NZSSN Courses: Introduction to R

Session 6 – Advanced Graphics

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SCIENCE
DEPARTMENT OF STATISTICS

ggplot2 package

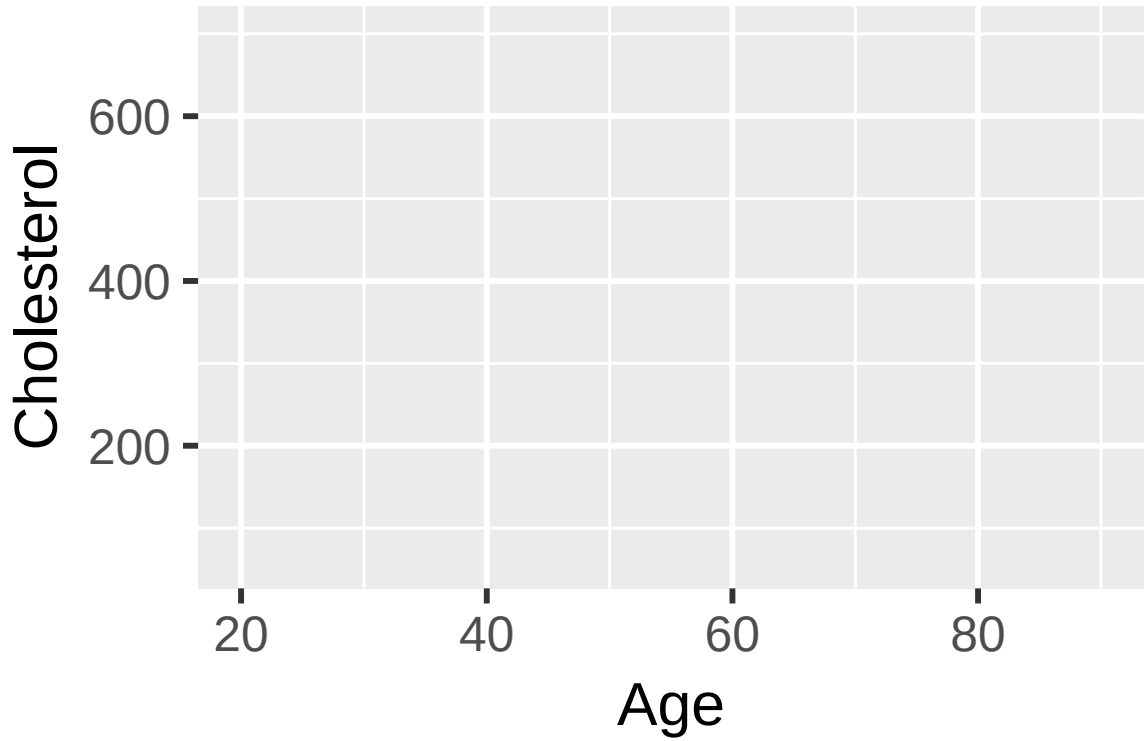
- Documentation: `http://docs.ggplot2.org/current/`
- recommended reading "The Layered Grammar of Graphics": `http://vita.had.co.nz/papers/layered-grammar.pdf`
- Load ggplot2 package

```
library(ggplot2)
```

Create a new ggplot

- Initialising a ggplot object.

```
ggplot(data = combined.long.df,
       mapping = aes(x = Age, y = Cholesterol))
```



Create a new ggplot

- Initialising a ggplot object.

```
ggplot(data = combined.long.df,
       mapping = aes(x = Age, y = Cholesterol))
```

There are three common ways to invoke ggplot:

- `ggplot(combined.long.df, aes(x, y, <other aesthetics>))`
- `ggplot(combined.long.df)`
- `ggplot()`

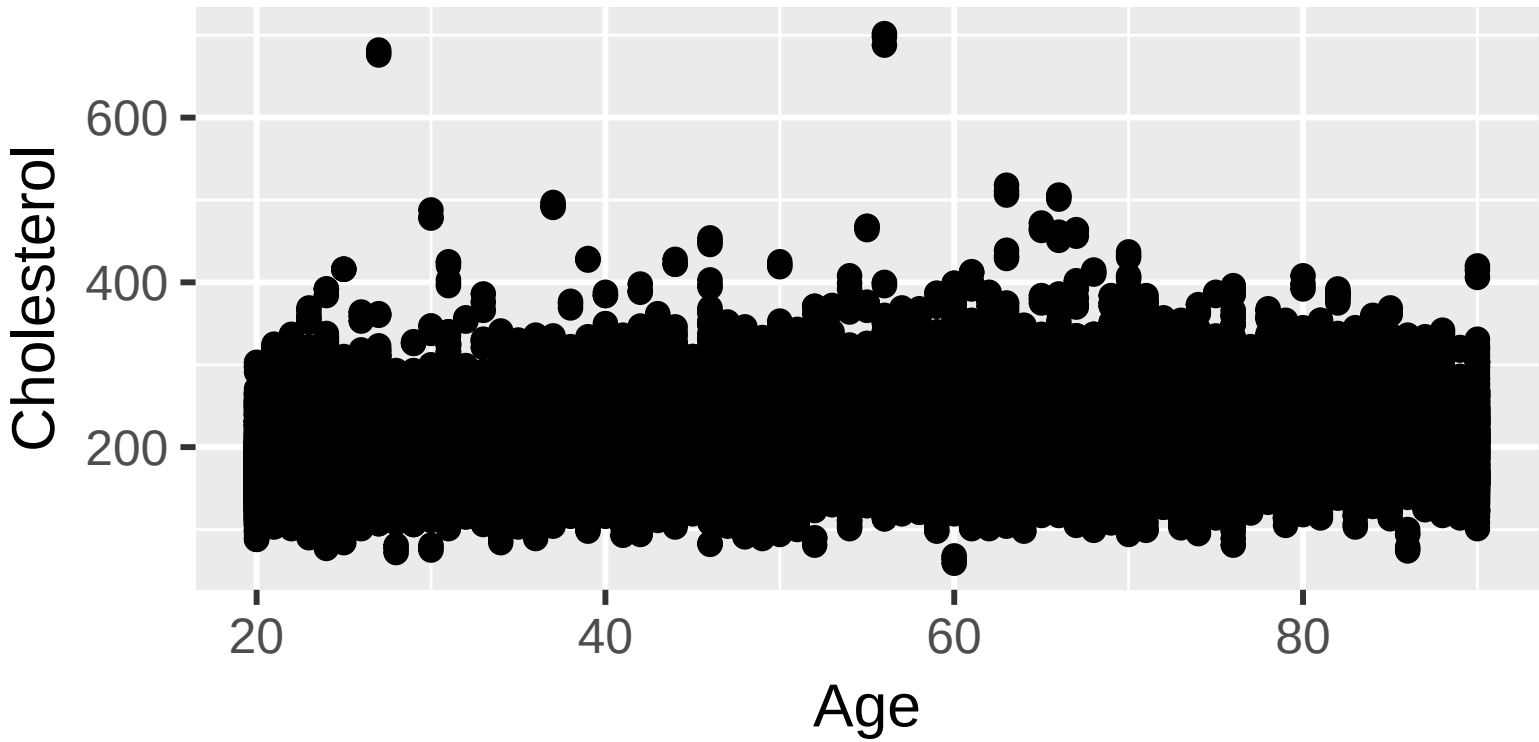
Create a new ggplot

- assign this ggplot object to a variable

```
g <- ggplot(data = combined.long.df,
       mapping = aes(x = Age, y =  Cholesterol))
```

Create a Scatterplot

```
g + geom_point()
```



- geom, short for geometric object, describes the type of plot you will produce.

Create a Scatterplot

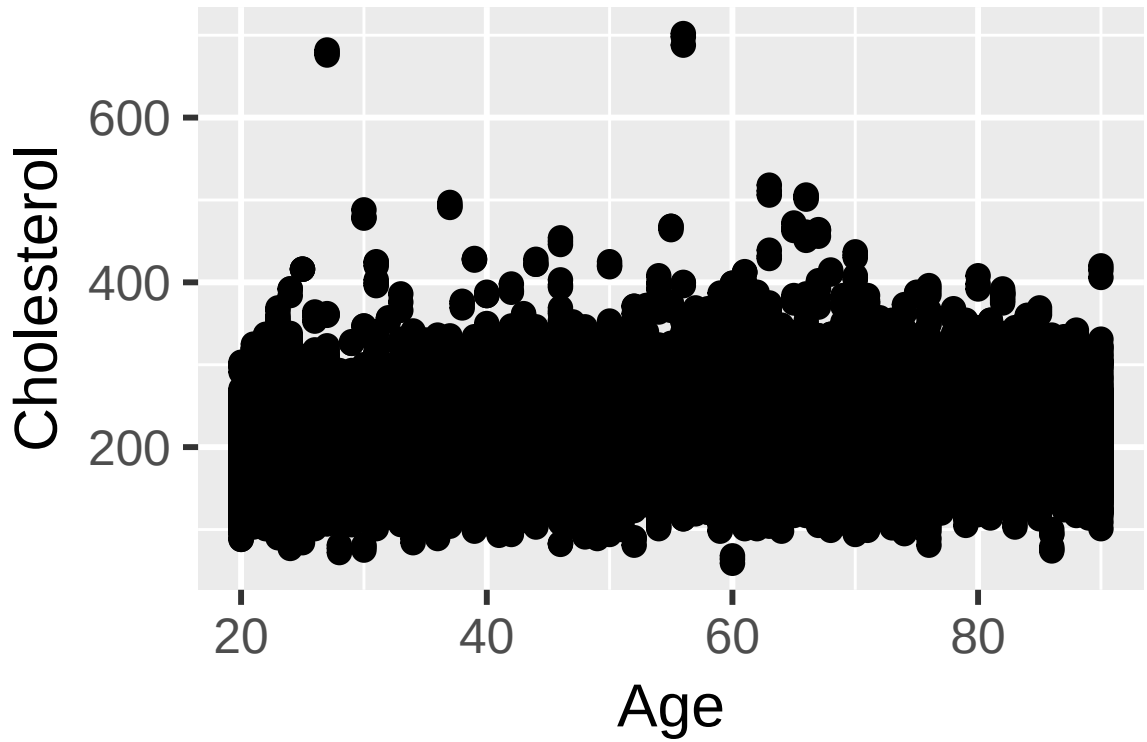
- Note that here are three common ways to invoke ggplot:

```
ggplot(data = combined.long.df,
       mapping = aes(x = Age, y =  Cholesterol)) + geom_point(
ggplot(data = combined.long.df) +
  geom_point( mapping = aes(x = Age, y =  Cholesterol))
ggplot() +
  geom_point(data = combined.long.df,
             mapping = aes(x = Age, y =  Cholesterol))
```

- always check the documentation, `?geom_point`, for which aesthetics can be used.

