

Drawing graphs

Our data

- To illustrate making graphs, we need some data.
- Data on 202 male and female athletes at the Australian Institute of Sport.
- Variables:
 - ▶ categorical: Sex of athlete, sport they play
 - ▶ quantitative: height (cm), weight (kg), lean body mass, red and white blood cell counts, haematocrit and haemoglobin (blood), ferritin concentration, body mass index, percent body fat.
- Values separated by tabs (which impacts reading in).

Packages for this section

```
library(tidyverse)
```

Reading data into R

- Use `read_tsv` (“tab-separated values”), like `read_csv`.
- Data in `ais.txt`:

```
my_url <- "http://ritsokiguess.site/datafiles/ais.txt"  
athletes <- read_tsv(my_url)
```

The data (some)

```
athletes
```

```
# A tibble: 202 x 13
```

| | Sex | Sport | RCC | WCC | Hc | Hg | Ferr | BMI | SSF |
|----|--------|---------|-------|-------|-------|-------|-------|-------|-------|
| | <chr> | <chr> | <dbl> | <dbl> | <dbl> | <dbl> | <dbl> | <dbl> | <dbl> |
| 1 | female | Netball | 4.56 | 13.3 | 42.2 | 13.6 | 20 | 19.2 | 49 |
| 2 | female | Netball | 4.15 | 6 | 38 | 12.7 | 59 | 21.2 | 110. |
| 3 | female | Netball | 4.16 | 7.6 | 37.5 | 12.3 | 22 | 21.4 | 89 |
| 4 | female | Netball | 4.32 | 6.4 | 37.7 | 12.3 | 30 | 21.0 | 98.3 |
| 5 | female | Netball | 4.06 | 5.8 | 38.7 | 12.8 | 78 | 21.8 | 122. |
| 6 | female | Netball | 4.12 | 6.1 | 36.6 | 11.8 | 21 | 21.4 | 90.4 |
| 7 | female | Netball | 4.17 | 5 | 37.4 | 12.7 | 109 | 21.5 | 107. |
| 8 | female | Netball | 3.8 | 6.6 | 36.5 | 12.4 | 102 | 24.4 | 157. |
| 9 | female | Netball | 3.96 | 5.5 | 36.3 | 12.4 | 71 | 22.6 | 101. |
| 10 | female | Netball | 4.44 | 9.7 | 41.4 | 14.1 | 64 | 22.8 | 126. |

```
# i 192 more rows  
# i 4 more variables: `Bfat` <dbl>, LBM <dbl>, Ht <dbl>,  
#   Wt <dbl>
```

Types of graph

Depends on number and type of variables:

| Categorical | Quantitative | Graph |
|-------------|--------------|--|
| 1 | 0 | bar chart |
| 0 | 1 | histogram |
| 2 | 0 | grouped bar charts |
| 1 | 1 | side-by-side boxplots |
| 0 | 2 | scatterplot |
| 2 | 1 | grouped boxplots |
| 1 | 2 | scatterplot with points identified by group (eg. by colour) |

With more (categorical) variables, might want *separate plots by groups*.
This is called `facetting` in R.

ggplot

- R has a standard graphing procedure `ggplot`, that we use for all our graphs.
- Use in different ways to get precise graph we want.
- Let's start with bar chart of the sports played by the athletes.

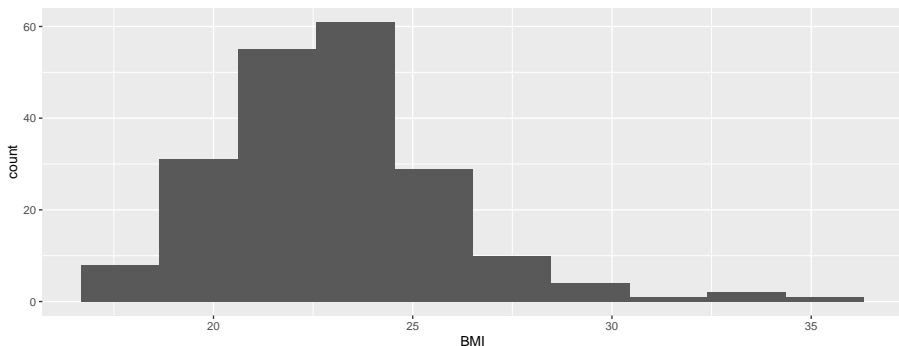
Bar chart

```
ggplot(athletes, aes(x = Sport)) + geom_bar()
```



