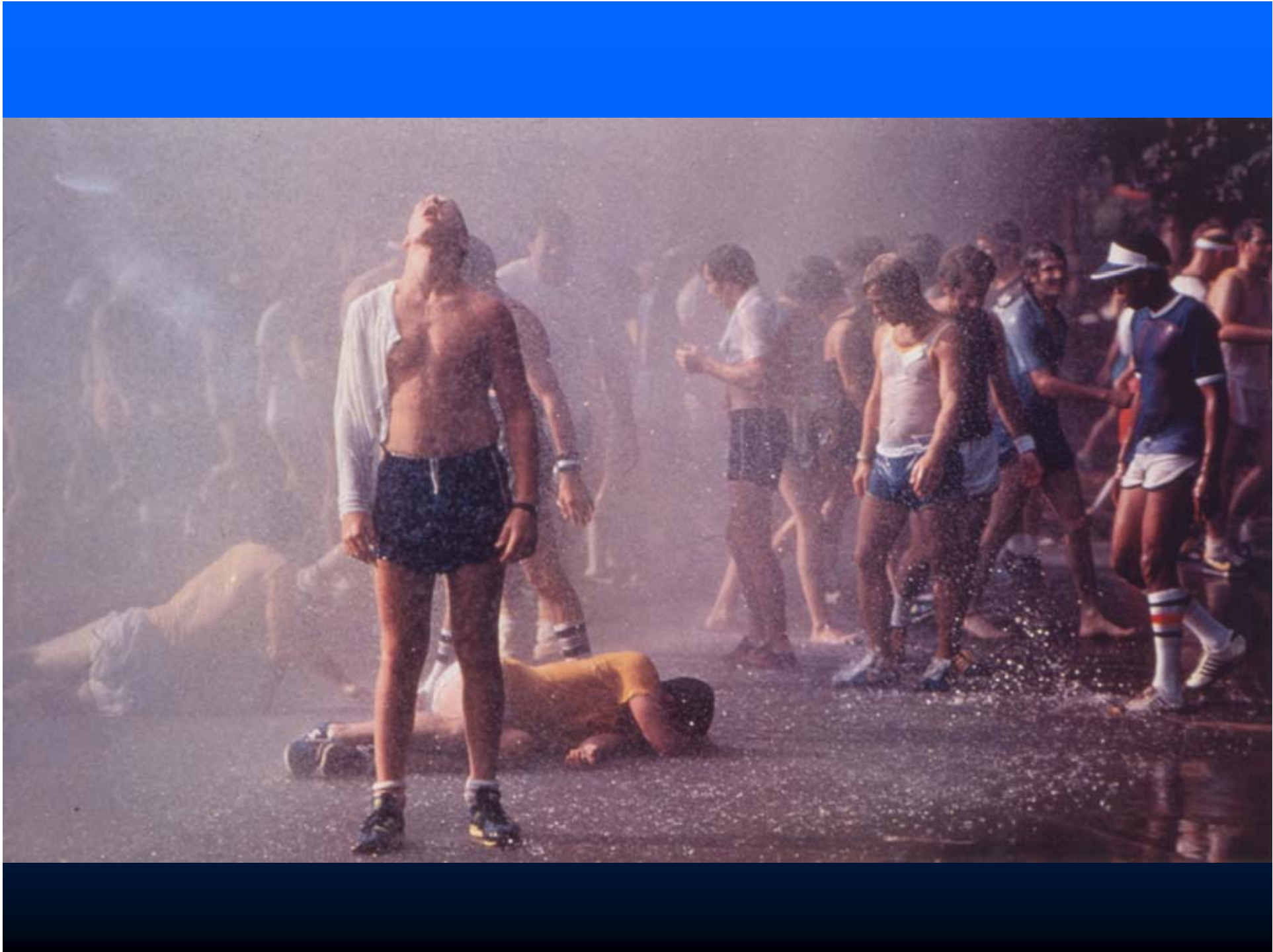
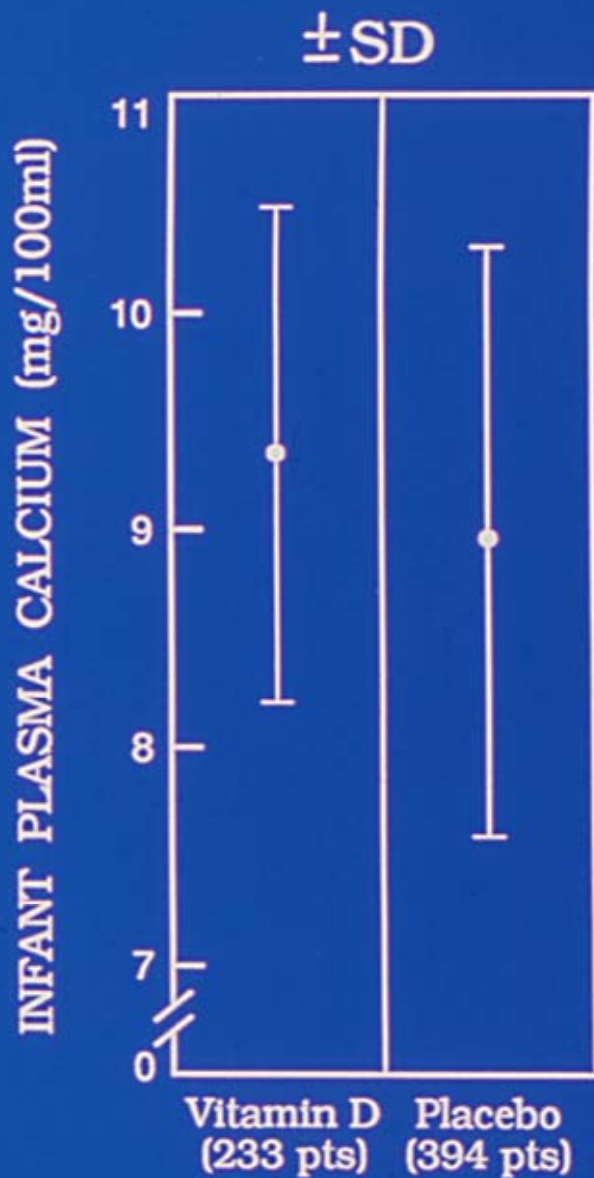


Stats 101

Phil Hahn
Queen's University





Objectives

- To understand and know how to calculate confidence intervals.
- Understand the relationship between confidence intervals and P values.
- Roadmap for picking the correct statistic.

Types of Data

Nominal Data



- Data which fits into categories
- Sex: male / female
- Pregnancy: yes / no
- Counts are compiled as a proportions

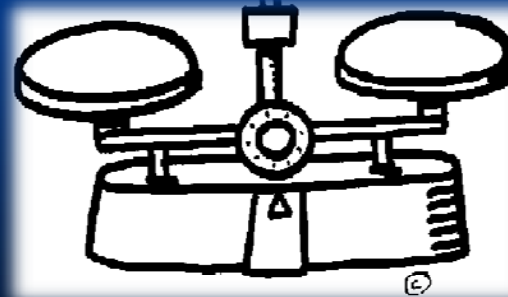
- Pregnancy Rate = 35%
- Proportion voting for Liberals = 60%

Ordinal Data

- **Categorical data with levels that can be ordered**
- **Pain: mild / moderate / severe**
- **Data often analyzed as ranks: 1, 2, 3**

Continuous Data

- Data obtained by measuring
- Height, weight, age, blood pressure
- Values are usually compiled as means



Type of Data

- Determines where you go with your statistical analysis.

