Assignment #3

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**Question 1.**

library(olsrr) #package for model selections

##   
## Attaching package: 'olsrr'

## The following object is masked from 'package:datasets':  
##   
## rivers

library(ggplot2) #package for plots  
library(dplyr) #package for filtering subplots

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

#import data  
bass = read.csv("hw3\_bass.csv", header=T)  
  
#fit linear regression model  
bass.lm = lm(Avg\_Mercury ~ Alkalinity + pH + Calcium + Chlorophyll, data=bass)  
  
#fit all possible regressions  
bass.all = ols\_step\_all\_possible(bass.lm)  
 #details of all possible regression models  
bass.all

## Index N Predictors R-Square Adj. R-Square Mallow's Cp  
## 1 1 1 Alkalinity 0.4254905 0.4142256 3.223111  
## 2 2 1 pH 0.3310853 0.3179693 11.804576  
## 3 3 1 Calcium 0.2386129 0.2236838 20.210347  
## 4 4 1 Chlorophyll 0.2130176 0.1975865 22.536973  
## 6 5 2 Alkalinity Calcium 0.4478582 0.4257726 3.189877  
## 7 6 2 Alkalinity Chlorophyll 0.4436411 0.4213868 3.573211  
## 5 7 2 Alkalinity pH 0.4292584 0.4064287 4.880607  
## 9 8 2 pH Chlorophyll 0.3444788 0.3182580 12.587099  
## 8 9 2 pH Calcium 0.3348995 0.3082955 13.457860  
## 10 10 2 Calcium Chlorophyll 0.3009248 0.2729618 16.546176  
## 13 11 3 Alkalinity Calcium Chlorophyll 0.4705171 0.4380997 3.130182  
## 11 12 3 Alkalinity pH Calcium 0.4576077 0.4244001 4.303642  
## 12 13 3 Alkalinity pH Chlorophyll 0.4436478 0.4095855 5.572602  
## 14 14 3 pH Calcium Chlorophyll 0.3484270 0.3085347 14.228213  
## 15 15 4 Alkalinity pH Calcium Chlorophyll 0.4719492 0.4279450 5.000000

#r^2 & adjusted r^2, and aic & mallows cp subplots of all possible regressions

#max r^2 by n  
p1max = bass.all %>% group\_by(n) %>% filter(rsquare==max(rsquare, na.rm=FALSE))  
 #ggplot of r^2 vs n  
p1.1 <- ggplot(bass.all, aes(n, rsquare)) + geom\_point(aes(n, rsquare), shape=21, size=2, fill='white') + geom\_point(data=p1max, aes(n, rsquare), shape=21, size=3, fill='red') + labs(x="", y = "R\u00B2") + theme(text = element\_text(size = 15), plot.title=element\_text(hjust=0.5))  
 #max r^2 by n  
p2max = bass.all %>% group\_by(n) %>% filter(adjr==max(adjr, na.rm=FALSE))  
 #ggplot of adjusted r^2 vs n  
p1.2 <- ggplot(bass.all, aes(n, adjr)) + geom\_point(aes(n, adjr), shape=21, size=2, fill='white') + geom\_point(data=p2max, aes(n, adjr), shape=21, size=3, fill='red') + labs(x = "Number of Predictors in Model", y = "Adjusted R\u00B2") + theme(text = element\_text(size = 15), plot.title=element\_text(hjust=0.5))

#min aic by n  
p3min = bass.all %>% group\_by(n) %>% filter(aic==min(aic, na.rm=FALSE))  
 #ggplot of adjusted r^2 vs n  
p1.3 <- ggplot(bass.all, aes(n, aic)) + geom\_point(aes(n, aic), shape=21, size=2, fill='white') + geom\_point(data=p3min, aes(n, aic), shape=21, size=3, fill='red') + labs(x="", y = "AIC") + theme(text = element\_text(size = 15), plot.title=element\_text(hjust=0.5))  
 #min cp by n  
p4min = bass.all %>% group\_by(n) %>% filter(cp==min(cp, na.rm=FALSE))  
 #ggplot of adjusted r^2 vs n  
p1.4 <- ggplot(bass.all, aes(n, cp)) + geom\_point(aes(n, cp), shape=21, size=2, fill='white') + geom\_point(data=p4min, aes(n, adjr), shape=21, size=3, fill='red') + labs(x = "Number of Predictors in Model", y = "Mallows' C\u209A") + theme(text = element\_text(size = 15), plot.title=element\_text(hjust=0.5))  
  
#subplots  
gridExtra::grid.arrange(p1.1, p1.2, nrow=2)

gridExtra::grid.arrange(p1.3, p1.4, nrow=2)

Graphical user interface, application

Description automatically generatedGraphical user interface, application

Description automatically generated

**1A.** The best model with one predictor and based off adjusted R2 selection criterion, uses Alkalinity to explain Average Mercury, and has an R2 of 0.4254905 and an adjusted R2 of 0.4142256.

