STATS 201 Assignment 3

Model Answers

```
## Loading required package: s20x
```

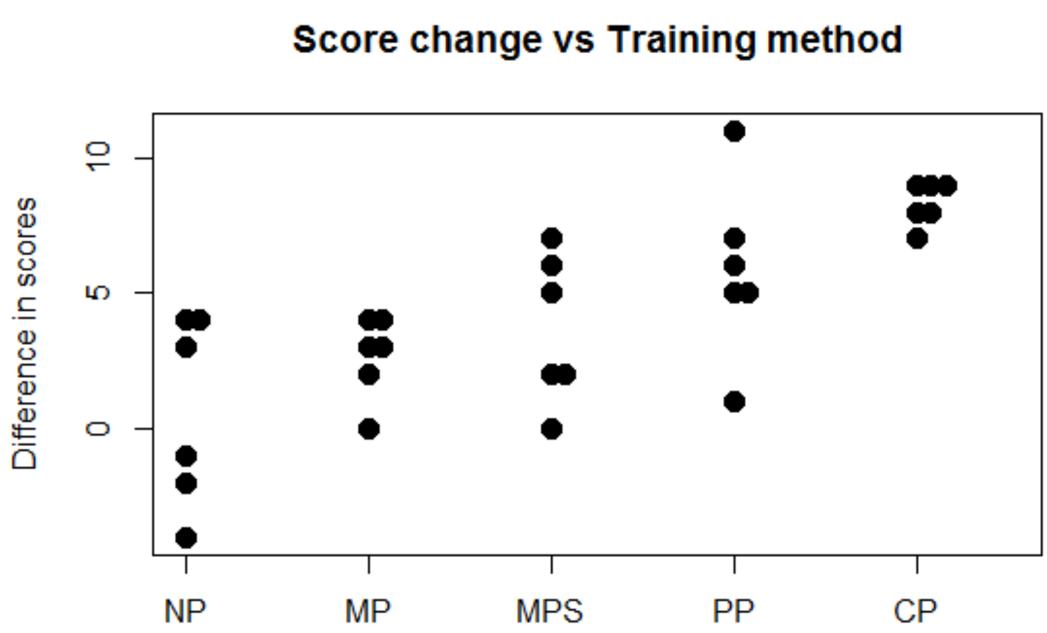
Question 1

Question of interest/goal of the study

We wish to identify the most promising trombone practice method. Doany of the methods show significant improvement? If so, which method shows the most significant improvement and by how much?

Read in and inspect the data:

```
trombone.df <- read.csv("trombone.csv")
trombone.df$method <-
factor(trombone.df$method,levels=c("NP","MP","MPS","PP","CP"))
stripchart(diff~method,data=trombone.df,vertical=T,pch=16,cex=1.5,method="sta
ck",ylab="Difference in scores",main="Score change vs Training method")
```




```
summaryStats(diff~method,data=trombone.df)
```

