

Statistics lab analysis

Your goal: Analyze your physiology dataset using descriptive statistics and a comparison test.

One product: Spreadsheet statistical analysis: summary statistics per condition, t-test result with interpretation, and reproducible step documentation.

Question: What does a comparison test support, and can another reader reproduce your analysis?

Start the work

1. Compute summary statistics for each condition in a spreadsheet.
2. Run or interpret a t-test comparing your conditions.
3. Determine whether the difference is statistically meaningful.
4. Record the analysis steps so they are reproducible.
5. Submit your completed statistical analysis.

If software, assignment access or the actual dataset is missing, save preparation and name the spreadsheet, actual-data and official tasks you still need to do. Paper calculations do not complete the spreadsheet submission.

Words you will use

physiology

How living bodies function.

condition

One setting or comparison level in a study.

pulse rate / bpm

How often the pulse occurs, expressed in beats per minute.

mean

The sum of the values divided by their count.

count / n

The number of observations or independent units specified for an analysis.

deviation

A value minus its mean.

sample variance

The sum of squared deviations divided by n minus one.

sample standard deviation / SD

The square root of sample variance; it has the original measurement units.

paired data

Measurements linked one-to-one, such as two readings from the same person.

independent pairs

Pairs whose results do not depend on other pairs. Measurements within a pair may be related.

difference

Here, the value in condition B minus the matched value in A.

null hypothesis

The model claim being tested; here the population mean paired difference is zero.

alternative hypothesis

The competing model claim; here the population mean paired difference is not zero.

two-sided test

A test that considers differences in either direction.

t-test

A comparison method that relates an estimated mean difference to its uncertainty under stated assumptions.

standard error

An estimate of the uncertainty of a sample mean. For paired differences here it is their SD divided by the square root of n .

degrees of freedom / df

A number used to choose the test distribution; for this paired test it is n minus one.

normal distribution

A symmetric bell-shaped probability model.

p-value

Under the null and model assumptions, the probability of a test statistic at least as extreme as the one calculated.

significance level / alpha

A cutoff chosen before examining the result; here 0.05.

statistically significant

A result whose p-value meets the chosen cutoff under the stated model. It need not be important or causal.

effect size

The size of a difference; here report the mean paired difference in bpm.

power

The chance that a test detects a specified effect when that effect exists, under its design and assumptions.

outlier

A value far from the others; investigate it rather than deleting it to improve a result.

reproducible analysis

An analysis another person can rerun from the same inputs and documented steps.

replication

A new investigation that checks whether a finding holds with new observations.

cell range

A named block of spreadsheet cells, such as B2:B7.

missing value

An expected observation that is unavailable; it is not automatically zero.

assumption

A condition a method relies on; calculating a result does not verify that condition.

bias

A systematic influence that can distort a result.

CER

Claim, Evidence, Reasoning: a conclusion, its support and the explanation connecting them.

E1: from values to summaries

Compute mean as sum divided by count. For sample SD, subtract the mean from each value, square each deviation, and add the squares. Divide by n minus one, then take the square root. NIST gives this sample formula.

Mean and SD retain bpm units here. Variance has squared bpm units. Report count for each condition. With paired data, also count complete pairs; do not count two measurements on one person as two independent people.

Overlap of condition values is a useful first look, but it does not determine a paired test. That test uses the matched differences and their spread.

E2: choose the model before the test

NIST describes paired comparisons through one-to-one differences. The paired t statistic is mean difference divided by its standard error. Here, $t = \text{mean difference} / (\text{SD of differences} / \text{square root of } n)$, with $df = n \text{ minus one}$.

For a small paired sample, the model needs independent pairs and a reasonably normal population of differences. OpenStax also identifies random sampling. A few tidy values cannot prove these assumptions. They are stipulated for D1 arithmetic only.

For actual work, verify pairing, independent units, sampling, timing, missing values and outliers with the teacher. Independent groups need a different test; do not force them into D1's paired formula. Never rearrange one column alone.

For D1 choose a two-sided paired test before looking at the result. Null: the modeled population mean B-minus-A difference is zero. Alternative: it is not zero. Set alpha to 0.05.