The best model with two predictors and based off adjusted R2 selection criterion, uses Alkalinity and Calcium to explain Average Mercury, and has an R2 of 0.4478582 and an adjusted R2 of 0.4257726.

The best model with three predictors and based off adjusted R2 selection criterion, uses Alkalinity, Calcium, and Chlorophyll to explain Average Mercury, and has an R2 of 0.4705171 and an adjusted R2 of 0.4380997.

The best model with four predictors and based off adjusted R2 selection criterion, uses Alkalinity, pH, Calcium, and Chlorophyll to explain Average Mercury, and has an R2 of 0.4719492 and an adjusted R2 of 0.4279450.

Alkalinity is common to all “best” models and appears to explain the most variation of the data. The single linear regression model using only the Alkalinity predictor explains over 42.5% of variation, which only increases by a few percent with the other “best” MLR models. Comparing all models with their adjusted R2 values, the three-predictor MLR model using Alkalinity, Calcium, and Chlorophyll has the highest adjusted R2 value (0.4380997), explains over 47% of the variability in the dataset, and provides the best model for predicting average mercury concentrations in fish.

**1B.** There is a minor difference between average mercury predictions when using the four-predictor versus three-predictor models. When we compare the given means 0.545 and 0.532 of the four- and three-predictor models, respectively, we see that the three-predictor model gives a lower mean. When we compare prediction intervals of (0.0164 to 1.073) and (0.0133 to 1.051) of the four- and three-predictor models, respectively, we see that means of both models fall within the prediction interval of both models, indicating similarity of the two models. However, when comparing the prediction intervals themselves, we see that the three-predictor model has a more narrow range of predicted values and thus a greater precision versus the four-predictor model.

**1C.** All “best fit” models give similar results in this example as can be seen by comparing their adjusted R2 values, which range from 0.4142256 (one predictor) to 0.4380997 (three predictors), although the three-predictor MLR using Alkalinity, Calcium, and Chlorophyll predictors provides the best model and explains over 47% of the variability. These results agree with the predicted values given in question 1B, which indicate that the three-predictor MLR using Alkalinity, Calcium, and Chlorophyll provides the most precision (most narrow prediction interval) of average mercury in fish as compared to the four-predictor MLR.

**Question 2.**

library(MASS) #package for stepAIC function

##   
## Attaching package: 'MASS'

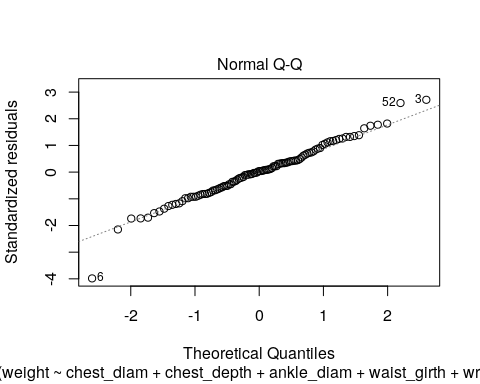
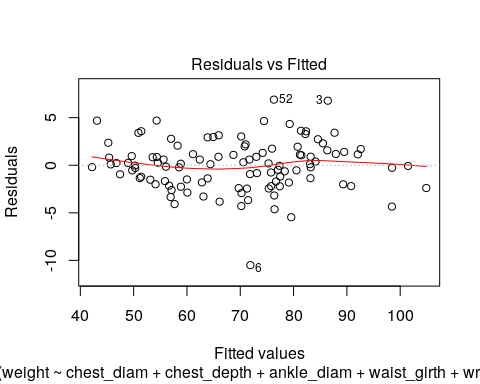
## The following object is masked from 'package:dplyr':  
##   
## select

