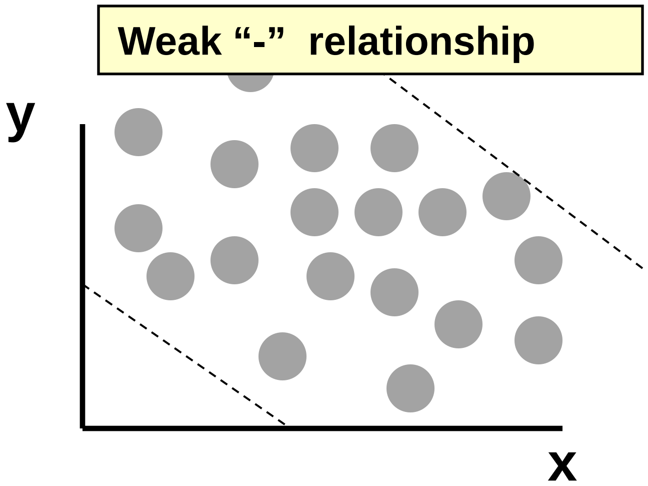
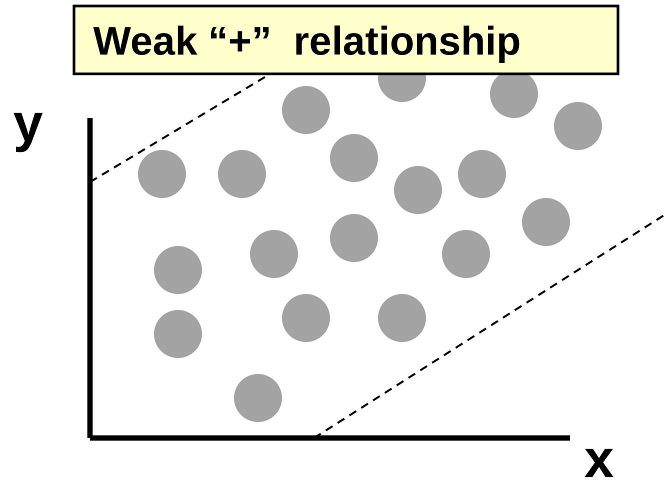
Pearson's Correlation (r)





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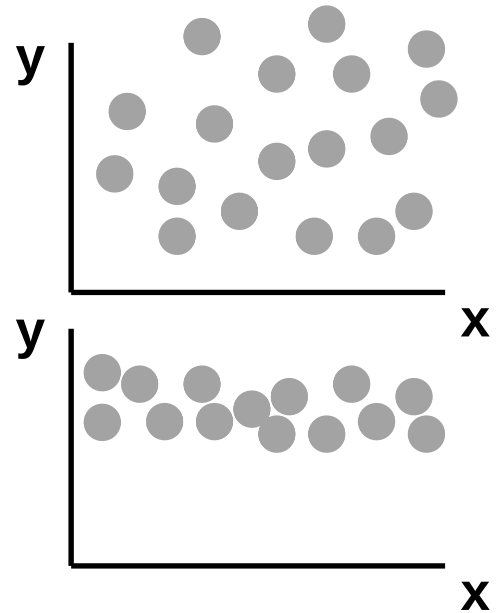
Pearson's Correlation (r)

No relationship



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Very Strong	Strong	Moderate	Weak	None	None	Weak	Moderate	Strong	Very Strong

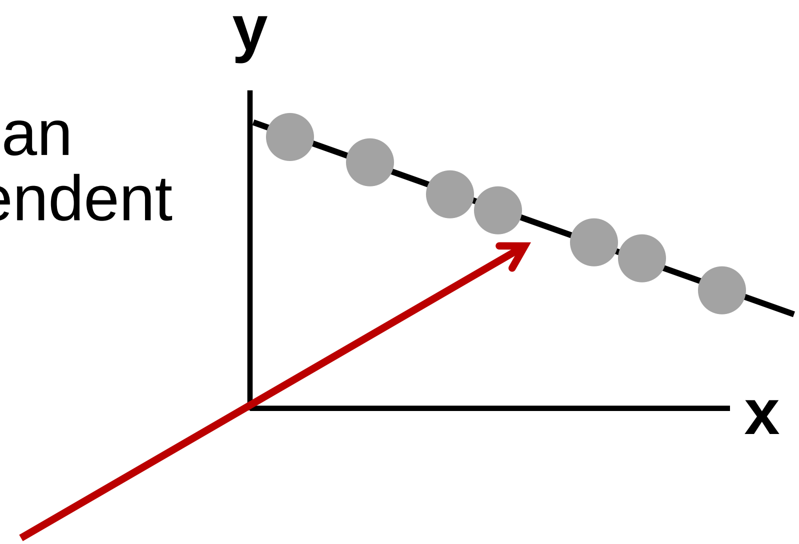
Scenario

- Aim 3: To predict the contribution of quad strength to IKDC score following ACLR.
    - H_3:

Linear Regression (r^2)

<u>Predict</u> the value of a dependent variable (*outcome* → *IKDC Score*) based on the value of at least one independent variable (*predictor* → *Quad Strength*)

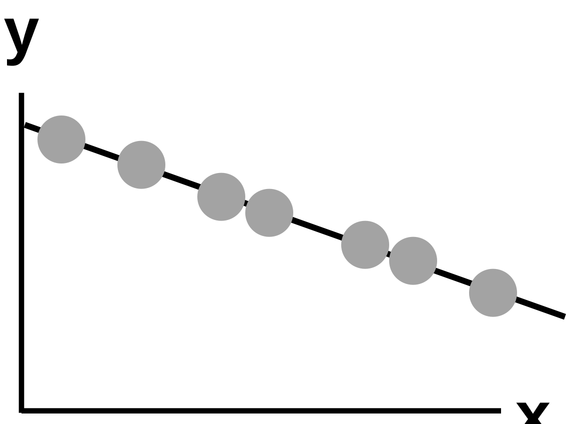
- Explain the impact of changes in an independent variable on the dependent variable



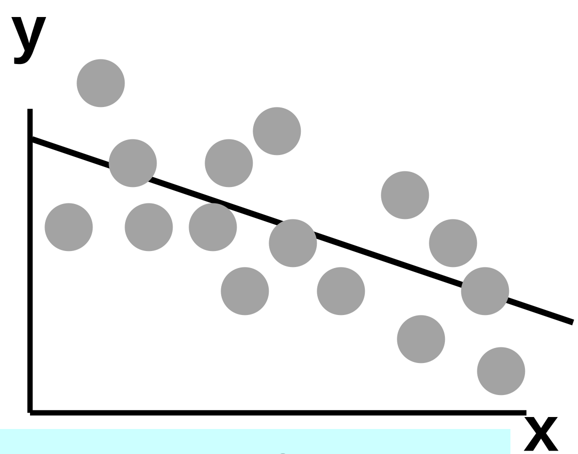
<u>Regression line</u> summarizes relationship between explanatory, x, & response variable, y

predict value of y for a given value of x

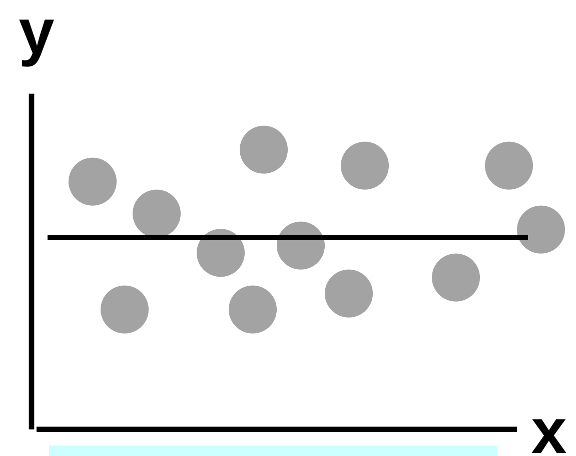
r & r^2 (How much explanation of variance?)



