Describing Variables

Stat 120

April 05 2023

Student Survey

Dataset on 362 responses to a student survey given at one college

Year	Gender	Smoke	Exercise	TV	Height	Weight	Siblings	BirthOrder	GPA	Pulse
Senior	M	No	10	1	71	180	4	4	3.13	54
Sophomore	F	Yes	4	7	66	120	2	2	2.50	66
FirstYear	M	No	14	5	72	208	2	1	2.55	130
Junior	M	No	3	1	63	110	1	1	3.10	78
Sophomore	F	No	3	3	65	150	1	1	2.70	40
Sophomore	F	No	5	4	65	114	2	2	3.20	80
FirstYear	F	No	10	10	66	128	1	1	2.77	94
Sophomore	M	No	13	8	74	235	1	1	3.30	77
Junior	F	No	3	6	61	NA	2	2	2.80	60
FirstYear	F	No	12	1	60	115	7	8	3.70	94

Distribution

In the given dataset, there are multiple variables (such as Gender, Smoke, Exercise, Height, Weight, etc.) for different students across various academic years.

Knowing the distribution of each variable can help us identify relationships, trends, and potential anomalies in the data.

Understanding distribution

Understanding the distribution of the data is useful for several reasons:

- *Descriptive analysis:*
- *Data quality:*
- *Assumption checking:*
- *Interpretation of results:*
- *Visualization:*

Distribution

"The distribution of the variable Y"

- *describes its center, variability and shape*
- *use both numbers and graphics*

Center: Mean or Average

Mean: ***average value in a sample or population***

- $\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$ ***is an average of*** n ***values*** y_i ***in a sample***
- μ ***is an average value of*** y ***in a population***

Center: Mean or Average

***Mean:* average value in a sample or population**

- $\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$ ***is an average of*** n ***values*** y_i ***in a sample***
- μ ***is an average value of*** y ***in a population***

Student Survey

```
survey <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/StudentSurvey.csv")
mean(survey$Pulse) # the command `mean` computes an average
[1] 69.57459
```

The mean pulse rate for this sample of students is $\bar{y} = 69.6$ beats per minute.

Center: Median

Median: *the middle value when the data are ordered*

- *The median splits the data in half*
- m *is the median value in a sample*
- M *is the median value in a population*

Center: Median

Median: ***the middle value when the data are ordered***

- ***The median splits the data in half***
- m ***is the median value in a sample***
- M ***is the median value in a population***

```
median(survey$Pulse) # the command `median` computes an median
[1] 70
```

The median pulse rate for this sample of students is $m = 70$ beats per minute.

Variability: Standard Deviation

Standard Devation (SD): average value in a sample or population

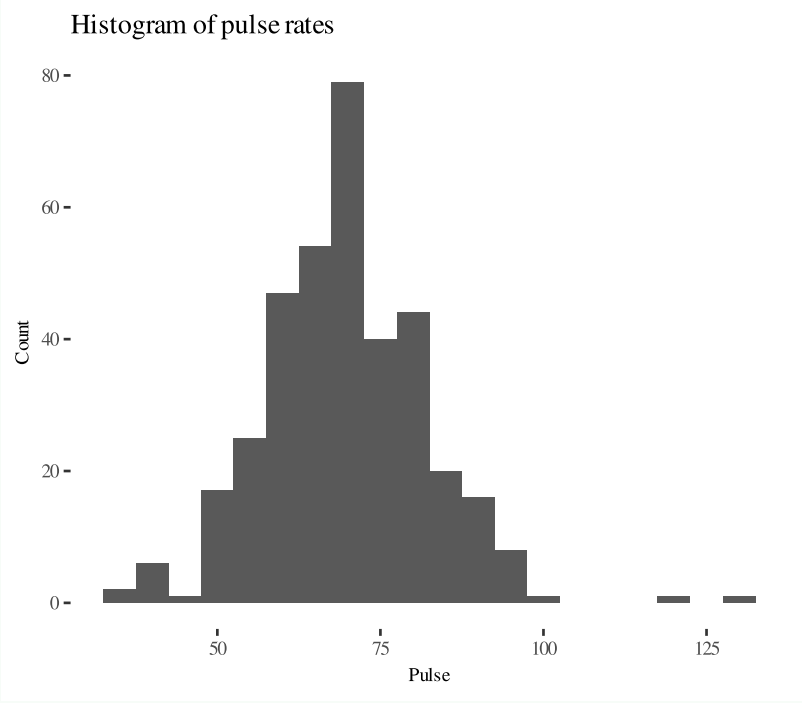
- $s = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}}$ ***is the SD of*** n ***values*** y_i ***in a sample***
- σ ***is the SD of values of*** y ***in a population***

```
sd(survey$Pulse) # the command `sd` computes an average
[1] 12.20514
```

The SD of pulse rates for this sample of students is $s = 12.2$ beats per minute. The "average" deviation of individual pulse rates around the mean value is about 12.2 beats per minute.

Shape: histogram

Histogram: aggregates values into bins and counts how many cases fall into each bin