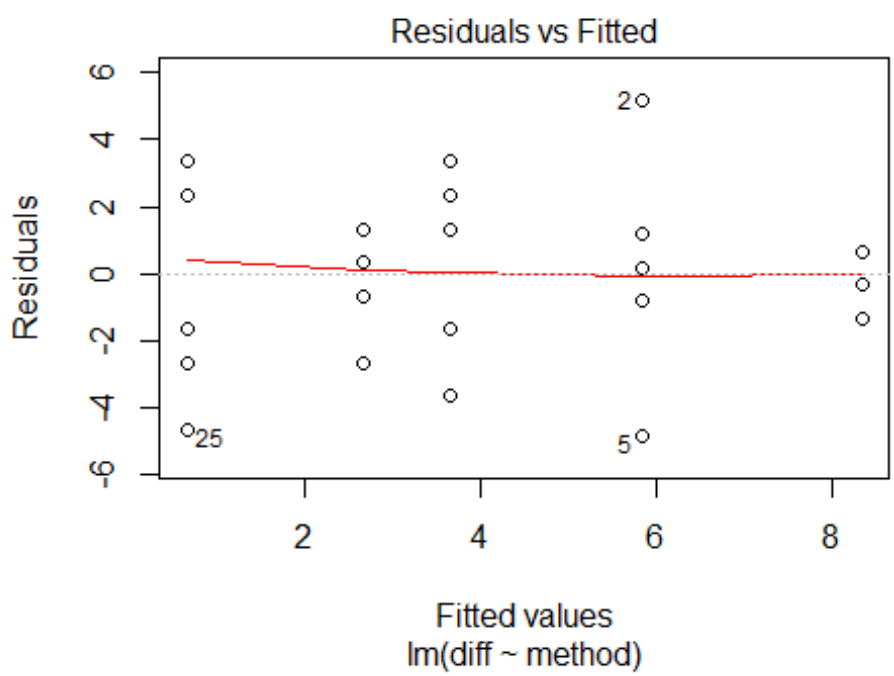
```
##      Sample Size      Mean Median   Std Dev Midspread
## NP             6 0.6666667    1.0 3.4448028      5.50
## MP             6 2.6666667    3.0 1.5055453      1.50
## MPS            6 3.6666667    3.5 2.7325202      3.75
## PP             6 5.8333333    5.5 3.2506410      1.75
## CP             6 8.3333333    8.5 0.8164966      1.00
```

Comment on plot(s) and/or summary statistics:

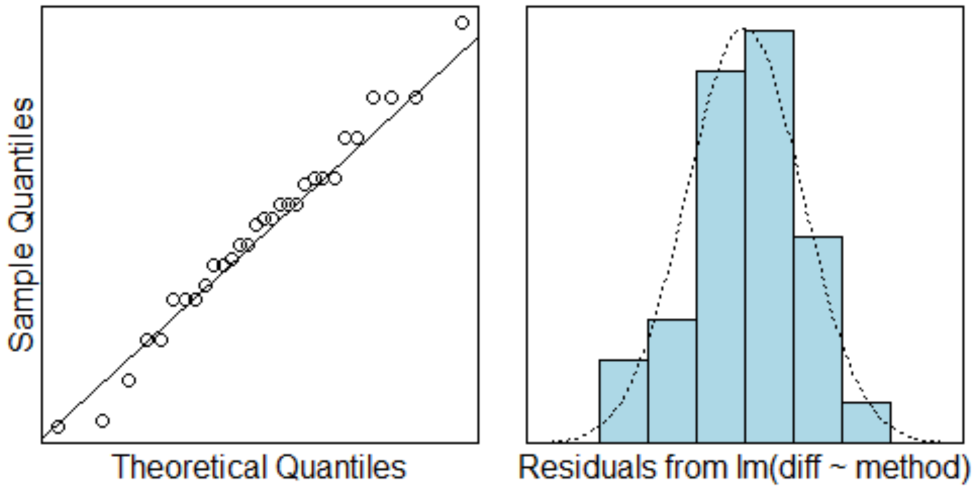
The no practice group has the lowest average change in score, with half of the students' scores dropping in value. The physical practice and combined mental and physical practice groups appeared to have the highest average increases in scores. The variabilities of the scores were similar for 3 groups, but are lower for the mental practice only and combined groups.

