

Supplement for Lecture 16: Techniques for Choosing Predictors

Load Data

```
data("BodyFat") # Load Data
```

```
bf = BodyFat
```

```
head(bf)
```

```
##   Bodyfat Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist
## 1    32.3  41 247.25  73.50 42.1 117.0   115.6  26.3   37.3  19.7
## 2    22.5  31 177.25  71.50 36.2 101.1    92.4  24.6   30.1  18.2
## 3    22.0  42 156.25  69.00 35.5  97.8    86.0  24.0   31.2  17.4
## 4    12.3  23 154.25  67.75 36.2  93.1    85.2  21.9   32.0  17.1
## 5    20.5  46 177.00  70.00 37.2  99.7    95.6  22.5   29.1  17.7
## 6    22.6  54 198.00  72.00 39.9 107.6   100.0  22.0   35.9  18.9
```

Check for Multicollinearity

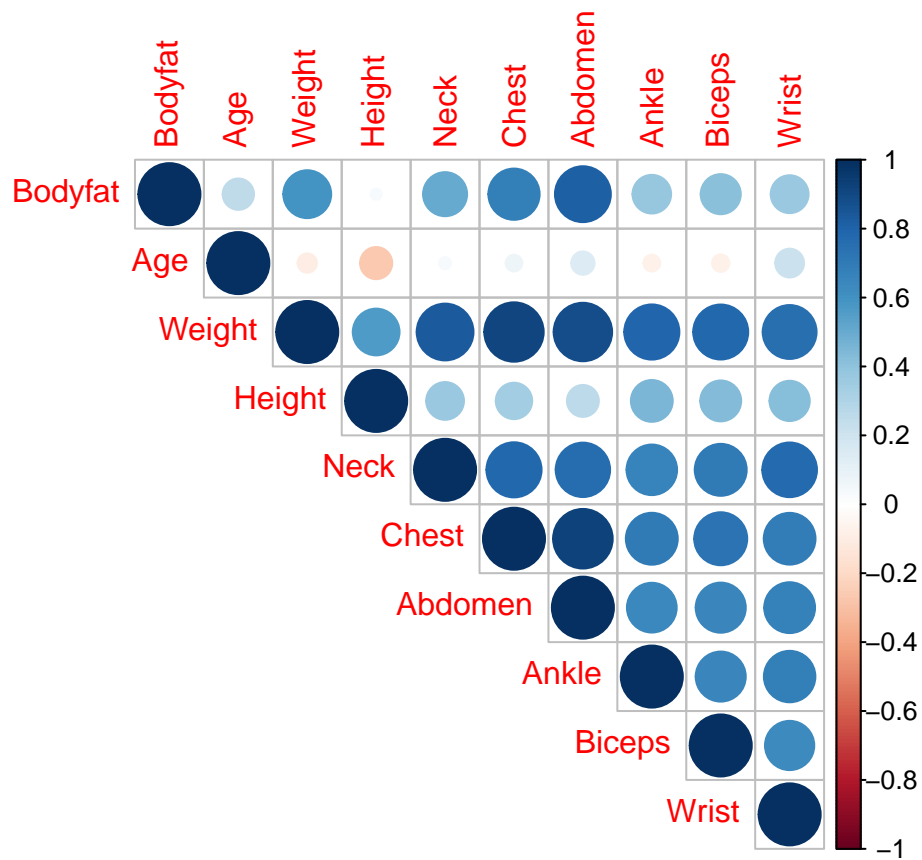
```
# Correlation Matrix from Base R
```

```
round(cor(bf),4)
```

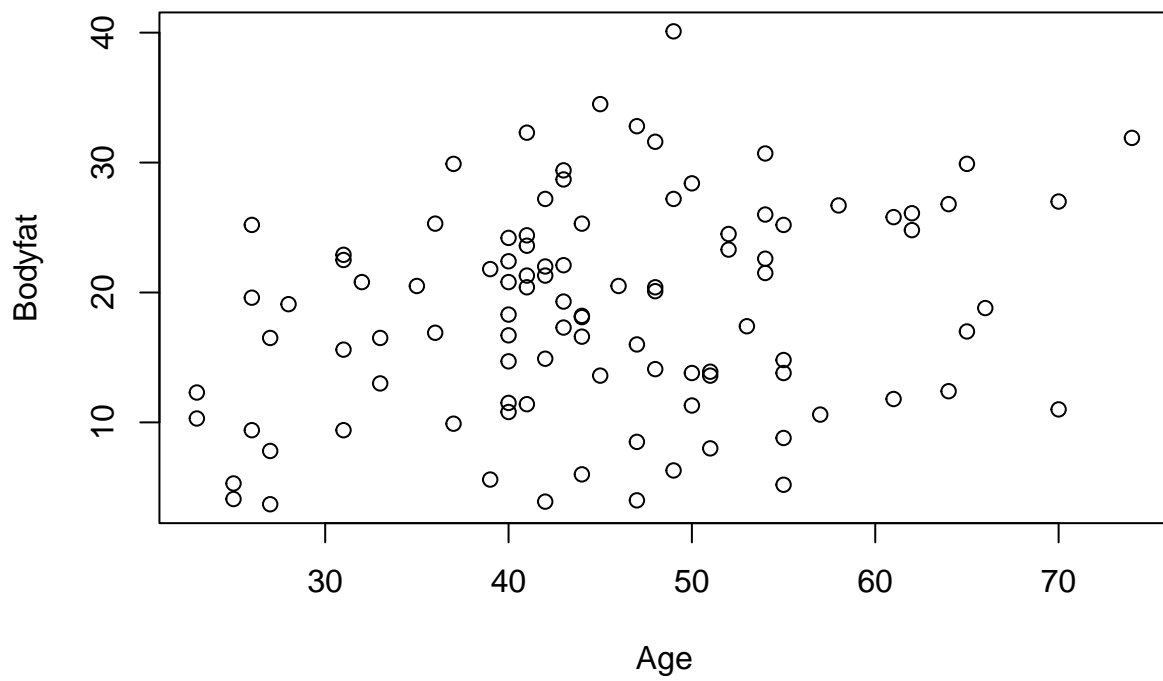
```
##      Bodyfat      Age      Weight      Height      Neck      Chest      Abdomen      Ankle      Biceps
## Bodyfat  1.0000  0.2558  0.5960  0.0322  0.5044  0.6823  0.8116  0.3879  0.4181
## Age      0.2558  1.0000 -0.0979 -0.2687  0.0385  0.0729  0.1413 -0.0735 -0.0794
## Weight   0.5960 -0.0979  1.0000  0.5684  0.8390  0.9160  0.8883  0.7904  0.7863
## Height   0.0322 -0.2687  0.5684  1.0000  0.3704  0.3453  0.2654  0.4550  0.4355
## Neck     0.5044  0.0385  0.8390  0.3704  1.0000  0.7898  0.7691  0.6641  0.7011
## Chest    0.6823  0.0729  0.9160  0.3453  0.7898  1.0000  0.9227  0.7001  0.7301
## Abdomen  0.8116  0.1413  0.8883  0.2654  0.7691  0.9227  1.0000  0.6432  0.6521
## Ankle    0.3879 -0.0735  0.7904  0.4550  0.6641  0.7001  0.6432  1.0000  0.6508
## Biceps   0.4181 -0.0794  0.7863  0.4355  0.7011  0.7301  0.6521  0.6508  1.0000
## Wrist    0.3731  0.2163  0.7551  0.4209  0.7773  0.6958  0.6721  0.6883  0.6305
## Wrist    0.3731  0.2163  0.7551  0.4209  0.7773  0.6958  0.6721  0.6883  0.6305
## Bodyfat  0.3731
## Age      0.2163
## Weight   0.7551
## Height   0.4209
## Neck     0.7773
## Chest    0.6958
## Abdomen  0.6721
## Ankle    0.6883
## Biceps   0.6305
## Wrist    1.0000
```

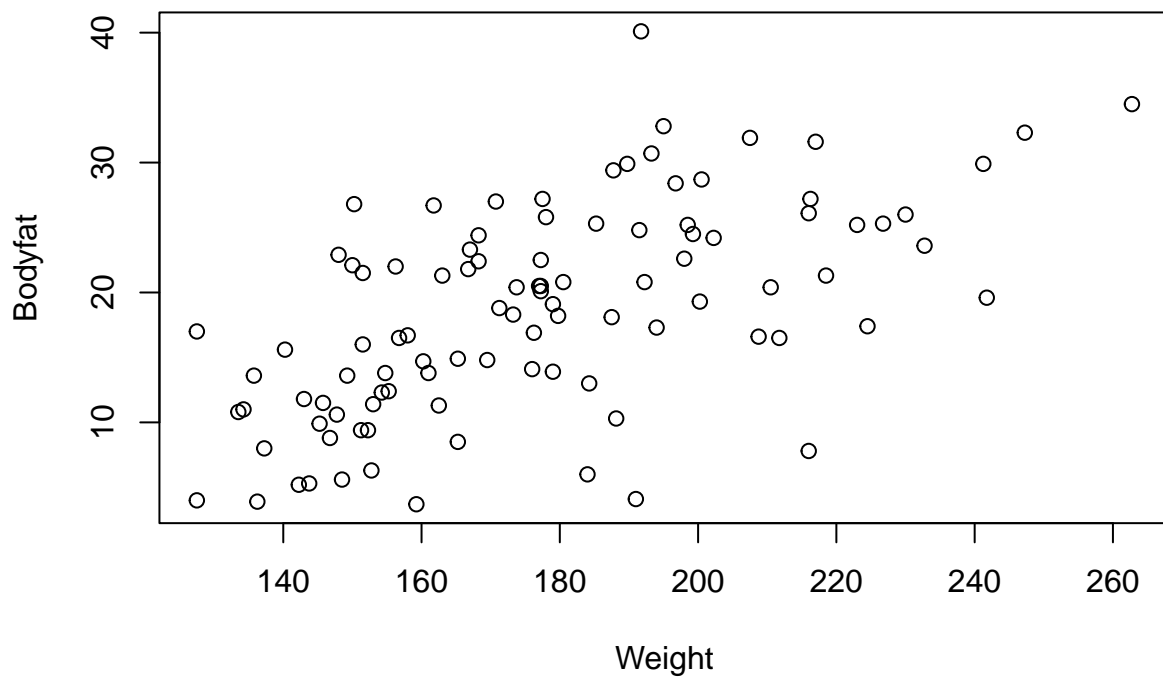
```
# Tile Plot of Correlation Matrix (Correlogram) from corrplot package
```