D1: original recovery data and design

Invented instructional pulse values, not participant observations. Six fictional people each have one A and one B value. A and B are neutral labels; no intervention, collection method or actual outcome is asserted. No data collection is authorized.

Enter this complete table in a blank approved spreadsheet. Row 1 headers: A1 Pair; B1 A (bpm); C1 B (bpm); D1 B minus A (bpm). Rows 2 through 7 are: P1,60,62; P2,62,65; P3,64,65; P4,66,70; P5,68,70; P6,70,73. D cells start blank.

For this practice, assume six independent pairs sampled from a model with normally distributed paired differences. This is a teaching assumption, not a tested claim. All twelve values are present; do not exclude any or add zeros. There are six pairs, not twelve people.

Keep each A/B pair on the same row. Condition A ranges from 60 to 70 bpm; B ranges from 62 to 73 bpm. The intervals overlap. Compute both means by hand before using functions.

R1: reproducible spreadsheet steps

Create a sheet named Practice with D1's headers and rows. Label the workbook Original recovery data. Compare every entered value against D1 before calculating. Use the following Excel formulas; another program needs its verified equivalent.

Enter $=C2-B2$ in D2 and fill through D7. In F1:I1 enter Summary, A, B, Difference. Put Mean, Sample SD and Count in F2:F4. In G2 enter $=\text{AVERAGE}(B2:B7)$; G3 $=\text{STDEV.S}(B2:B7)$; G4 $=\text{COUNT}(B2:B7)$.

In H2:H4 use the same functions with C2:C7. In I2:I4 use them with D2:D7. These are three separate formulas per column. Display two decimal places for means and SDs, but keep full stored precision.

In F6 write Paired two-sided p. In G6 enter `=T.TEST(C2:C7,B2:B7,2,1)`. Microsoft defines 2 as two tails and 1 as paired. Display at least six decimal places for p. Do not replace it with zero.

In F7 write Alpha and enter 0.05 in G7. In F8 write Decision and enter your comparison in G8. In F9 write Mean B minus A (bpm) and enter `=AVERAGE(D2:D7)` in G9.

On a Notes sheet record data origin, sheet/ranges, units, six pairs, hypotheses, assumptions, exclusions (none for D1), formulas, software/version and rounding. Add the numerical result, interpretation and limitations. Save both sheets in the same workbook.

If spreadsheet access is missing, calculate and interpret E4 on paper as preparation. Ask how to complete the spreadsheet execution and file submission; after uploading, check that Schoology shows Submitted. This does not replace the required spreadsheet product.

E3: what a p-value says

A p-value describes compatibility with a specified null model. It is the probability, under that model and its assumptions, of a statistic at least as extreme as the calculated statistic.

For this exercise compare p with $\alpha = 0.05$. A lower p supports rejecting the zero-mean-difference null within the assumed model. A higher p means insufficient evidence to reject it; it does not prove equality.

The ASA warns that a p-value does not give the probability a hypothesis is true or measure effect size. It does not prove causation, practical importance or future replication. Show the difference and limitations alongside it.

Running documented steps on the same data can reproduce a calculation. Replicating a biological result needs new observations. Neither a reproducible mistake nor a low p-value guarantees a true clinical claim.

E4: recovery check results

Check after attempting D1. Each count should be 6. Each mean should equal its column sum divided by 6 and fall inside that column's range. Recompute one sample SD by hand with E1's steps.

Subtract A from B on each row, keeping every pair on its own row. The mean difference should equal mean B minus mean A. Six complete pairs give $df = 5$.

Your two-sided paired p-value comes from G6's T.TEST formula; check that it uses both columns, 2 tails and type 1, and displays at least six decimal places. Compare it with $\alpha = 0.05$ and state your decision about the zero-mean-difference null under the stipulated model.

Report the mean B-minus-A difference in bpm from your sheet. These invented numbers establish no actual change in a person and no clinical benefit. If your sheet differs, check ranges, paired rows, sample SD and test arguments before changing data.

P1: actual work and official holds

Your actual-data analysis remains required when assigned. Recover the submitted physiology table and March 11 graph locally. Check their match, units, conditions, pair structure, independent units and missing values. Do not paste private records into public work.