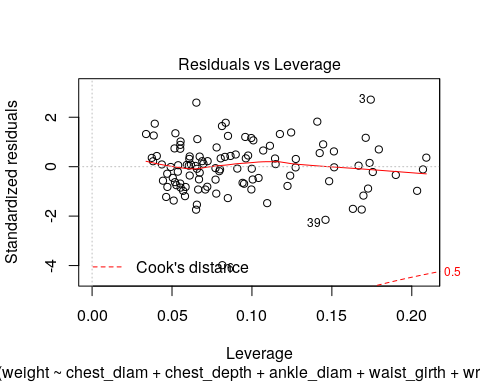
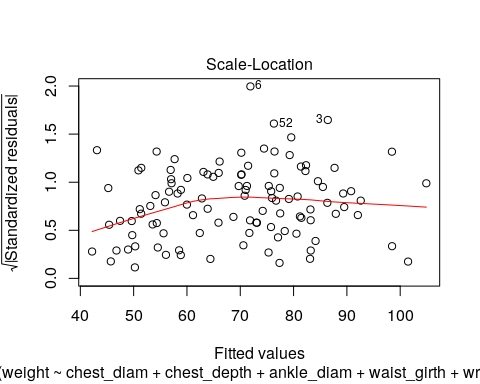
## The following object is masked from 'package:olsrr':  
##   
## cement

#import data  
bd = read.csv("hw3\_body.csv", header=T)  
  
#fit linear regression model  
bd.lm <- lm(weight ~ chest\_diam + chest\_depth + ankle\_diam + waist\_girth + wrist\_girth + wrist\_diam + age + height + gender, data=bd)  
 #linear regression summary  
summary(bd.lm)

##   
## Call:  
## lm(formula = weight ~ chest\_diam + chest\_depth + ankle\_diam +   
## waist\_girth + wrist\_girth + wrist\_diam + age + height + gender,   
## data = bd)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -10.5003 -1.7345 0.0929 1.4414 6.8888   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -119.33349 6.83670 -17.455 < 2e-16 \*\*\*  
## chest\_diam 1.39294 0.21325 6.532 2.91e-09 \*\*\*  
## chest\_depth 0.59732 0.20463 2.919 0.00436 \*\*   
## ankle\_diam 1.26351 0.44921 2.813 0.00594 \*\*   
## waist\_girth 0.64234 0.05178 12.404 < 2e-16 \*\*\*  
## wrist\_girth 0.80607 0.42221 1.909 0.05916 .   
## wrist\_diam 0.08803 0.55213 0.159 0.87366   
## age -0.14840 0.03199 -4.639 1.08e-05 \*\*\*  
## height 0.38080 0.04747 8.022 2.28e-12 \*\*\*  
## gender -7.64330 1.12288 -6.807 8.02e-10 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.75 on 98 degrees of freedom  
## Multiple R-squared: 0.9678, Adjusted R-squared: 0.9648   
## F-statistic: 327.1 on 9 and 98 DF, p-value: < 2.2e-16

plot(bd.lm)





**2A.**

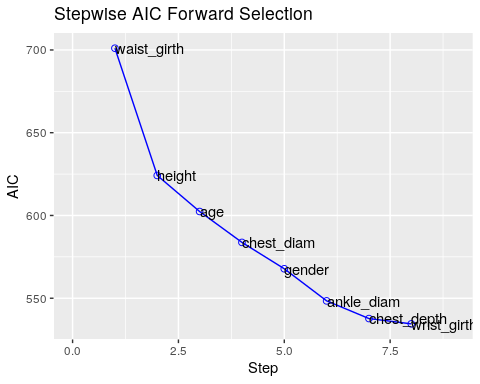
#calculate forward selection model with OSLRR::ols\_step\_forward\_aic  
bd.forward = ols\_step\_forward\_aic(bd.lm)  
 #forward selection model summary  
bd.forward

##   
## Selection Summary   
## -----------------------------------------------------------------------  
## Variable AIC Sum Sq RSS R-Sq Adj. R-Sq   
## -----------------------------------------------------------------------  
## waist\_girth 701.054 19057.564 3943.939 0.82854 0.82692   
## height 624.158 21101.854 1899.648 0.91741 0.91584   
## age 602.394 21477.054 1524.449 0.93372 0.93181   
## chest\_diam 583.729 21742.548 1258.954 0.94527 0.94314   
## gender 567.787 21935.244 1066.258 0.95364 0.95137   
## ankle\_diam 548.390 22126.878 874.624 0.96198 0.95972   
## chest\_depth 537.700 22223.839 777.664 0.96619 0.96382   
## wrist\_girth 534.503 22260.379 741.123 0.96778 0.96518   
## -----------------------------------------------------------------------