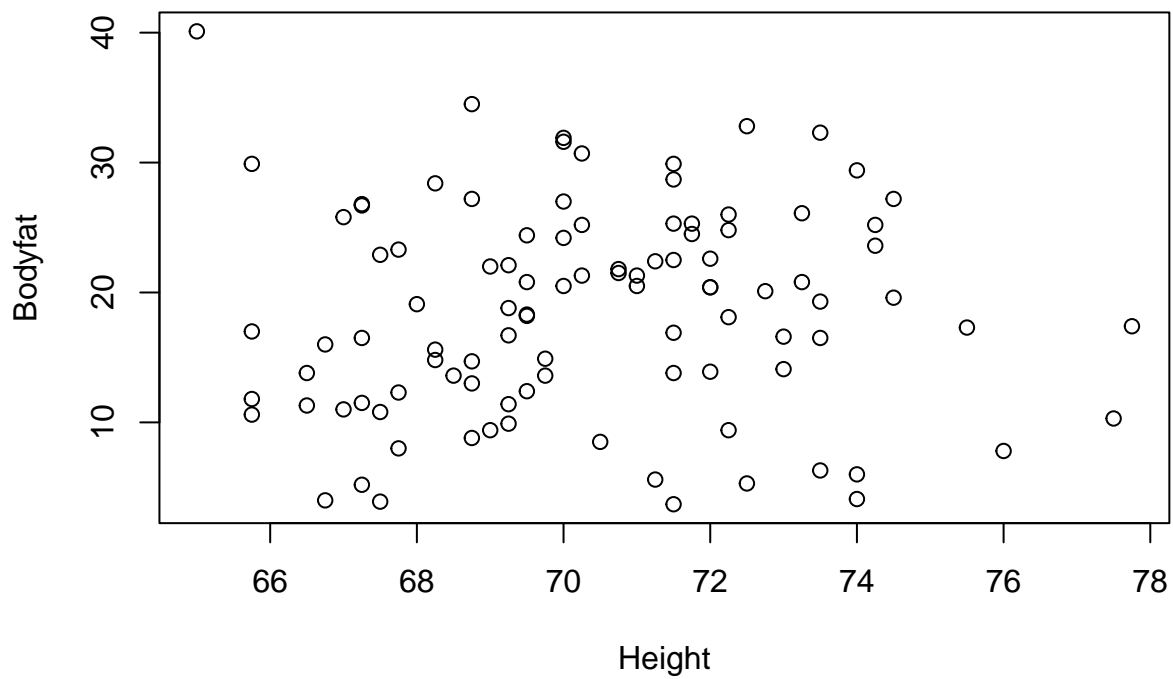
```
corrplot(cor(bf), type="upper")
```

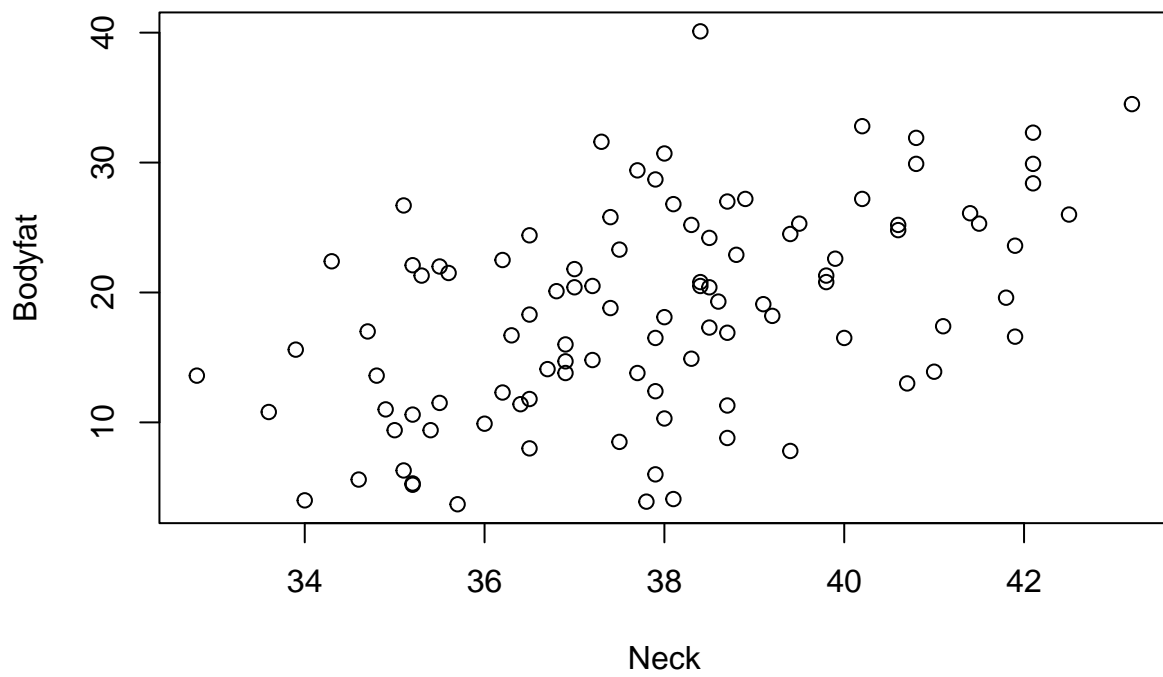


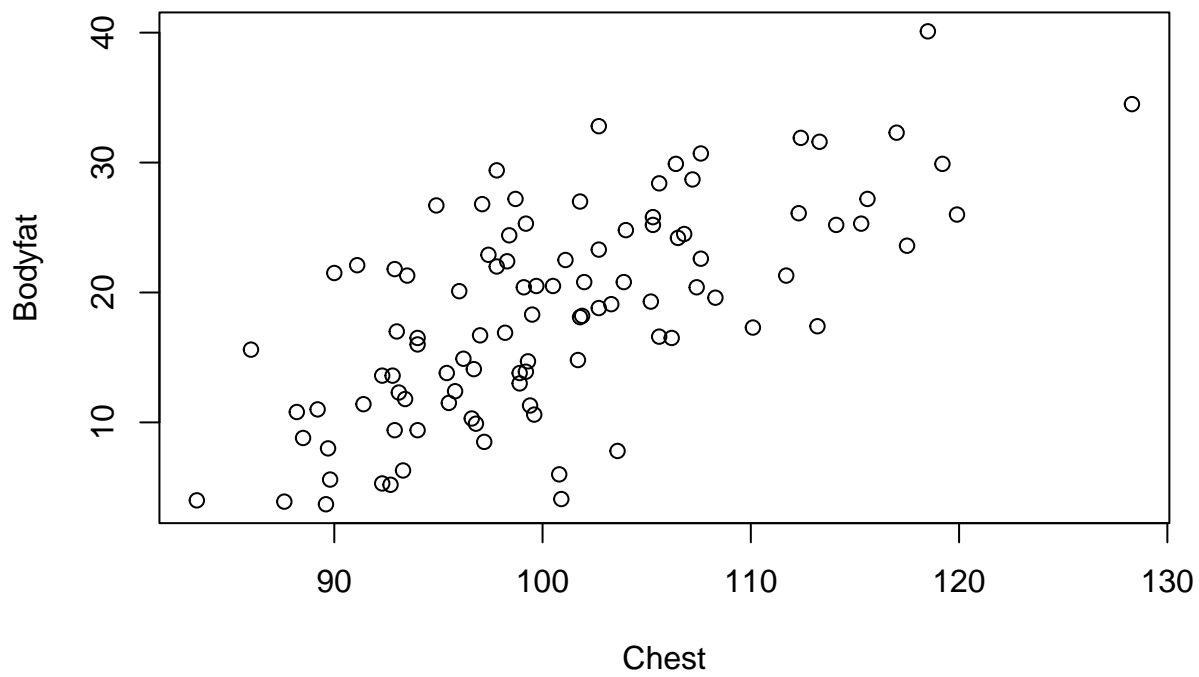
```
#Scatterplots of Bodyfat Variable with Each Other Predictor
plot(Bodyfat~., data=bf)
```