Fit model and check assumptions

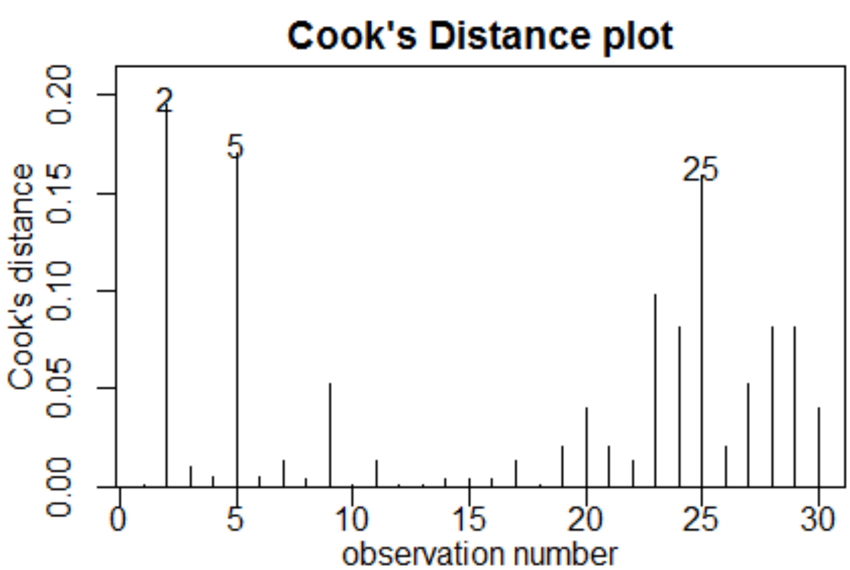
```r
trombone.fit <- lm(diff~method,data=trombone.df)
plot(trombone.fit,which=1)
```




```r
normcheck(trombone.fit)
```




```r
cooks20x(trombone.fit)
```




```r
anova(trombone.fit)
```

```
## Analysis of Variance Table
##
## Response: diff
##           Df Sum Sq Mean Sq F value    Pr(>F)
## method     4 209.20  52.300  7.9645 0.0002771 ***
## Residuals 25 164.17   6.567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(trombone.fit)
```

```
##
## Call:
## lm(formula = diff ~ method, data = trombone.df)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -4.833 -1.583  0.250  1.333  5.167
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.6667     1.0462   0.637   0.5298
## methodMP      2.0000     1.4795   1.352   0.1885
## methodMPS     3.0000     1.4795   2.028   0.0534 .
## methodPP      5.1667     1.4795   3.492   0.0018 **
## methodCP      7.6667     1.4795   5.182 2.33e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.563 on 25 degrees of freedom
## Multiple R-squared:  0.5603, Adjusted R-squared:   0.49
## F-statistic: 7.964 on 4 and 25 DF,  p-value: 0.0002771
```

```
trombone.mc <- multipleComp(trombone.fit)
trombone.mc[trombone.mc[,4] <.05,]
```

```
##              Estimate  Tukey.L Tukey.U Tukey.p
## NP  -  PP  -5.166667  -9.5117 -0.8216  0.0141
## NP  -  CP  -7.666667 -12.0117 -3.3216  0.0002
## MP  -  CP  -5.666667 -10.0117 -1.3216  0.0063
## MPS  -  CP -4.666667  -9.0117 -0.3216  0.0309
```

Methods and assumption checks

As we have one explanatory variable which is a factor with five levels we have fitted a oneway ANOVA model to the data.

One student's performance should not affect the performance of another, and the students are assigned randomly. There are differences in the within-group variabilities, but we have very small individual sample sizes. As we have equal sample sizes and there is not a consistent pattern in the residuals (the variability does not increase with the average), the EOV assumptions should be valid. The residuals look approximately normal. There do not appear to be any influential points. We can therefore rely on the results from fitting this linear model.

Our model is:

$$diff_i = \beta_0 + \beta_{MP} \times MP_i + \beta_{MPS} \times MPS_i + \beta_{PP} \times PP_i + \beta_{CP} \times CP_i + \epsilon_i$$

where MP_i equals 1 if student i was trained using mental practice only and 0 otherwise (similar for MPS_i, PP_i and CP_i), and $\epsilon_i \sim iid\ N(0, \sigma^2)$. (Note: β_0 is the mean improvement of students without any practice.)

Alternatively our model is: $diff_{ij} = \mu_i + \epsilon_{ij}$ where μ_i is the mean improvement score for students working under strategy j.

or

$diff_{ij} = \mu + \alpha_i + \epsilon_{ij}$ where μ is the overall mean improvement score for all students and α_i is the effect of working under strategy i.

Our model explains 56% of the variation in improvement scores.

Executive Summary

A musical college wished to study the effectiveness of various practice methods for its trombonists. Four methods: mental practice only; mental practice with simulated slide movement; physical practice only; and combined mental and physical practice were trialled and compared to no practice.