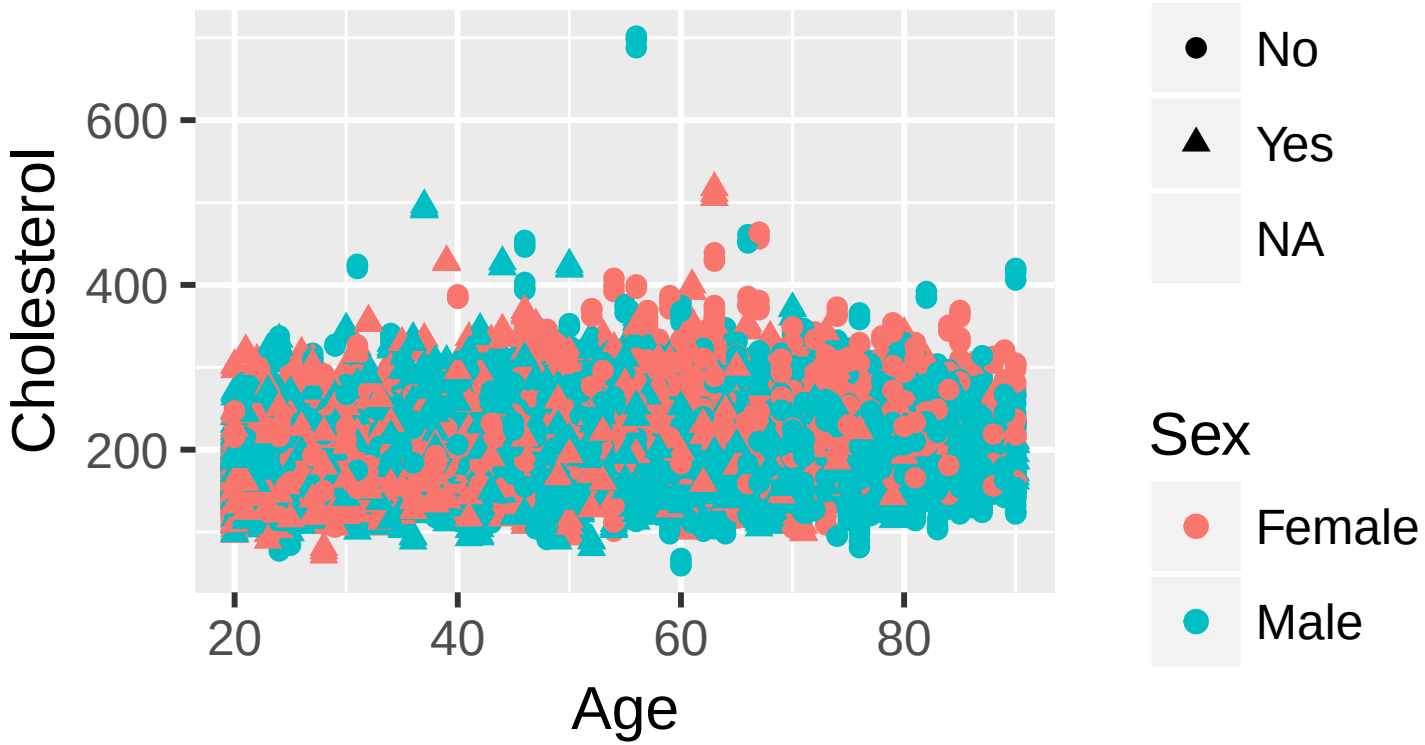
First method is recommended

```
g <- ggplot(data = combined.long.df,
       mapping = aes(x = Age, y =  Cholesterol))
g + geom_point()
```



Control colour and shape

```
g + geom_point(aes(colour = Sex, shape = Smoke.group))
```



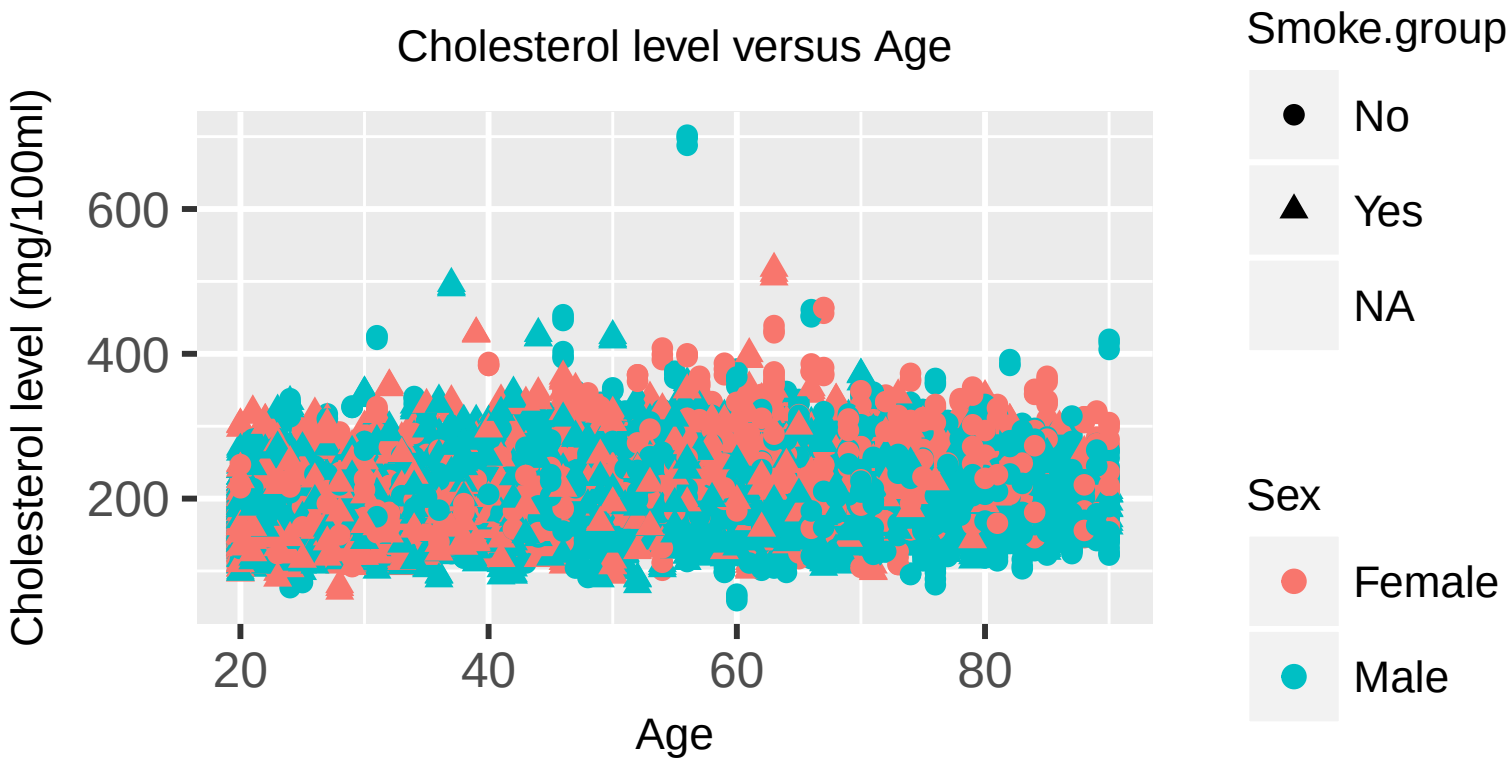
- always check the documentation, `?geom_point`, for which aesthetics can be used.
- note the missing values in the legend labelling

Modify axis, legend, and plot labels

```
(g <- g + geom_point(aes(colour = Sex, shape = Smoke.group)) +
   labs(title = "Cholesterol level versus Age",
   x = "Age", y = "Cholesterol level (mg/100ml)"))
```

Theme controls non-data components of the plot

```
g + theme(plot.title = element_text(size=8, hjust = 0.5),
          axis.title = element_text(size=8),
          legend.title = element_text(size=8),
          legend.text = element_text(size=8) )
```



Create a Scatterplot

```
g <- ggplot(
  data = na.omit(combined.long.df[,
                c("Age", "Cholesterol", "Sex", "Smoke.group")]),
  mapping = aes(x = Age, y =  Cholesterol,
                color = Sex, shape = Smoke.group)) +
  geom_point() +
  labs(title ="Total score versus Age",
       x = "Age", y = "Total score")
```

- ggplot object can be further modified.

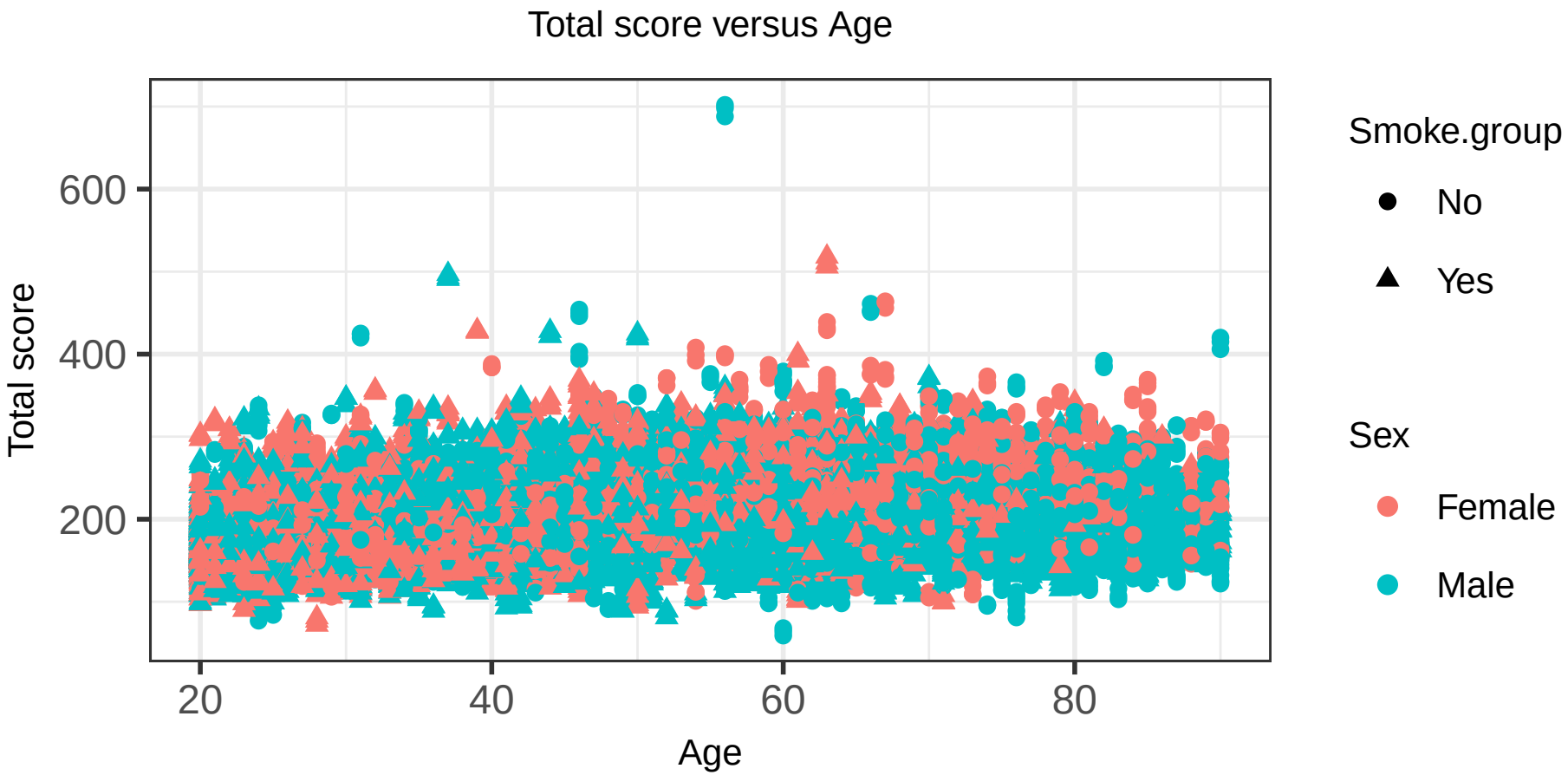
Create a Scatterplot

```
myTheme <- theme_bw() +
  theme(plot.title = element_text(size=8, hjust = 0.5),
        axis.title=element_text(size=8),
        legend.title = element_text(size=8),
        legend.text = element_text(size=8) )
```