Histogram of body mass index

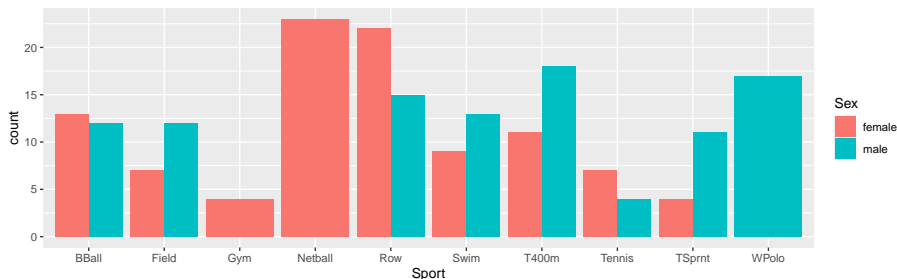
```
ggplot(athletes, aes(x = BMI)) + geom_histogram(bins = 10)
```



Which sports are played by males and females?

Grouped bar chart:

```
ggplot(athletes, aes(x = Sport, fill = Sex)) +  
  geom_bar(position = "dodge")
```



BMI by gender

```
ggplot(athletes, aes(x = Sex, y = BMI)) + geom_boxplot()
```



Height vs. weight

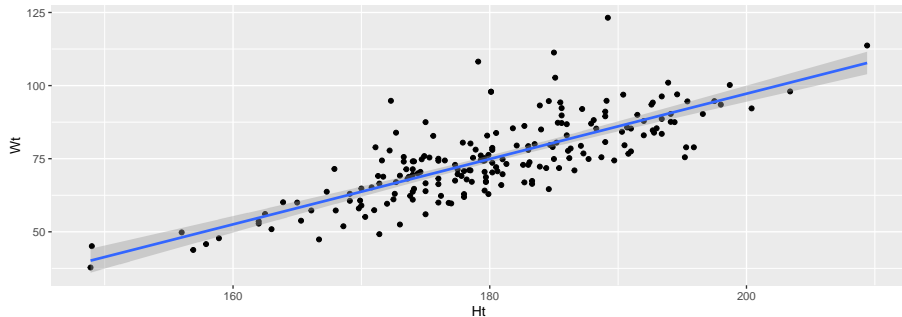
Scatterplot:

```
ggplot(athletes, aes(x = Ht, y = Wt)) + geom_point()
```



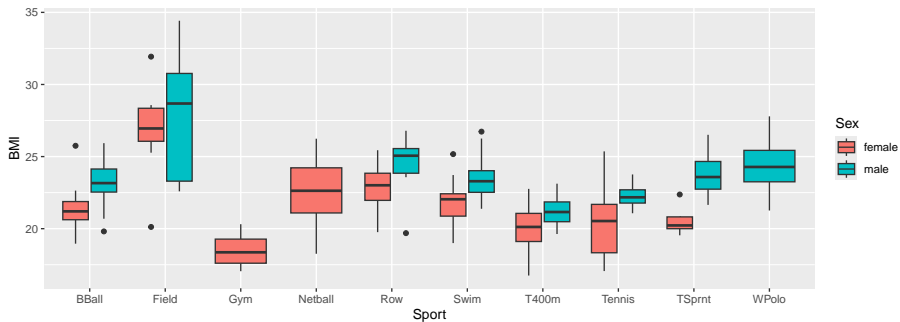
With regression line

```
ggplot(athletes, aes(x = Ht, y = Wt)) +  
  geom_point() + geom_smooth(method = "lm")
```