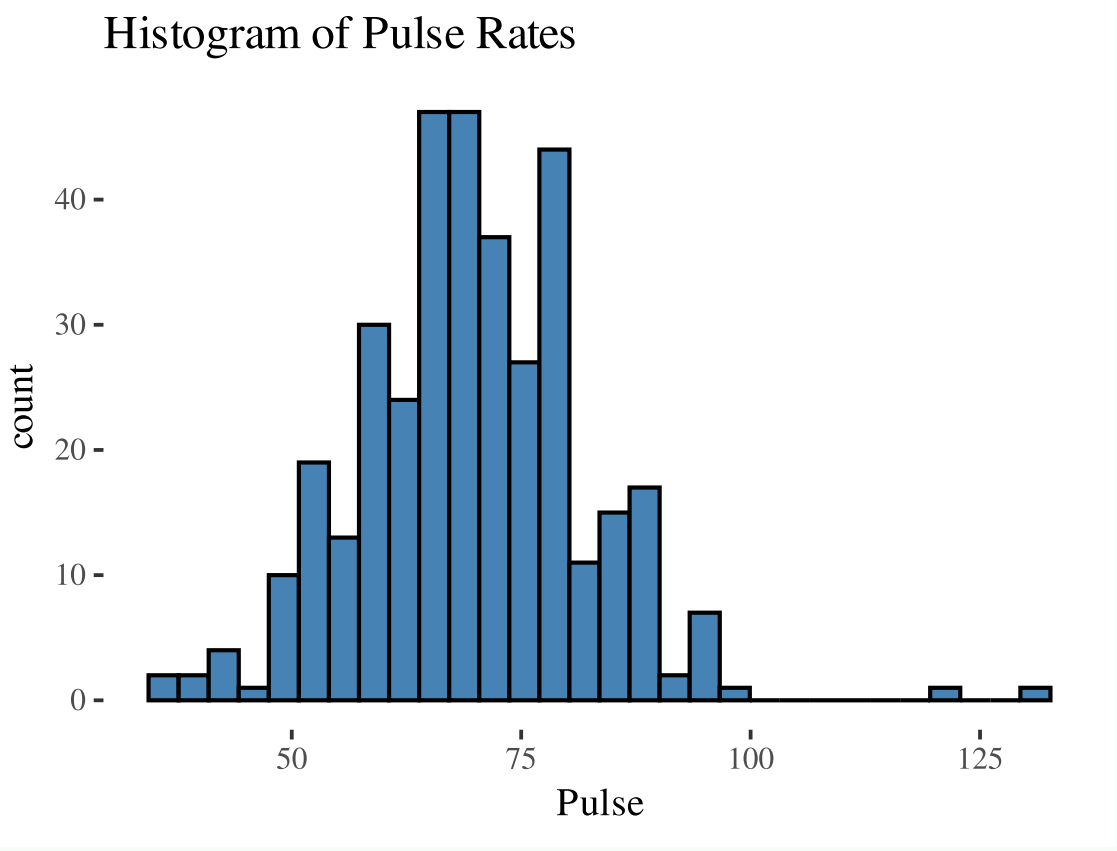


- ***Pulse rates are symmetrically distributed around a rate of about 70 beats per minute.***
- ***Symmetric distributions are "centered" around a mean and median that are roughly the same in value.***

Shape and Stats

Mean and standard deviation are good summary stats of a **symmetric** distribution.

Similar variation to the left and right of the mean so one measure of SD is fine.




```
# mean
mean(survey$Pulse)
[1] 69.57459
```

```
# standard deviation
sd(survey$Pulse)
[1] 12.20514
```

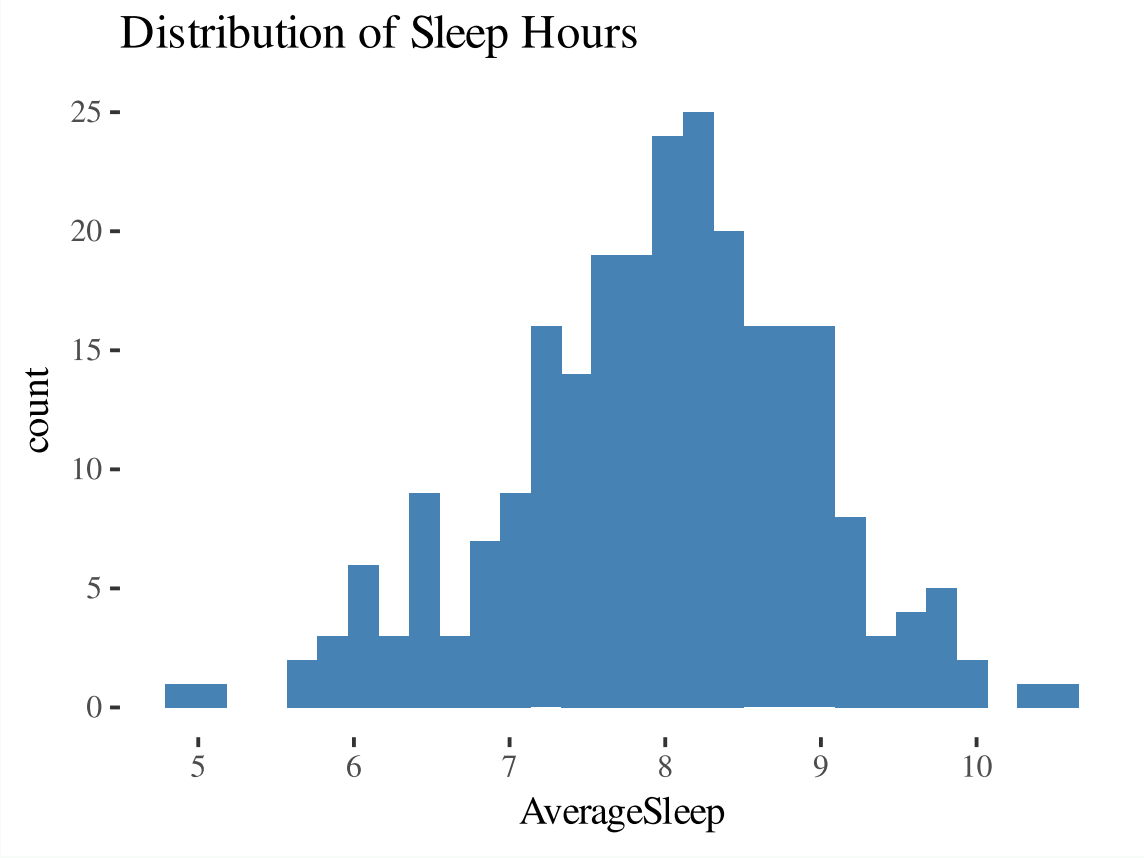
Shape: data distribution

If a distribution of data is approximately bell-shaped, about 95% of the data should fall within two standard deviations of the sample mean.