- myTheme can be reused for different types of plot.

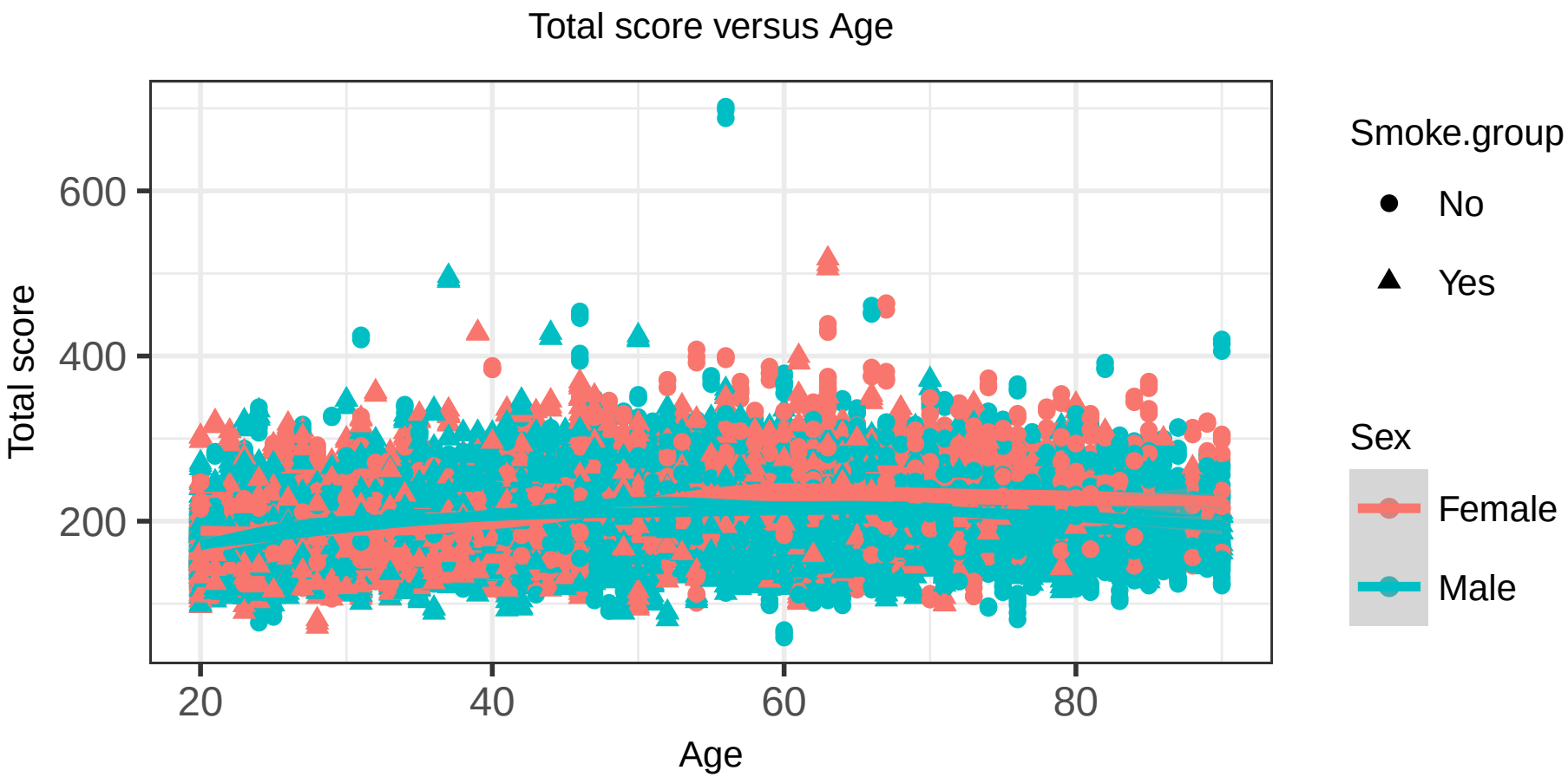
Scatterplot

```
g +  myTheme
```



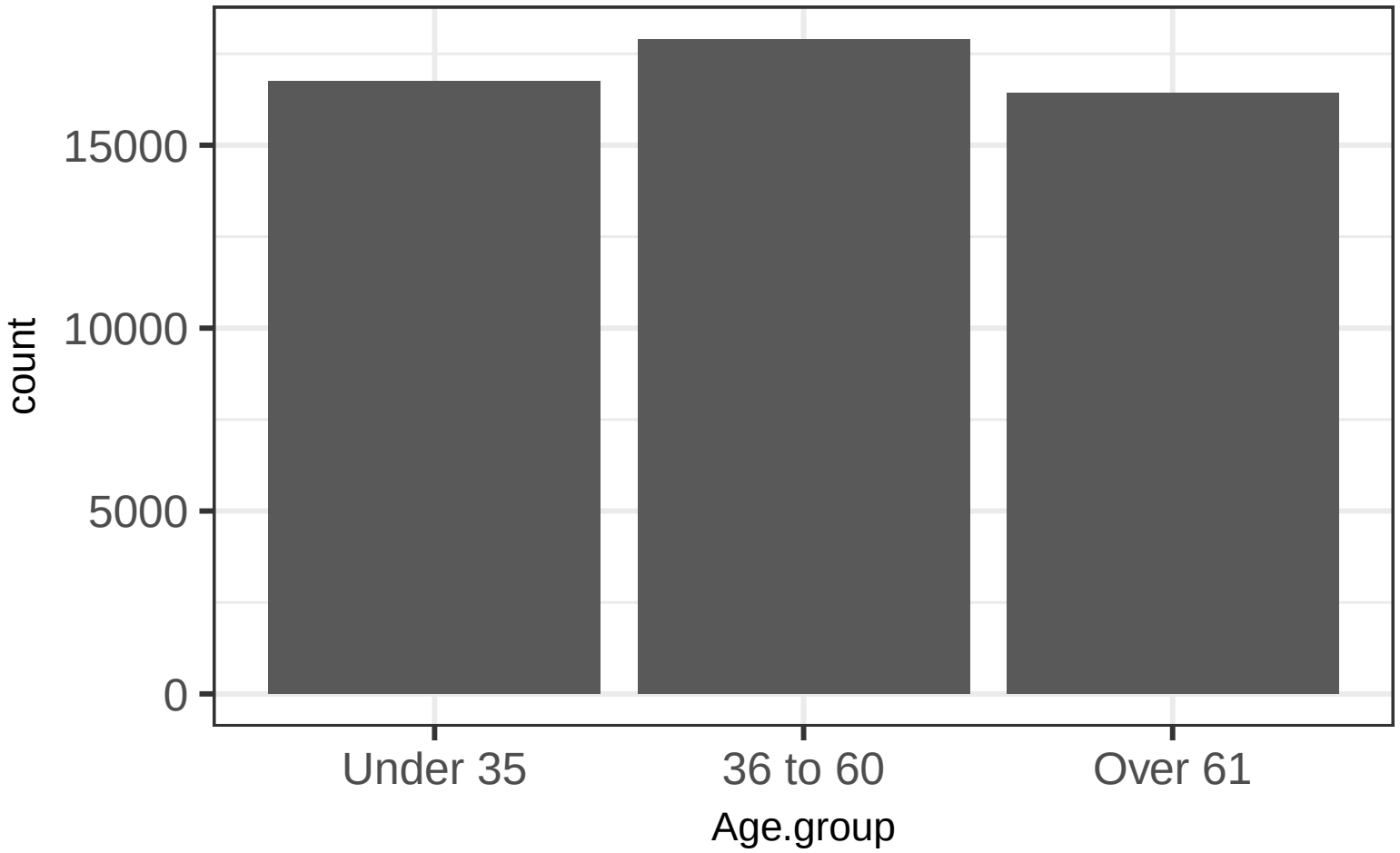
Scatterplot with a smoother

```
g +  geom_smooth() + myTheme
```