BMI by sport and gender

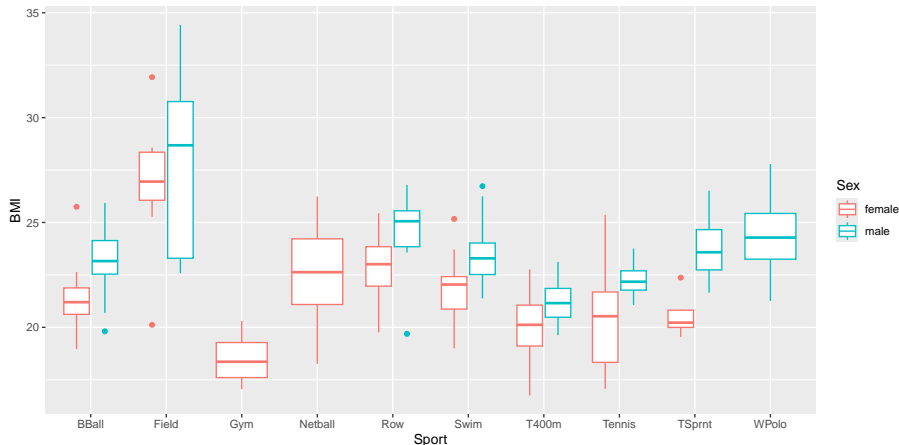
```
ggplot(athletes, aes(x = Sport, y = BMI, fill = Sex)) +  
  geom_boxplot()
```



Or...

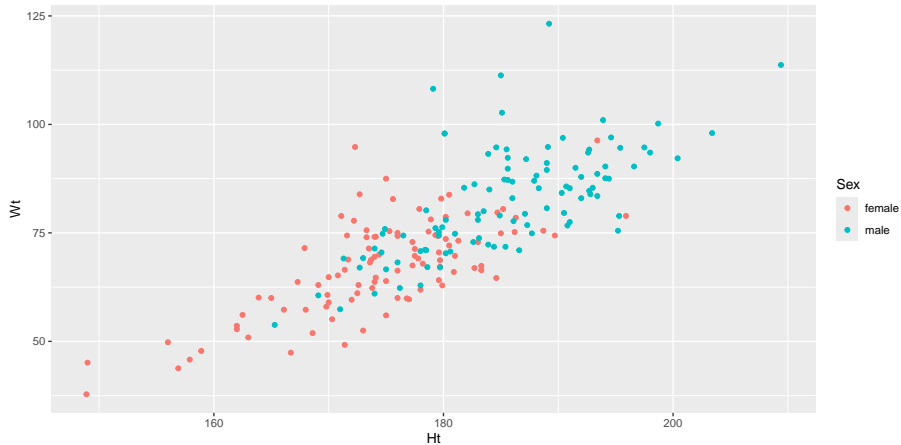
A variation that uses colour instead of fill:

```
ggplot(athletes, aes(x = Sport, y = BMI, colour = Sex)) +  
  geom_boxplot()
```



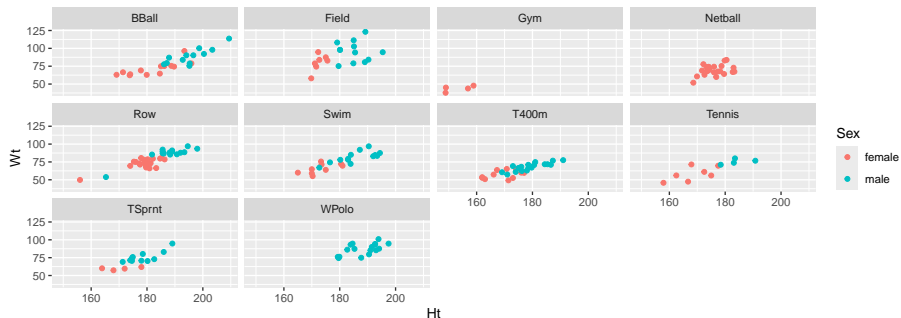
Height and weight by gender

```
ggplot(athletes, aes(x = Ht, y = Wt, colour = Sex)) +  
  geom_point()
```