We found strong evidence that practice method had an influence on the students improvement scores.

Both physical practice only and a combination of physical and mental practice showed significantly better improvement in scores than the no practice schedule, with the combination showing the largest improvement.

On average, a student following a combined practice schedule improved by between 3.3 and 12 points more compared to a student with the no practice schedule.

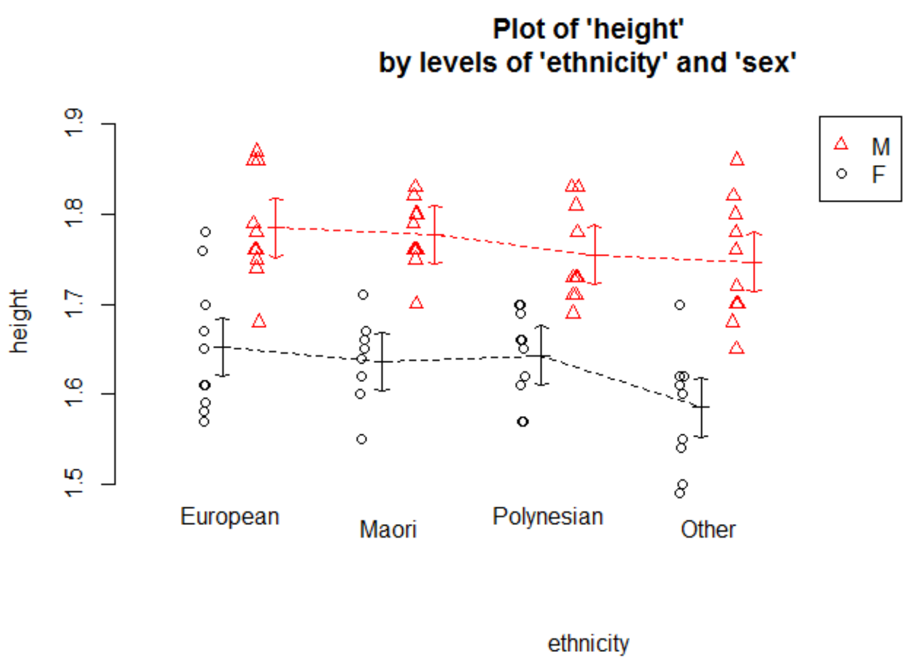
Question 2

Question of interest/goal of the study

We are interested in how much males tend to be taller than females and if this height difference depended on the ethnicity of people.

Read in and inspect the data:

```
height.df=read.table("height.txt",header=T)

interactionPlots(height~ethnicity+sex,data=height.df)
```



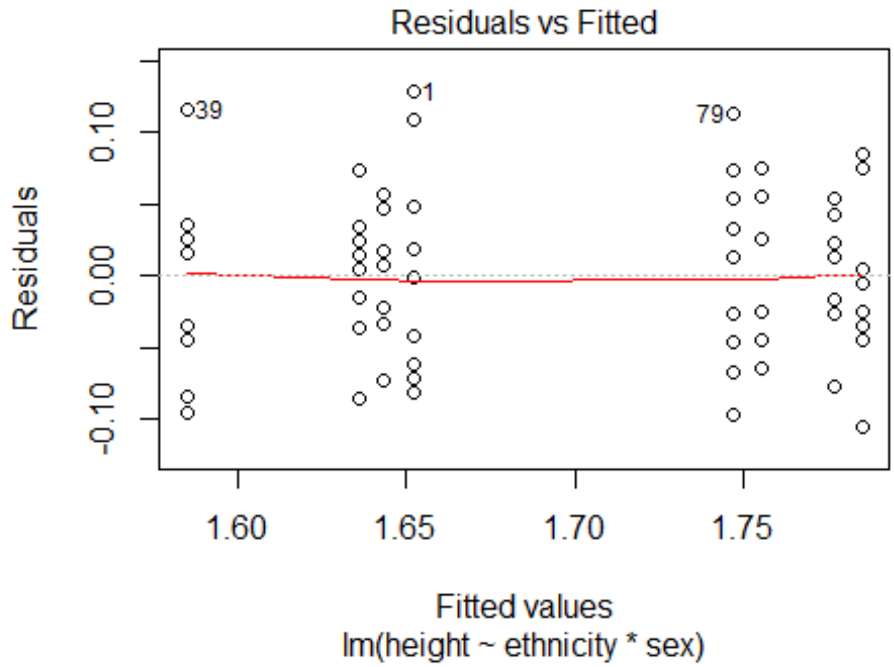
Comment on plot(s) and/or summary statistics:

Males are taller than females. This difference looks constant across the four ethic groups, though maybe the difference is a bit larger in the “Other” group. This doesn’t seem to strongly suggest the presence of interaction. There doesn’t appear to be any major differences in heights between ethnicities, althouh the “Other” group is slightly shorter (mainly due to the females).

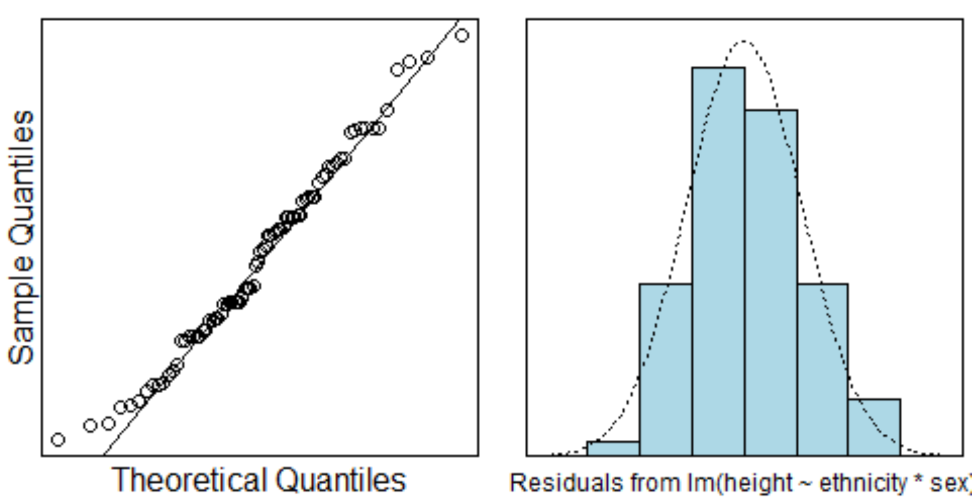
The heights in the “Other” and European groups seem to be a little more varied than the heights in the Maori and Polynesian groups.

Fit model and check assumptions

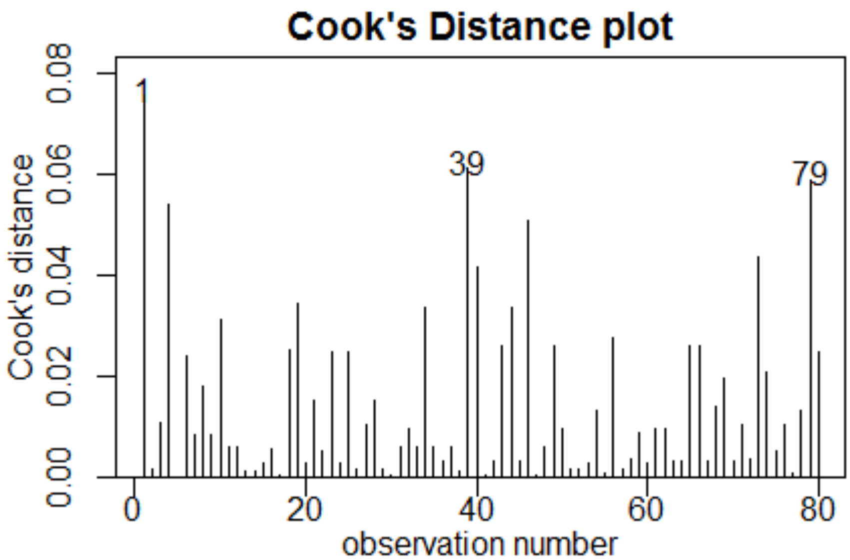
```
height.fit1=lm(height~ethnicity*sex,data=height.df)
plot(height.fit1,which=1)
```




```
normcheck(height.fit1,main="")
```