Descriptive Statistics

Continuous Data

Measures of Central Tendency

- Mean - average
- Median - middle
- Mode - most

Measures of Dispersion

- How variable is the data set?

Range

- **Lowest - highest value**
- **Not really that informative**
- **Usually the outliers**
- **Not used in any statistical methods**

Variance

- Measure of the spread of the data
- Average of the squared deviations of the individual values from the mean
- $$\frac{\text{Sum } (\text{Mean} - \text{value})^2}{(n - 1)}$$
- See: Gaddis & Gaddis. Introduction to Biostatistics: Part 2, Descriptive statistics. Annals of Emergency Medicine 1990 March;19(3):312-13.

Variance

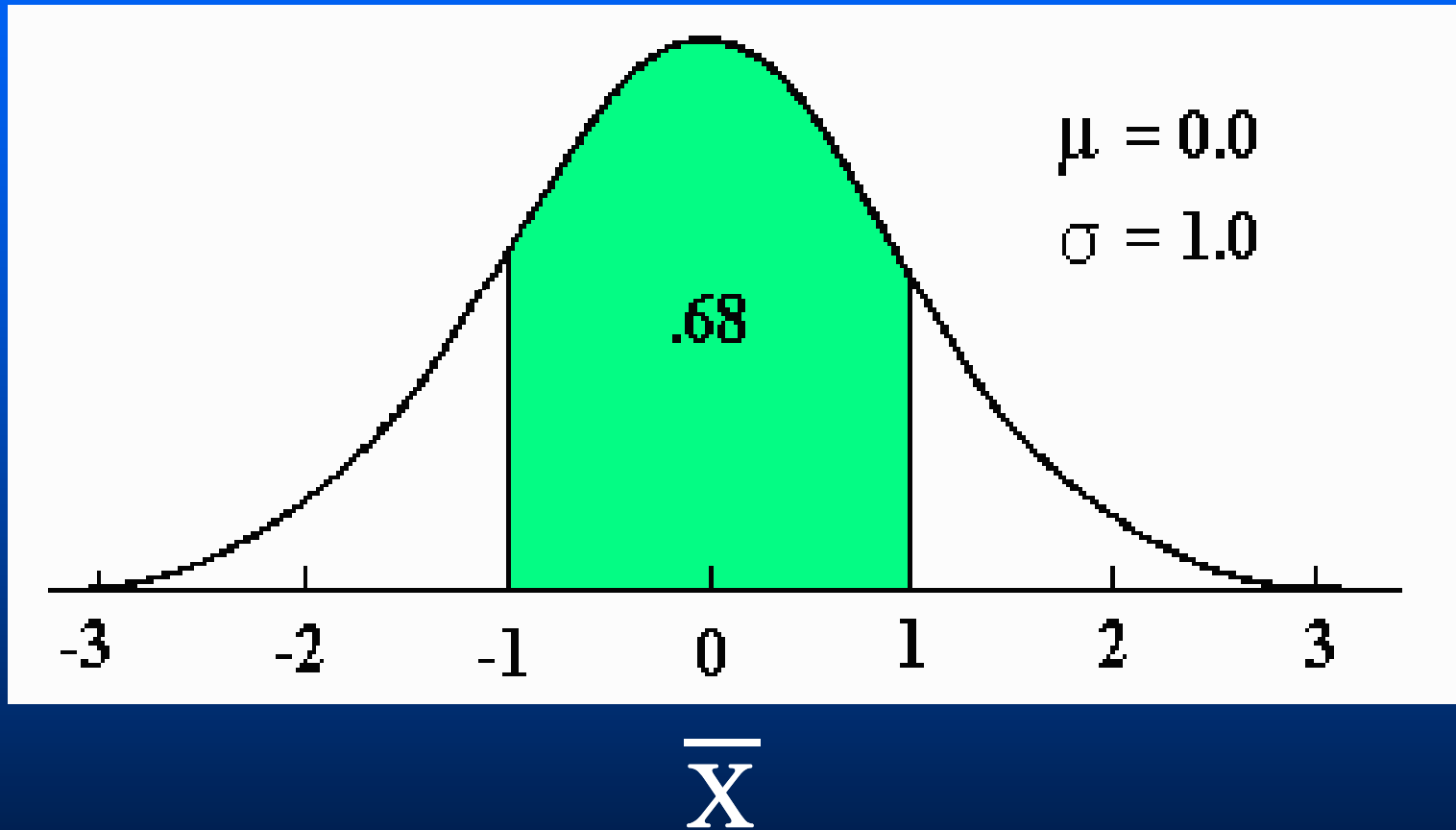
- $\frac{\text{Sum } (\underline{\text{Mean} - \text{value}})^2}{(n - 1)}$

- Squared units aren't very meaningful

Standard Deviation (SD)

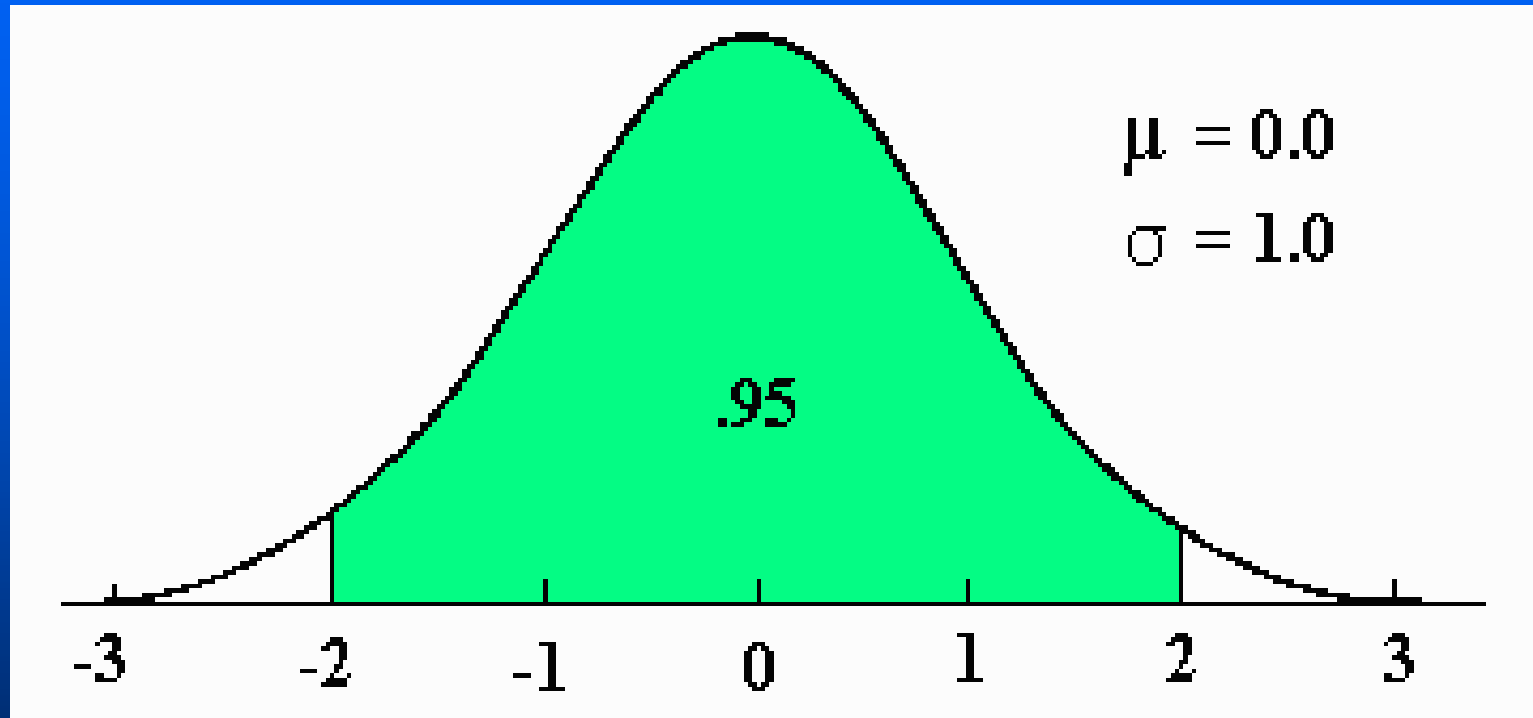
- Square root of the variance
- Measure of the spread of the sample data