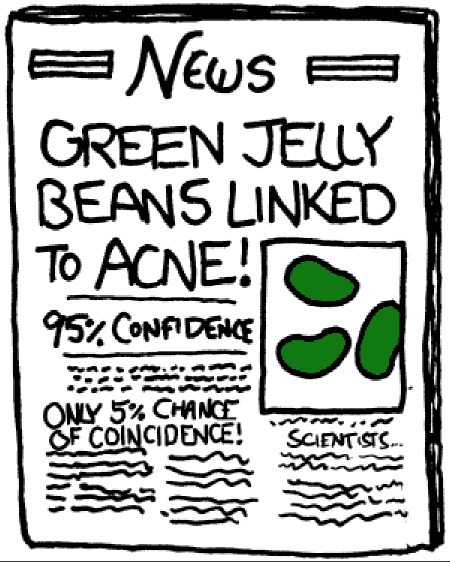
r = -1; r^2 = 1

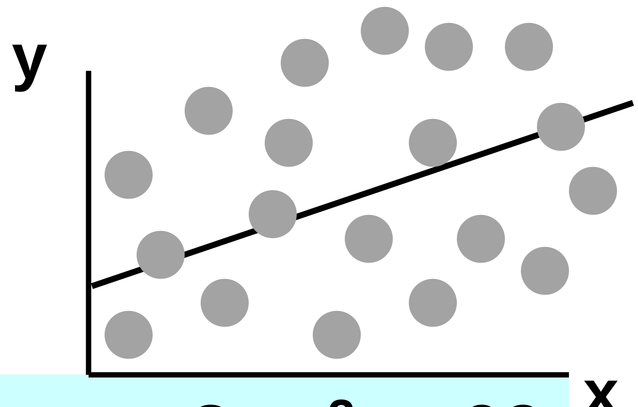


r = -.6 ; r^2 = .36

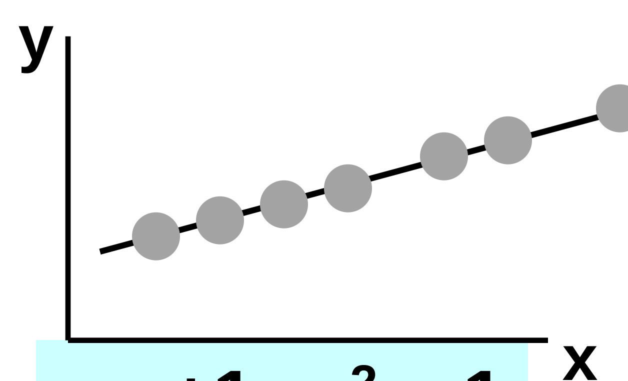


r = 0 ; r^2 = 0





r = +.3 ; r^2 = .09



r = +1 ; r^2 = 1

What are these?

- P – value
- T-test
- ANOVA
- Pearsons Correlation
- Regression

Have you had enough yet…?

Diagnostic Testing….oh boy…

	Reference Standard Positive	Reference Standard Negative
Diagnostic Test Positive	True + Results a	False + Results b
Diagnostic Test Negative	False - Results c	True - Results d

Statistic	Formula	Description
Overall Accuracy	(a+d)/(a+b+c+d)	Percentage of patients who are correctly diagnosed
Sensitivity	a/(a+c)	Proportion of patients with the condition who have a + test result
Specificity	d/(b+d)	Proportion of patients without the condition who have a - test result
Positive Predictive Value	a/(a+b)	Proportion of patients with a + test result who have the condition
Negative Predictive Value	d/(c+d)	Proportion of patients with a - test result who don't have the condition
Positive Likelihood Ratio	Sensitivity/1- Specificity)	If the test is +, the increase in odds favoring the condition
Negative Likelihood Ratio	(1- Sensitivity)/Specificity	If the test is -, the decrease in odds favoring the condition

SnNOut: High Sensitivity, Negative test, Rule out Condition
SpPIn: High specificity, Positive test, Rule In condition

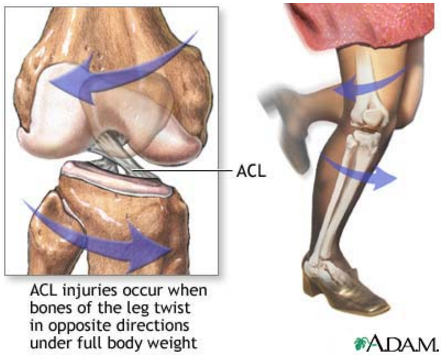
		Condition		
		Positive	**Negative**	
Test Outcome	**Positive**	True Positive	False Positive	**PPV** TP/(TP+FP)
	Negative	False Negative	True Negative	**NPV** TN/(FN+TN)
		Sensitivity TP/(TP+FN)	**Specificity** TN/(FP+TN)	

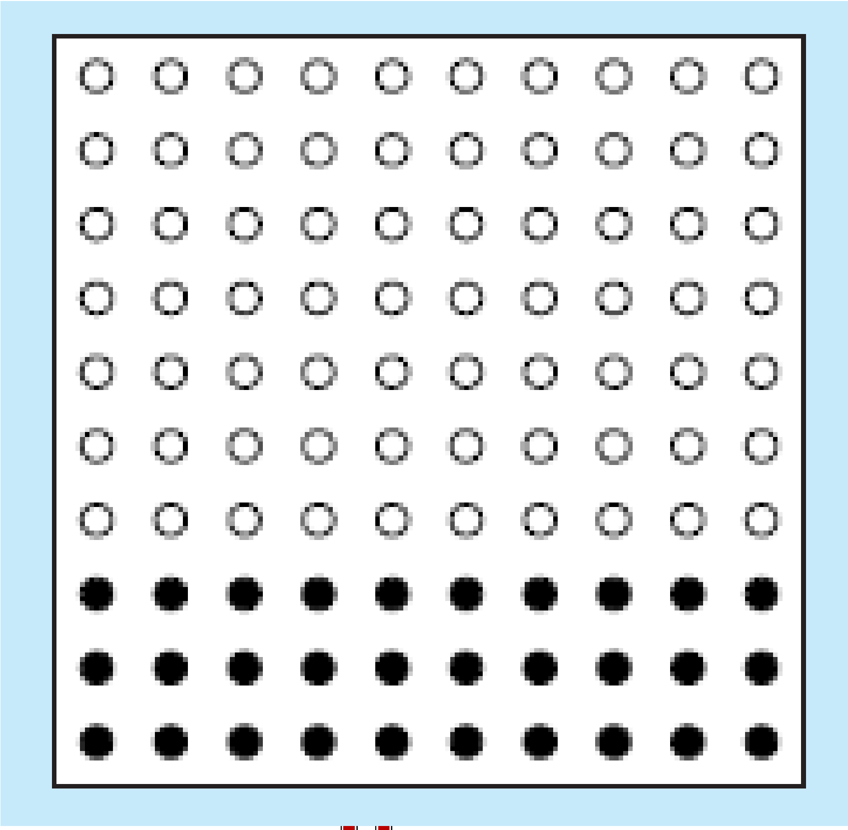
SnNOut: High Sensitivity, Negative test, Rule out Condition
SpPIn: High specificity, Positive test, Rule In condition

		ACL Tear		
		Positive	**Negative**	
Lachman	**Positive**	**24**	**14**	**PPV** 24/(24+14)
	Negative	**6**	**56**	**NPV** 56/(6+56)
		Sensitivity 24/(24+6)	**Specificity** 56/(14+56)	**Total = 100**