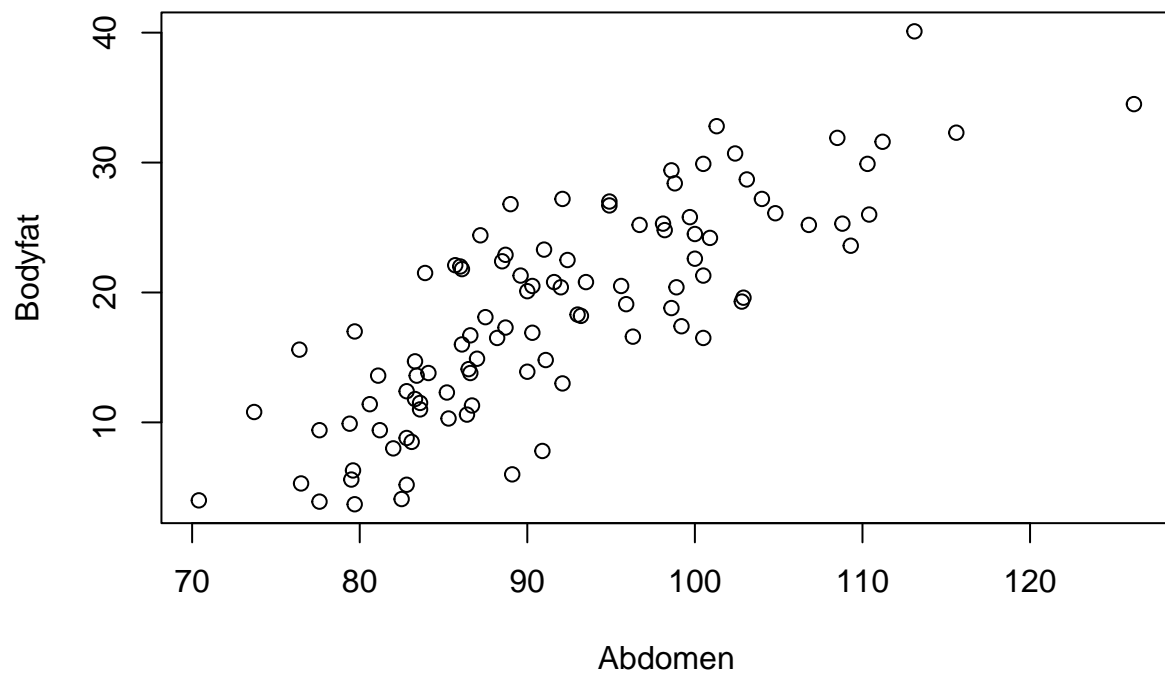


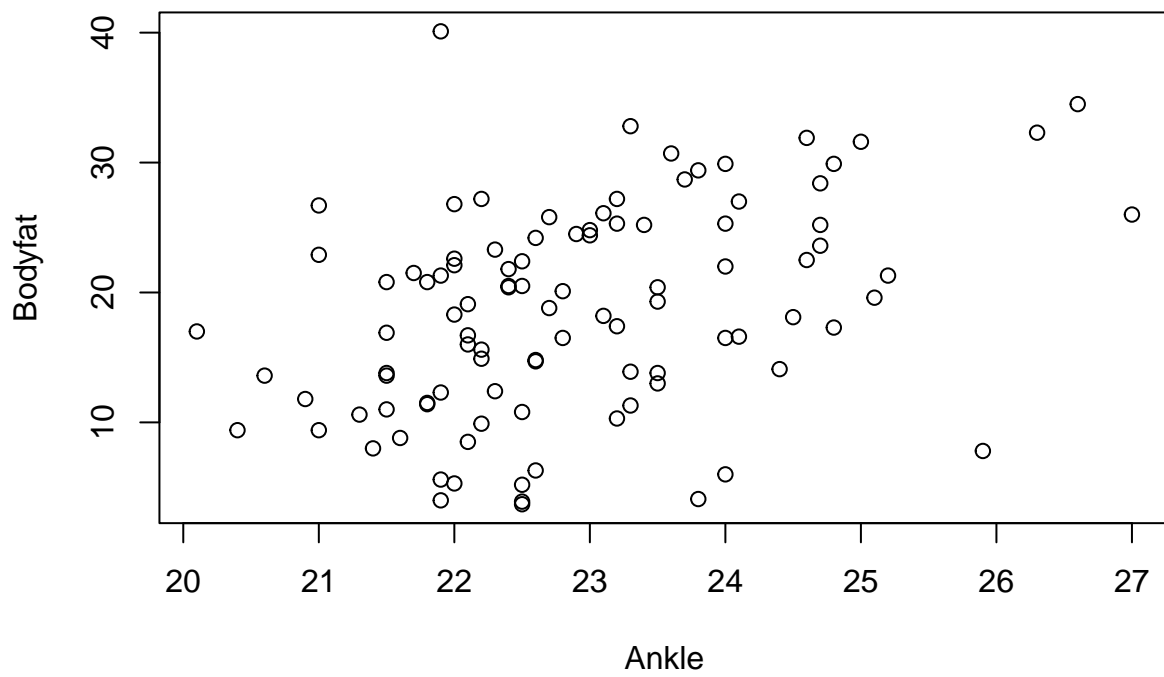


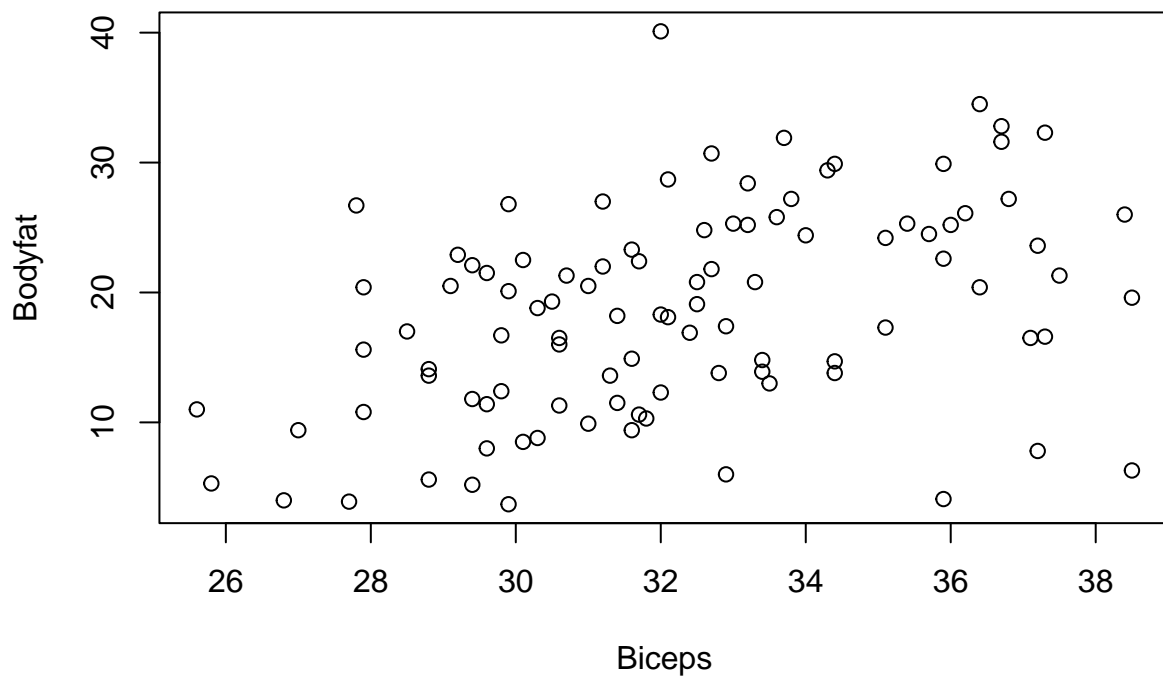


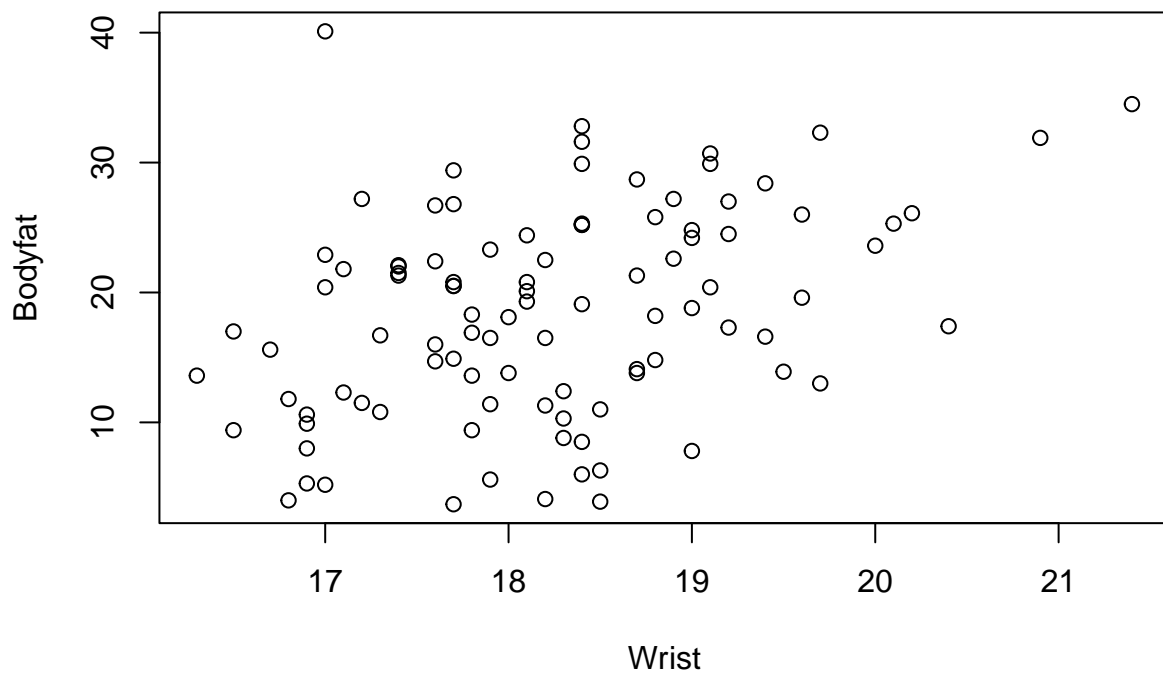




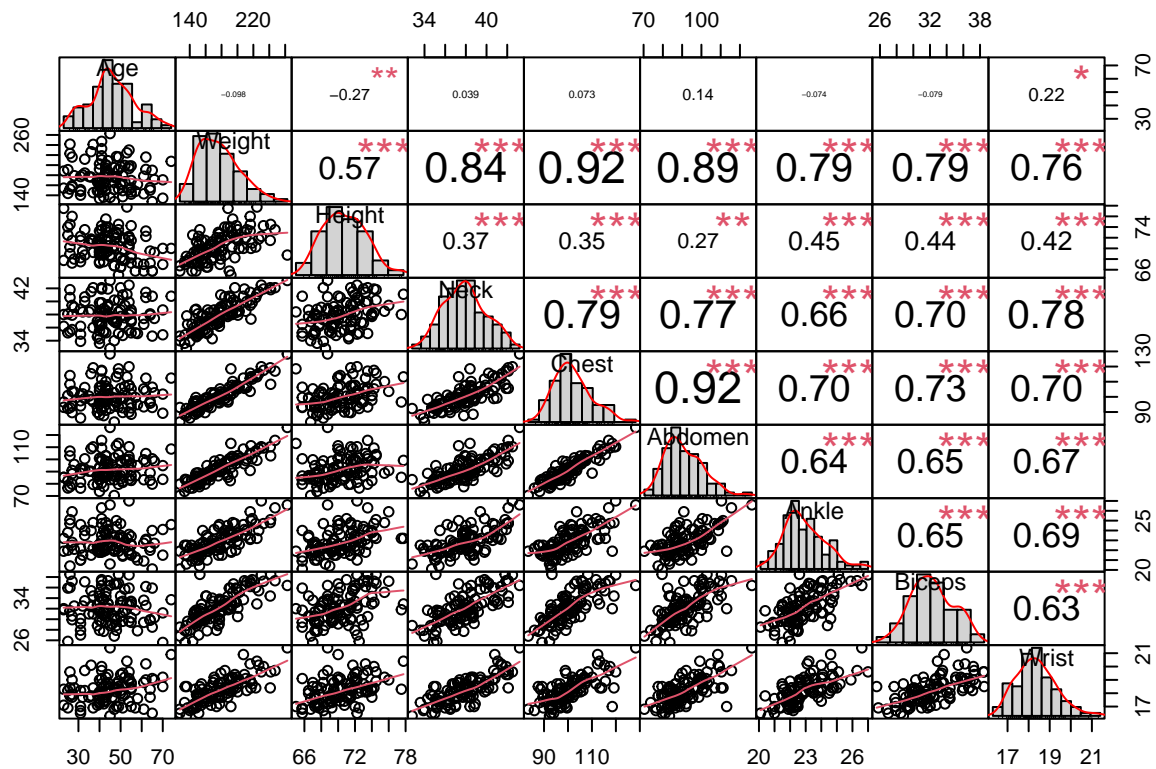








```
# Cool Visual from PerformanceAnalytics package  
chart.Correlation(bf[, -1], histogram=TRUE)
```