- *for a sample: 95% of values between* $\bar{y} - 2s$ *and* $\bar{y} + 2s$
- *for a population: 95% of values between* $\mu - 2\sigma$ *and* $\mu + 2\sigma$

Bell-shaped distribution and standard deviation

```
sleep <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/SleepStudy.csv")
```



Question *The standard deviation for hours of sleep per night is closest to*

(a) 0.5

(b) 1

(c) 2

(d) 4

Standardizing data: z-score

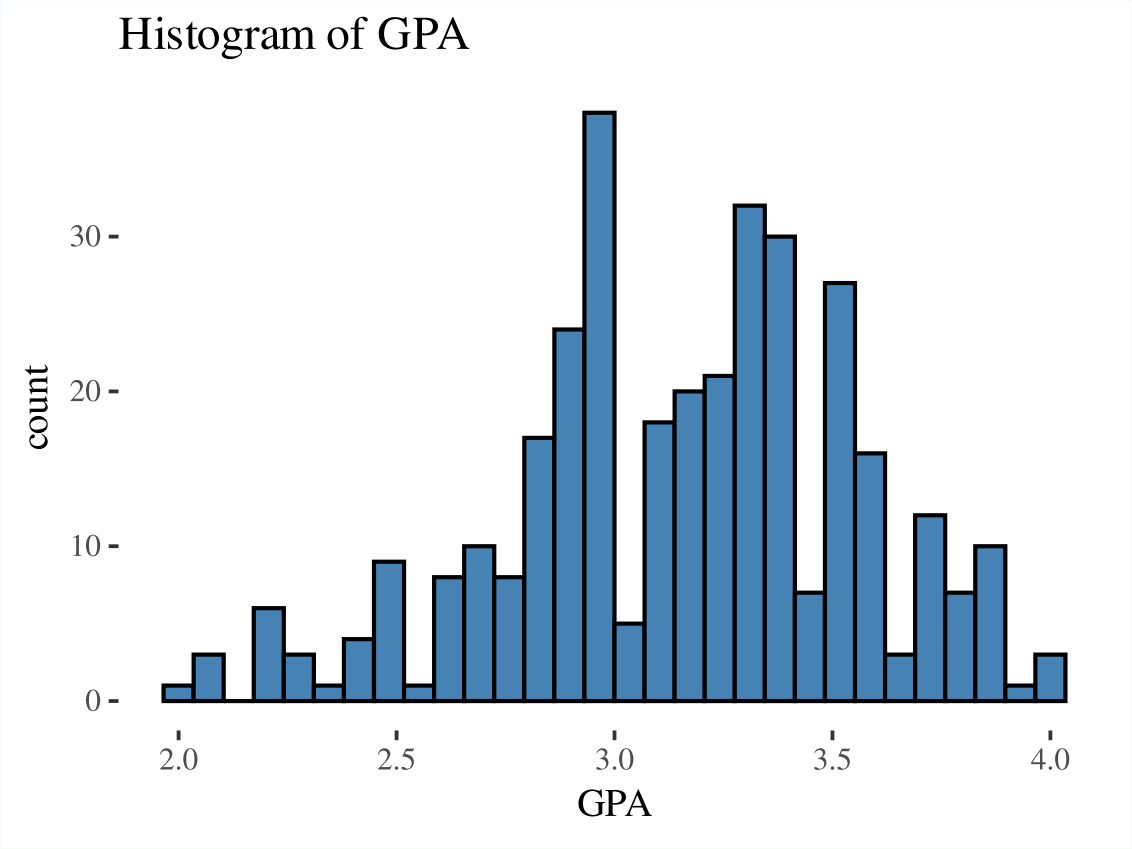
The z-score of a data value, x, tells us how many standard deviations the value is above or below the mean:

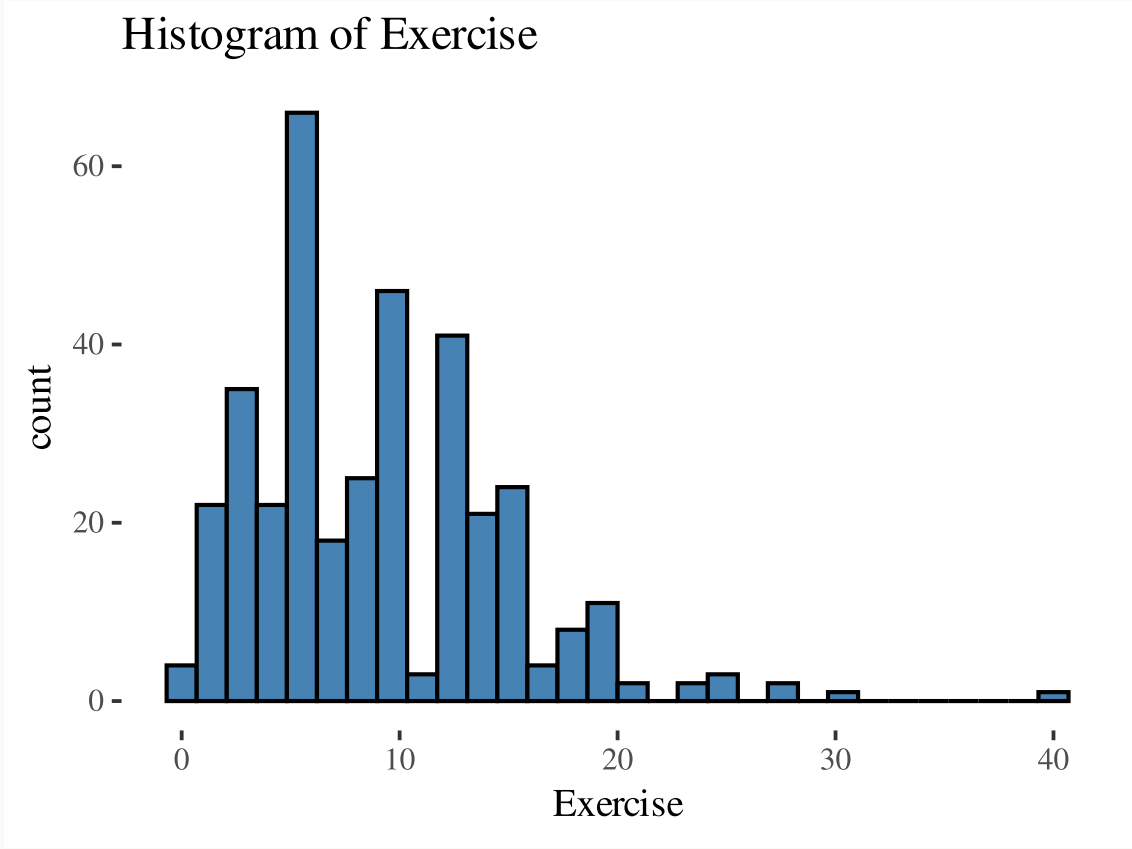
$$z = \frac{x - \text{mean}}{\text{SD}}$$