Example

- Population/Sample: 100
- Torn ACL: 30
- Prevalence: 30/100= 30%





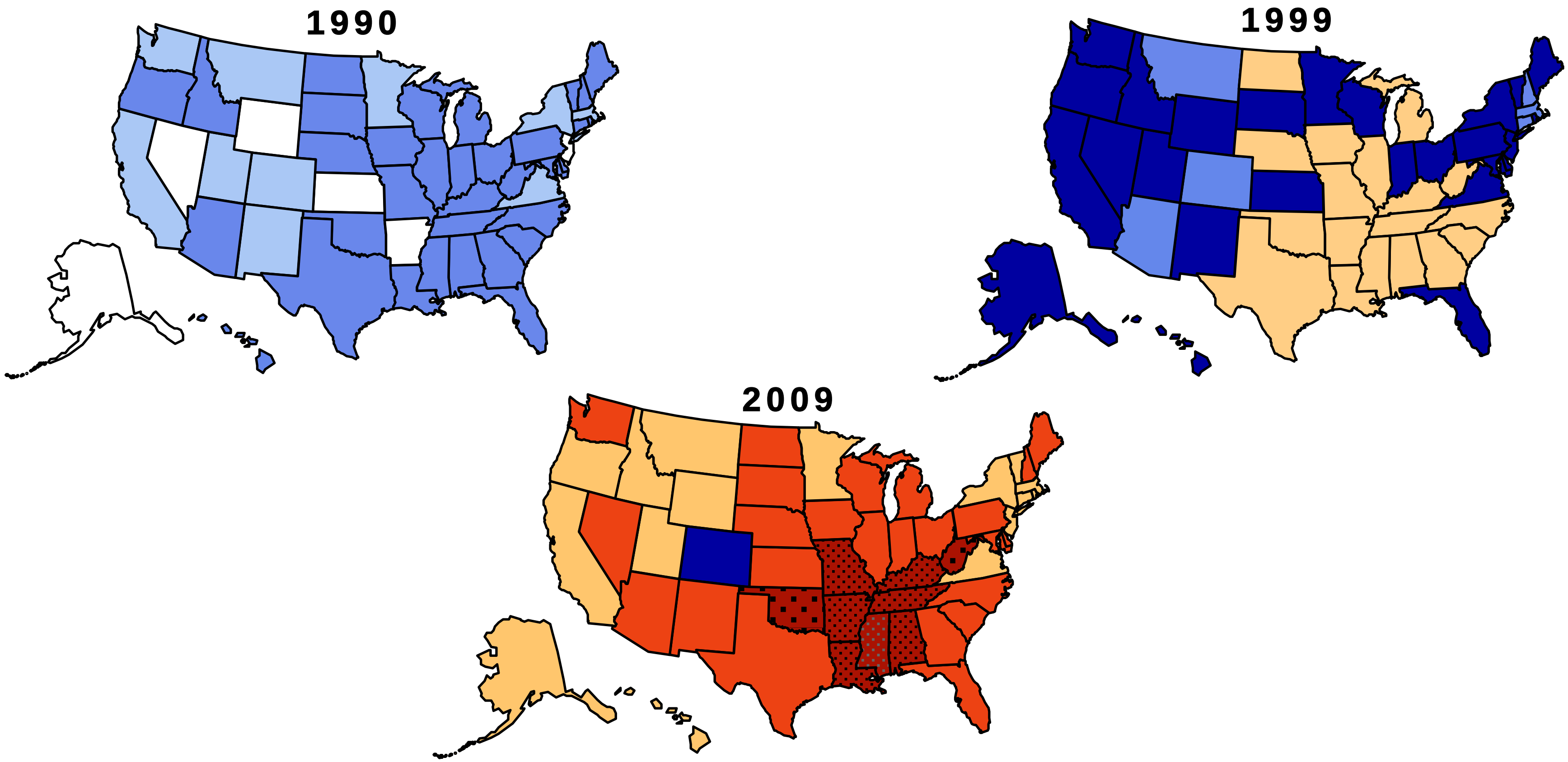
How much is what…?

- **Prevalence**:
  - how much of condition is in population at a **particular point in time**
  - 30 case in a sample of 100
    - 30/100= 0.30
    - 0.30 x 100 = 30%
  - % or # cases per 100,000

% of Obesity* Among U.S. Adults

BRFSS, 1990, 1999, 2009

(*BMI ≥30, or about 30 lbs. overweight for 5’4” person)



No Data | <10% | 10%–14% | 15%–19% | 20%–24% | 25%–29% | ≥30%

http://cdc.gov/obesity/data/trends.html#State

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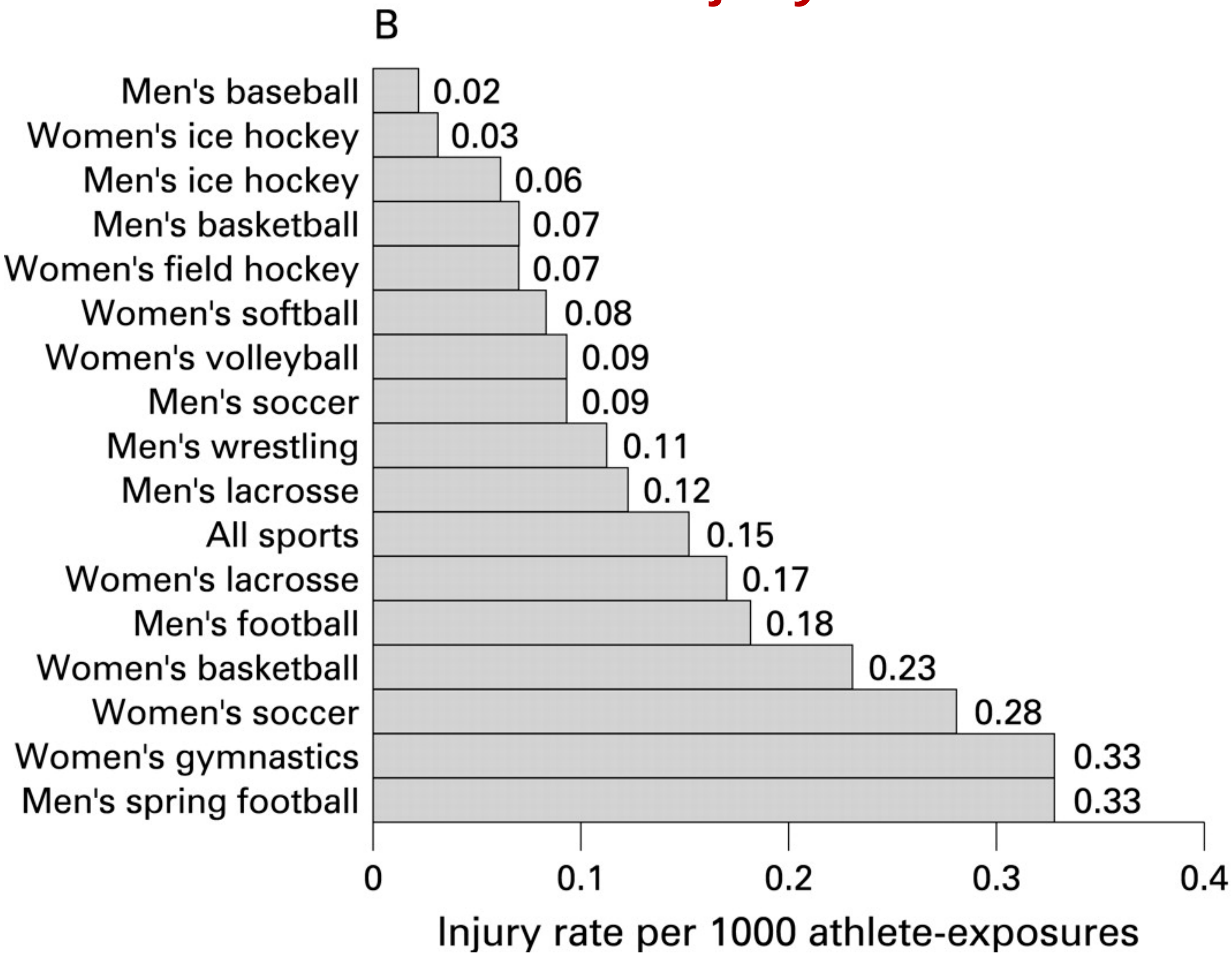
How much is what…?

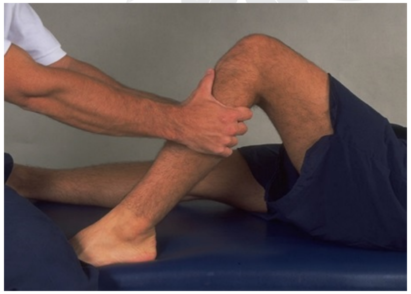
- **Incidence:**
  - **Rate** (in month/year/etc.) of occurrence of new cases of a disease or condition
  - (# new cases (over time course) / total population)
  - # cases per 100,000