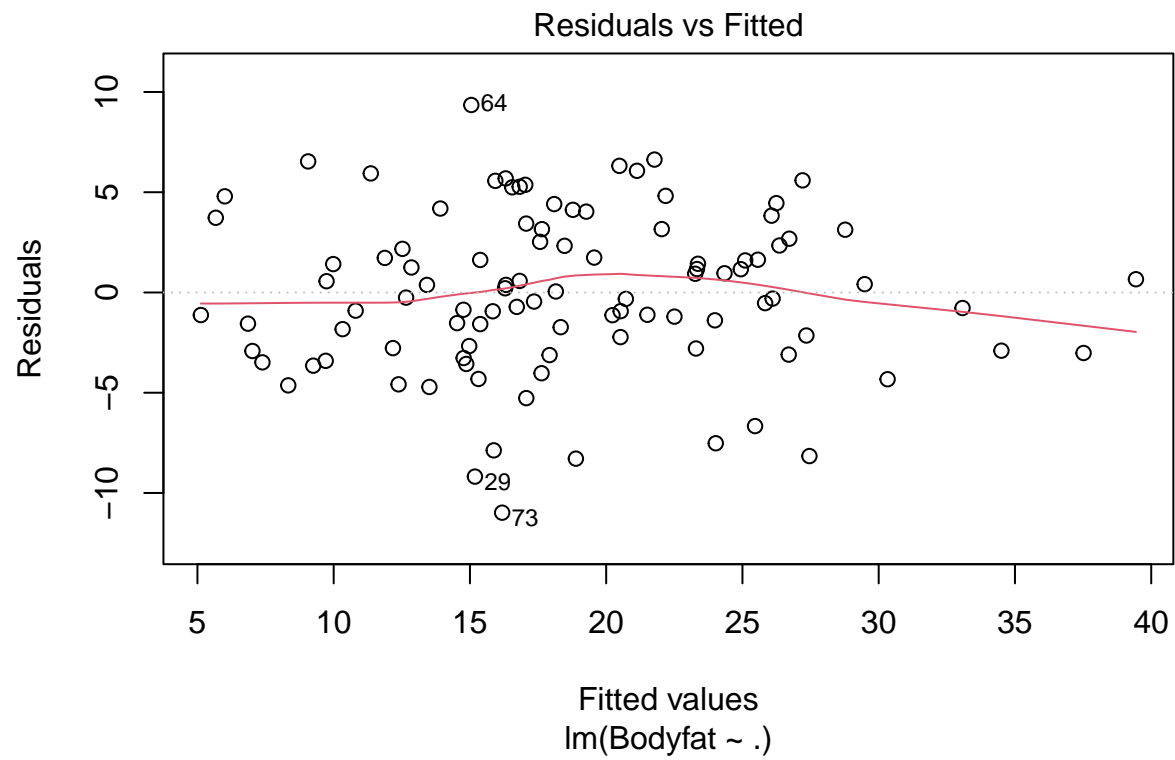


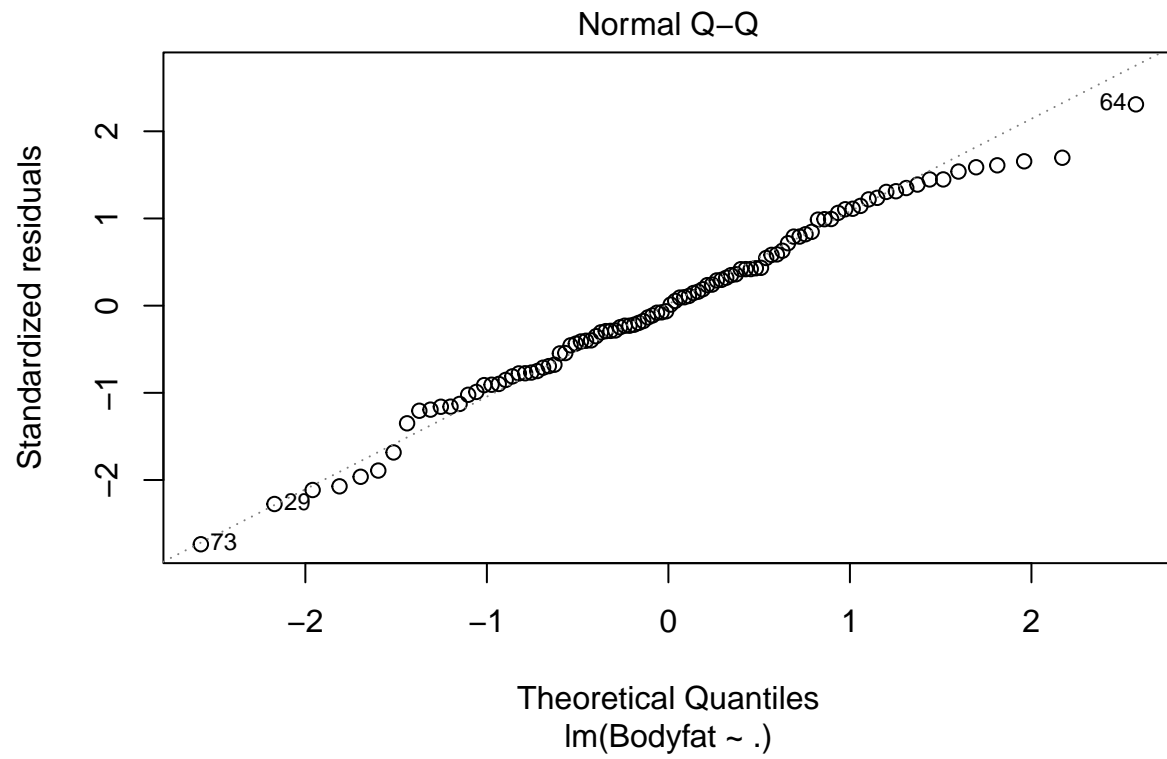
Variance Inflation Factor

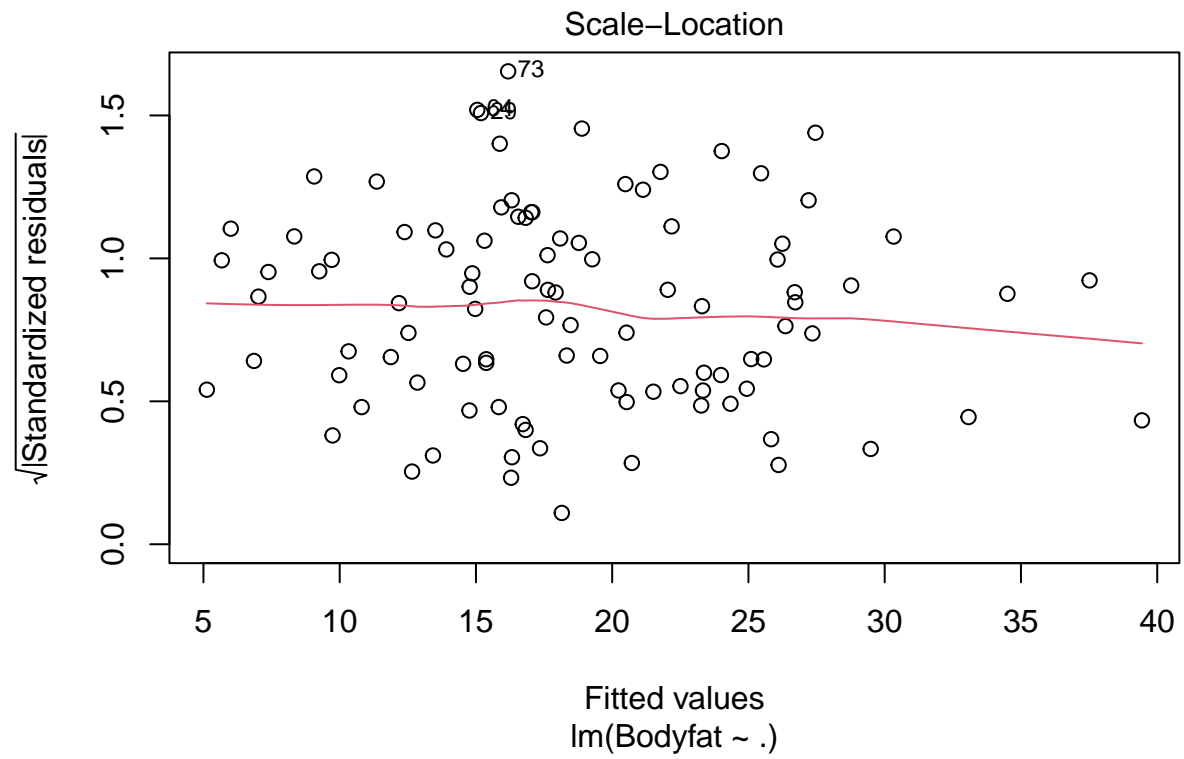
```
mod.full = lm(Bodyfat~.,data=bf)
summary(mod.full)
```

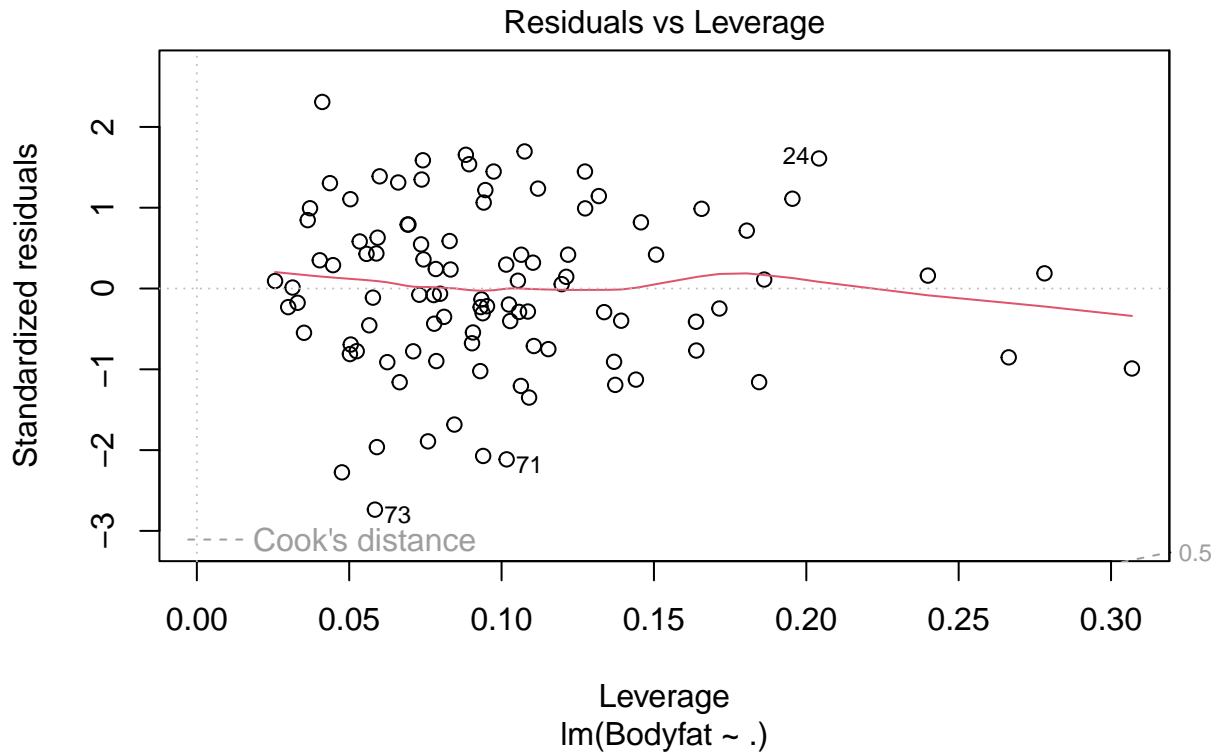
```
##
## Call:
## lm(formula = Bodyfat ~ ., data = bf)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.9819  -2.7798  -0.1037   2.7939   9.3505
##
## Coefficients:
##              Estimate Std. Error t value    Pr(>|t|)
## (Intercept) -23.664200  29.459443  -0.803    0.42393
## Age           0.083779   0.050655   1.654    0.10163
## Weight       -0.083322   0.084706  -0.984    0.32792
## Height        0.035932   0.265770   0.135    0.89276
## Neck          0.001123   0.380079   0.003    0.99765
## Chest        -0.138742   0.160900  -0.862    0.39082
## Abdomen       1.032741   0.145857   7.080 0.000000000306 ***
## Ankle         0.225943   0.541725   0.417    0.67761
## Biceps        0.148276   0.229519   0.646    0.51990
## Wrist        -2.203399   0.812923  -2.710    0.00805 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##  
## Residual standard error: 4.136 on 90 degrees of freedom  
## Multiple R-squared:  0.7575, Adjusted R-squared:  0.7332  
## F-statistic: 31.23 on 9 and 90 DF,  p-value: < 0.00000000000000022  
plot(mod.full)
```









```
vif(mod.full) # From car package
```

```
##      Age      Weight      Height      Neck      Chest      Abdomen      Ankle      Biceps
## 1.936408 36.164456 3.013450 4.435176 10.869437 12.966704 3.079738 2.864922
##      Wrist
## 3.820191
```

```
mod.noWeight = lm(Bodyfat~.-Weight,data=bf)
vif(mod.noWeight)
```

```
##      Age      Height      Neck      Chest      Abdomen      Ankle      Biceps      Wrist
## 1.423017 1.535216 3.996662 8.987621 7.398178 2.634682 2.647918 3.678592
```

```
mod.noWeightChest = lm(Bodyfat~.-Weight-Chest,data=bf)
vif(mod.noWeightChest)
```

```
##      Age      Height      Neck      Abdomen      Ankle      Biceps      Wrist
## 1.422846 1.530002 3.942897 2.936500 2.564204 2.447678 3.678552
```