- E.g. if a value x has $z = -1.5$ then the value x is **1.5 standard deviations below** the mean.

Question: ***If we standardize all values in a bell-shaped distribution, 95% of all z-scores fall between what values?***

Shape: Left Skew & Right Skew

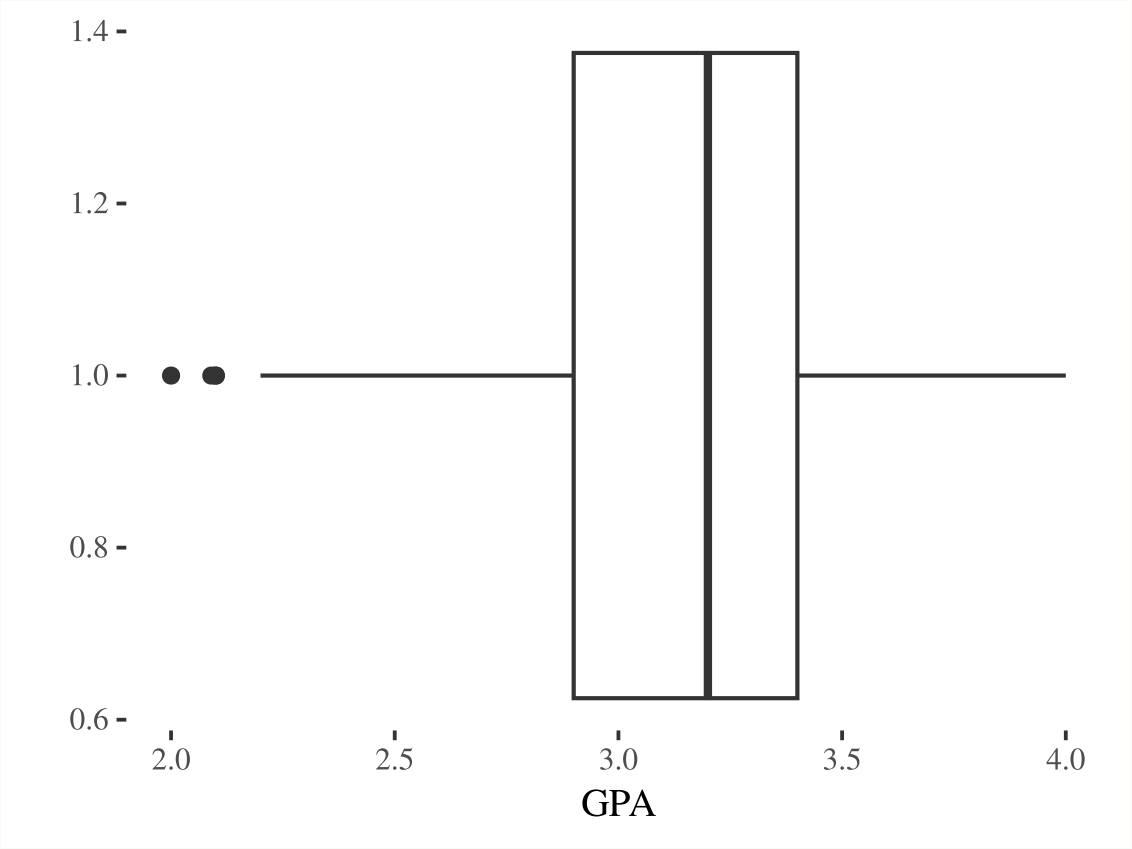


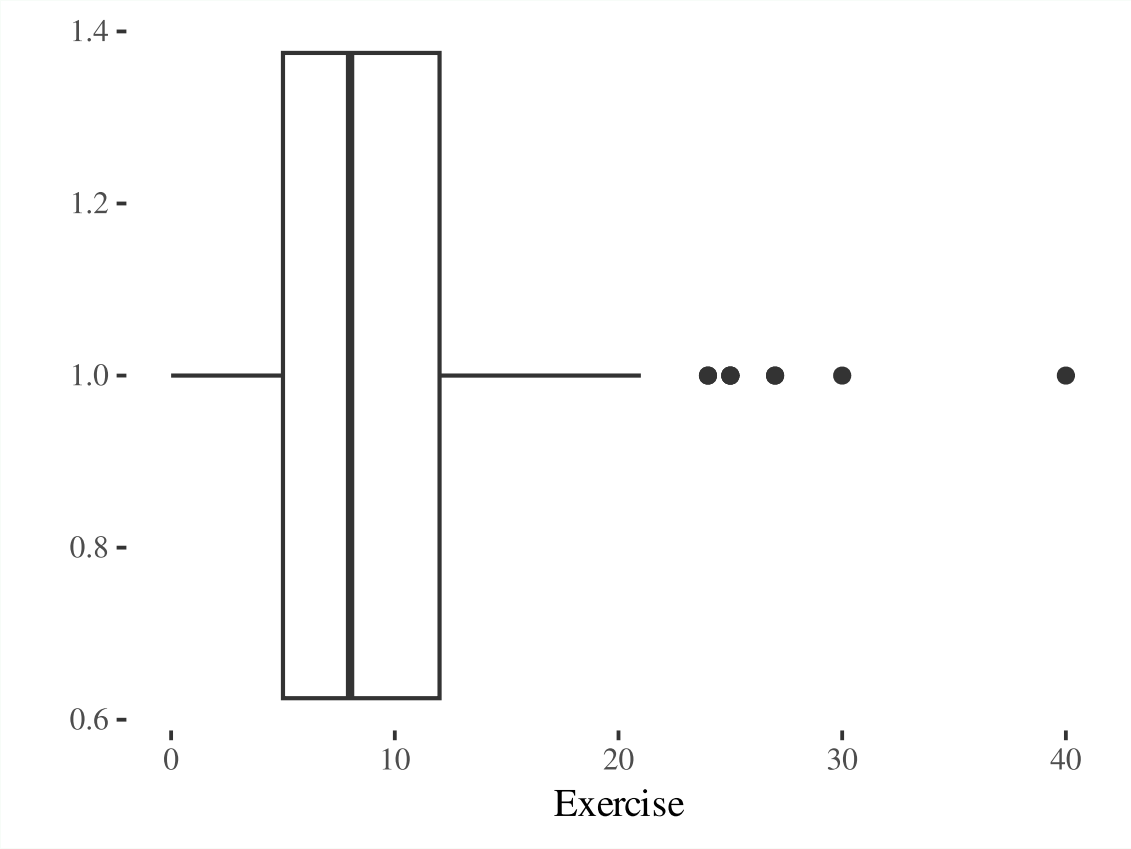



```
mean(survey$GPA, na.rm =T)
[1] 3.157942
median(survey$GPA, na.rm = T)
[1] 3.2
```

```
mean(survey$Exercise, na.rm =T)
[1] 9.054017
median(survey$Exercise, na.rm = T)
[1] 8
```

Shape: Left Skew & Right Skew (Boxplots)






```
mean(survey$GPA, na.rm =T)
[1] 3.157942
median(survey$GPA, na.rm = T)
[1] 3.2
```

```
mean(survey$Exercise, na.rm =T)
[1] 9.054017
median(survey$Exercise, na.rm = T)
[1] 8
```

Shape: boxplots

Boxplots: A graphical representation of the distribution of a dataset, showing the median, quartiles, and outliers.

- ***Box:*** *Represents the interquartile range (IQR) between the 1st quartile (Q1) and the 3rd quartile (Q3)*
- ***Median:*** *The middle value of the dataset, represented by a line inside the box*
- ***Whiskers:*** *Extend from the box to the minimum and maximum data points within 1.5 times the IQR*
- ***Outliers:*** *Data points outside of the whiskers, often represented as individual points*

Shape: boxplots