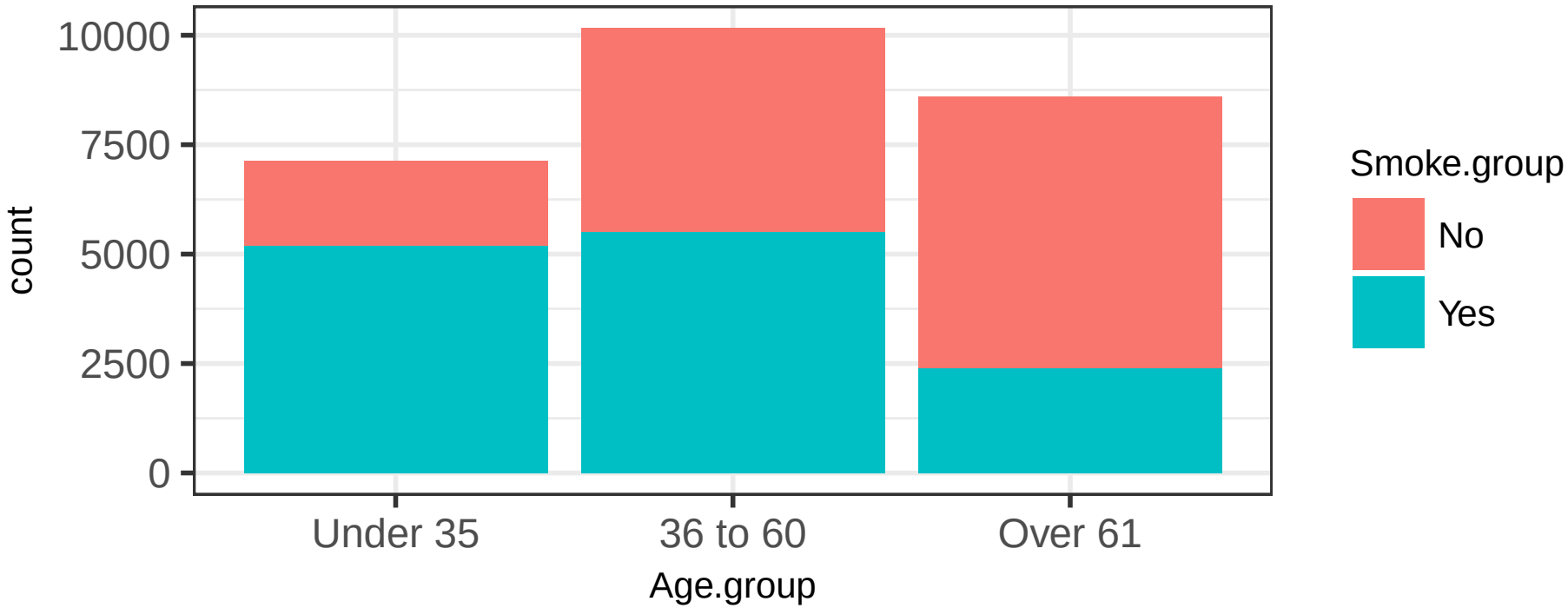
Bar chart

```
ggplot(combined.long.df, aes(x = Age.group)) + geom_bar() + my
```



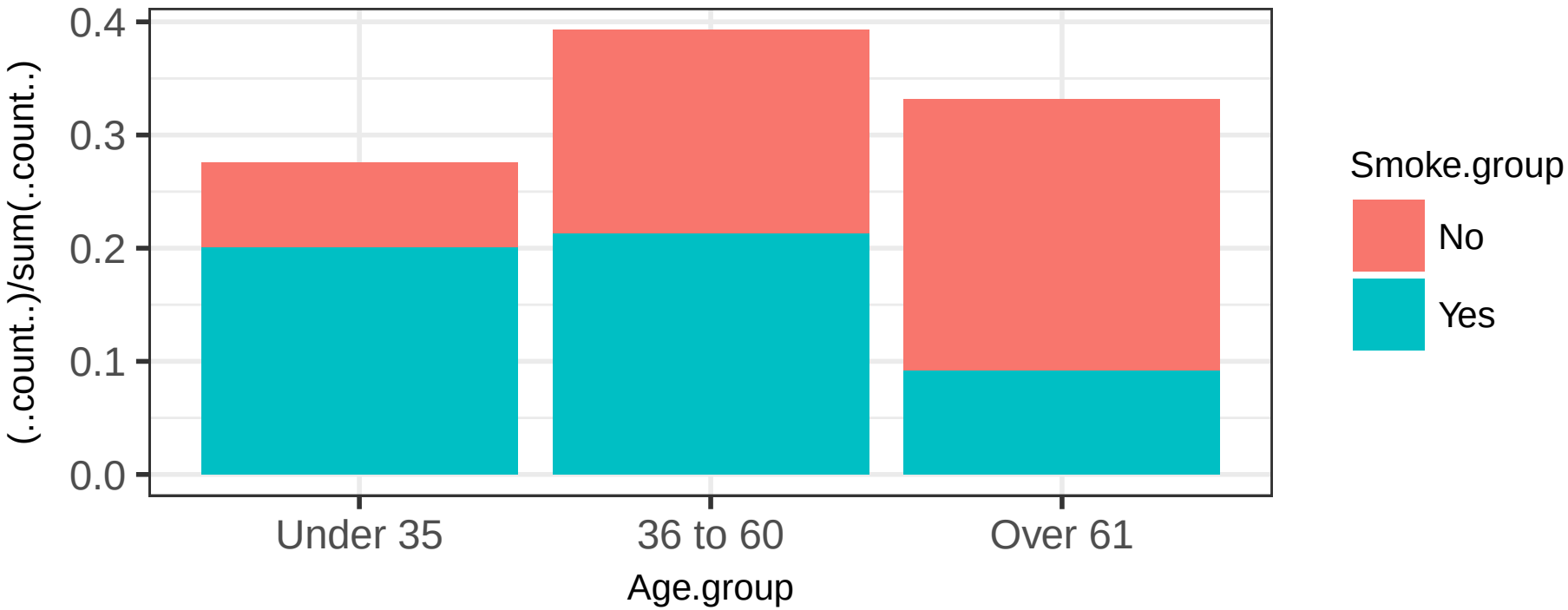
Smoking group by Age group

```
ggplot(na.omit(combined.long.df[,c("Age.group", "Smoke.group"))),
       aes(x = Age.group, fill = Smoke.group)) +
      geom_bar() + myTheme
```



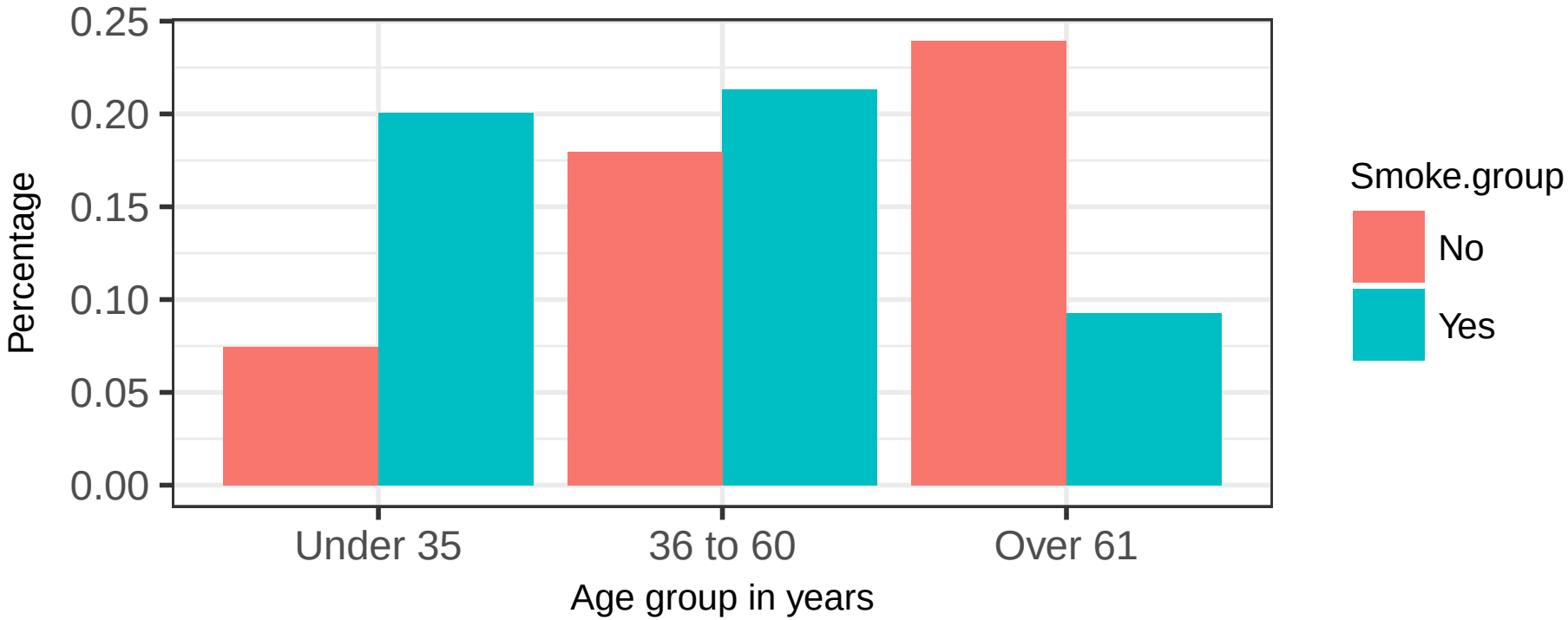
Bar chart on proportions

```
g <- ggplot(na.omit(combined.long.df[,c("Age.group", "Smoke.gr
  aes(x = Age.group, y = (..count..)/sum(..count..),
      fill = Smoke.group))
g + geom_bar() + myTheme
```



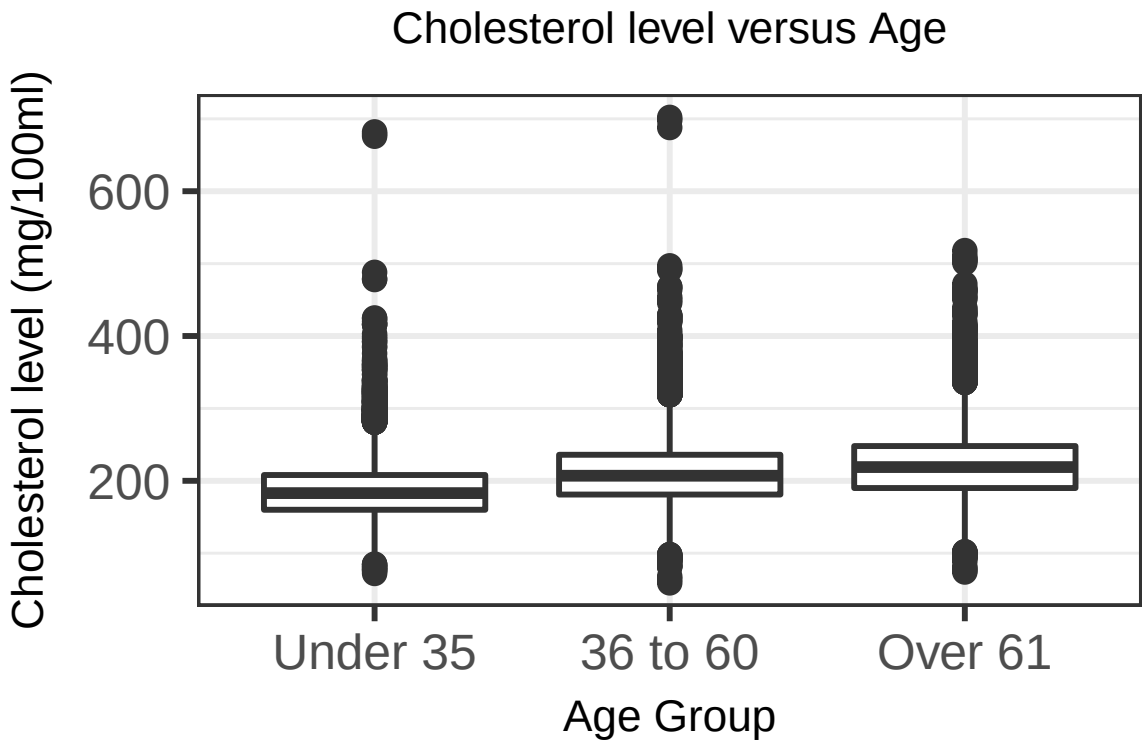
Bar chart on proportions

```
g + geom_bar(position = "dodge") +
  labs( x = "Age group in years", y = "Percentage")+
  myTheme
```