Get the teacher's approved test, direction, threshold and missing-value policy before applying functions to actual data. Document your real sheet names and ranges. Ask the teacher to resolve any unknown design decision; do not copy D1 assumptions onto a different design.

The absence route uses D1 and R1 as original shared practice. Follow the written steps and run the test when software is available. Then identify what is needed to bring your own data through the appropriate path. D1 is not the missing teacher-provided dataset or your collected observations.

The async task remains spreadsheet summaries, a run or interpretation of a t-test and reproducible steps. No homework is due before this class. Actual spreadsheet access and assigned data are still necessary.

Your teacher may assign Activity 2.1.3 Making Results Meaningful and will confirm its screens, format and stop point. An original workbook does not mark that official activity or tracker complete.

Weekly physiology table, sensor lab, graphing, mean/SD/error and Problem 2 physiology-data evidence remain separate. The weekly supplied biometric dataset is not provided here. Unit bias/error, graph, data-based CER and replication limitation also remain open for actual evidence. Keep work for March 16's CER mini-report.

X1: warmups, checks and sample size

Warmup one: two means differ by 3. What else is needed? Name units, spreads, counts and design or pairing. Warmup two: explain why another reader needs exact data and steps to reproduce a calculation.

Self-check is hypothetical: $p = 0.02$ with $\alpha = 0.05$. That crosses the cutoff. Under the null and assumptions, a statistic at least this extreme has probability 0.02. It does not mean a 98 percent chance that the effect is real.

Extension: in two sentences explain $p = 0.03$ and what it does not mean. Then name why a small sample could miss a real effect. Its uncertainty can be too large relative to the effect to cross the cutoff.

Exit: doubling independent sample size can reduce standard error if spread and design stay comparable. It does not guarantee a changed decision because new values and assumptions matter. Copying existing rows doubles a row count, not independent information.

Restart at the first unfinished step: summaries, appropriate test or teacher-confirmed result interpretation, decision, then reproducible notes. Keep actual and recovery results clearly labeled.

M1: different-question worked model, measuring strips

Invented model: four strips are each measured by two rulers. In cm, ruler A values are 10,12,14,16; matched ruler B values are 10,17,12,22. No measurements occurred.

Differences B minus A are 0,5,-2,6 cm. Their mean is 2.25 cm. Squared deviations sum to 44.75; divide by 3 for sample variance, then take the square root: $SD = 3.862210$ cm.

With independent normally distributed differences stipulated for practice, $t = 2.25 / (3.862210 / \text{square root of } 4) = 1.165136$, $df = 3$. A two-sided paired test gives $p = 0.328185$. At alpha 0.05, do not reject zero mean difference within this model; that does not show the rulers agree.

A model report names the paired design, exact input rows, formula, p, difference and assumptions. It does not claim either ruler is accurate without a reference. Transfer this reporting structure to D1, not these numbers.

Try the decision

Which conclusion correctly uses D1's test result?

- Compare the paired practice p-value with 0.05 under its stipulated model; either decision establishes no actual clinical effect.
- Interpreting the p-value as the chance that condition B truly changes everyone's pulse.
- Because condition ranges overlap, no paired difference can be statistically significant.

Explain your choice using the reading. Discuss it or say it to yourself. This practice does not add another submission.

Your 80-minute flow

0–10 minutes	Recover actual table or choose D1; check inputs, hand means, overlap and both warmups.
10–30 minutes	Read E1/E2 and build the R1 summary table; compare E4 after trying.
30–55 minutes	Study M1/E3; run or interpret the appropriate test and record assumptions.
55–65 minutes	Write p , threshold, difference and bounded conclusion.
65–77 minutes	Complete Notes; submit workbook or state missing access and official inputs.
77–80 minutes	Answer doubled-sample exit and confirm remaining work.

Your response record

Use these labels in your workbook. Check Turn in your work below for the required file format.

Verify inputs and estimate by hand

Choose actual data with confirmed design or labeled D1 recovery. Compute both condition means by hand and describe overlap. Answer both X1 warmups.