Normal Distribution



Mean \pm 1SD contains 68% of data points

Normal Distribution



Mean \pm 2SD contains 95% of data points

Standard Error of the Mean (SEM)

- Indicates the degree of uncertainty in calculating a point estimate (mean or proportion)
- Somewhat abstract
- Mathematically simple: $SE = SD \div \sqrt{n}$
- Used to construct confidence intervals

Confidence Interval (CI)

- Range of values within which the 'true' population parameter is believed to be found, with a given level of confidence.

95% Confidence Interval (CI)

- Range of possible truths.
- We can be 95% certain that the true value lies within this range.

Confidence Interval (CI)

Mathematically

95% CI = sample estimate \pm 1.96 x SE
(mean)
(proportion)

Confidence Interval (CI)

Example

- Clinical Trial for prevention of infant hypocalcaemia



- Infant's plasma Ca measured after birth.

Infant Plasma Ca (mg per 100 ml)

Group:	N	Mean	SD
<i>Vitamin D</i>	233	9.36	1.15
Placebo	394	9.01	1.33

What is the mean infant plasma Ca level if all pregnant women were given *Vitamin D*?

$$SE = SD \div \sqrt{n} = 1.15 \div \sqrt{233} = 0.075$$

Infant Plasma Ca (mg per 100 ml)

Group:	N	Mean	SD
<i>Vitamin D</i>	233	9.36	1.15
Placebo	394	9.01	1.33

SE = 0.075

**95% CI = sample mean \pm 1.96 (SE)
= 9.36 \pm 1.96 (0.075)
= 9.21 to 9.51**

Infant Plasma Ca (mg per 100 ml)

Group:	N	Mean	SD
<i>Vitamin D</i>	233	9.36	1.15
Placebo	394	9.01	1.33

95% CI = 9.21 to 9.51

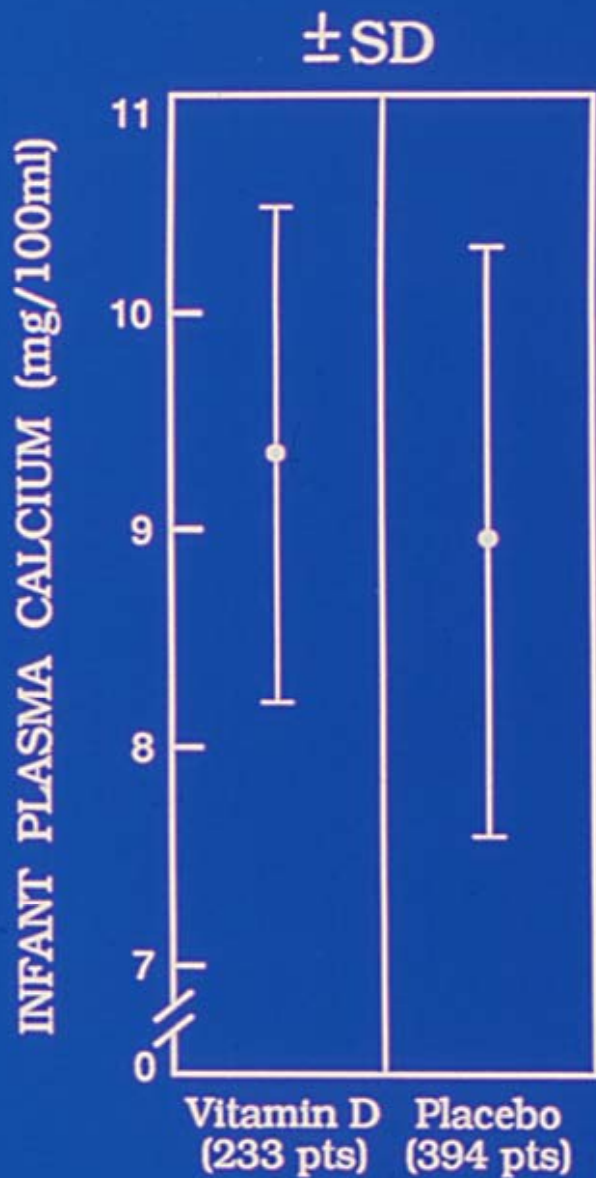
The 'true' population mean for all infants from moms on Vitamin D is between 9.21 and 9.51, with 95% certainty.

Infant Plasma Ca (mg per 100 ml)

Group:	N	Mean	SD
<i>Vitamin D</i>	233	9.36	1.15
Placebo	394	9.01	1.33

95% CI = 9.21 to 9.51

There is a 1 in 20 chance that the 'true' mean is outside this range.



P value

- Comes with statistical tests: t tests and chi square tests.
- Tells us the probability that the observed difference occurred by chance.

Small P values

- Indicate that the observed difference is unlikely due to chance.

P value < 0.05

- **Considered statistically significant**
- **Means that the probability the result is a chance finding is less than 5%**

P value = 0.004

- Means that the probability of observing such a difference by chance is 4 in 1000.

t test

- continuous data
- 1 comparison between 2 independent groups

2 groups

Lean vs Obese Women

Energy Expenditure
(MJ per day)

Means 8.1 vs 10.3

LEAN (n = 13)	OBESE (n = 9)
6.1	8.8
7.1	9.2
7.5	9.2
7.5	9.7
7.5	9.7
7.6	10.0
7.9	11.5
8.1	11.9
8.1	12.8
8.1	
8.4	
10.1	
10.9	
Mean = 8.1	Mean = 10.3

*Extracted from: Douglas G. Altman DG.
Practical statistics for medical research.
(Chapman & Hall, London, 1991), p.192-3.*

t test

Ho: No difference in energy expenditure

$$t = \frac{\text{mean1} - \text{mean2}}{\text{SE (mean diff)}}$$

$$t = \frac{10.3 - 8.1}{0.56} = \frac{2.2}{0.56}$$

$$= 3.95$$

From t table
or computer program

$$P = 0.001$$

LEAN (n1 = 13)	OBESE (n2 = 9)
6.1	8.8
7.1	9.2
7.5	9.2
7.5	9.7
7.5	9.7
7.6	10.0
7.9	11.5
8.1	11.9
8.1	12.8
8.1	
8.4	
10.1	
10.9	
Mean1 = 8.1	Mean2 = 10.3

t test

P = 0.001

There is a 1 in 1000 chance of observing a difference of 2.2 when the means are really equal.