ACL injury

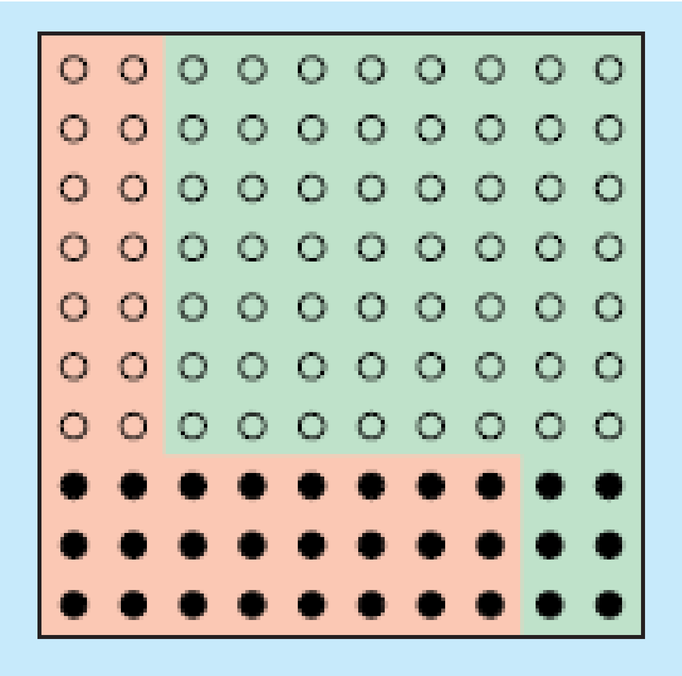


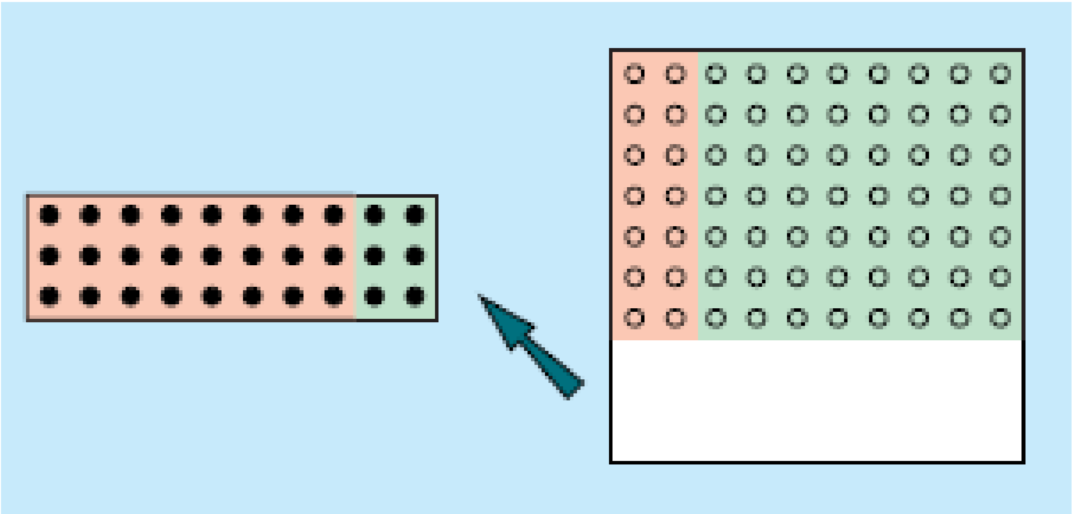
Renstrom, P et a. Non-contact ACL injuries in female athletes: an International Olympic Committee current concepts statement. *Br J Sports Med* 2008;42:394-412 doi:10.1136/bjsm.2008.048934

Sensitivity

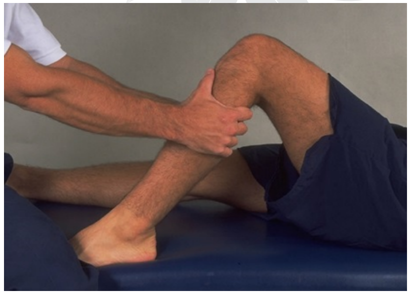


- How good a test is at correctly identifying people who have a "disease/condition"
- *"…test's ability to identify positive results."*
  - 24 out of 30 → [24/(24+6)]=0.80

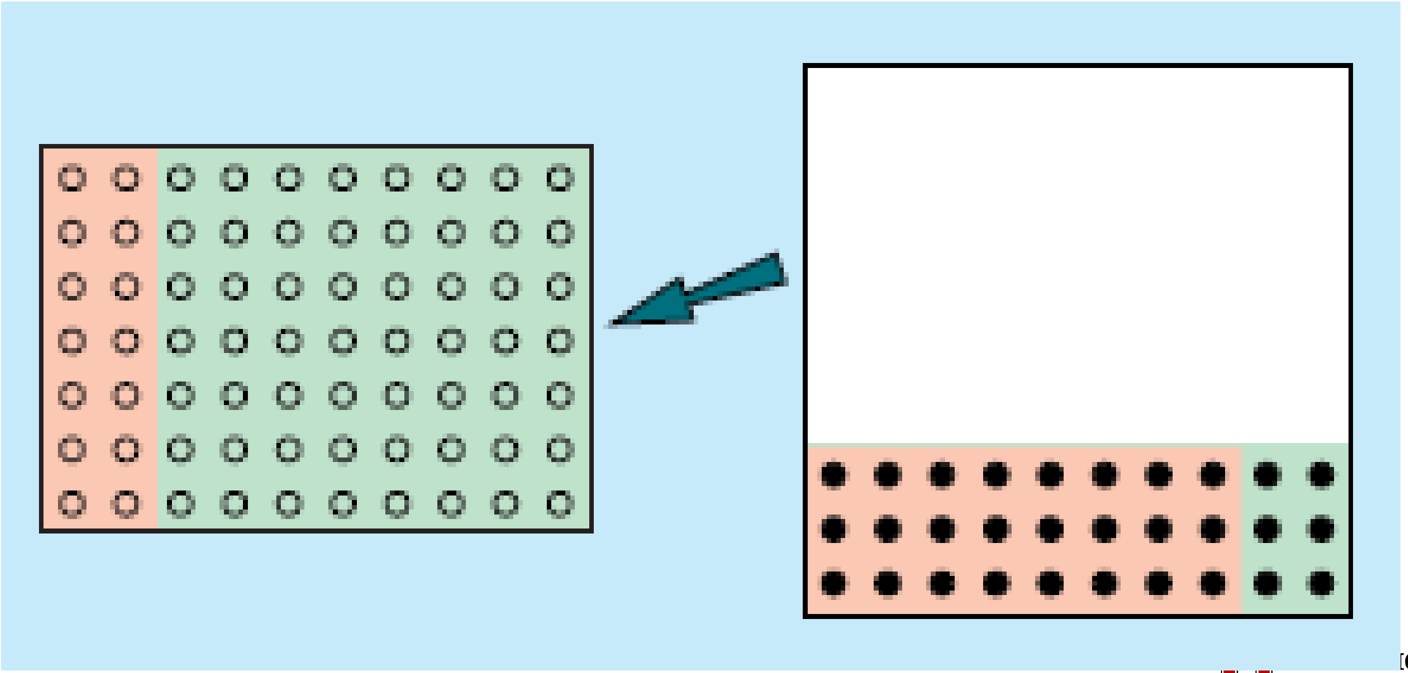




Specificity

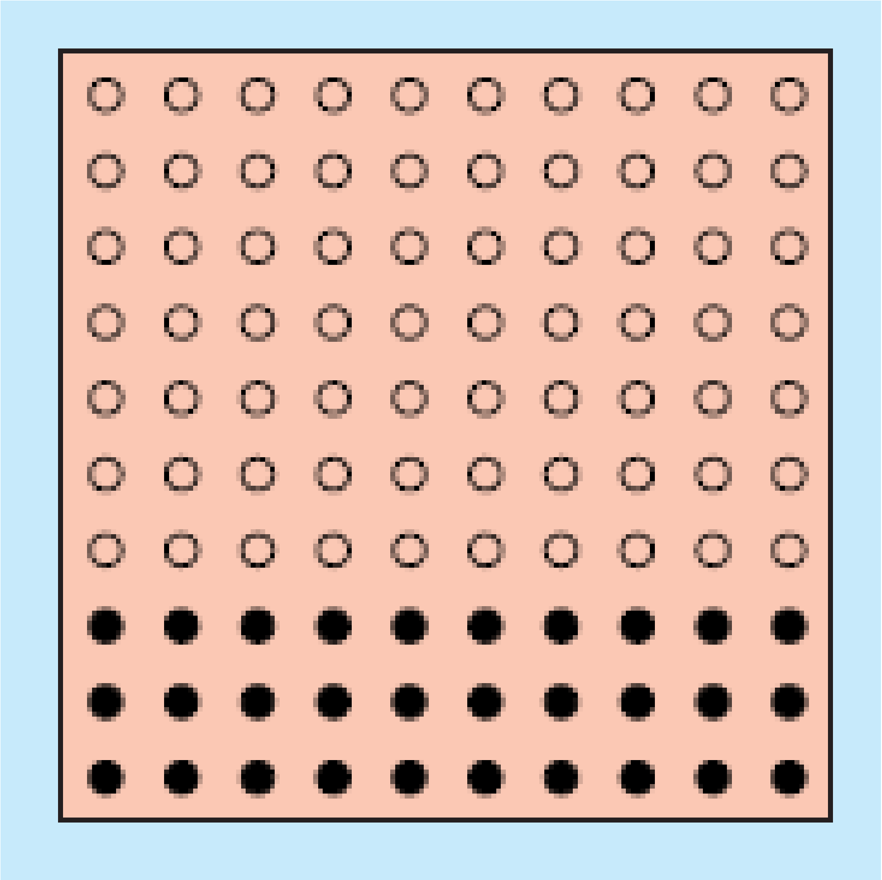


- How good a test is at correctly identifying people who are well
- *"…ability of the test to identify negative results."*
  - 56 out of 70 → [56/(14+56)]=0.80