Height by weight by gender for each sport, with facets

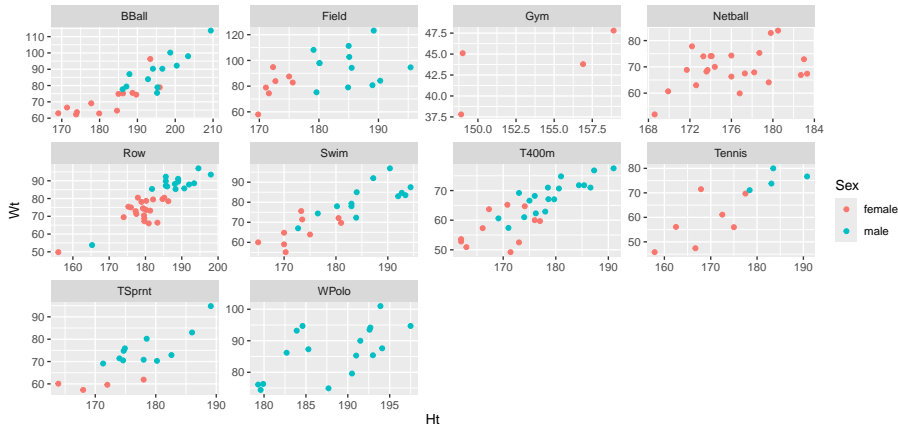
```
ggplot(athletes, aes(x = Ht, y = Wt, colour = Sex)) +  
  geom_point() + facet_wrap(~Sport)
```



Filling each facet

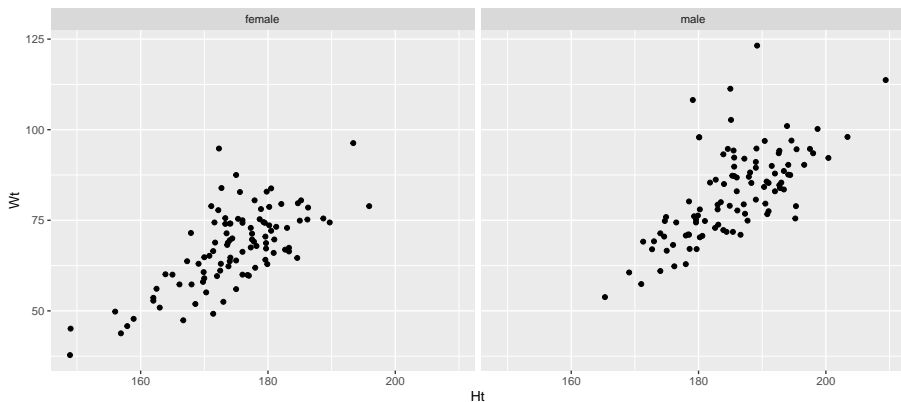
Default uses same scale for each facet. To use different scales for each facet, this:

```
ggplot(athletes, aes(x = Ht, y = Wt, colour = Sex)) +  
  geom_point() + facet_wrap(~Sport, scales = "free")
```



Another view of height vs weight

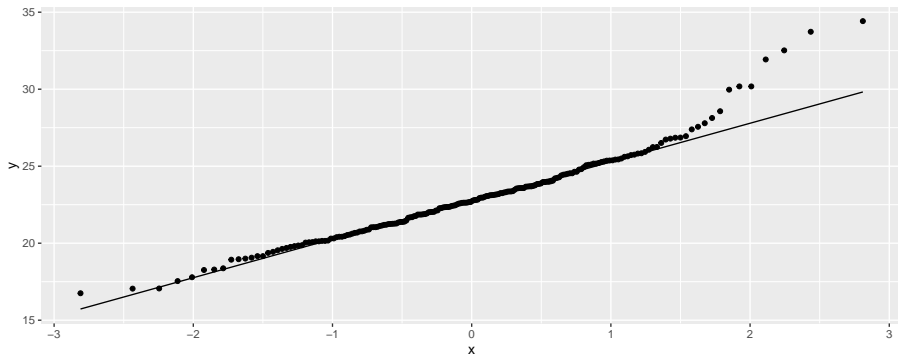
```
ggplot(athletes, aes(x = Ht, y = Wt)) +  
  geom_point() + facet_wrap(~ Sex)
```



Normal quantile plot

For assessing whether a column has a normal distribution or not:

```
ggplot(athletes, aes(sample = BMI)) + stat_qq() +  
  stat_qq_line()
```