LEAN (n = 13)	OBESE (n = 9)
6.1	8.8
7.1	9.2
7.5	9.2
7.5	9.7
7.5	9.7
7.6	10.0
7.9	11.5
8.1	11.9
8.1	12.8
8.1	
8.4	
10.1	
10.9	
8.1	10.3

t test

Ho: No difference in energy expenditure

$P = 0.001$ (less than 0.05)

Reject Ho:

Conclusion: Energy expenditure in obese women was significantly higher than lean women.

LEAN (n = 13)	OBESE (n = 9)
6.1	8.8
7.1	9.2
7.5	9.2
7.5	9.7
7.5	9.7
7.6	10.0
7.9	11.5
8.1	11.9
8.1	12.8
8.1	
8.4	
10.1	
10.9	
8.1	10.3

95% CI

Mean Difference

= 1.05 to 3.41

Does not include 0

Statistically significant

LEAN (n1 = 13)	OBESE (n2 = 9)
6.1	8.8
7.1	9.2
7.5	9.2
7.5	9.7
7.5	9.7
7.6	10.0
7.9	11.5
8.1	11.9
8.1	12.8
8.1	
8.4	
10.1	
10.9	
8.1	10.3

Important Relationship

- P values and Confidence Intervals are related.
- If $P < 0.05$, 95% confidence interval does not include the null value.
 - Difference = 0
 - Relative Risk or Odds Ratio = 1

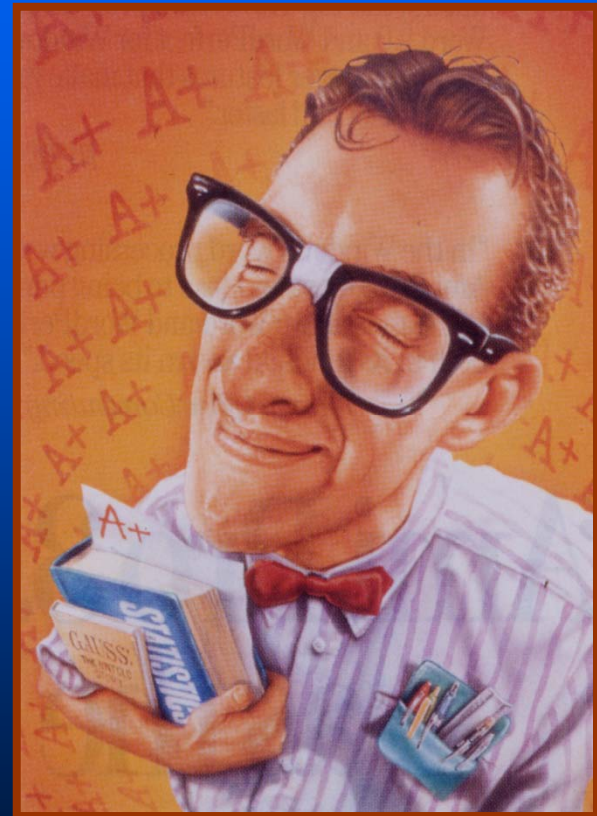
Example using computer programs.

Microsoft Excel

GraphPad InStat

...easiest stats

package in the world



Microsoft Excel - Energy Expenditure Data.xls

File Edit View Insert Format Tools Data Window StatsDirect Help

Type a question for help

Prompt

100% Arial 10 B I U

Reply with Changes... End Review...

A3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Energy Expenditure (MJ/day): Lean versus Obese Women														
2															
3		LEAN	OBESE												
4		(n=13)	(n=9)												
5		6.1	8.8												
6		7.1	9.2												
7		7.5	9.2												
8		7.5	9.7												
9		7.5	9.7												
10		7.6	10												
11		7.9	11.5												
12		8.1	11.9												
13		8.1	12.8												
14		8.1													
15		8.4													
16		10.1													
17		10.9													
18															
19	Average	8.069	10.311												
20	SD	1.234	1.4022												
21															
22	Altman D. Practical Statistics for Medical Research, 1st Edition (1991)														
23	Two Independent Groups, p. 192-3.														
24															

Sheet1 / Sheet2 / Sheet3 /

Ready

Microsoft Excel - Energy Expenditure Data.xls

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Type a question for help

Prompt

100% Arial 14 B I U

B5 6.1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Energy Expenditure (MJ/day): Lean versus Obese Women														
2															
3		LEAN	OBESE												
4		(n=13)	(n=9)												
5		6.1	8.8												
6		7.1	9.2												
7		7.5	9.2												
8		7.5	9.7												
9		7.5	9.7												
10		7.6	10												
11		7.9	11.5												
12		8.1	11.9												
13		8.1	12.8												
14		8.1													
15		8.4													
16		10.1													
17		10.9													
18															
19	Average	8.069	10.311												
20	SD	1.234	1.4022												
21															
22	Altman D. Practical Statistics for Medical Research, 1st Edition (1991)														
23	Two Independent Groups, p. 192-3.														
24															

Select and Copy Data

Sheet1 / Sheet2 / Sheet3 /

Ready Count=22

First step: What kind of data do you wish to enter?

A. Specify your goal

- Compare means (or medians)
- Regression and correlation
- Analyze a contingency table

Example:

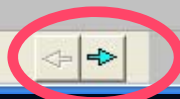
Compare blood pressures of two or more groups, or compare BP of one group with a theoretical value.

B. Choose a data entry format

- Raw data
- Averaged data. Mean, SD & N.
- Averaged data. Mean, SEM & N.
- X and Y (or two or more Y replicates).
- Y and 2 or more X variables (multiple reg).
- Two rows, two columns.
- Larger contingency table.

Based on your choices, InStat will be able to perform these tests:

- 1 group:** One sample t test
Wilcoxon rank sum test
- 2 groups:** Unpaired t test
Paired t test.
Mann-Whitney test
Welch's corrected t test
Wilcoxon matched pairs test
- 3-26 groups:** One-way ANOVA
Repeated measures ANOVA
Kruskal-Wallis test
Friedman test
(All with post tests)



GraphPad InStat Demo - [DATASET1.ISD]

File Edit Data Steps Window Help

Ordering InStat

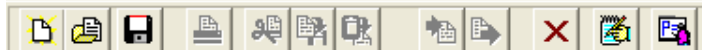
Title

	Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Gr
	LEAN	OBESE							
... 1		6.1	8.8						
... 2		7.1	9.2						
... 3		7.5	9.2						
... 4		7.5	9.7						
... 5		7.5	9.7						
... 6		7.6	10.0						
... 7		7.9	11.5						
... 8		8.1	11.9						
... 9		8.1	12.8						
... 10		8.1							
... 11		8.4							
... 12		10.1							
... 13		10.9							
... 14									
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... 20									
... 21									
... 22									
... 23									
... 24									
... 25									
... 26									
... 27									

Paste

Arranging data Importing data Steps: 1st

Col. title	Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H
Mean	8.0692307692	10.3111111111						
Standard deviation (SD)	1.234	1.402						
Sample size (N)	13	9						
Std. error of mean(SEM)	0.3424	0.4674						
Lower 95% conf. limit	7.323	9.233						
Upper 95% conf. limit	8.815	11.389						
Minimum	6.100	8.800						
Median (50th percentile)	7.900	9.700						
Maximum	10.900	12.800						
Normality test KS	0.2593	0.2545						
Normality test P value	>0.10	>0.10						
Passed normality test?	Yes	Yes						



Ordering InStat

Selected: A&B

Select other columns

1. Is each value paired (matched) with the value next to it?

- No. Perform unpaired test.
- Yes. Perform paired test.