Symmetry: *If the median is roughly centered within the box, and the whiskers are of similar length, the distribution is likely symmetric.*

Skewness:

- ***Left-skewed:*** *The median is closer to the upper quartile (Q3), and the left whisker is longer than the right whisker.*
- ***Right-skewed:*** *The median is closer to the lower quartile (Q1), and the right whisker is longer than the left whisker.*

Adding a categorical variable: stats

Use `group_by()` and `summarise()` to get summary statistics using `dplyr` package to compare distributions across different levels of a categorical variable

```
survey %>%
  group_by(Smoke) %>%
  summarise(
    Min = min(Pulse, na.rm = TRUE),
    Q1 = quantile(Pulse, 0.25, na.rm = TRUE),
    Median = median(Pulse, na.rm = TRUE),
    Mean = mean(Pulse, na.rm = TRUE),
    Q3 = quantile(Pulse, 0.75, na.rm = TRUE),
    Max = max(Pulse, na.rm = TRUE),
    SD = sd(Pulse, na.rm = TRUE),
    N = n() )
# A tibble: 2 × 9
  Smoke   Min    Q1 Median  Mean    Q3   Max    SD     N
  <chr> <int> <dbl>  <int> <dbl> <dbl> <int> <dbl> <int>
1 No       35    61     69  69.3    77   130  12.3   319
2 Yes      42    65     72  71.8    79    96  11.7    43
```

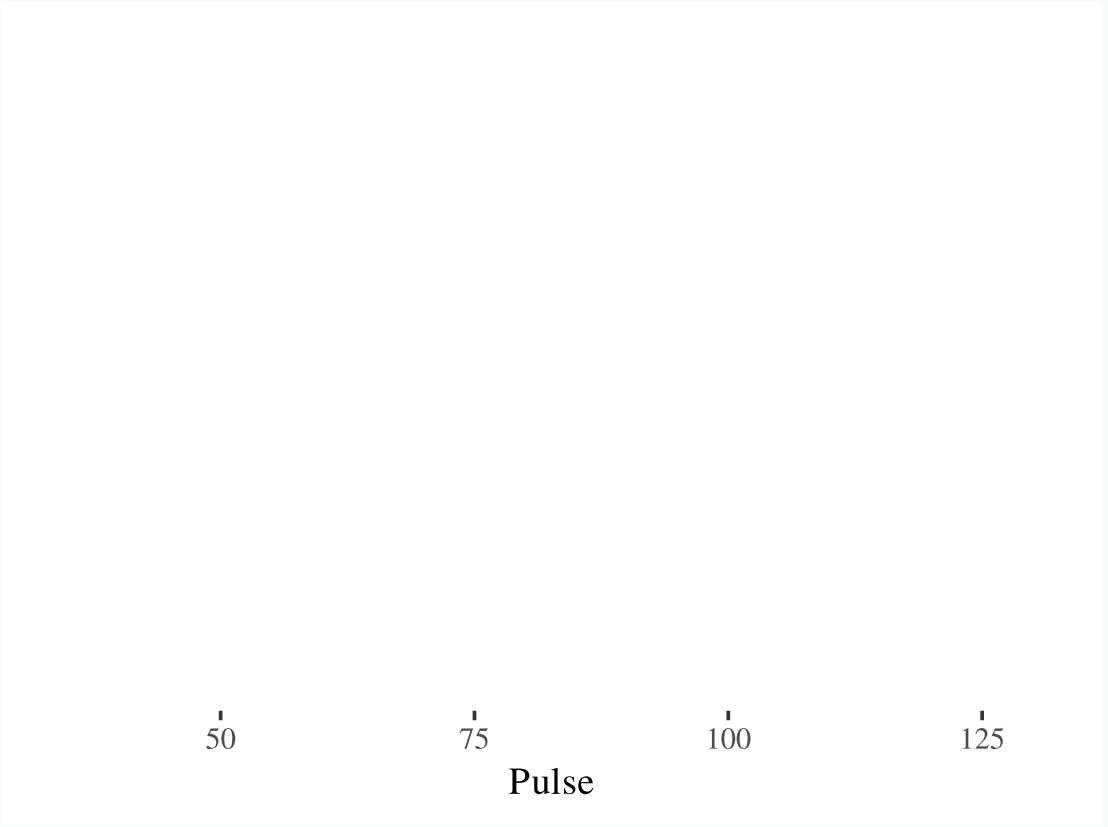
Pulse rate stats by smoking status: Smoker have a slightly higher mean pulse rate than non-smokers (71.8 vs. 69.3).