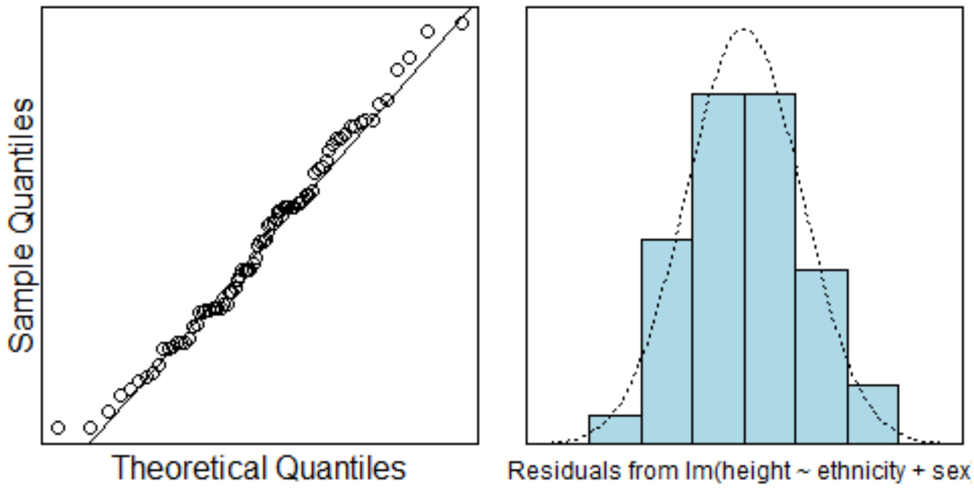


```r
cooks20x(height.fit1)
```

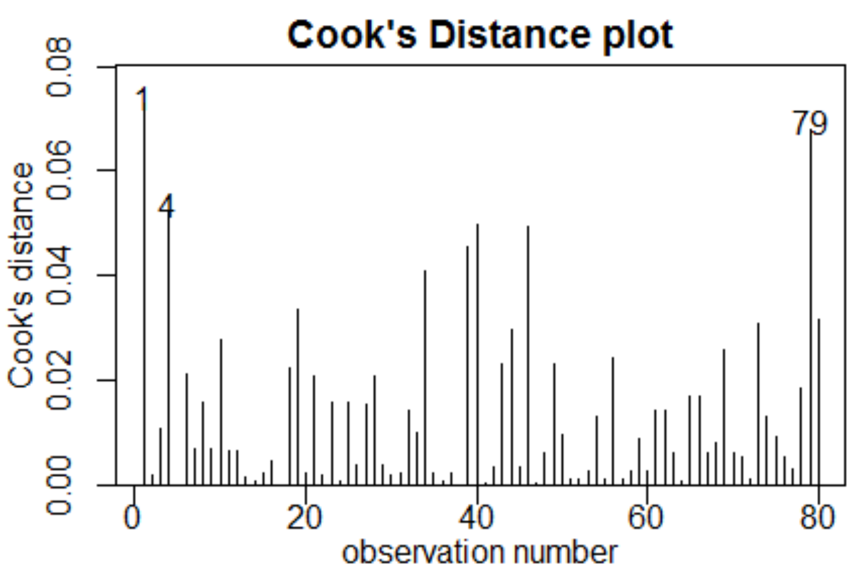



```r
anova(height.fit1)

## Analysis of Variance Table
##
## Response: height
##                Df  Sum Sq Mean Sq  F value    Pr(>F)
## ethnicity       3 0.03033 0.01011   3.0232    0.0351 *
## sex             1 0.37538 0.37538 112.2492 2.427e-16 ***
## ethnicity:sex   3 0.00641 0.00214   0.6389    0.5924
## Residuals      72 0.24078 0.00334
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#Interaction not significant

height.fit2=lm(height~ethnicity+sex,data=height.df)
```

```r
normcheck(height.fit2,main="")
```




```r
cooks20x(height.fit2)
```



```r
anova(height.fit2)

## Analysis of Variance Table
## 
## Response: height
##           Df  Sum Sq Mean Sq  F value Pr(>F)    
## ethnicity  3 0.03033 0.01011   3.0675  0.033 *  
## sex        1 0.37538 0.37538 113.8942 <2e-16 ***
## Residuals 75 0.24719 0.00330                    
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(height.fit2)

## 
## Call:
## lm(formula = height ~ ethnicity + sex, data = height.df)
## 
## Residuals:
##      Min       1Q   Median       3Q      Max 
## -0.10750 -0.03850  0.00100  0.03463  0.13000 
## 
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)    
## (Intercept)           1.65000    0.01435 114.963  < 2e-16 ***
## ethnicityMaori       -0.01200    0.01815  -0.661  0.51064    
## ethnicityOther       -0.05250    0.01815  -2.892  0.00501 ** 
## ethnicityPolynesian -0.01950    0.01815  -1.074  0.28622    
## sexM                  0.13700    0.01284  10.672  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 0.05741 on 75 degrees of freedom
## Multiple R-squared:  0.6214, Adjusted R-squared:  0.6012 
## F-statistic: 30.77 on 4 and 75 DF,  p-value: 3.695e-15

summary2way(height.fit2,page="nointeraction")

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