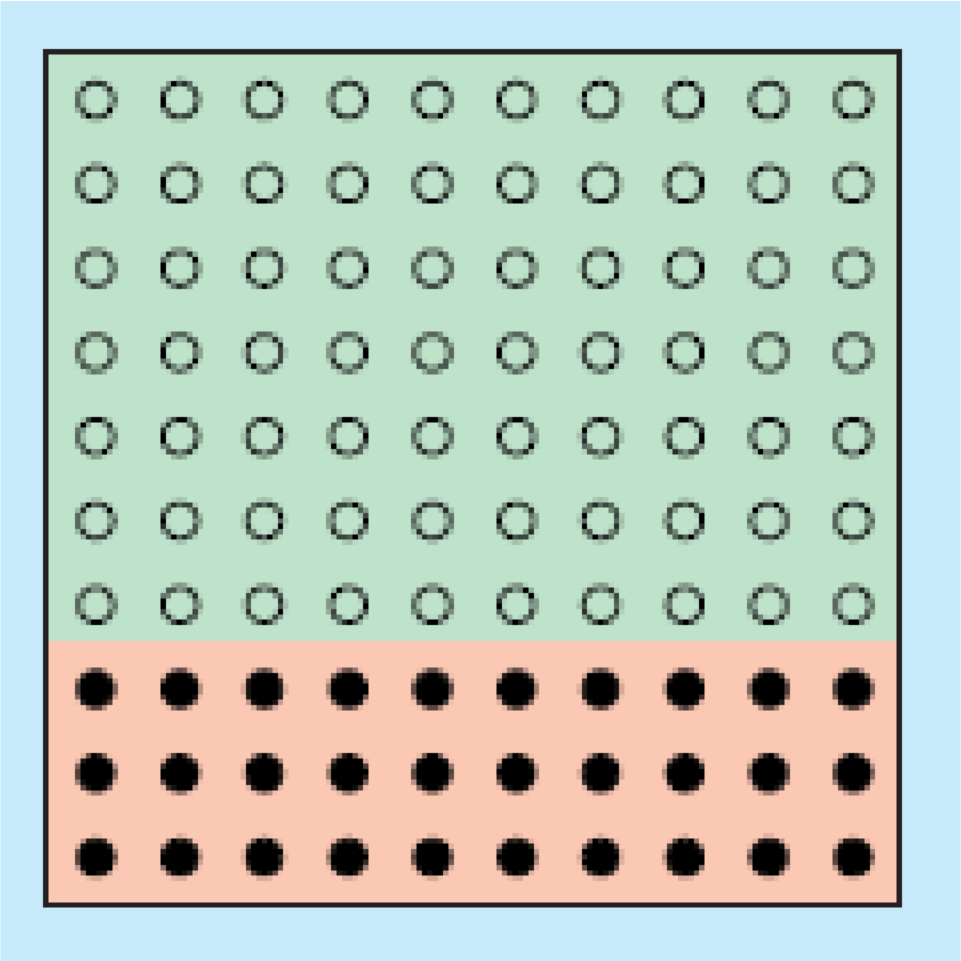


100% Sensitivity

- *"…test's ability to identify positive results."*

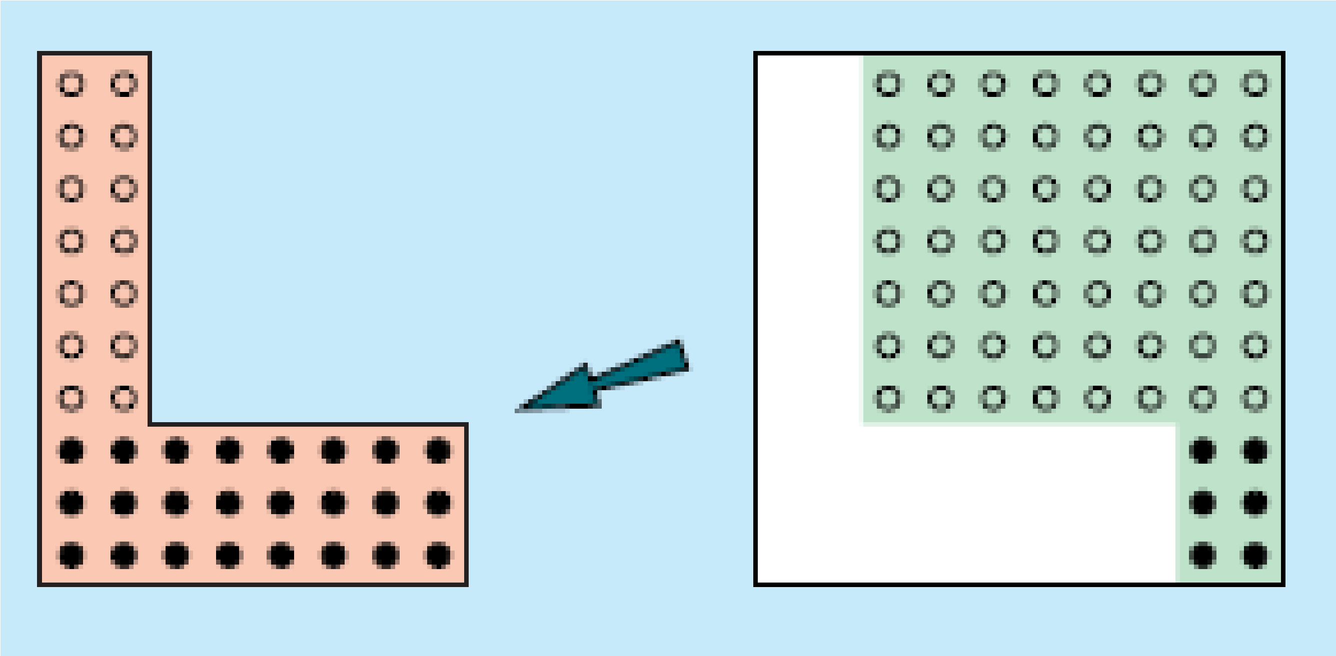


Perfect Test



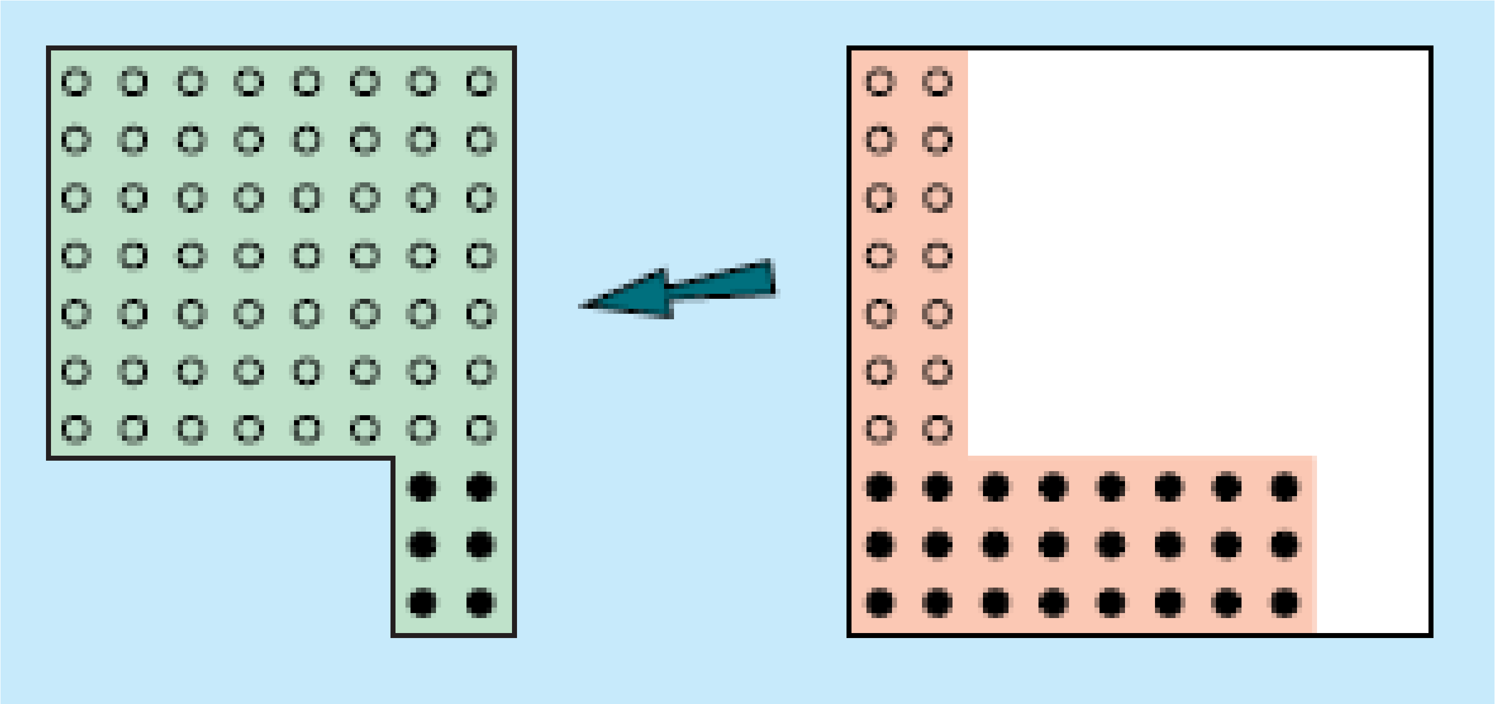
Positive Predictive Value

- The chance that a positive test result will be correct.
- 24 out of 38 positive tests correct: [24/(24+14)]= 0.63



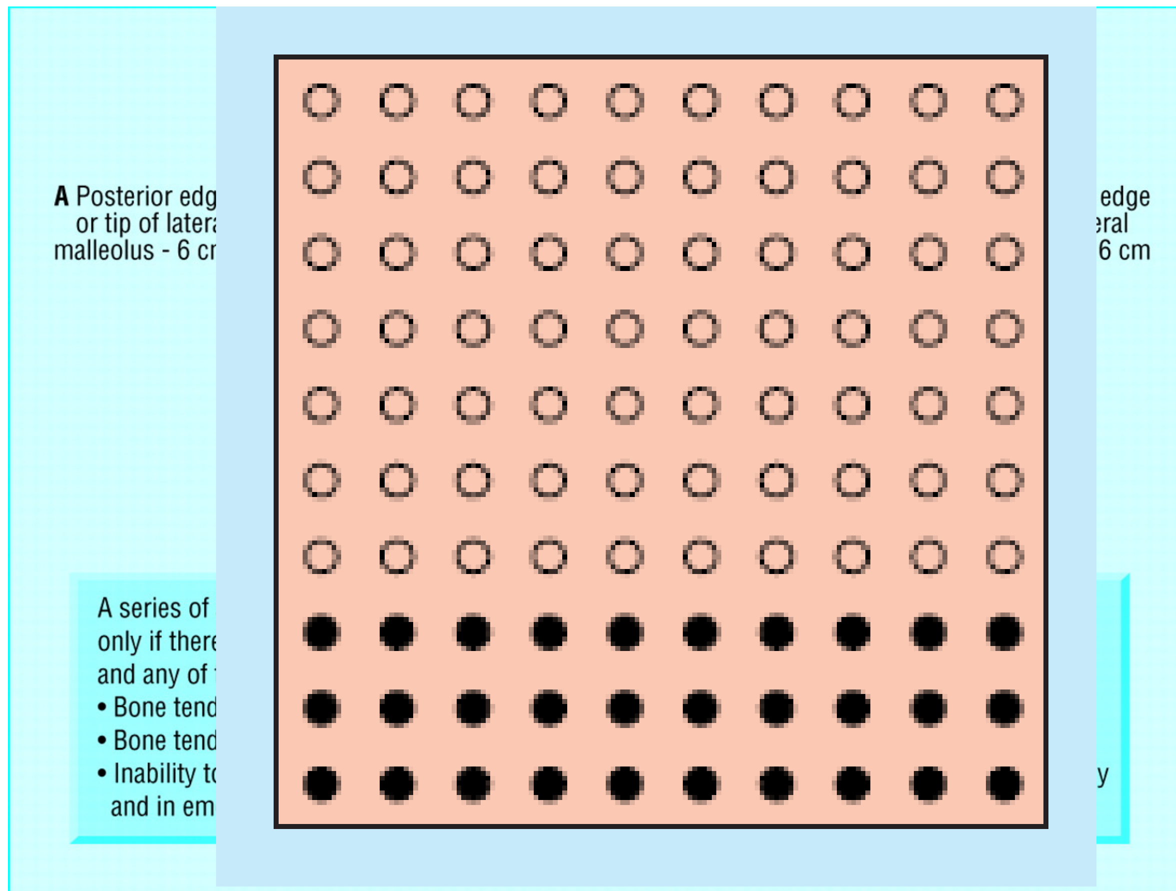
Negative Predictive Value

- The chance that a negative test result will be correct
- 56 out of 62 neg. results correct: [56/(6+56)]= 0.90



Ottawa Ankle Rules example…

- Sensitivity ~100%
- Specificity: 48%
- PPV: 15%
- NPV: ~100%



What is the Likelihood Ratio (LR)

The probability of a clinical finding in patients with a condition divided by the probability of the same finding in patients without the condition

Direct estimate of how much a test result will change the odds of having a disease/condition.

Likelihood of a disorder or condition being present

LR “+” / “-”

<u>Increased diagnostic confidence:</u>

“*Probability estimate of presence/absence of the condition of interest*”

- **LR+** tells you **how much the odds of the condition increase when a test is positive**.