Adding a categorical variable: graphics

```
library(ggplot2)
```

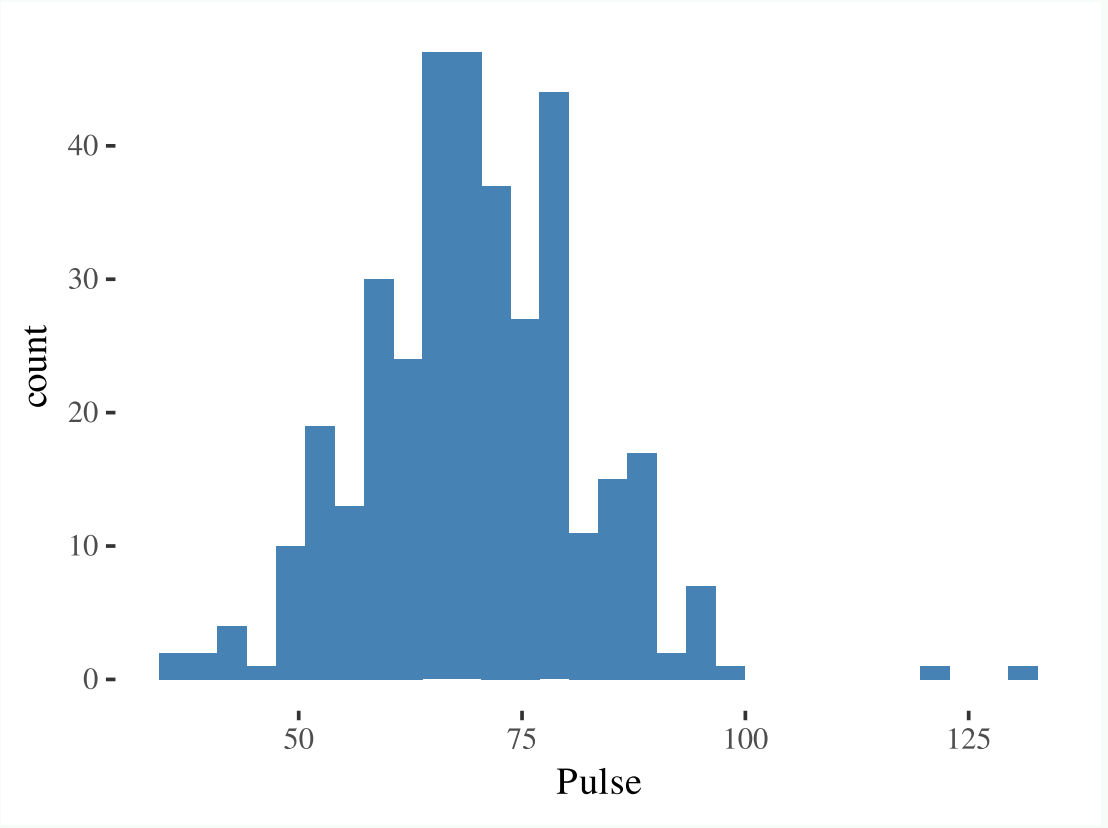
Adding a categorical variable: graphics

```
library(ggplot2)
ggplot(survey, aes(x=Pulse))
```



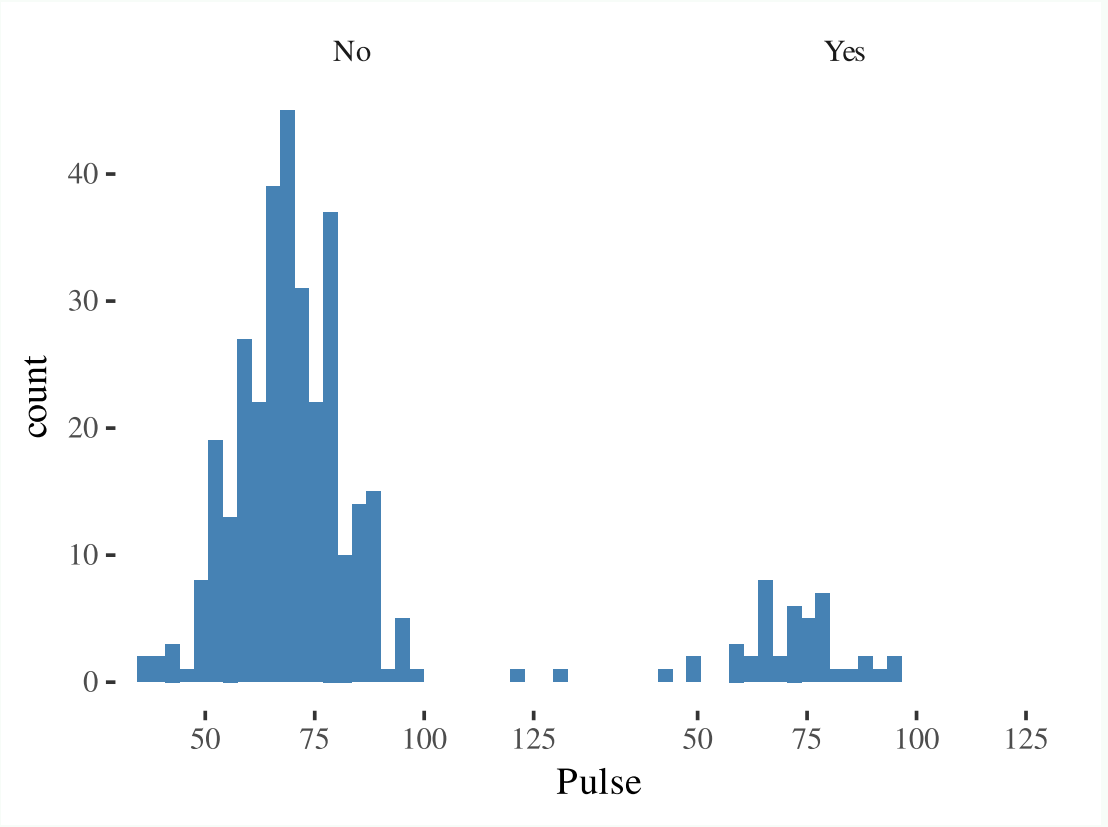
Adding a categorical variable: graphics

```
library(ggplot2)
ggplot(survey, aes(x=Pulse)) +
  geom_histogram(fill="steelblue")
```