Fit All Subsets

The `regsubsets()` function fits all subset models up to a maximum number of variables. Notice the `nvmax` argument. The asterisk indicates which variables are included in the best model for each possible choice for k .

```
all = regsubsets(Bodyfat~., data = bf) #From leaps package
summary(all)
```

```
## Subset selection object
```



```
## Call: regsubsets.formula(Bodyfat ~ ., data = bf)
## 9 Variables (and intercept)
##      Forced in Forced out
## Age      FALSE      FALSE
## Weight    FALSE      FALSE
## Height    FALSE      FALSE
## Neck      FALSE      FALSE
## Chest     FALSE      FALSE
## Abdomen   FALSE      FALSE
## Ankle     FALSE      FALSE
## Biceps    FALSE      FALSE
## Wrist     FALSE      FALSE
## 1 subsets of each size up to 8
## Selection Algorithm: exhaustive
##      Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist
## 1 ( 1 ) " " " " " " " " "*" " " " " " "
## 2 ( 1 ) " " "*" " " " " " " "*" " " " " " "
## 3 ( 1 ) " " "*" " " " " " " "*" " " " " "*"
## 4 ( 1 ) "*" "*" " " " " " " "*" " " " " "*"
## 5 ( 1 ) "*" "*" " " " " "*" "*" " " " " "*"
## 6 ( 1 ) "*" "*" " " " " "*" "*" " " "*" "*"
## 7 ( 1 ) "*" "*" " " " " "*" "*" "*" "*" "*"
## 8 ( 1 ) "*" "*" "*" " " "*" "*" "*" "*" "*"

all12 = regsubsets(Bodyfat~., data = bf,nvmax=9) #From leaps package
summary(all12)
```

```
## Subset selection object
## Call: regsubsets.formula(Bodyfat ~ ., data = bf, nvmax = 9)
## 9 Variables (and intercept)
##      Forced in Forced out
## Age      FALSE      FALSE
## Weight    FALSE      FALSE
## Height    FALSE      FALSE
## Neck      FALSE      FALSE
## Chest     FALSE      FALSE
## Abdomen   FALSE      FALSE
## Ankle     FALSE      FALSE
## Biceps    FALSE      FALSE
## Wrist     FALSE      FALSE
## 1 subsets of each size up to 9
## Selection Algorithm: exhaustive
##      Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist
## 1 ( 1 ) " " " " " " " " "*" " " " " " "
## 2 ( 1 ) " " "*" " " " " " " "*" " " " " " "
## 3 ( 1 ) " " "*" " " " " " " "*" " " " " "*"
## 4 ( 1 ) "*" "*" " " " " " " "*" " " " " "*"
## 5 ( 1 ) "*" "*" " " " " "*" "*" " " " " "*"
## 6 ( 1 ) "*" "*" " " " " "*" "*" " " "*" "*"
## 7 ( 1 ) "*" "*" " " " " "*" "*" "*" "*" "*"
## 8 ( 1 ) "*" "*" "*" " " "*" "*" "*" "*" "*"
## 9 ( 1 ) "*" "*" "*" "*" "*" "*" "*" "*" "*" "
```

Now we identify the “best” model based off the criteria R-Squared, adjusted R-Squared, and Mallows’s Cp. We can use the `ShowSubsets()` function created by Dr. McLean.

```
out2 = ShowSubsets(all2)
out2
```

```
##           Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist   Rsq adjRsq
## 1  ( 1 )                                     *           65.87  65.52
## 2  ( 1 )                                     *           73.28  72.73
## 3  ( 1 )                                     *           * 74.71  73.92
## 4  ( 1 )      *      *                                     * 75.40  74.37
## 5  ( 1 )      *      *                                     * 75.59  74.29
## 6  ( 1 )      *      *                                     * 75.70  74.13
## 7  ( 1 )      *      *                                     * 75.74  73.90
## 8  ( 1 )      *      *      *      *      *      *      * 75.75  73.62
## 9  ( 1 )      *      *      *      *      *      *      * 75.75  73.32
##
##           Cp
## 1  ( 1 ) 30.66
## 2  ( 1 )  5.17
## 3  ( 1 )  1.83
## 4  ( 1 )  1.27
## 5  ( 1 )  2.60
## 6  ( 1 )  4.18
## 7  ( 1 )  6.02
## 8  ( 1 )  8.00
## 9  ( 1 ) 10.00
```

```
# Best Model According to R-Squared
out2[which.max(out2$Rsq),]
```

```
##           Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist   Rsq adjRsq
## 8  ( 1 )      *      *      *      *      *      *      * 75.75  73.62
##
##           Cp
## 8  ( 1 )  8
```

```
# Best Model According to Adjusted R-Squared
out2[which.max(out2$adjRsq),]
```

```
##           Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist   Rsq adjRsq
## 4  ( 1 )      *      *                                     * 75.4  74.37
##
##           Cp
## 4  ( 1 ) 1.27
```

```
# Best Model According to Mallows Cp
out2[which.min(out2$Cp),]
```

```
##           Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist   Rsq adjRsq
## 4  ( 1 )      *      *                                     * 75.4  74.37
##
##           Cp
## 4  ( 1 ) 1.27
```

We can also tell the function using `nbest` the number of top models for each choice of k that we want to see in the output. We can also calculate the BIC for each of the models and identify the best model according to BIC.

```
all3 = regsubsets(Bodyfat~., data = BodyFat, nvmax=9, nbest=2)
out3 = ShowSubsets(all3)
out3
```

```
##           Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist   Rsq adjRsq
## 1  ( 1 )                                     *           65.87  65.52
```

```
## 1 ( 2 ) * 46.55 46.00
## 2 ( 1 ) * 73.28 72.73
## 2 ( 2 ) * 71.29 70.69
## 3 ( 1 ) * 74.71 73.92
## 3 ( 2 ) * 74.66 73.86
## 4 ( 1 ) * * 75.40 74.37
## 4 ( 2 ) * * 75.28 74.24
## 5 ( 1 ) * * 75.59 74.29
## 5 ( 2 ) * * 75.47 74.17
## 6 ( 1 ) * * 75.70 74.13
## 6 ( 2 ) * * 75.63 74.06
## 7 ( 1 ) * * 75.74 73.90
## 7 ( 2 ) * * 75.70 73.85
## 8 ( 1 ) * * 75.75 73.62
## 8 ( 2 ) * * 75.74 73.61
## 9 ( 1 ) * * 75.75 73.32
```

```
## Cp
```

```
## 1 ( 1 ) 30.66
## 1 ( 2 ) 102.35
## 2 ( 1 ) 5.17
## 2 ( 2 ) 12.56
## 3 ( 1 ) 1.83
## 3 ( 2 ) 2.05
## 4 ( 1 ) 1.27
## 4 ( 2 ) 1.72
## 5 ( 1 ) 2.60
## 5 ( 2 ) 3.03
## 6 ( 1 ) 4.18
## 6 ( 2 ) 4.42
## 7 ( 1 ) 6.02
## 7 ( 2 ) 6.18
## 8 ( 1 ) 8.00
## 8 ( 2 ) 8.02
## 9 ( 1 ) 10.00
```

```
#Get BIC for each of the models
```

```
summ.all3 = summary(all3)
summ.all3$bic
```

```
## [1] -98.28408 -53.42961 -118.14668 -110.96042 -119.07503 -118.83843
## [7] -117.23164 -116.74943 -113.37315 -112.89961 -109.22590 -108.95840
## [13] -104.80096 -104.62649 -100.21719 -100.19689 -95.61203
```

```
#Find Best Model According to BIC
```

```
out3[which.min(summ.all3$bic),]
```

```
## Age Weight Height Neck Chest Abdomen Ankle Biceps Wrist Rsq adjRsq
## 3 ( 1 ) * * 74.71 73.92
## Cp
## 3 ( 1 ) 1.83
```