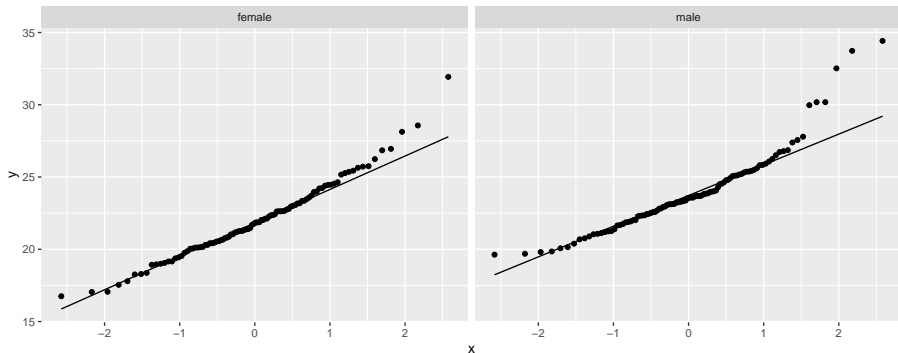
Comments

- Data on y -axis
- on x -axis, the z -scores you would expect if normal distribution correct
- if the points follow the line, distribution is normal
- the way in which the points *don't* follow line tell you about how the distribution is not normal
- in this case, the highest values are too high (long upper tail).

Facetting

Male and female athletes' BMI separately:

```
ggplot(athletes, aes(sample = BMI)) + stat_qq() +  
  stat_qq_line() + facet_wrap(~ Sex)
```



Comments

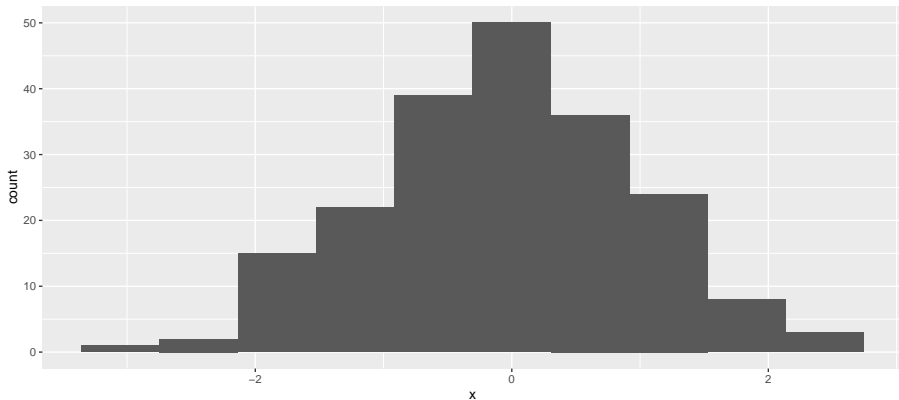
- The distribution of BMI for females is closer to normal, with only the highest few values being too high
- The distribution of BMI values for males might even be right-skewed: not only are the upper values too high, but some of the lowest ones are not low enough.

More normal quantile plots

- How straight does a normal quantile plot have to be?
- There is randomness in real data, so even a normal quantile plot from normal data won't look perfectly straight.
- With a small sample, can look not very straight even from normal data.
- Looking for systematic departure from a straight line; random wiggles ought not to concern us.
- Look at some examples where we know the answer, so that we can see what to expect.

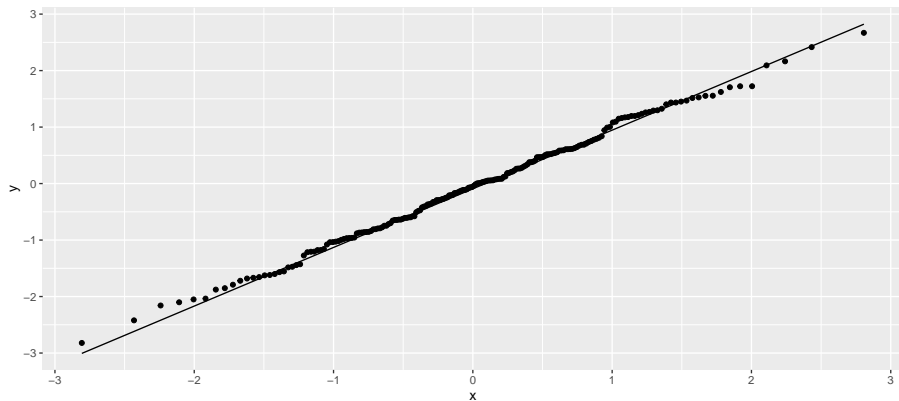
Normal data, large sample

```
d <- tibble(x=rnorm(200))  
ggplot(d, aes(x=x)) + geom_histogram(bins=10)
```