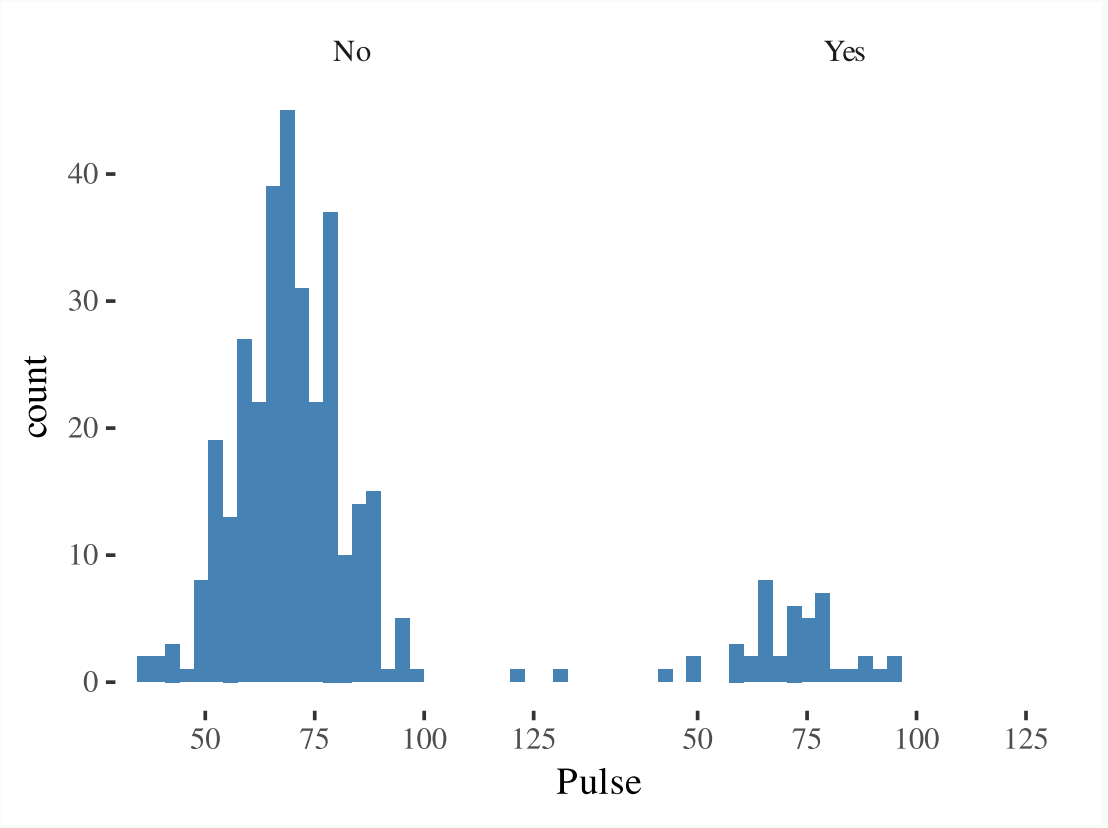
Adding a categorical variable: graphics

```
library(ggplot2)
ggplot(survey, aes(x=Pulse)) +
  geom_histogram(fill="steelblue") +
  facet_wrap(~Smoke)
```