Boxplot using geom_boxplot()

```
ggplot(na.omit(combined.long.df[,c("Age.group", "Cholesterol")]),
       aes(x = Age.group, y = Cholesterol)) +
  geom_boxplot()  +
  labs(title = "Cholesterol level versus Age",
      x = "Age Group", y = "Cholesterol level (mg/100ml)") +
```

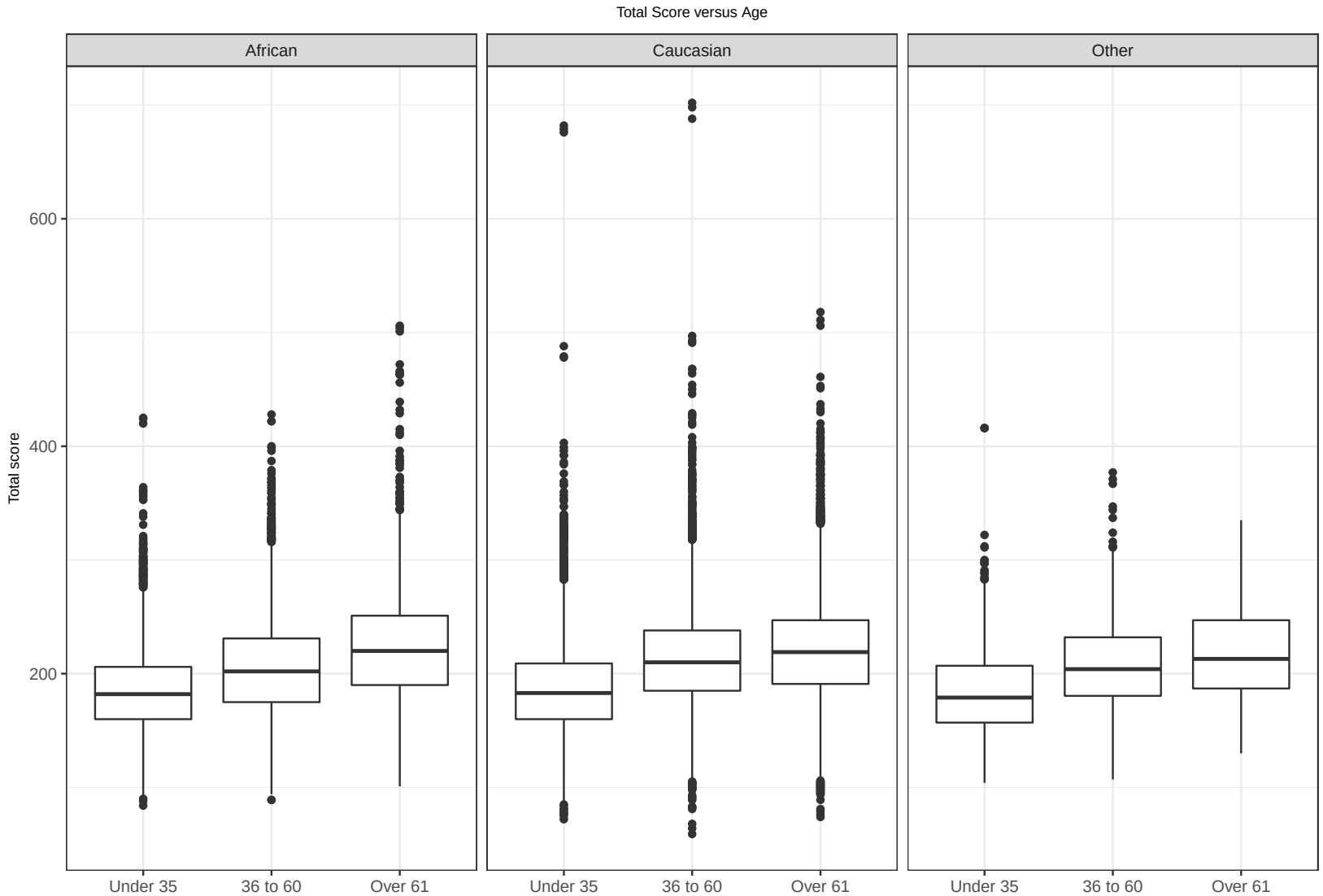


Boxplot with panels using facet_wrap()

```
g <- ggplot(na.omit(combined.long.df[,c("Age.group",
                                        "Cholesterol", "Race.group")]),
       aes(x = Age.group, y = Cholesterol)) +
  geom_boxplot()  + labs(title = "Total Score versus Age",
             x = "Age Group", y = "Total score")
```

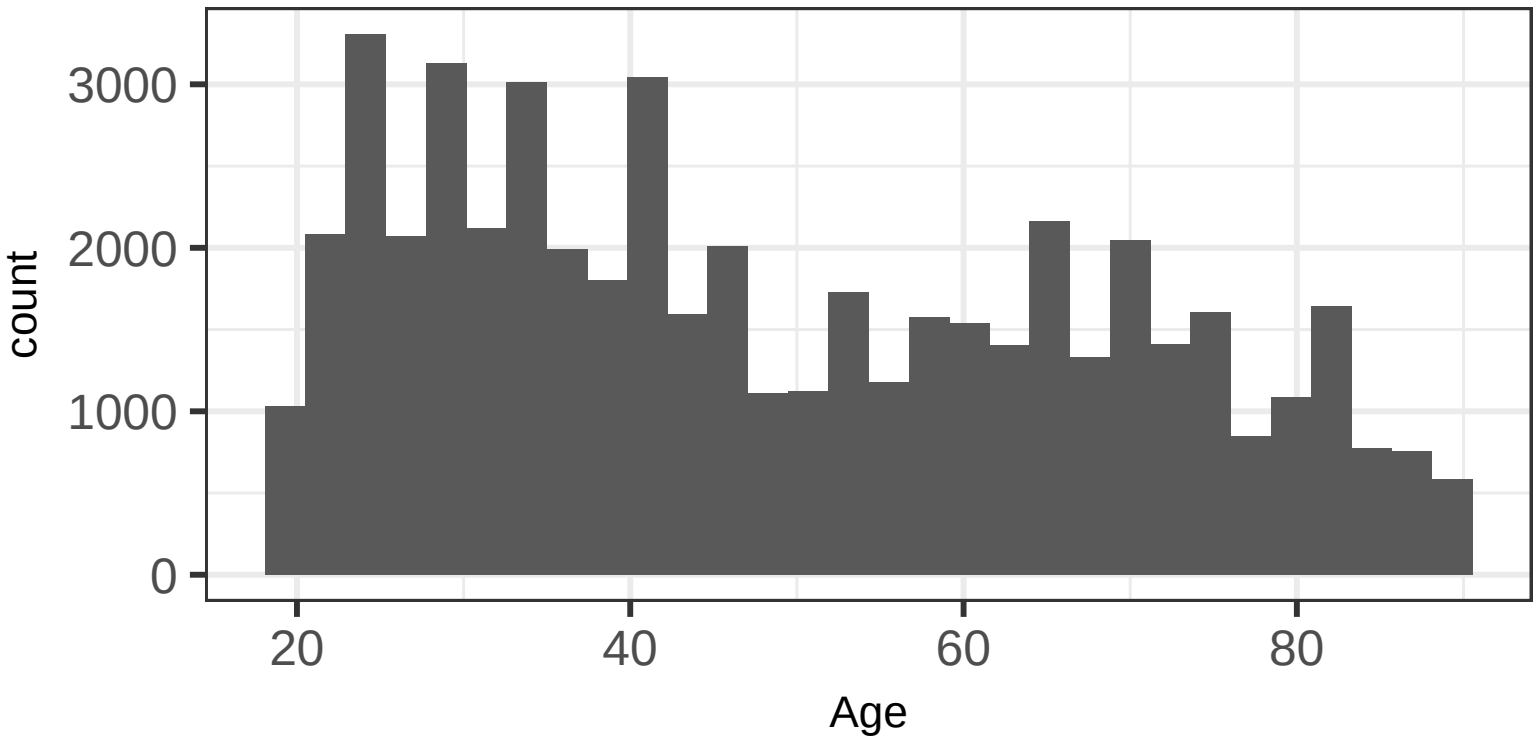
Boxplot with panels using facet_wrap()

```
g + facet_wrap(~Race.group) + myTheme
```