#final forward selection model  
bd.forward$model

##   
## Call:  
## lm(formula = paste(response, "~", paste(preds, collapse = " + ")),   
## data = l)  
##   
## Coefficients:  
## (Intercept) waist\_girth height age chest\_diam gender ankle\_diam chest\_depth wrist\_girth   
## -119.2782 0.6440 0.3806 -0.1478 1.3969 -7.6488 1.2813 0.5941 0.8354  
##

#aic vs forward selection step  
plot(bd.forward)



#best forward selection model with MASS::stepAIC  
step\_forward = stepAIC(bd.lm, direction = "forward")

## Start: AIC=227.98  
## weight ~ chest\_diam + chest\_depth + ankle\_diam + waist\_girth +   
## wrist\_girth + wrist\_diam + age + height + gender

#details of best model  
summary(step\_forward)

##   
## Call:  
## lm(formula = weight ~ chest\_diam + chest\_depth + ankle\_diam +   
## waist\_girth + wrist\_girth + wrist\_diam + age + height + gender,   
## data = bd)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -10.5003 -1.7345 0.0929 1.4414 6.8888   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -119.33349 6.83670 -17.455 < 2e-16 \*\*\*  
## chest\_diam 1.39294 0.21325 6.532 2.91e-09 \*\*\*  
## chest\_depth 0.59732 0.20463 2.919 0.00436 \*\*   
## ankle\_diam 1.26351 0.44921 2.813 0.00594 \*\*   
## waist\_girth 0.64234 0.05178 12.404 < 2e-16 \*\*\*  
## wrist\_girth 0.80607 0.42221 1.909 0.05916 .   
## wrist\_diam 0.08803 0.55213 0.159 0.87366   
## age -0.14840 0.03199 -4.639 1.08e-05 \*\*\*  
## height 0.38080 0.04747 8.022 2.28e-12 \*\*\*  
## gender -7.64330 1.12288 -6.807 8.02e-10 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.75 on 98 degrees of freedom  
## Multiple R-squared: 0.9678, Adjusted R-squared: 0.9648   
## F-statistic: 327.1 on 9 and 98 DF, p-value: < 2.2e-16

#ANOVA of best model  
step\_forward$anova

## Stepwise Model Path   
## Analysis of Deviance Table  
##   
## Initial Model:  
## weight ~ chest\_diam + chest\_depth + ankle\_diam + waist\_girth +   
## wrist\_girth + wrist\_diam + age + height + gender  
##   
## Final Model:  
## weight ~ chest\_diam + chest\_depth + ankle\_diam + waist\_girth +   
## wrist\_girth + wrist\_diam + age + height + gender  
##   
##   
## Step Df Deviance Resid. Df Resid. Dev AIC  
## 1 98 740.9312 227.9839

The final model calculated by forward selection using OSLRR::ols\_step\_forward\_aic is given by the equation:

*weight = -119.2782 + 0.6440(waist\_girth) + 0.3806(height) - 0.1478(age) + 1.3969(chest\_diam) - 7.6488(gender) + 1.2813(ankle\_diam) + 0.5941(chest\_depth) + 0.8354(wrist\_girth)*

The final model calculated by forward selection using MASS::stepAIC is slightly different than that shown above calculated with OSLRR::ols\_step\_forward\_aic, and is given by the equation:

*weight = -119.33349 + 0.64234(waist\_girth) + 0.38080(height) - 0.14840(age) + 1.39294(chest\_diam) - 7.64330(gender) + 1.26351(ankle\_diam) + 0.59732(chest\_depth) + 0.80607(wrist\_girth)*

**2B.**

#calculate backward elimination model using OSLRR::ols\_step\_backward  
bd.back = ols\_step\_backward\_aic(bd.lm)

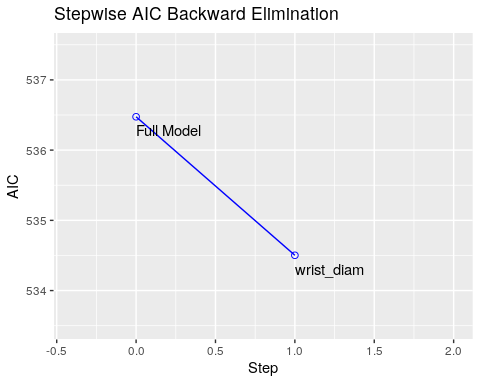
#backward elimination model summary  
bd.back