- **LR-** tells you **how much the odds of the condition decrease when a test is negative**.

LR -				LR+		
0 - .1	.1 - .2	.2 - .5	.5 - 2	2 - 5	5 - 10	>10
Important		Unimportant			Important	

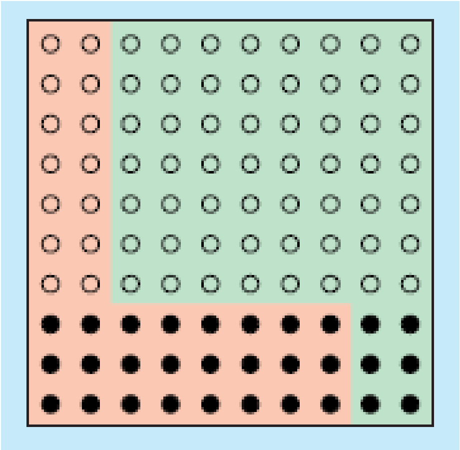
Likelihood Ratios

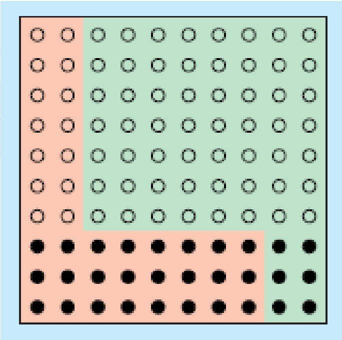
		Condition		
		+	-	
Test	+	True Positive	False Positive	PPV
	-	False Negative	True Negative	NPV
		Sensitivity	Specificity	Total

$$LR+ = \frac{Pr(T+|D+)}{Pr(T+|D-)} = \frac{\text{True Positive}}{\text{False Positive}} = \frac{\text{sensitivity}}{\text{1-specificity}}$$

$$LR- = \frac{Pr(T-|D+)}{Pr(T-|D-)} = \frac{\text{False Negative}}{\text{True Negative}} = \frac{\text{1-sensitivity}}{\text{specificity}}$$

		ACL Tear		
		Positive	**Negative**	
Lachman	**Positive**	24	14	**PPV** 24/(24+14)
	Negative	6	56	**NPV** 56/(6+56)
		Sensitivity 24/(24+6)	**Specificity** 56/(14+56)	





		Actual ACL Tear		
		Positive	**Negative**	
Anterior Drawer	**Positive**	**24**	**14**	**PPV** **24**/(24+14)
	Negative	**6**	**56**	**NPV** **56**/(6+**56**)
Total		30	70	
		Sensitivity 24/(24+6) = 0.80	**Specificity** 56/(**14**+56)`	

What is the proportion of patients with an ACL tear who have a “+” Lachman?