2. Assume values are sampled from Gaussian distributions?

- No. Perform nonparametric test.
- Yes. Also assume the populations have equal SDs.
- Yes, but assume the populations may have different SDs.

3. One- vs two-tail P value

- One-tail P value.
- Two-tail P value. Recommended.

Based on your answers above, InStat will perform this test:

Unpaired t test

Help me choose

? Selecting columns

Steps: 1st



Unpaired t test

Do the means of LEAN and OBESE differ significantly?

P value

The two-tailed P value is 0.0008, considered extremely significant.

t = 3.964 with 20 degrees of freedom.

95% confidence interval

Mean difference = 2.242 (Mean of OBESE minus mean of LEAN)

The 95% confidence interval of the difference: 1.062 to 3.422

Assumption test: Are the standard deviations equal?

The t test assumes that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.290

The P value is 0.3332.

This test suggests that the difference between the two SDs is not significant.

Assumption test: Are the data sampled from Gaussian distributions?

The t test assumes that the data are sampled from populations that follow Gaussian distributions. This assumption is tested using the method Kolmogorov and Smirnov:

Group	KS	P Value	Passed normality test?
LEAN	0.2593	>0.10	Yes
OBESE	0.2545	>0.10	Yes

Summary of Data





 Unpaired t test

Do the means of LEAN and OBESE differ significantly?

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The two-tailed P value is 0.0008, considered extremely significant.

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Group	KS	P Value	Passed normality test?
=====	=====	=====	=====

GraphPad InStat Demo - [DATASET1.ISD]

File Edit Data Steps Window Help

Ordering InStat

Unpaired t test

Do the means of LEAN and OBESE differ significantly?

P value
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LEAN	0.2593	>0.10	Yes
OBESE	0.2545	>0.10	Yes