##   
##   
## Backward Elimination Summary   
## ---------------------------------------------------------------------  
## Variable AIC RSS Sum Sq R-Sq Adj. R-Sq   
## ---------------------------------------------------------------------  
## Full Model 536.475 740.931 22260.571 0.96779 0.96483   
## wrist\_diam 534.503 741.123 22260.379 0.96778 0.96518   
## ---------------------------------------------------------------------

bd.back$model

##   
## Call:  
## lm(formula = paste(response, "~", paste(preds, collapse = " + ")),   
## data = l)  
##   
## Coefficients:  
## (Intercept) chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth   
## -119.2782 1.3969 0.5941 1.2813 0.6440 0.8354   
## age height gender   
## -0.1478 0.3806 -7.6488

#plot AIC vs step of backward elimination  
plot(bd.back)



#calculate backward elimination model using MASS::stepAIC  
step\_backward = stepAIC(bd.lm, direction = "backward")

## Start: AIC=227.98  
## weight ~ chest\_diam + chest\_depth + ankle\_diam + waist\_girth +   
## wrist\_girth + wrist\_diam + age + height + gender  
##   
## Df Sum of Sq RSS AIC  
## - wrist\_diam 1 0.19 741.12 226.01  
## <none> 740.93 227.98  
## - wrist\_girth 1 27.56 768.49 229.93  
## - ankle\_diam 1 59.81 800.75 234.37  
## - chest\_depth 1 64.42 805.35 234.99  
## - age 1 162.71 903.64 247.42  
## - chest\_diam 1 322.59 1063.52 265.02  
## - gender 1 350.30 1091.23 267.80  
## - height 1 486.54 1227.47 280.50  
## - waist\_girth 1 1163.30 1904.23 327.93  
##   
## Step: AIC=226.01  
## weight ~ chest\_diam + chest\_depth + ankle\_diam + waist\_girth +   
## wrist\_girth + age + height + gender  
##   
## Df Sum of Sq RSS AIC  
## <none> 741.12 226.01  
## - wrist\_girth 1 36.54 777.66 229.21  
## - chest\_depth 1 64.37 805.49 233.01  
## - ankle\_diam 1 65.56 806.68 233.17  
## - age 1 163.73 904.85 245.57  
## - chest\_diam 1 328.81 1069.93 263.67  
## - gender 1 351.14 1092.26 265.90  
## - height 1 486.38 1227.50 278.51  
## - waist\_girth 1 1215.83 1956.95 328.88

#details of model  
summary(step\_backward)

##   
## Call:  
## lm(formula = weight ~ chest\_diam + chest\_depth + ankle\_diam +   
## waist\_girth + wrist\_girth + age + height + gender, data = bd)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -10.5112 -1.7170 0.0759 1.4250 6.8222   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -119.27818 6.79419 -17.556 < 2e-16 \*\*\*  
## chest\_diam 1.39688 0.21077 6.627 1.81e-09 \*\*\*  
## chest\_depth 0.59405 0.20259 2.932 0.00418 \*\*   
## ankle\_diam 1.28130 0.43298 2.959 0.00386 \*\*   
## waist\_girth 0.64395 0.05053 12.744 < 2e-16 \*\*\*  
## wrist\_girth 0.83541 0.37813 2.209 0.02946 \*   
## age -0.14779 0.03160 -4.677 9.24e-06 \*\*\*  
## height 0.38058 0.04722 8.060 1.78e-12 \*\*\*  
## gender -7.64878 1.11682 -6.849 6.36e-10 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.736 on 99 degrees of freedom  
## Multiple R-squared: 0.9678, Adjusted R-squared: 0.9652   
## F-statistic: 371.7 on 8 and 99 DF, p-value: < 2.2e-16

#ANOVA of model  
step\_backward$anova

## Stepwise Model Path   
## Analysis of Deviance Table  
##   
## Initial Model:  
## weight ~ chest\_diam + chest\_depth + ankle\_diam + waist\_girth +   
## wrist\_girth + wrist\_diam + age + height + gender  
##   
## Final Model:  
## weight ~ chest\_diam + chest\_depth + ankle\_diam + waist\_girth +   
## wrist\_girth + age + height + gender  
##   
## ## Step Df Deviance Resid. Df Resid. Dev AIC  
## 1 98 740.9312 227.9839  
## 2 - wrist\_diam 1 0.1921794 99 741.1234 226.0119

The final model calculated by backward elimination using OLSRR::ols\_step\_backward\_aic is given by the equation:

*weight = -119.2782 + 1.3969(chest\_diam) + 0.5941(chest\_depth) + 1.2813(ankle\_diam) + 0.6440(waist\_girth) + 0.8354(wrist\_girth) - 0.1478(age) + 0.3806(height) - 7.6488(gender)*

This is the same as that calculated by backward elimination with MASS::stepAIC. This is also the same as that calculated by forward selection with OSLRR::ols\_step\_forward\_aic.