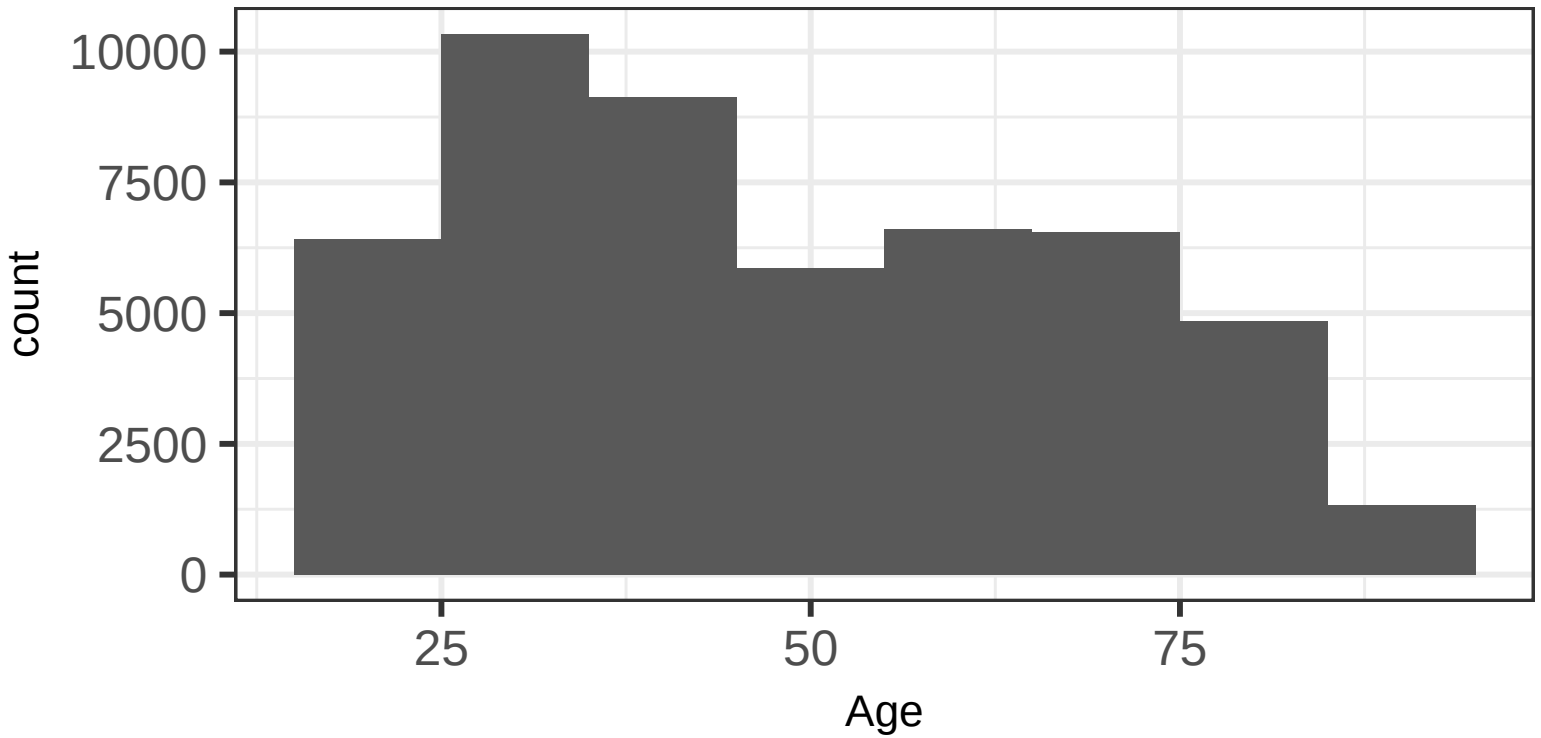
Histogram

```
ggplot(combined.long.df, aes(x = Age)) +
  geom_histogram() + myTheme
```



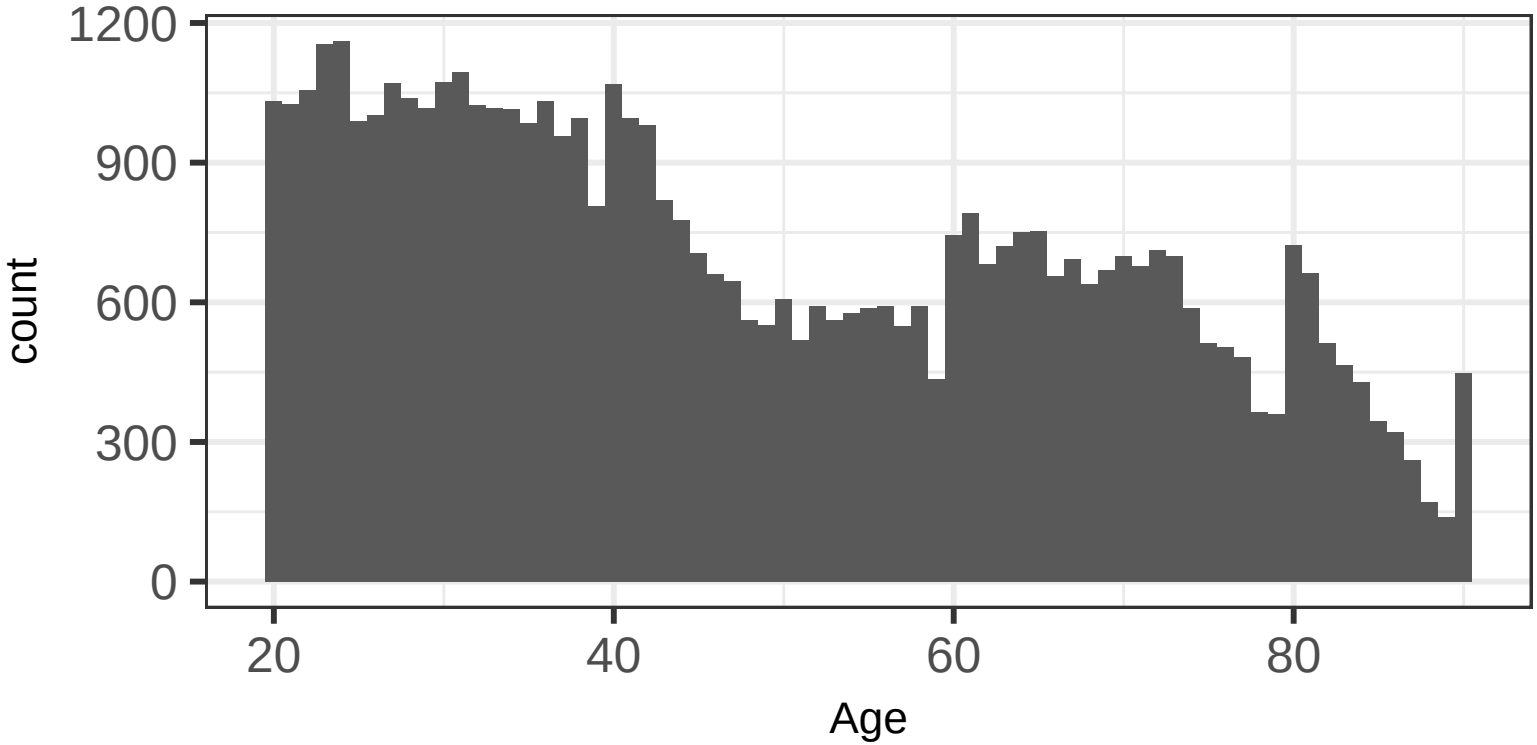
Histogram with wider binwidth

```
ggplot(combined.long.df, aes(x = Age)) +
  geom_histogram(binwidth = 10)+
  labs(x = "Age") + myTheme
```



Histogram with narrower binwidth

```
ggplot(combined.long.df, aes(x = Age)) +
  geom_histogram(binwidth = 1)+
  labs(x = "Age")  + myTheme
```



Plot means in context

```
with(combined.long.df, tapply(Cholesterol, Age.group,
                              mean, na.rm = TRUE))
```

```
## Under 35 36 to 60  Over 61
## 186.2989 210.6702 221.1820
```

- Means are all but meaningless unless they are presented in context.
- Always present with standard deviations (SDs) or standard error of means (SEs) or confidence intervals.
- Plot means with 95% confidence intervals ($\pm$ 1.96 $\times$ SE).
  - $\pm$ 1 $\times$ SE yields (approx.) a 68% confidence interval. Equivalent to using a 16% level of significance!!!!
  - $\pm$ 1 $\times$ SD tells us **ABSOLUTELY NOTHING** about whether two means are statistically different from one another.

Calculating 95% CIs

- 95% CI = Mean $\pm$ 1.96 $\times$ SE
- Standard Errors = $\frac{\text{Standard Deviation}}{\sqrt{\text{Sample Size}}}$

```
my.m <- with(combined.long.df, tapply(Cholesterol, Age.group,
                                      na.rm = TRUE))
my.m
```

```
## Under 35 36 to 60  Over 61
## 186.2989 210.6702 221.1820
```

```
my.sd <- with(combined.long.df, tapply(Cholesterol, Age.group,
                                       na.rm = TRUE))
my.sd
```

```
## Under 35 36 to 60  Over 61
## 38.98416 43.74297 45.62359
```

Calculating 95% CIs

```
my.n <- with(combined.long.df, tapply(Cholesterol, Age.group,
            function(x)length(which(!is.na(x)))))
my.n
```

```
## Under 35 36 to 60  Over 61
##    15780    17040    15366
```

```
my.stder <- my.sd/sqrt(my.n)
ci.upper <- my.m + 1.96*my.stder
ci.lower <- my.m - 1.96*my.stder
```

Calculating 95% CIs

```
my.stder <- my.sd/sqrt(my.n)
ci.upper <- my.m + 1.96*my.stder
ci.lower <- my.m - 1.96*my.stder

cbind(my.m, ci.lower, ci.upper)
```

```
##                my.m ci.lower ci.upper
## Under 35  186.2989 185.6907 186.9072
## 36 to 60  210.6702 210.0134 211.3270
## Over 61   221.1820 220.4606 221.9033
```