D1 supplies all recovery inputs. Overlap alone does not determine the paired result.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

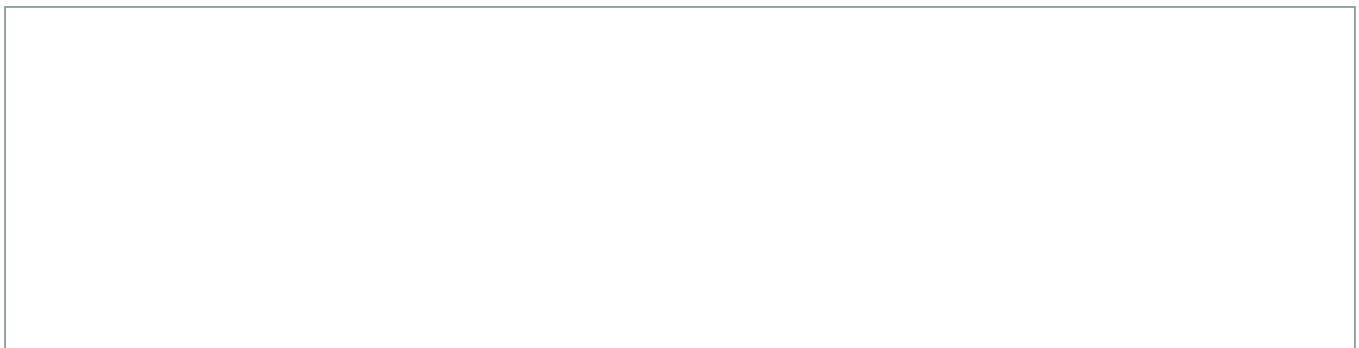


Spreadsheet summary table

Use R1 to calculate mean, sample SD and count per condition, plus paired differences where appropriate. Record units and complete-pair count.

For D1 use six rows and sample SD. Compare with E4 after trying. Do not use invented values for missing real observations.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

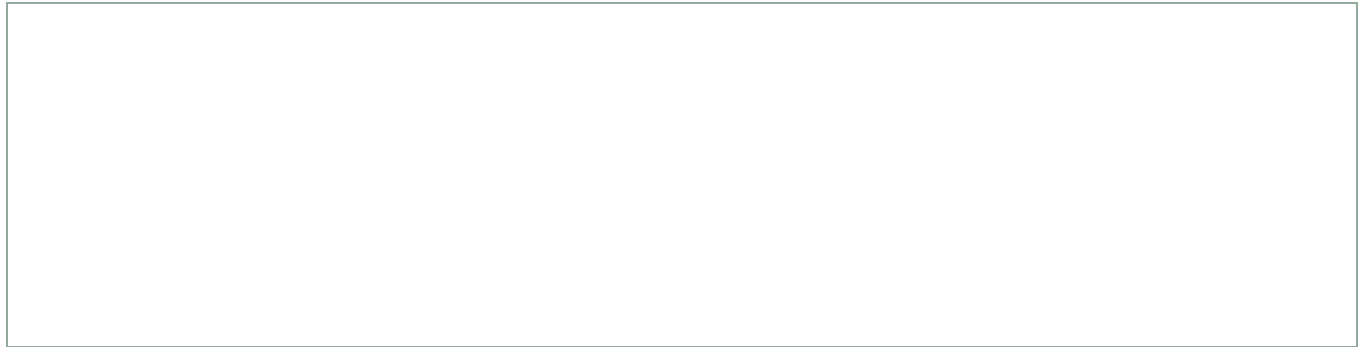


Comparison test and interpretation

State hypotheses, design, assumptions, alpha and test type. Run the appropriate test or interpret the D1 result your teacher confirms. Report p, mean difference and a bounded conclusion.