Summary of Data

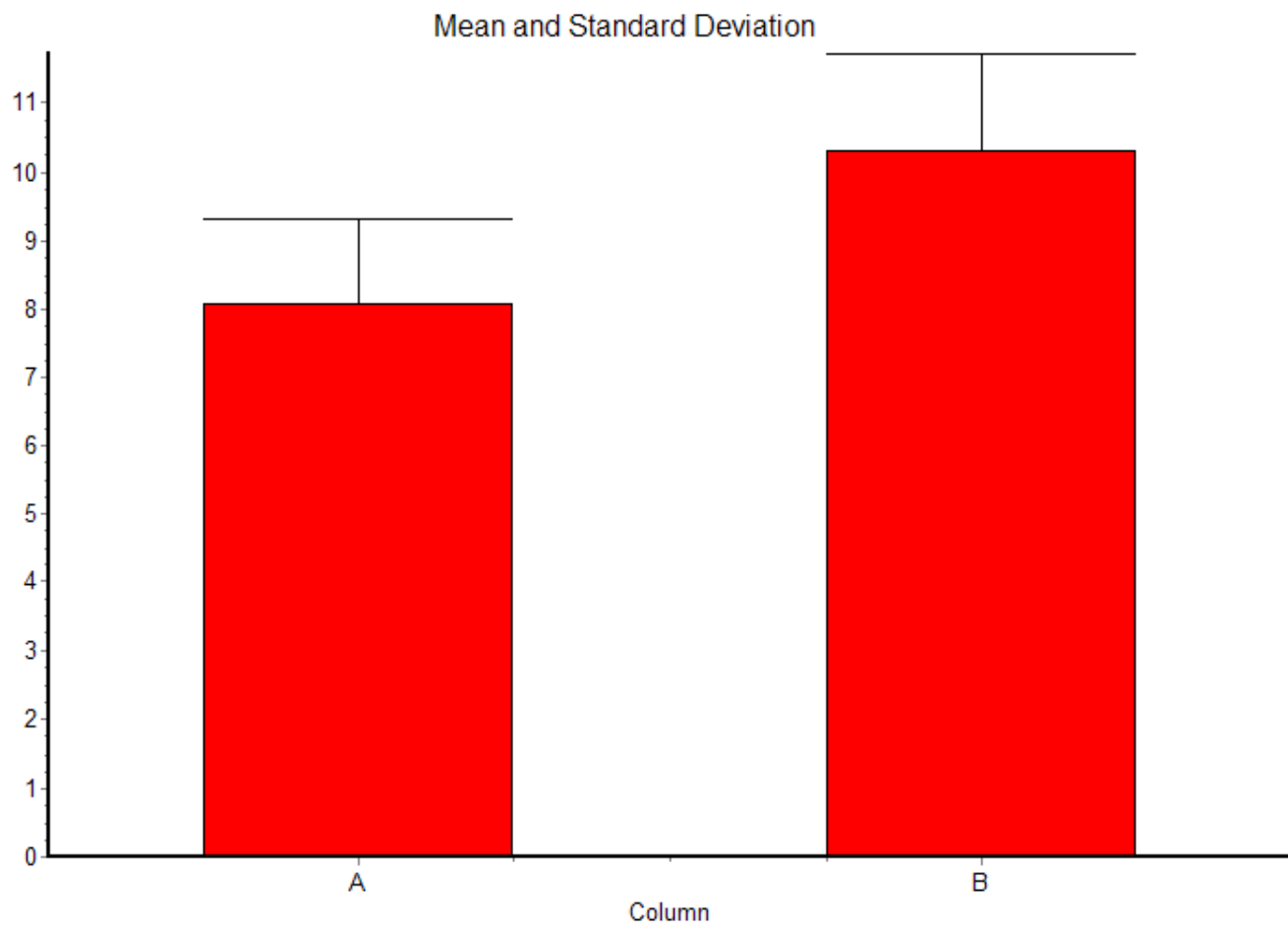
Checklist What's next? Steps: 1st

← →

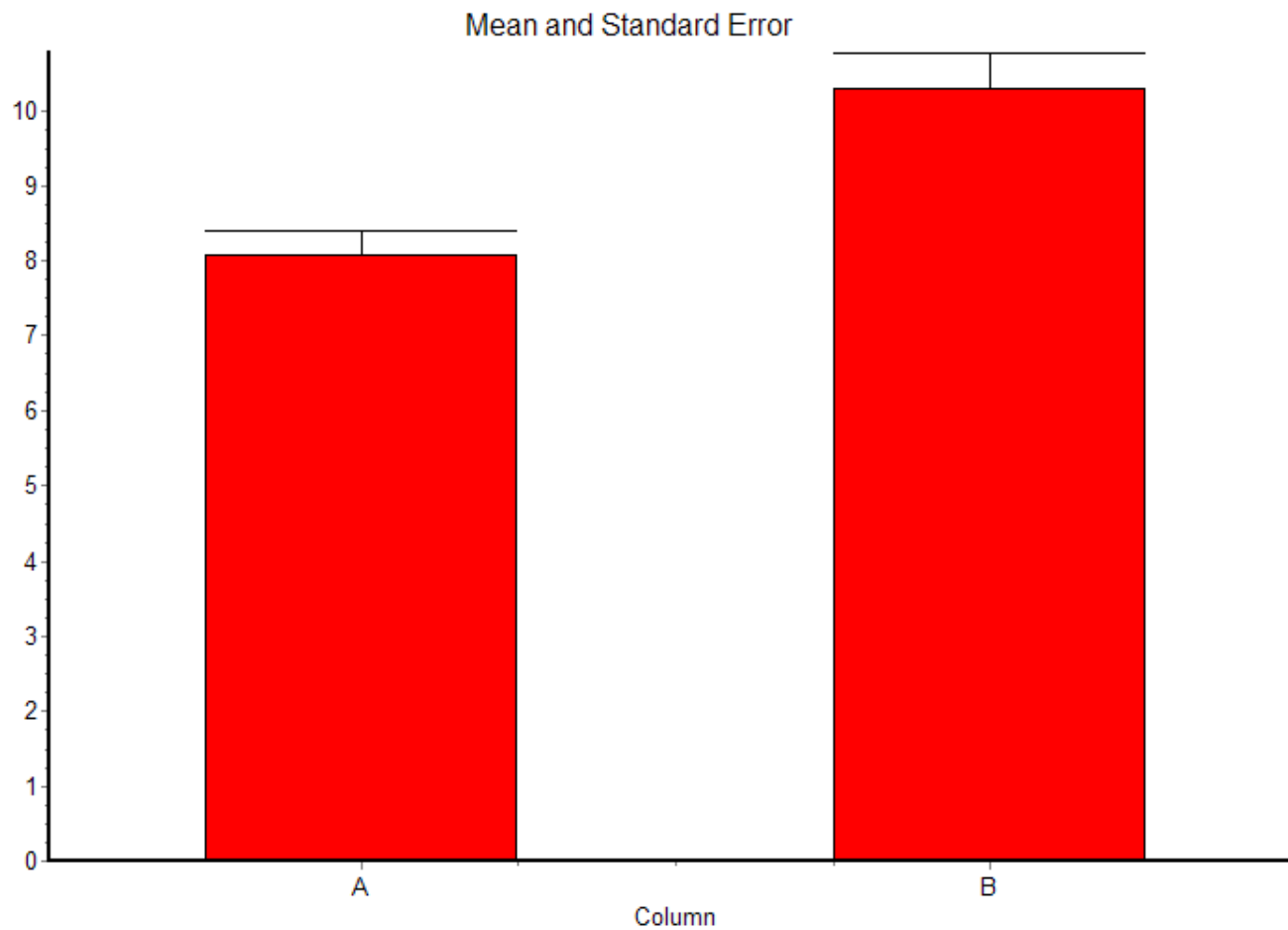
Mean difference = 2.24

P < 0.001, t test

95% CI = 1.06 to 3.42



SEM SD



SEM SD



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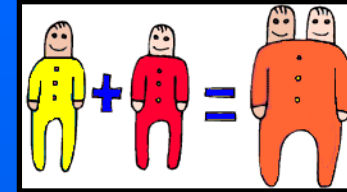
UPS Air to Hawaii, Alaska & \$35.00 5 days

Puerto Rico:

How to Pick the Correct Statistic

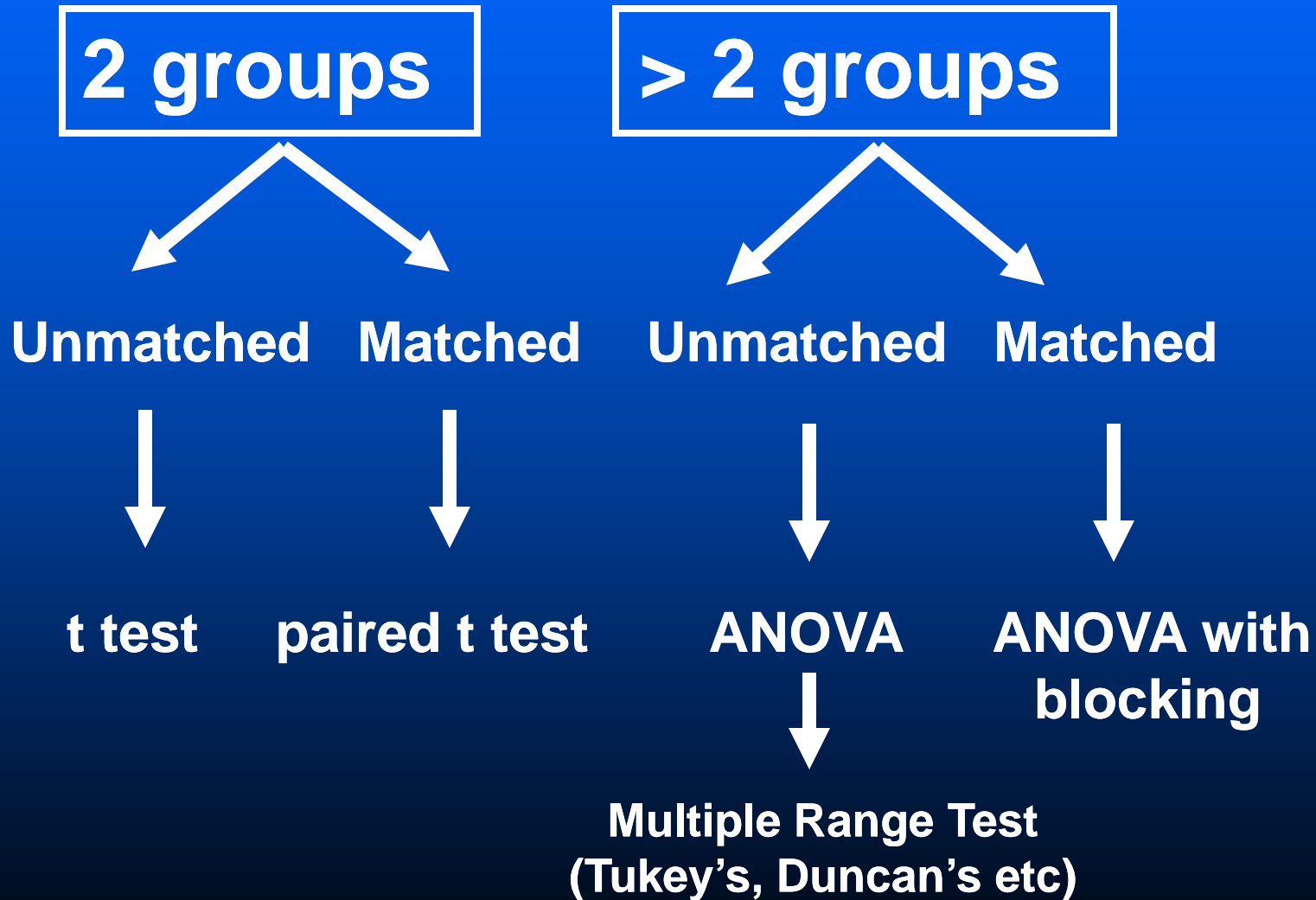
1. Type of data
2. Number of comparison groups
3. Are the groups independent (or are they matched)

What is matching?