[24/(24+6)] = 0.80 (sensitivity)

What is the p

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What is the p

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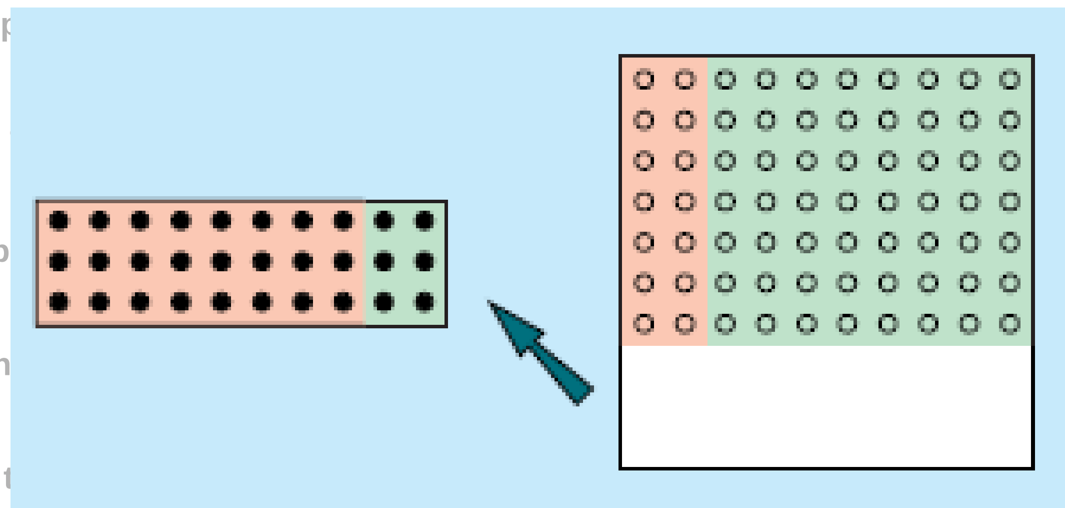
If t

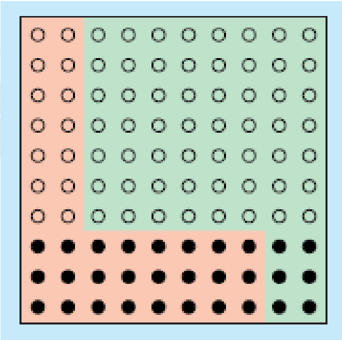


-LR = (1-sensitivity)/specificty = .20/.80 = .25

In other words, a “+” Lachman is **4x’s** more likely in a patient who has an ACL tear than a patient who does not have an ACL tear

AND

A “-” Lachman is only ¼ **(0.25)** more likely in those who have an ACL tear.



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		Positive	Negative	
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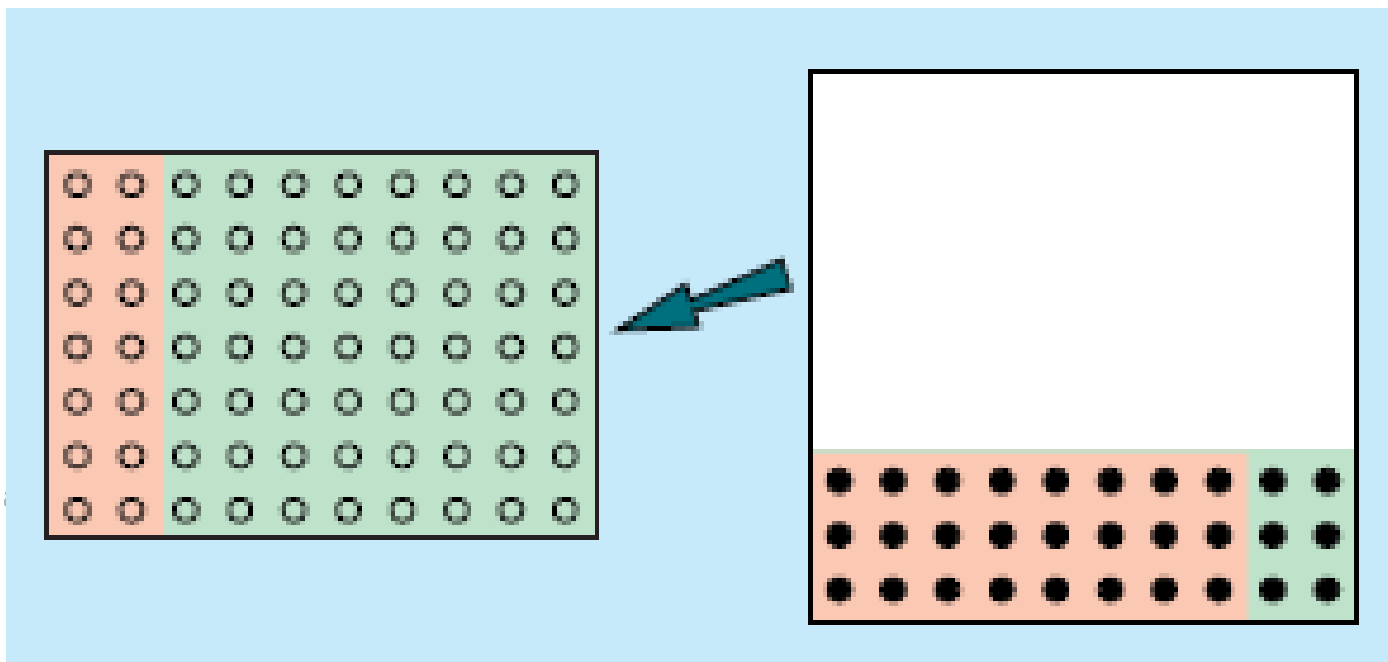
Total		30	70	
		Sensitivity 24/(24+6) = 0.80	Specificity 56/(14+56)`	

What is the proportion of patients with an ACL tear who have a "+" Lachman?

[24/(24+6)] = 0.80 (sensitivity)

What is the proportion of patients without an ACL tear who have a "- " Lachman?

[56/(14+56)] = 0.80 (specificity)



In other words, a

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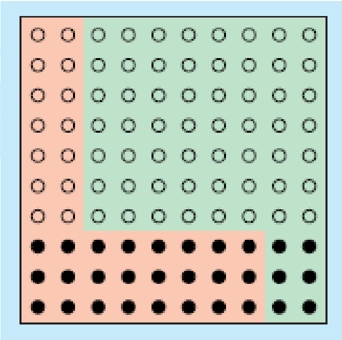


		Actual ACL Tear		
		Positive	**Negative**	
Anterior Drawer	**Positive**	**24**	**14**	**PPV** **24**/(24+14)
	Negative	**6**	**56**	**NPV** **56**/(6+**56**)
Total		30	70	
		Sensitivity 24/(24+6) = 0.80	**Specificity** 56/(**14**+56)`	

What is the proportion of patients with an ACL tear who have a “+” Lachman?

