1. A researcher wants to study whether hours of sleep are related to test scores. Which pair of variables is being investigated?

A. Eye color and shoe size
B. Hours of sleep and test scores
C. Age and favorite color
D. Height and blood type

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2. If two variables tend to increase together, the relationship is called:

A. Negative association
B. No association
C. Positive association
D. Categorical association

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3. A scatterplot shows that as study time increases, exam scores generally increase. This suggests:

A. A negative association
B. A positive association
C. No association
D. A misleading graph

- **Two-variable statistics** explore the relationship between two variables (e.g., height vs. weight).
- Variables can be **categorical** (e.g., gender vs. choice of beverage) or **quantitative** (e.g., age vs. income).
- **Scatterplots** are used to visualize relationships between two quantitative variables.
- The **correlation coefficient (r)** measures the strength and direction of a linear relationship.
- **Regression analysis** helps model the relationship and make predictions (e.g., linear regression).

- **Association (关联 / 相关)** – a relationship between two variables where knowing one helps predict the other.
- **Positive association (正相关)** – as one variable increases, the other tends to increase.
- **Negative association (负相关)** – as one variable increases, the other tends to decrease.
- **Strength (强度)** – how closely the values of one variable relate to the other; strong vs. weak association.
- **Direction (方向)** – whether the relationship is positive or negative.

A study collects data on 60 adults, recording their **daily hours of exercise** and **resting heart rate**.

(a) Describe the **direction** of the association you would expect between exercise and resting heart rate.
(b) Explain whether you would expect the association to be **strong or weak**, and why.
(c) State which variable is **explanatory** and which is **response**.

(a) Direction of association:

- **Negative association (负相关)** – as daily exercise increases, resting heart rate tends to decrease.

(b) Strength of association:

- Likely **moderate to strong**, because exercise generally has a clear effect on lowering resting heart rate, though individual differences exist.

(c) Explanatory and response variables:

- **Explanatory variable:** Daily hours of exercise
- **Response variable:** Resting heart rate

Introducing Statistics: How Variables Are Related — Stretch & Challenge FRQs

FRQ 1: Study Time and Test Scores

A teacher records the number of hours spent studying and the test score for 20 students. A scatterplot shows a strong positive linear association.

Questions

a) Describe the direction, form, and strength of the relationship.

b) Explain what a positive association means in this context.

c) Does the scatterplot prove that studying more causes higher test scores? Explain.

d) Identify one possible lurking variable that could affect the relationship.

FRQ 2: Exercise and Resting Heart Rate

A fitness coach collects data on weekly exercise hours and resting heart rate for 50 adults. The scatterplot shows a moderately strong negative association.

Questions

a) Describe the relationship between the variables.

b) Interpret the negative association in context.

c) Predict whether a person who exercises 10 hours per week is likely to have a higher or lower resting heart rate than a person who exercises 2 hours per week.

d) Explain why the prediction may not always be correct.

FRQ 1: Study Time and Test Scores

a) Strong, positive, linear association.

b) Students who study more tend to score higher.

c) No. Association does not prove causation.

d) Motivation, prior knowledge, tutoring, etc.

FRQ 2: Exercise and Resting Heart Rate

a) Moderately strong negative linear association.

b) More exercise tends to be associated with a lower resting heart rate.

c) Lower resting heart rate.

d) Individual differences and other factors affect heart rate.

Correlation and Properties

1. **Correlation (相关性)** — Measure of how two variables are related.
2. **Positive correlation (正相关)** — Both variables increase or decrease together.
3. **Negative correlation (负相关)** — One variable increases while the other decreases.
4. **No correlation (无相关性 / 零相关)** — No clear relationship.
5. **Correlation coefficient (相关系数, r)** — Number between -1 and 1 indicating strength and direction.
6. **Linear relationship (线性关系)** — Relationship forms a straight line.
7. **Nonlinear relationship (非线性关系)** — Relationship follows a curve.
8. **Outlier (离群值 / 异常值)** — Data point far from the overall pattern.
9. **Strength (强度)** — How closely points follow a pattern.
10. **Causation (因果关系)** — One variable directly causes changes in another.

1. **Correlation measures association** — Shows how two quantitative variables are related.
2. **Direction matters** — Relationships can be positive (both increase) or negative (one increases, one decreases).
3. **Strength of correlation** — Strong, moderate, or weak depending on how closely points follow a pattern.
4. **Linear vs. nonlinear** — Correlation measures only linear relationships; curves require other analysis.
5. **Correlation coefficient (r)** — Numerical measure between -1 and 1:
   - $r > 0$: positive
   - $r < 0$: negative
   - $r = 0$: no linear relationship
6. **Perfect correlation** — All points lie exactly on a straight line ($r = 1$ or $r = -1$).
7. **Outliers affect correlation** — A single unusual point can strengthen, weaken, or reverse perceived relationships.
8. **Association ≠ causation** — A relationship does not mean one variable causes the other.
9. **Scatterplots visualize correlation** — They show direction, strength, and form.
10. **Lurking/confounding variables —** Hidden variables can explain associations without direct causation.

FRQ: Study Time and Test Scores

A teacher records the number of hours 25 students spent studying for a test and their corresponding test scores. The scatterplot shows a strong positive linear association.

Questions:

a) Describe the direction, form, and strength of the relationship.

b) Explain what a positive correlation indicates in this context.

c) Identify one possible outlier and explain how it might affect the correlation.

d) Can we conclude that studying more causes higher test scores? Explain.

e) Suggest one lurking variable that could influence the relationship.

a) Strong, positive, linear association.

b) Students who study more tend to score higher.

c) Outlier = point far from the pattern; may weaken or distort the correlation.

d) No; correlation does not prove causation.

e) Lurking variable: motivation, prior knowledge, tutoring, or sleep.

TRUE or FALSE

- A positive correlation means that one variable causes the other.
- A correlation coefficient of 0 indicates no linear relationship.
- Outliers can affect the strength and direction of a correlation.