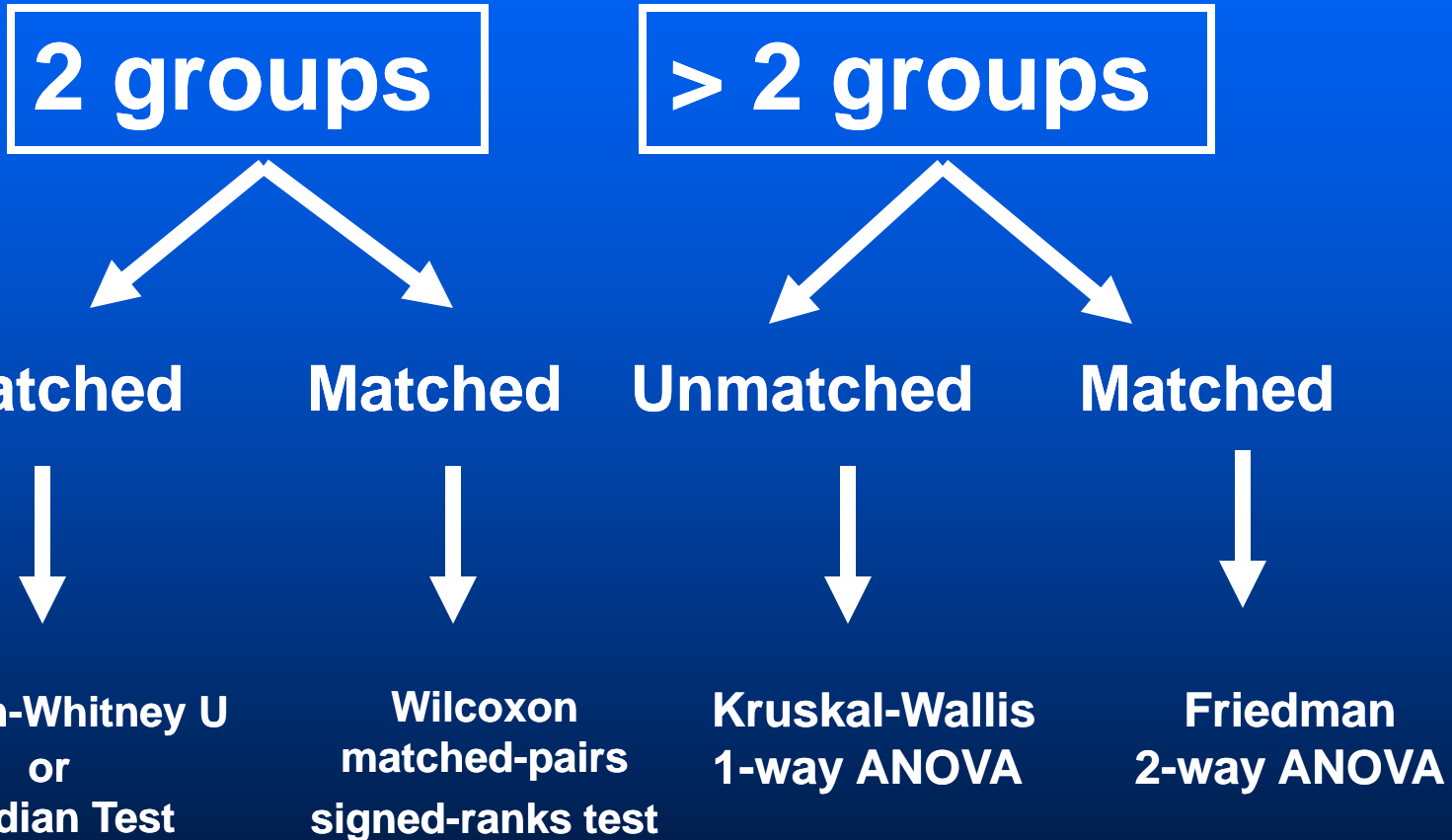


- Observations or measurements made on the same subject (or on individually matched subjects) are said to be “matched” or “paired.”
- Examples: Before and after measurements in the same subject. Cases matched to controls on a confounding factor such as age.
- Most tests (t test, ANOVA, Fisher’s exact test) assume independence.