The normal quantile plot

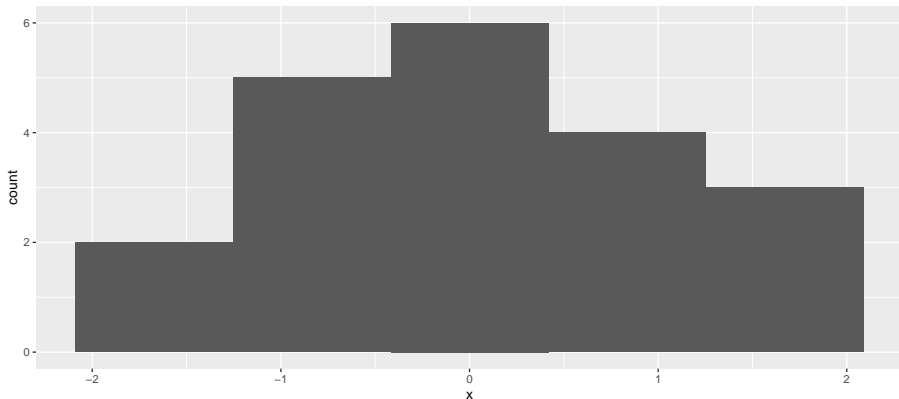
```
ggplot(d,aes(sample=x))+stat_qq()+stat_qq_line()
```



Normal data, small sample

- Not so convincingly normal, but not obviously skewed:

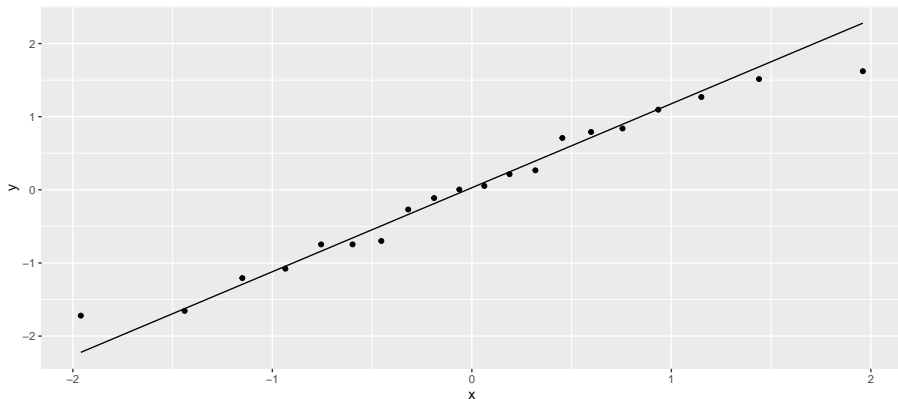
```
d <- tibble(x=rnorm(20))  
ggplot(d, aes(x=x)) + geom_histogram(bins=5)
```



The normal quantile plot

Good, apart from the highest and lowest points being slightly off. I'd call this good:

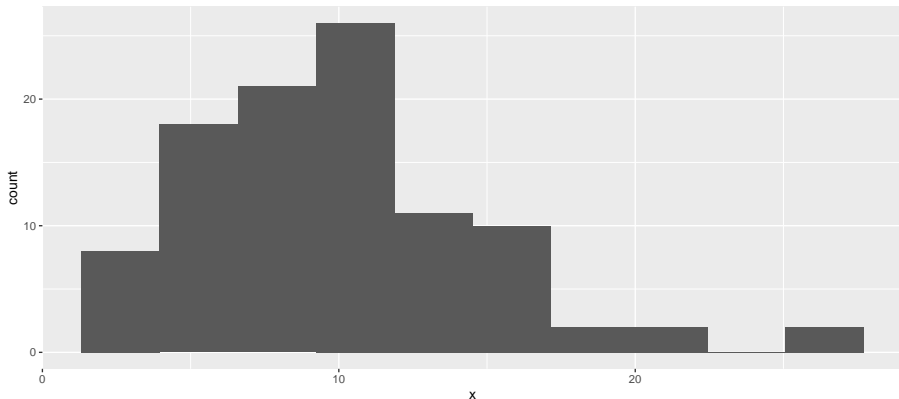
```
ggplot(d, aes(sample=x)) + stat_qq() + stat_qq_line()
```