Calculating 95% CIs

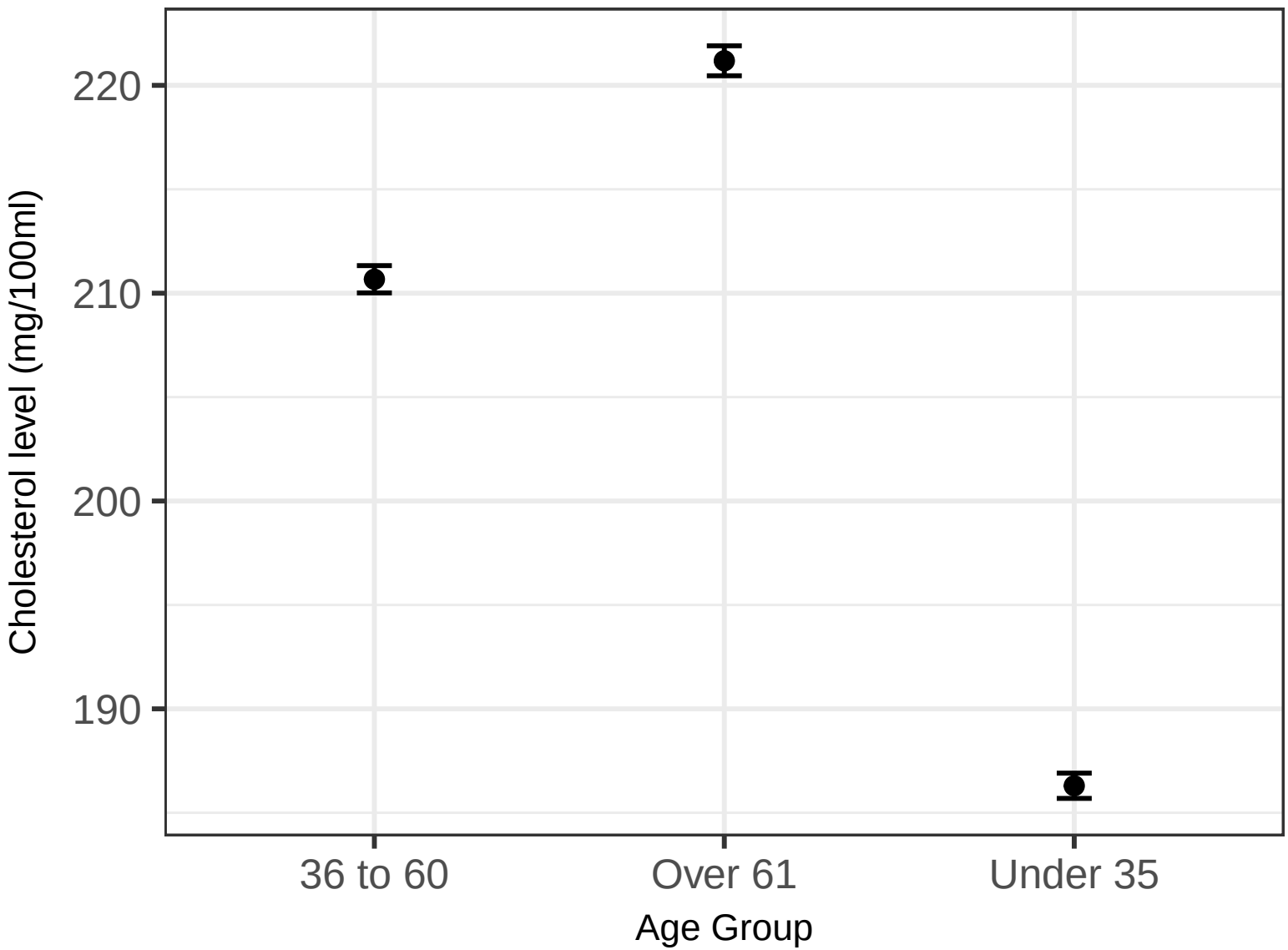
```
y.df = data.frame(age.group =  factor(names(my.m)),
                  my.m, ci.upper, ci.lower)

y.df
```

```
##           age.group     my.m ci.upper ci.lower
## Under 35  Under 35 186.2989 186.9072 185.6907
## 36 to 60  36 to 60 210.6702 211.3270 210.0134
## Over 61    Over 61 221.1820 221.9033 220.4606
```

Errorbars

```
ggplot(y.df, aes(x = age.group, y = my.m))+geom_point() +
     geom_errorbar(aes(ymax = ci.upper, ymin = ci.lower),
                   width = 0.1)+
     xlab("Age Group")+
     ylab("Mean total feminist score") +
  myTheme
```

Errorbars


220
210
200
190
Cholesterol level (mg/100ml)
36 to 60
Over 61
Under 35
Age Group

Any interaction between Gender and Age group?

```
GA.m <- with(combined.long.df, tapply(Cholesterol,
           list(Sex, Age.group), mean, na.rm = TRUE))
GA.m
```

```
##        Under 35 36 to 60  Over 61
## Female 184.7069 209.6103 231.4096
## Male   188.1431 211.8985 210.1405
```

Calculating 95% CIs

```
GA.sd <- with(combined.long.df,
              tapply(Cholesterol,
                     list(Sex, Age.group),
                          sd, na.rm = TRUE))

GA.n <- with(combined.long.df, tapply(Cholesterol,
      list(Sex, Age.group),
      function(x)length(which(!is.na(x)))))
GA.stder <- GA.sd/sqrt(GA.n)
GA.upper <- GA.m + 1.96*GA.stder
GA.lower <- GA.m - 1.96*GA.stder
```

Calculating 95% CIs

```
GA.df <- data.frame(
  Age.group = factor(rep(colnames(GA.m), 2),
                     levels = colnames(GA.m)),
  Gender = rep(rownames(GA.m), c(3, 3)),
  Mean = c(GA.m[1,], GA.m[2,]),
  Upper = c(GA.upper[1,], GA.upper[2,]),
  Lower = c(GA.lower[1,], GA.lower[2,])
  )
```

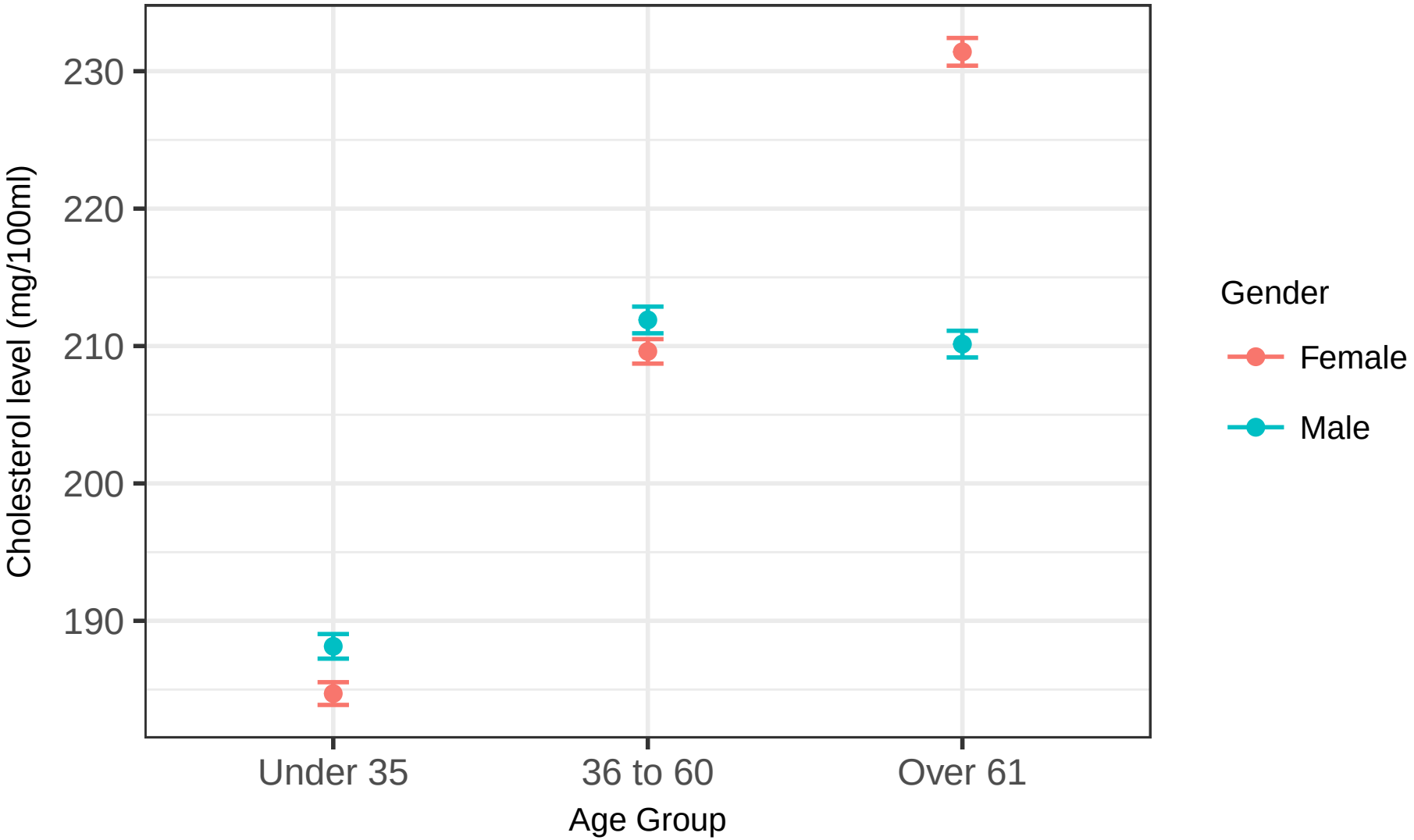
Calculating 95% CIs

```
##   Age.group Gender     Mean    Upper    Lower
## 1  Under 35 Female 184.7069 185.5337 183.8801
## 2  36 to 60 Female 209.6103 210.5015 208.7191
## 3   Over 61 Female 231.4096 232.4182 230.4009
## 4  Under 35   Male 188.1431 189.0392 187.2469
## 5  36 to 60   Male 211.8985 212.8694 210.9276
## 6   Over 61   Male 210.1405 211.1114 209.1695
```

Plotting mean ± 95% CI:

```
g <- ggplot(GA.df, aes(x = Age.group, y = Mean,
                       color = Gender)) +
  xlab("Age Group")+
  ylab("Cholesterol level (mg/100ml)")

g + geom_point()+
  geom_errorbar(aes(ymax = Upper, ymin = Lower),
                width = 0.1) +
  myTheme
```

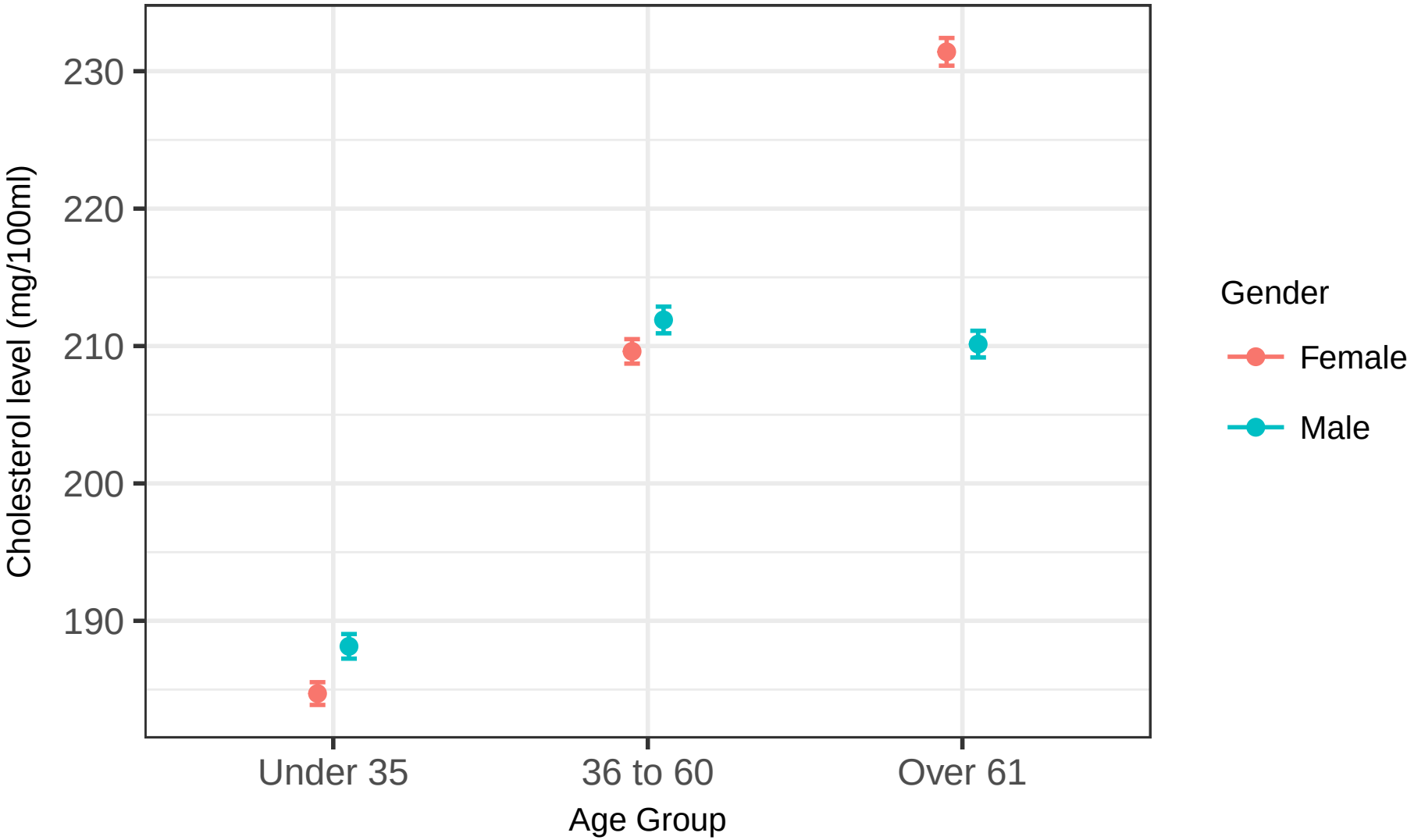
Plotting mean ± 95% CI:



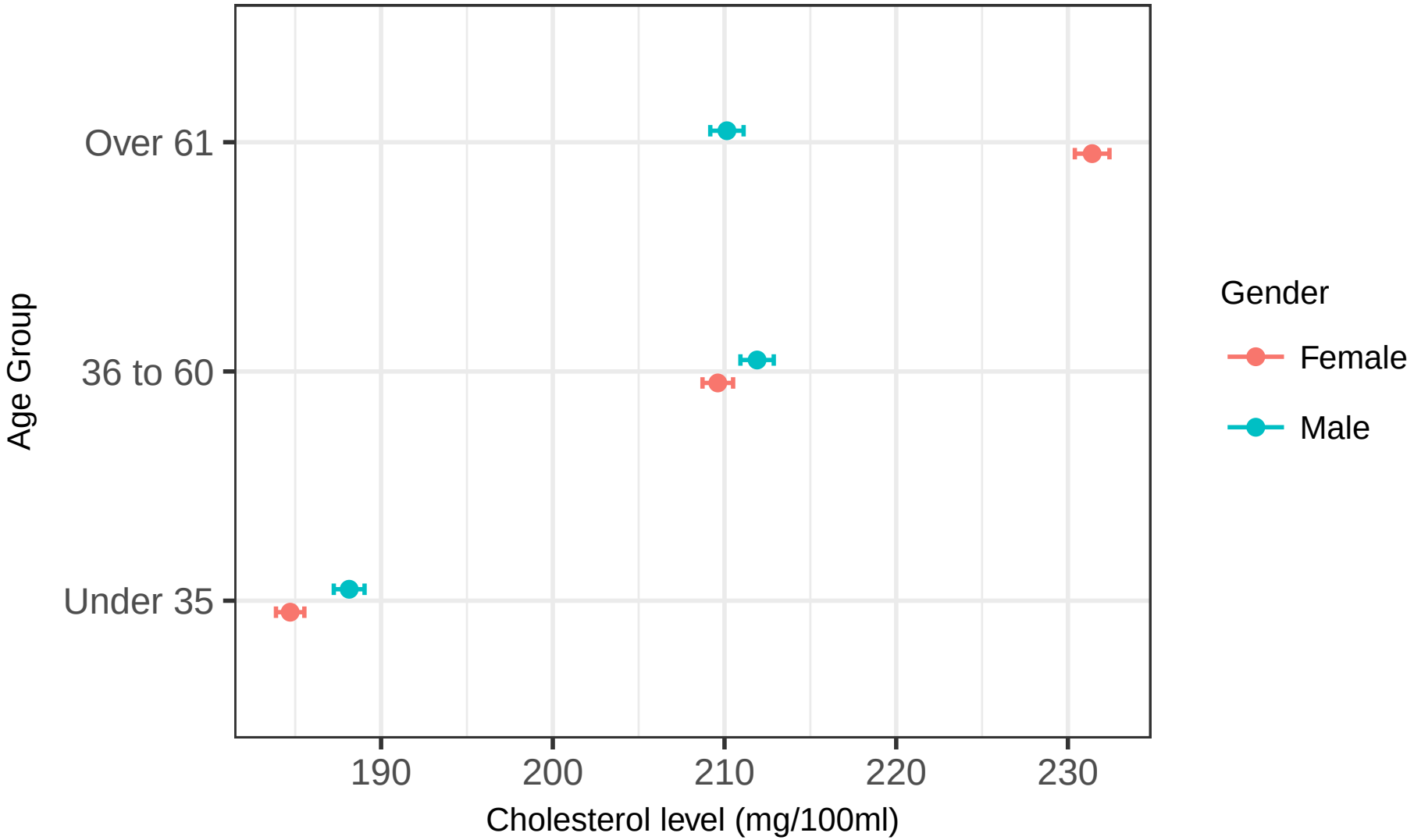
Side-by-side?

```
dodge <- position_dodge(width=0.2)

g + geom_point(position = dodge) +
  geom_errorbar(aes(ymax = Upper, ymin = Lower),
                width = 0.1, position = dodge) +
  myTheme
```

Side-by-side


230
220
210
200
190
Cholesterol level (mg/100ml)
Under 35
36 to 60
Over 61
Age Group
Gender
Female
Male

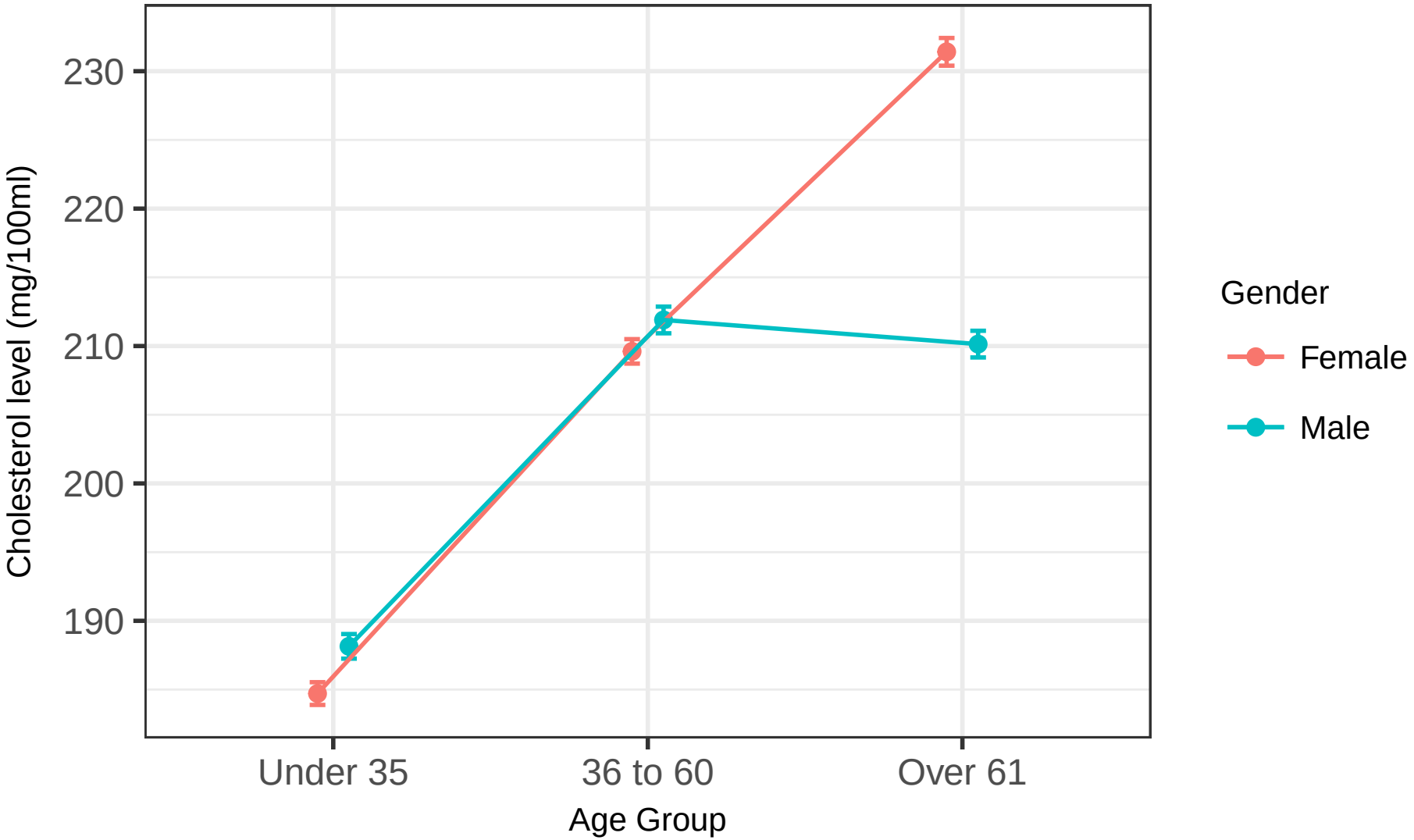
Flip


Over 61
36 to 60
Under 35
Age Group
190
200
210
220
230
Cholesterol level (mg/100ml)
Gender
Female
Male

Connect the points?

```
g + geom_point(position = dodge) +
  geom_errorbar(aes(ymax = Upper, ymin = Lower),
                width = 0.1, position = dodge) +
  geom_path(aes(x = as.numeric(Age.group)),
            position = dodge) +
  myTheme
```

Connect the points



Save a ggplot

```
ggsave("mtcars.pdf")
ggsave("mtcars.png")

ggsave("mtcars.pdf", width = 4, height = 4)
ggsave("mtcars.pdf", width = 20, height = 20, units = "cm")
```

Summary

Plot Types	`geom` functions
Scatterplot	`geom_point()`
Bars chart	`geom_bar()`
Histogram	`geom_histogram()`
Boxplot	`geom_boxplot()`
Line plot	`geom_path()`
Errorbar	`geom_errorbar()`

- `ggplot2` Documentation: `http://docs.ggplot2.org/current/`
- cheatsheets:
  `https://www.rstudio.com/resources/cheatsheets/`