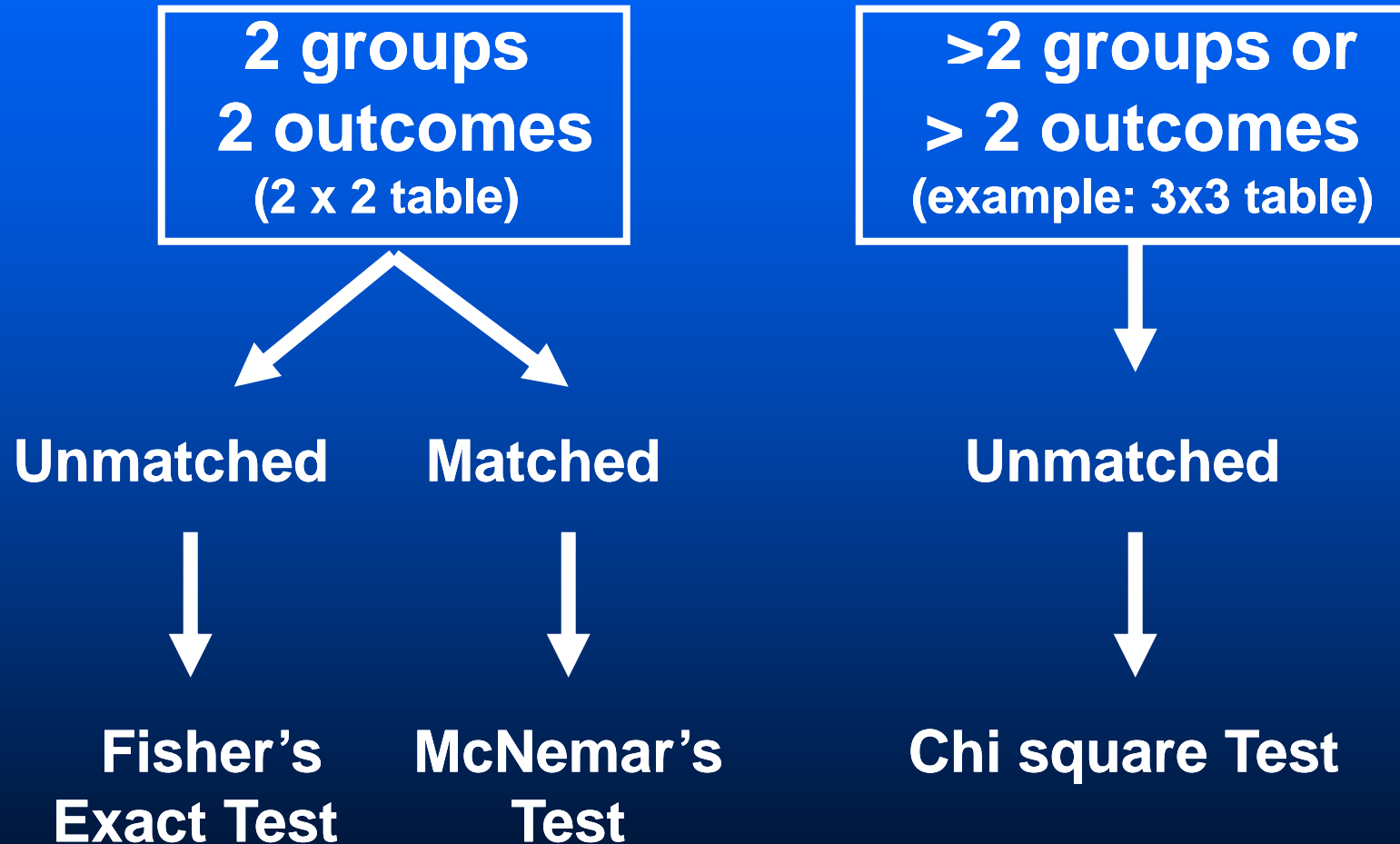
Continuous Data



Ordinal Data



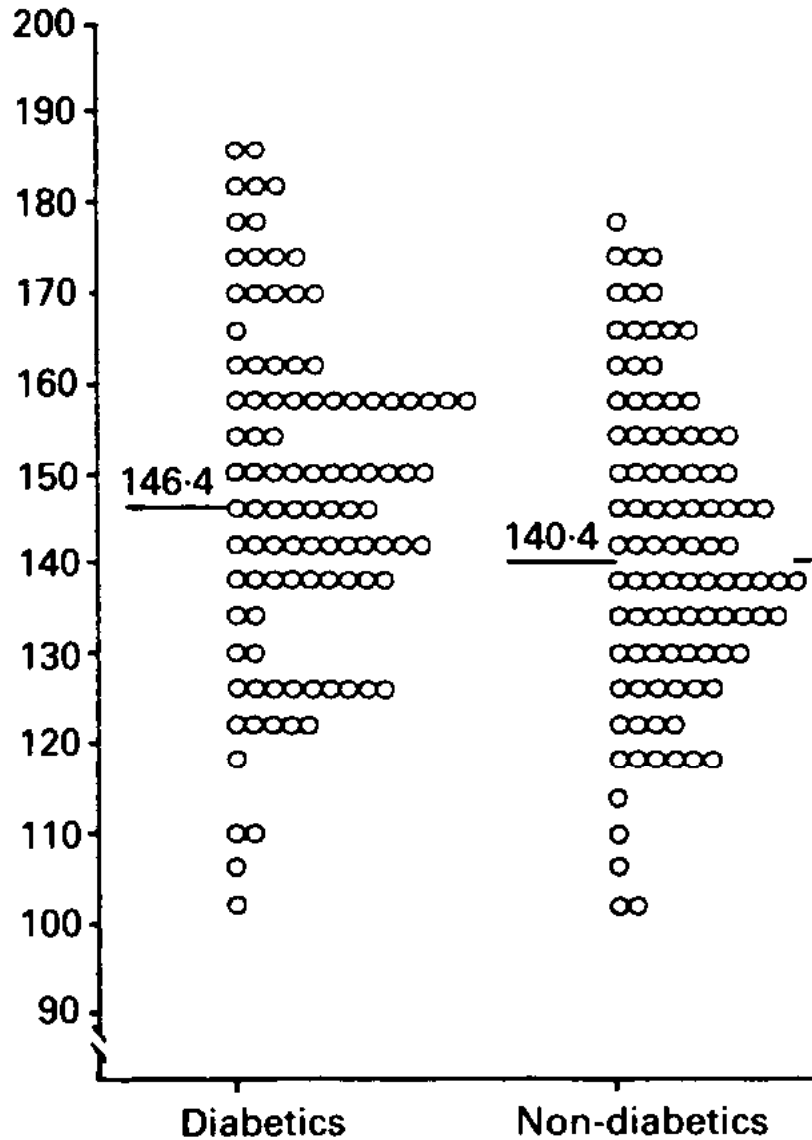
Nominal Data



References

- Martin J. Gardner, Douglas G. Altman. Confidence intervals rather than P values: Estimation rather than hypothesis testing. *BMJ* 1986;292:746-50.
- Douglas G. Altman. Why we need confidence intervals. *World Journal of Surgery* 2005;29:554-5.

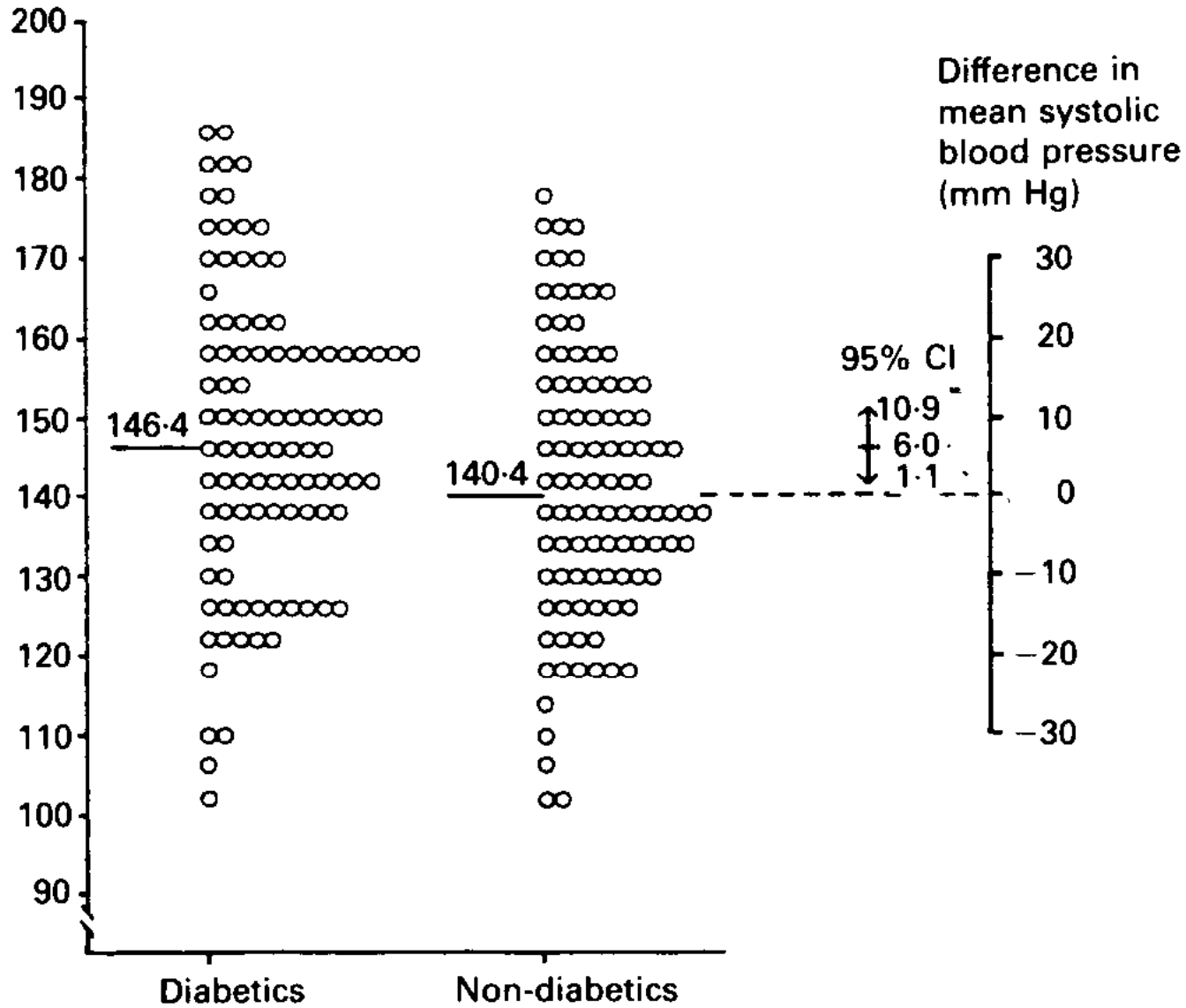
Systolic blood pressure (mm Hg)



**What
measure
of
precision
would
best
compare
these
group
means?**

Systolic blood pressure (mm Hg)

95% CI around the Mean Difference



Questions?