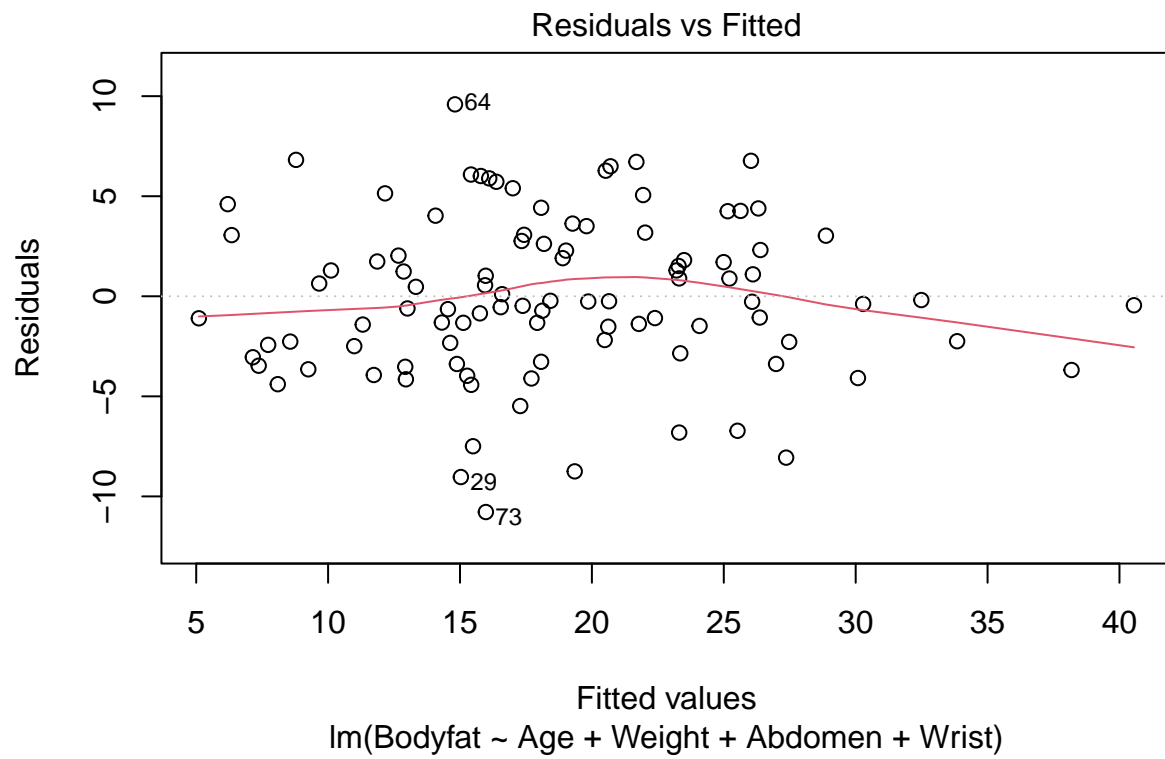
```
#Calculated adjusted R-squared by hand
```

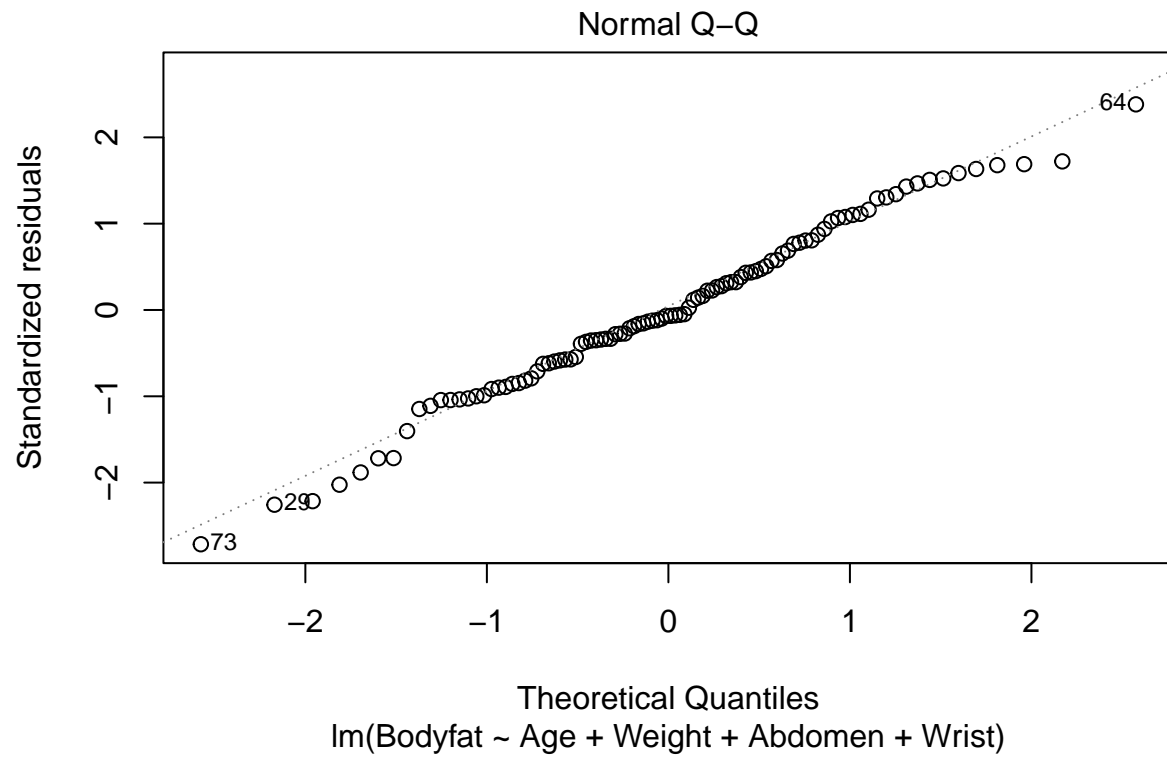
```
1-(1-0.7471)*((100-1)/(100-3-1)) #NOTice these equals the adjusted R-Squared in the BIC Model
```

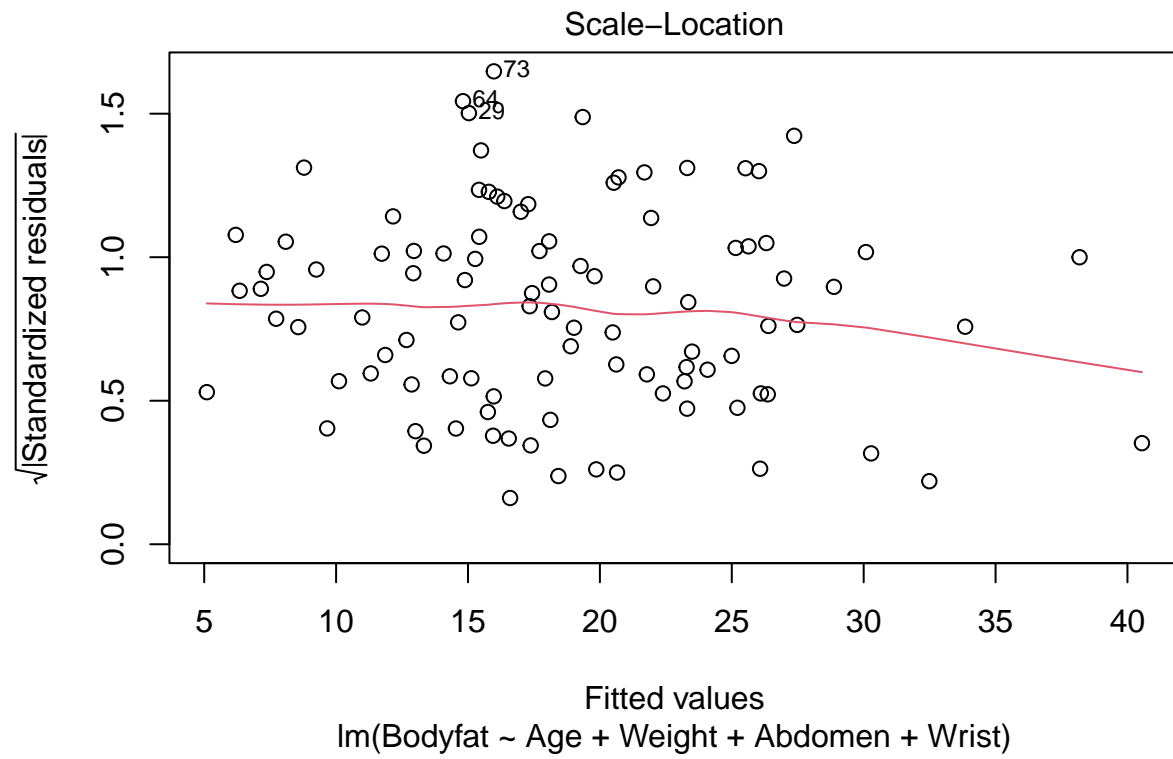
```
## [1] 0.7391969
```

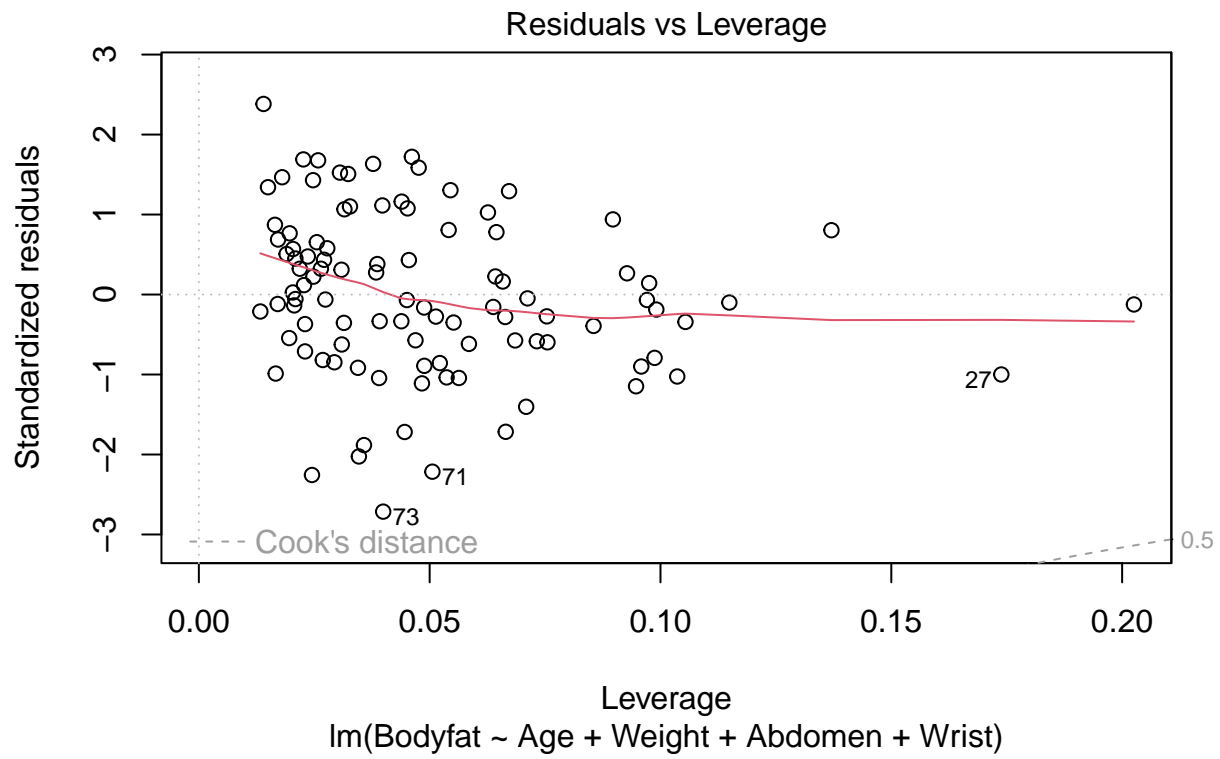
Now we fit our “best” models according to adjusted R-squared/Mallow’s Cp and BIC.

```
mod.rsqmallow = lm(Bodyfat ~ Age + Weight + Abdomen + Wrist, data=bf)
plot(mod.rsqmallow)
```