Chi-squared data, $df = 10$

Somewhat skewed to right:

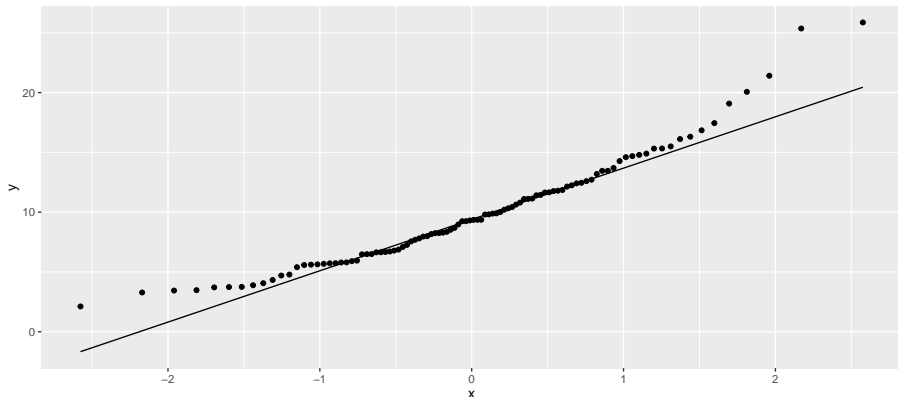
```
d <- tibble(x=rchisq(100, 10))  
ggplot(d,aes(x=x)) + geom_histogram(bins=10)
```



The normal quantile plot

Somewhat opening-up curve:

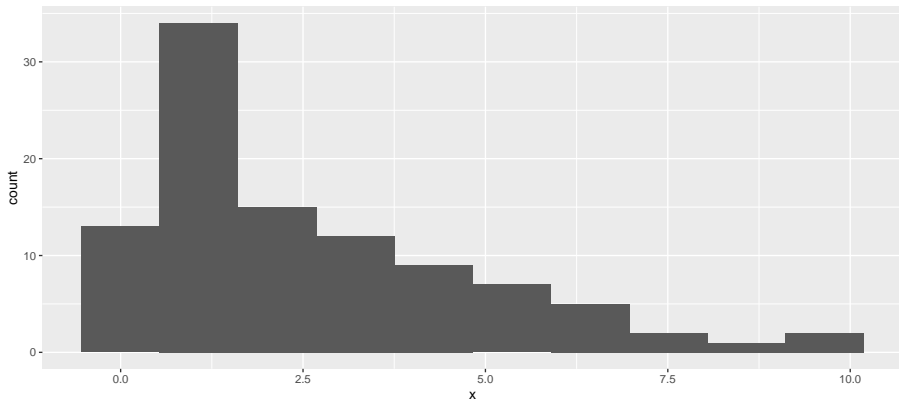
```
ggplot(d,aes(sample=x))+stat_qq()+stat_qq_line()
```



Chi-squared data, $df = 3$

Definitely skewed to right:

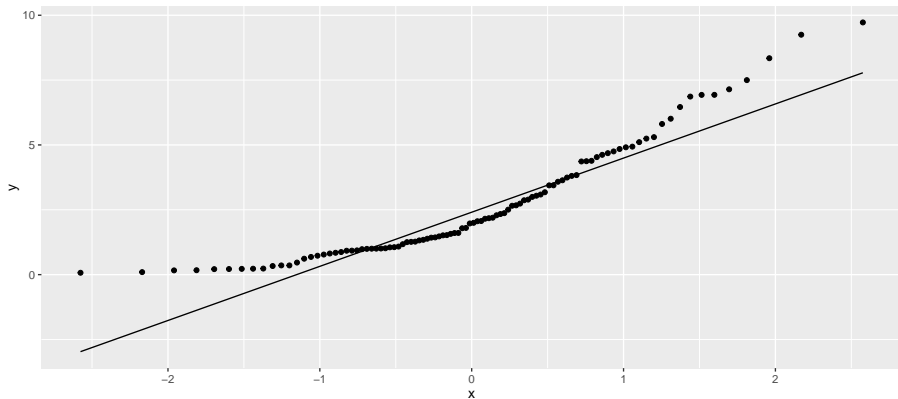
```
d <- tibble(x=rchisq(100, 3))  
ggplot(d, aes(x=x)) + geom_histogram(bins=10)
```



The normal quantile plot

Clear upward-opening curve:

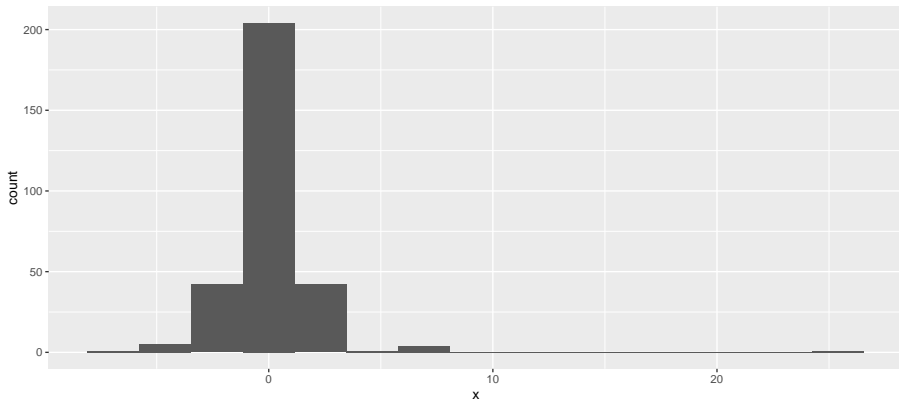
```
ggplot(d,aes(sample=x))+stat_qq()+stat_qq_line()
```



t-distributed data, $df = 3$

Long tails (or a very sharp peak):

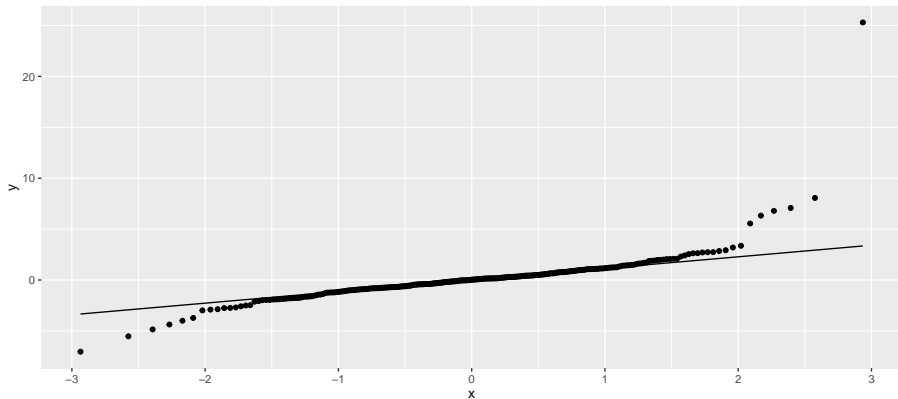
```
d <- tibble(x=rt(300, 3))  
ggplot(d, aes(x=x)) + geom_histogram(bins=15)
```



The normal quantile plot

Low values too low and high values too high for normal.

```
ggplot(d,aes(sample=x))+stat_qq()+stat_qq_line()
```



Summary

On a normal quantile plot:

- points following line (with some small wiggles): normal.
- kind of deviation from a straight line indicates kind of nonnormality:
 - ▶ a few highest point(s) too high and/or lowest too low: outliers
 - ▶ else see how points at each end off the line:

| High points | | |
|-------------|-------------|--------------|
| Low points | Too low | Too high |
| Too low | Skewed left | Long tails |
| Too high | Short tails | Skewed right |