R1/E2/E3/E4 supply the recovery method. Ask for the missing actual design or software. No causal or clinical claim follows.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

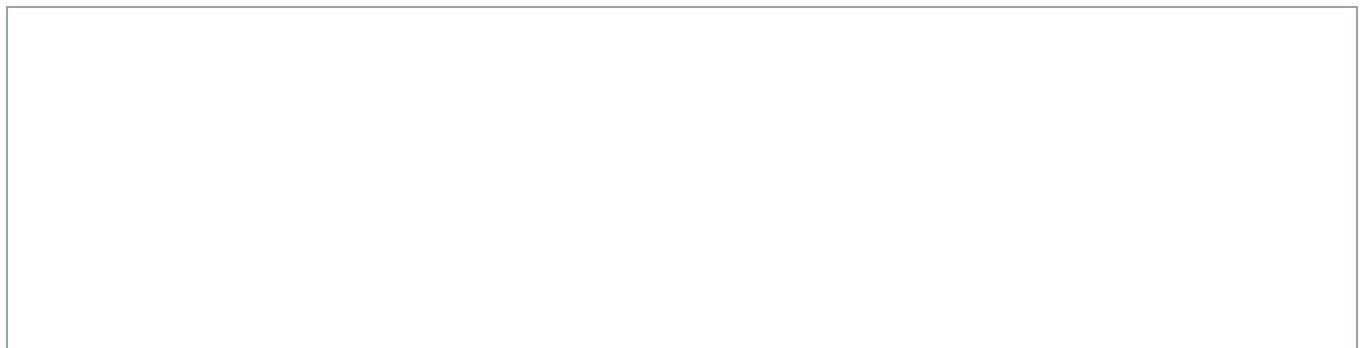


Reproducible analysis record

Document data origin, ranges, units, formulas, software, exclusions, precision and interpretation on Notes. Submit the same workbook through the confirmed route.

Keep Practice and Notes together. State whether this is recovery or actual analysis, and list remaining official/data tasks.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



Significance and doubled-sample check

Answer X1's $p = 0.02$ check and doubled-sample exit. If ready, add the $p = 0.03$ extension and a small-sample missed-effect explanation.

State the null-model condition. Neither p nor more rows proves a result real, important or repeatable.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

Check your product

- My condition summaries include mean, sample SD, count and units.
- My test matches the paired or independent design and states its assumptions.
- I report a p-value, threshold, mean difference and limited conclusion.
- Another reader can locate the inputs and rerun the recorded steps.
- Recovery, actual data and official completion remain distinct.

Keep the limit: D1 and M1 are invented arithmetic practice. Calculated significance under stipulated assumptions cannot establish any participant outcome, causal effect, clinical importance or official completion.

Turn in your work

Submit your spreadsheet statistical analysis, including condition summaries, t-test result/interpretation and reproducible Notes, through the linked BI assignment. Label recovery explicitly. After uploading, check that Schoology shows Submitted.

If software, assignment access or the actual dataset is missing, save preparation and name the spreadsheet, actual-data and official tasks you still need to do. Paper calculations do not complete the spreadsheet submission.

[Open this assignment in Schoology.](#)

Carry forward

Record the design, inputs and calculations; interpret the p-value within that model, not as proof.

Keep the verified analysis for the March 16 CER mini-report. Ask for missing actual data and official-work instructions. Which calculated result belongs in the CER, and what can it establish?

Sources and resources

[Open today's page](#)

[Practice workbook](#)

NIST-SD · Measures of Scale

NIST/SEMATECH

<https://www.itl.nist.gov/div898/handbook/eda/section3/eda356.htm>

NIST-PAIR · Analysis of paired observations

NIST/SEMATECH

<https://www.itl.nist.gov/div898/handbook/prc/section3/prc311.htm>

OPENSTAX · Matched or Paired Samples

OpenStax Statistics, section 10.4

<https://openstax.org/books/statistics/pages/10-4-matched-or-paired-samples-optional>

ASA · Statement on Statistical Significance and P-Values

American Statistical Association, 2016

<https://www.amstat.org/asa/files/pdfs/p-valuestatement.pdf>

EXCEL-T · T.TEST function

Microsoft Support

<https://support.microsoft.com/en-us/excel/functions/t-test-function>

EXCEL-SD · STDEV.S function

Microsoft Support

<https://support.microsoft.com/en-us/excel/functions/stdev-s-function>

EXCEL-MEAN · AVERAGE function

Microsoft Support

<https://support.microsoft.com/en-us/excel/functions/average-function>

EXCEL-N · COUNT function

Microsoft Support

<https://support.microsoft.com/en-us/excel/functions/count-function>