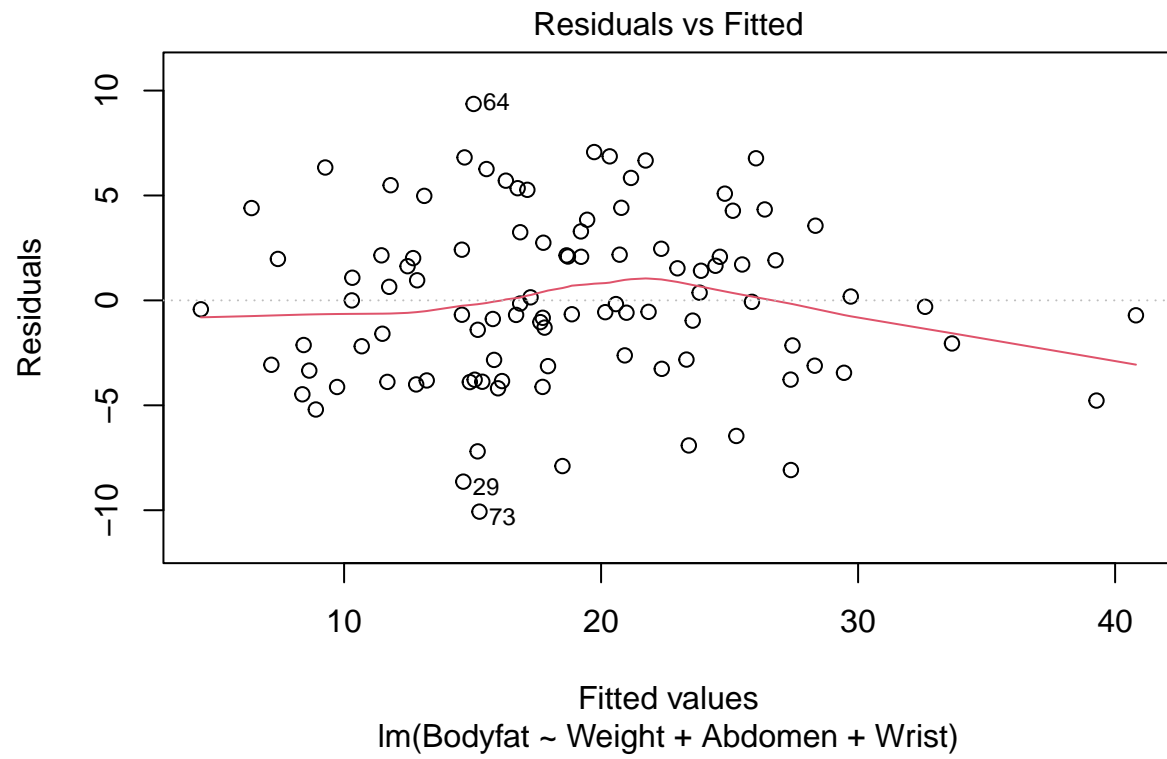


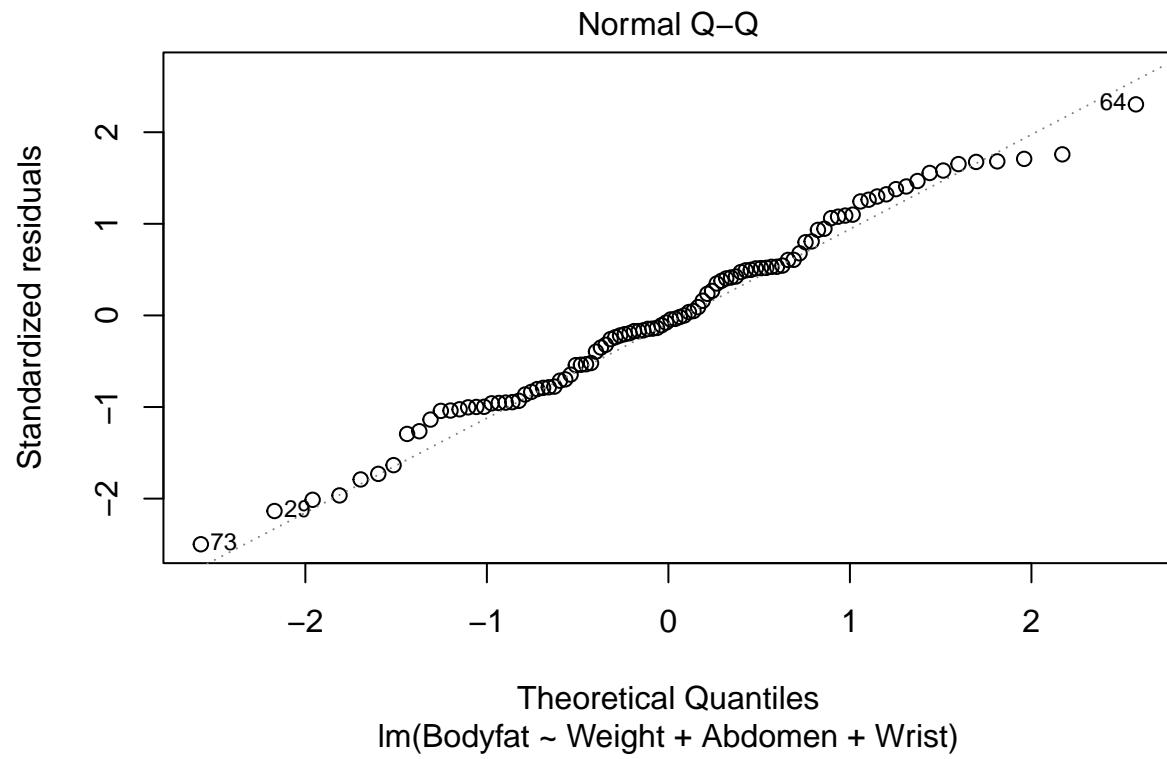


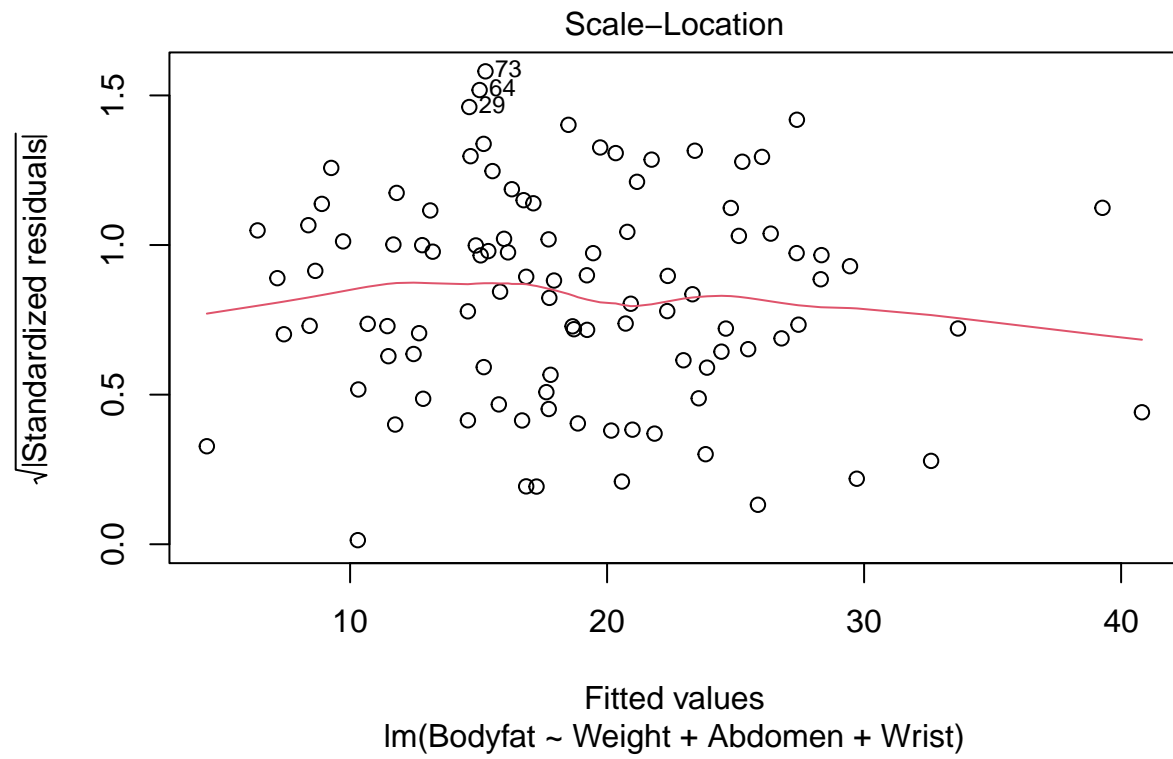
```
vif(mod.rsqmallow)
```

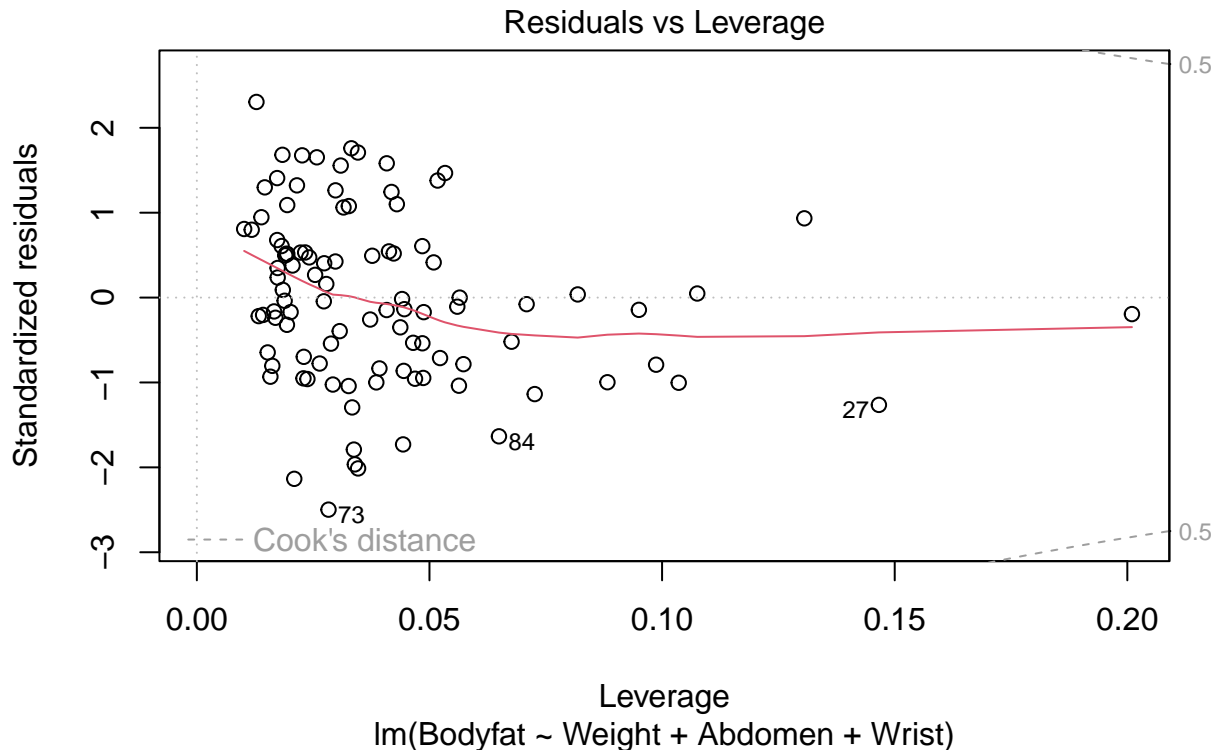
```
##      Age      Weight      Abdomen      Wrist
## 1.821182 10.501749  6.860258  3.149493
```

```
mod.bic = lm(Bodyfat ~ Weight + Abdomen + Wrist, data=bf)
plot(mod.bic)
```









```
vif(mod.bic)
```

```
## Weight Abdomen Wrist
## 6.049705 4.741816 2.326765
```