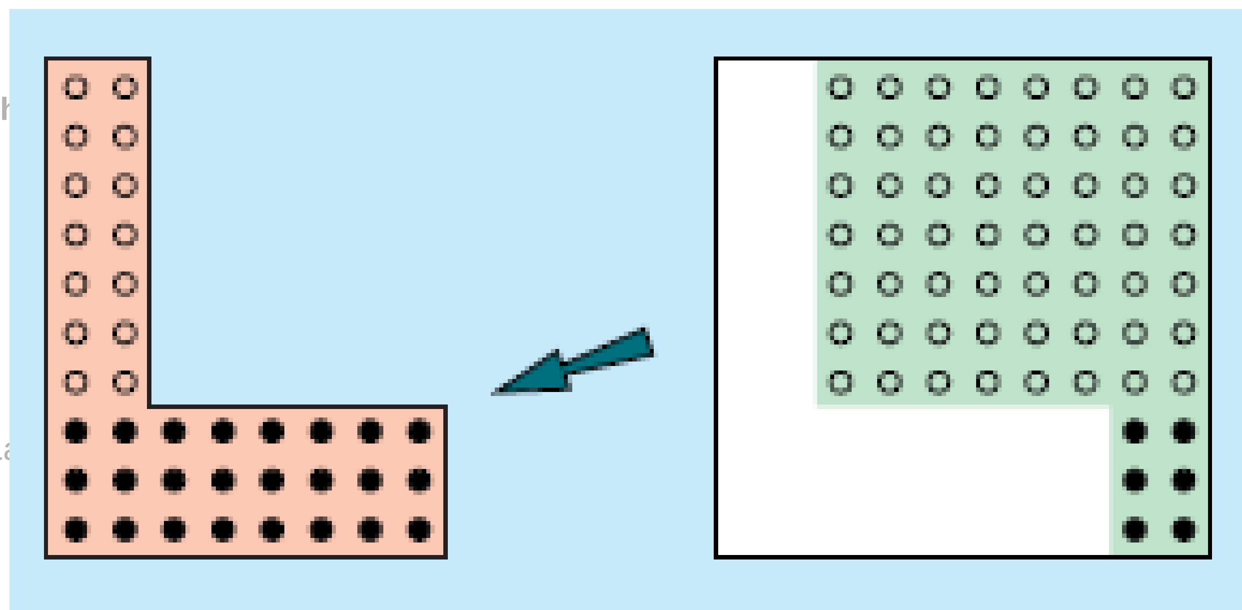
[24/(24+6)] = 0.80 (sensitivity)

What is the proportion of patients without an ACL tear who have a “- “ Lachman?

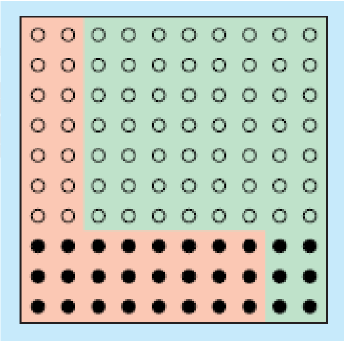
[56/(14+56)] = 0.80 (specificity)

What is the proportion of patients with a “+” Lachman have an ACL tear?

Wh



In other words, a “+” La ... have an ACL tear



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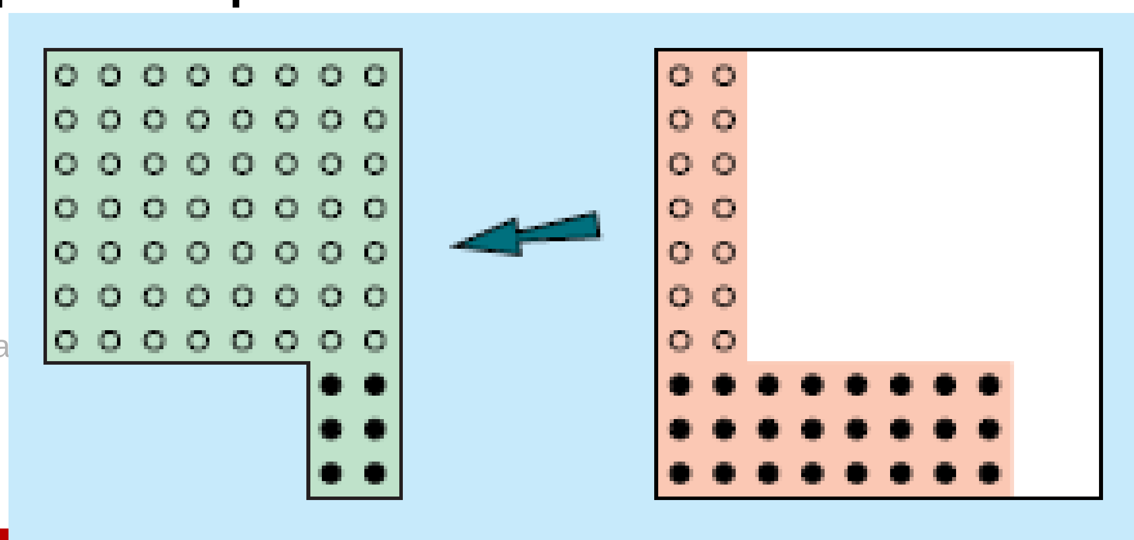
[24/(24+14)]=0.63% (PPV)

What is the proportion of patients with a “-” Lachman who don’t have an ACL tear?



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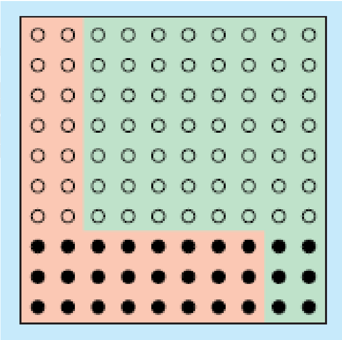

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If the Lachman's is "+", what are the odds favoring an ACL tear?

+LR = sensitivity/(1-specificity) = .0.80/0.20 = 4

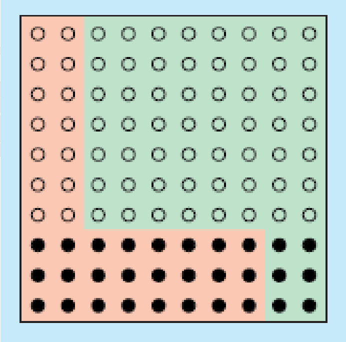
If the Lachman's "-" what are the odds favoring an ACL tear?

-LR = (1-sensitivity)/specificity = .20/.80 = .25

In other words, a "+" Lachman is **4x's** more likely in a patient who has an ACL tear than a patient who does not have an ACL tear

AND

A "-" Lachman is only ¼ **(0.25)** more likely in those who have an ACL tear.



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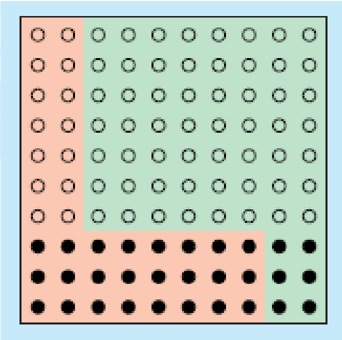
THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER



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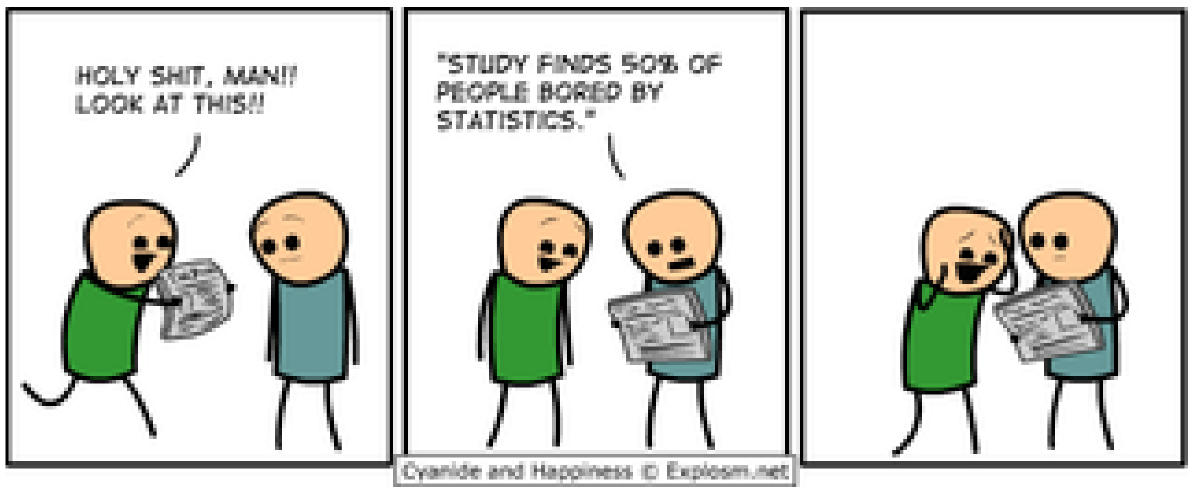
HOLY SHIT, MAN!! LOOK AT THIS!!
"STUDY FINDS 50% OF PEOPLE BORED BY STATISTICS."
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