## 
## Fit: aov(formula = fit)
## 
## $ethnicity
##                         diff         lwr          upr     p adj
## Maori-European      -0.0120 -0.05970245  0.035702453 0.9113383
## Other-European      -0.0525 -0.10020245 -0.004797547 0.0252634
## Polynesian-European -0.0195 -0.06720245  0.028202453 0.7062804
## Other-Maori         -0.0405 -0.08820245  0.007202453 0.1243221
## Polynesian-Maori    -0.0075 -0.05520245  0.040202453 0.9760576
## Polynesian-Other     0.0330 -0.01470245  0.080702453 0.2731829
```

```
##
## $sex
##      diff      lwr      upr p adj
## M-F 0.137 0.111427 0.162573     0
```

Methods and assumption checks

We have two explanatory factors and a continuous response variable, so have fitted a Twoway ANOVA model to the data. All assumptions looked fine. The interaction between sex and ethnicity was not significant and was removed.

Our model is: $height_{ijk} = \mu + \alpha_i + \beta_j + \epsilon_{ijk}$

where μ is the overall mean, α_i is the effect of gender i, β_j is the effect of ethnicity j and $\epsilon_{ijk} \sim iid\ N(0, \sigma^2)$.

We could also write this as a dummy variable model, but this gets messy: $height_i = \beta_0 + \beta_1 \times EthnicityMaori_i + \beta_2 \times EthnicityOther_i + \beta_3 \times EthnicityPolynesian_i + \beta_4 \times SexM_i + \epsilon_i$

where $EthnicityMaori_i$ = 1 if the ith person is Maori and 0 otherwise, …, and $SexM_i$ is 1 if the ith person was male and 0 if they were female and $\epsilon_i \sim iid\ N(0, \sigma^2)$

Our model explained 62% of the variation in heights (and won't be much good for prediction — but that doesn't matter since it wasn't a research objective).

Executive Summary

We are interested in how much males tend to be taller than females and if this height difference depended on the ethnicity of people.

Not surprisingly, we found that males were taller than females, but the amount by which they were taller did not depend on the ethnicity of the person.

We estimate that, on average, males are between 11cm and 16cm taller than females.

There was little evidence of differences in height between the four ethnic groups. The only significant difference found was that Europeans were taller than the "Other" ethnicities group. We estimate that, on average, Europeans are between 0.5cm and 10cm taller than "Other" ethnicities.