Backwards, Forwards, and Stepwise Algorithms

Built-in `step()` function doesn't use p-values to determine what variables to remove or keep. It uses the AIC measurement which is similar to BIC. Let's first look at backward's elimination.

```
Full = lm(Bodyfat~.,data=bf)
back.out = step(Full, direction="backward")
```

```
## Start: AIC=293.39
## Bodyfat ~ Age + Weight + Height + Neck + Chest + Abdomen + Ankle +
## Biceps + Wrist
##
##      Df Sum of Sq  RSS   AIC
## - Neck      1      0.00 1539.2 291.39
## - Height     1      0.31 1539.5 291.41
## - Ankle      1      2.98 1542.2 291.58
## - Biceps     1      7.14 1546.4 291.85
## - Chest      1     12.72 1551.9 292.21
## - Weight     1     16.55 1555.8 292.46
## <none>                 1539.2 293.39
## - Age        1     46.78 1586.0 294.38
## - Wrist      1    125.65 1664.9 299.23
```

```

## - Abdomen 1      857.41 2396.6 335.67
##
## Step: AIC=291.39
## Bodyfat ~ Age + Weight + Height + Chest + Abdomen + Ankle + Biceps +
##      Wrist
##
##           Df Sum of Sq    RSS    AIC
## - Height   1         0.33 1539.6 289.41
## - Ankle     1         3.02 1542.2 289.58
## - Biceps    1         7.19 1546.4 289.85
## - Chest     1        12.73 1552.0 290.21
## - Weight    1        18.33 1557.6 290.57
## <none>                        1539.2 291.39
## - Age       1        46.82 1586.0 292.38
## - Wrist     1       144.48 1683.7 298.36
## - Abdomen   1       862.49 2401.7 333.88
##
## Step: AIC=289.41
## Bodyfat ~ Age + Weight + Chest + Abdomen + Ankle + Biceps + Wrist
##
##           Df Sum of Sq    RSS    AIC
## - Ankle     1         2.78 1542.3 287.59
## - Biceps     1         6.91 1546.5 287.86
## - Chest      1        14.74 1554.3 288.36
## - Weight     1        27.96 1567.5 289.21
## <none>                        1539.6 289.41
## - Age        1        49.53 1589.1 290.57
## - Wrist      1       145.64 1685.2 296.45
## - Abdomen    1      1153.22 2692.8 343.32
##
## Step: AIC=287.59
## Bodyfat ~ Age + Weight + Chest + Abdomen + Biceps + Wrist
##
##           Df Sum of Sq    RSS    AIC
## - Biceps     1         7.08 1549.4 286.05
## - Chest       1        14.43 1556.8 286.52
## - Weight      1        25.22 1567.5 287.21
## <none>                        1542.3 287.59
## - Age        1        49.72 1592.1 288.76
## - Wrist       1       143.37 1685.7 294.48
## - Abdomen     1      1168.38 2710.7 341.98
##
## Step: AIC=286.05
## Bodyfat ~ Age + Weight + Chest + Abdomen + Wrist
##
##           Df Sum of Sq    RSS    AIC
## - Chest       1        11.61 1561.0 284.79
## - Weight      1        19.16 1568.6 285.27
## <none>                        1549.4 286.05
## - Age        1        50.55 1600.0 287.26
## - Wrist       1       139.74 1689.2 292.68
## - Abdomen     1      1186.64 2736.1 340.91
##
## Step: AIC=284.79

```

```
## Bodyfat ~ Age + Weight + Abdomen + Wrist
##
##           Df Sum of Sq    RSS    AIC
## <none>                1561.0 284.79
## - Age       1      43.71 1604.7 285.55
## - Weight    1      47.51 1608.5 285.79
## - Wrist     1     134.38 1695.4 291.05
## - Abdomen   1    1373.33 2934.3 345.91
```

```
summary(back.out)
```

```
##
## Call:
## lm(formula = Bodyfat ~ Age + Weight + Abdomen + Wrist, data = bf)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.7803  -2.4434  -0.2681   2.8294   9.5902
##
## Coefficients:
##              Estimate Std. Error t value      Pr(>|t|)
## (Intercept) -21.06107   10.52814  -2.000    0.04831 *
## Age           0.07854    0.04815   1.631    0.10620
## Weight       -0.07608    0.04474  -1.700    0.09231 .
## Abdomen        0.95069    0.10399   9.142 0.00000000000000113 ***
## Wrist         -2.06898    0.72350  -2.860    0.00521 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.054 on 95 degrees of freedom
## Multiple R-squared:  0.754, Adjusted R-squared:  0.7437
## F-statistic: 72.81 on 4 and 95 DF,  p-value: < 0.00000000000000022
```

```
vif(back.out)
```

```
##      Age      Weight  Abdomen      Wrist
## 1.821182 10.501749  6.860258  3.149493
```

Now let's look at forward selection. In this case, we need to start by initiating the empty model and telling the `step()` function to consider all models up to possibly the full model.

```
Empty = lm(Bodyfat~1,data=bf)
forward.out = step(Empty,scope=list(upper=Full),direction="forward",trace=F)
summary(forward.out)
```

```
##
## Call:
## lm(formula = Bodyfat ~ Abdomen + Weight + Wrist + Age, data = bf)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.7803  -2.4434  -0.2681   2.8294   9.5902
##
## Coefficients:
##              Estimate Std. Error t value      Pr(>|t|)
## (Intercept) -21.06107   10.52814  -2.000    0.04831 *
## Abdomen        0.95069    0.10399   9.142 0.00000000000000113 ***
```

```
## Weight      -0.07608    0.04474   -1.700          0.09231 .
## Wrist       -2.06898    0.72350   -2.860          0.00521 **
## Age         0.07854    0.04815    1.631          0.10620
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.054 on 95 degrees of freedom
## Multiple R-squared:  0.754, Adjusted R-squared:  0.7437
## F-statistic: 72.81 on 4 and 95 DF,  p-value: < 0.00000000000000022
```

```
vif(forward.out)
```

```
## Abdomen      Weight      Wrist      Age
## 6.860258 10.501749  3.149493  1.821182
```

Now, we specify the `direction="both"` to conduct stepwise regression where variables can be both added and removed.

```
Empty = lm(Bodyfat~1,data=bf)
step.out = step(Empty,scope=list(upper=Full),direction="both",trace=F)
summary(step.out)
```

```
##
## Call:
## lm(formula = Bodyfat ~ Abdomen + Weight + Wrist + Age, data = bf)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.7803  -2.4434  -0.2681   2.8294   9.5902
##
## Coefficients:
##              Estimate Std. Error t value      Pr(>|t|)
## (Intercept) -21.06107   10.52814  -2.000    0.04831 *
## Abdomen      0.95069    0.10399   9.142 0.0000000000000113 ***
## Weight     -0.07608    0.04474   -1.700    0.09231 .
## Wrist       -2.06898    0.72350   -2.860    0.00521 **
## Age         0.07854    0.04815    1.631    0.10620
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.054 on 95 degrees of freedom
## Multiple R-squared:  0.754, Adjusted R-squared:  0.7437
## F-statistic: 72.81 on 4 and 95 DF,  p-value: < 0.00000000000000022
```

```
vif(step.out)
```

```
## Abdomen      Weight      Wrist      Age
## 6.860258 10.501749  3.149493  1.821182
```

All Models Summarized

```
mod.full
```

```
##
## Call:
## lm(formula = Bodyfat ~ ., data = bf)
```

```
##
## Coefficients:
## (Intercept)      Age      Weight      Height      Neck      Chest
## -23.664200    0.083779   -0.083322   0.035932   0.001123   -0.138742
##      Abdomen      Ankle      Biceps      Wrist
##      1.032741    0.225943    0.148276   -2.203399
```

```
mod.noWeight
```

```
##
## Call:
## lm(formula = Bodyfat ~ . - Weight, data = bf)
##
## Coefficients:
## (Intercept)      Age      Height      Neck      Chest      Abdomen
##      2.45399    0.10944   -0.14717   -0.11644   -0.20460    0.93872
##      Ankle      Biceps      Wrist
##      0.02337    0.08614   -2.35735
```

```
mod.noWeightChest
```

```
##
## Call:
## lm(formula = Bodyfat ~ . - Weight - Chest, data = bf)
##
## Coefficients:
## (Intercept)      Age      Height      Neck      Abdomen      Ankle
##      1.419294    0.110102   -0.162629   -0.174955    0.819076   -0.091225
##      Biceps      Wrist
##      0.001288   -2.353703
```

```
mod.rsqmallow
```

```
##
## Call:
## lm(formula = Bodyfat ~ Age + Weight + Abdomen + Wrist, data = bf)
##
## Coefficients:
## (Intercept)      Age      Weight      Abdomen      Wrist
##      -21.06107    0.07854   -0.07608    0.95069   -2.06898
```

```
mod.bic
```

```
##
## Call:
## lm(formula = Bodyfat ~ Weight + Abdomen + Wrist, data = bf)
##
## Coefficients:
## (Intercept)      Weight      Abdomen      Wrist
##      -28.7531   -0.1236    1.0449   -1.4659
```

```
back.out
```

```
##
## Call:
## lm(formula = Bodyfat ~ Age + Weight + Abdomen + Wrist, data = bf)
##
## Coefficients:
```

## (Intercept)	Age	Weight	Abdomen	Wrist
## -21.06107	0.07854	-0.07608	0.95069	-2.06898

forward.out

##

Call:

lm(formula = Bodyfat ~ Abdomen + Weight + Wrist + Age, data = bf)

##

Coefficients:

## (Intercept)	Abdomen	Weight	Wrist	Age
## -21.06107	0.95069	-0.07608	-2.06898	0.07854

step.out

##

Call:

lm(formula = Bodyfat ~ Abdomen + Weight + Wrist + Age, data = bf)

##

Coefficients:

## (Intercept)	Abdomen	Weight	Wrist	Age
## -21.06107	0.95069	-0.07608	-2.06898	0.07854