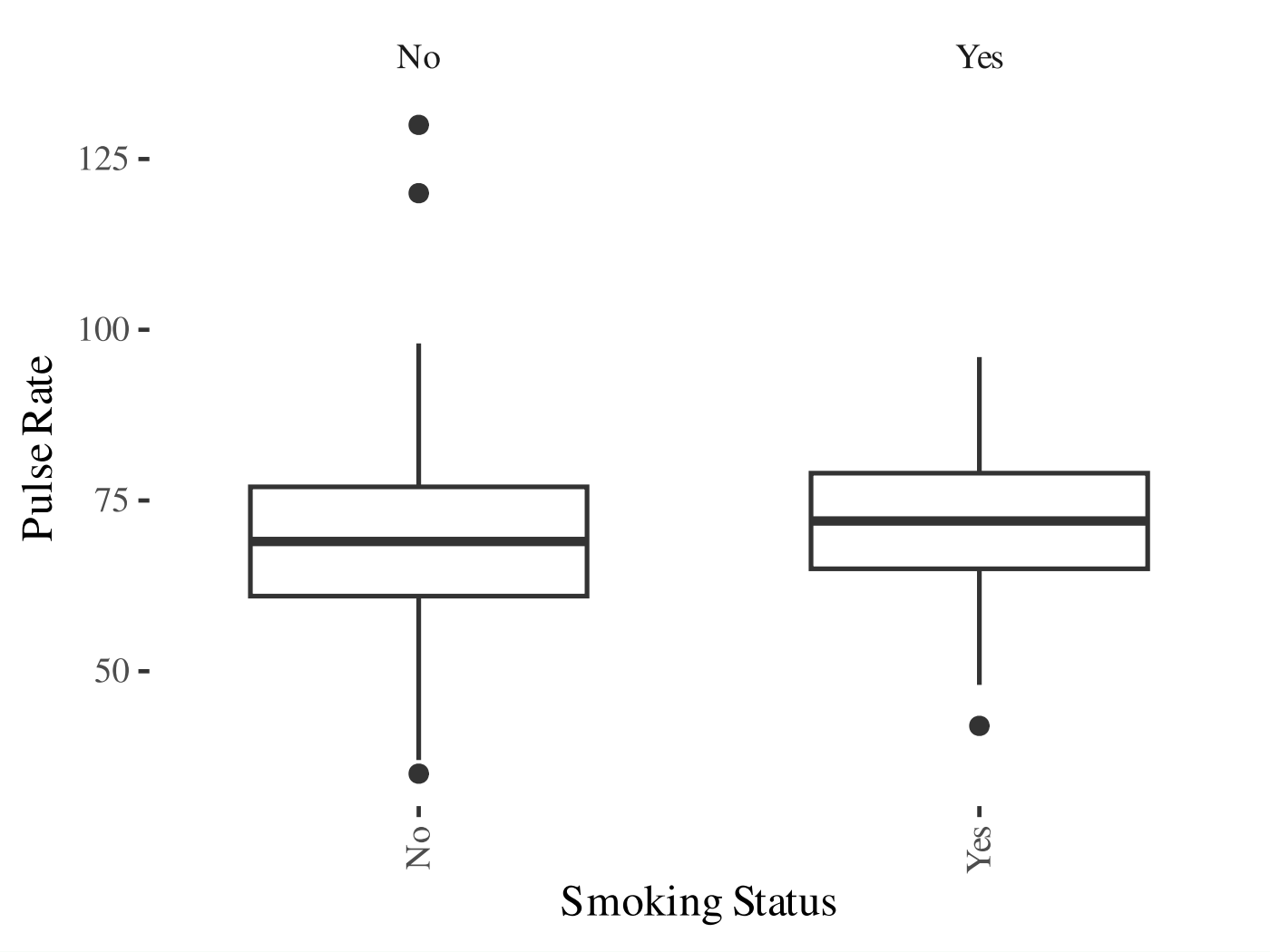


Adding a categorical variable: graphics

```
library(ggplot2)
ggplot(survey, aes(x=Pulse)) +
  geom_histogram(fill="steelblue") +
  facet_wrap(~Smoke)
```



Side-by-side boxplot Code

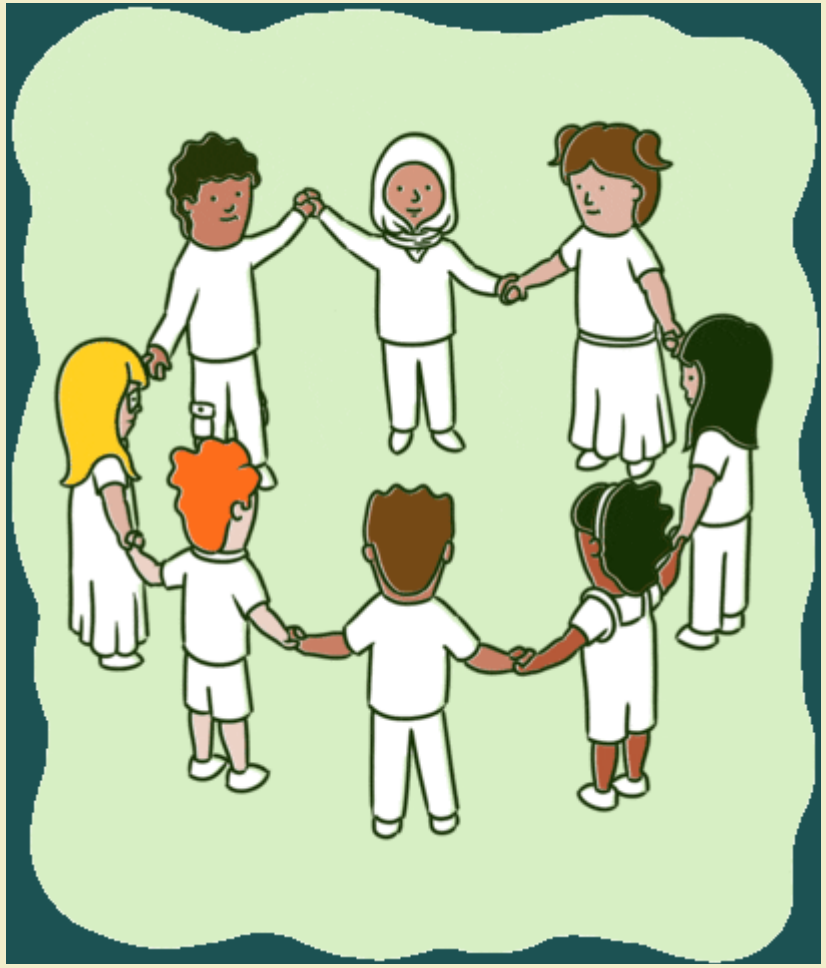


Side-by-side boxplot | Code

```
# Create boxplots using facet_wrap()
ggplot(survey, aes(x = Smoke, y = Pulse)) +
  geom_boxplot() +
  facet_wrap(~ Smoke, scales = "free_x") +
  labs(x = "Smoking Status", y = "Pulse Rate")
```

YOUR TURN 1

10:00



- Please go over the in-class activity
- Talk to your neighbor
- Let me know if you have any questions