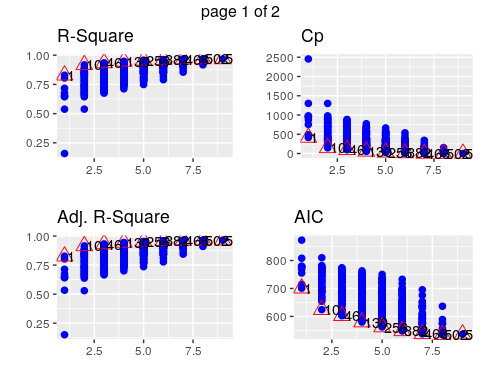
**2C.**

#fit all possible regression models  
bd.all = ols\_step\_all\_possible(bd.lm)  
bd.all

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Index | N | Predictors | R-Square | Adj. R-Square | Mallow's Cp |
| 4 | 1 | 1 | waist\_girth | 0.8285356 | 0.8269180 | 417.648929 |
| 1 | 2 | 1 | chest\_diam | 0.8049210 | 0.8030806 | 489.492049 |
| 2 | 3 | 1 | chest\_depth | 0.7171416 | 0.7144732 | 756.544656 |
| 3 | 4 | 1 | ankle\_diam | 0.6763765 | 0.6733234 | 880.565142 |
| 5 | 5 | 1 | wrist\_girth | 0.6538421 | 0.6505765 | 949.121757 |
| 8 | 6 | 1 | height | 0.6481209 | 0.6448013 | 966.527599 |
| 6 | 7 | 1 | wrist\_diam | 0.6439702 | 0.6406114 | 979.155309 |
| 9 | 8 | 1 | gender | 0.5379359 | 0.5335768 | 1301.745153 |
| 7 | 9 | 1 | age | 0.1583909 | 0.1504512 | 2456.441263 |
| 34 | 10 | 2 | waist\_girth height | 0.9174120 | 0.9158389 | 149.258844 |
| 12 | 11 | 2 | chest\_diam waist\_girth | 0.8908871 | 0.8888088 | 229.955943 |
| 25 | 12 | 2 | ankle\_diam waist\_girth | 0.8833744 | 0.8811529 | 252.812021 |
| 31 | 13 | 2 | waist\_girth wrist\_girth | 0.8765049 | 0.8741526 | 273.711148 |
| 10 | 14 | 2 | chest\_diam chest\_depth | 0.8706237 | 0.8681594 | 291.603521 |
| 32 | 15 | 2 | waist\_girth wrist\_diam | 0.8567145 | 0.8539852 | 333.919913 |
| 19 | 16 | 2 | chest\_depth waist\_girth | 0.8506084 | 0.8477628 | 352.496612 |
| 16 | 17 | 2 | chest\_diam height | 0.8492376 | 0.8463659 | 356.667079 |
| 11 | 18 | 2 | chest\_diam ankle\_diam | 0.8465629 | 0.8436403 | 364.804333 |
| 33 | 19 | 2 | waist\_girth age | 0.8456397 | 0.8426995 | 367.612906 |
| 35 | 20 | 2 | waist\_girth gender | 0.8317010 | 0.8284953 | 410.018826 |
| 13 | 21 | 2 | chest\_diam wrist\_girth | 0.8283602 | 0.8250909 | 420.182488 |
| 14 | 22 | 2 | chest\_diam wrist\_diam | 0.8278896 | 0.8246113 | 421.614444 |
| 23 | 23 | 2 | chest\_depth height | 0.8235375 | 0.8201763 | 434.854723 |
| 15 | 24 | 2 | chest\_diam age | 0.8050297 | 0.8013160 | 491.161320 |
| 17 | 25 | 2 | chest\_diam gender | 0.8049210 | 0.8012052 | 491.491983 |
| 18 | 26 | 2 | chest\_depth ankle\_diam | 0.7864137 | 0.7823454 | 547.797024 |
| 21 | 27 | 2 | chest\_depth wrist\_diam | 0.7855686 | 0.7814842 | 550.368227 |
| 20 | 28 | 2 | chest\_depth wrist\_girth | 0.7741367 | 0.7698345 | 585.147737 |
| 41 | 29 | 2 | wrist\_diam height | 0.7654901 | 0.7610233 | 611.453212 |
| 29 | 30 | 2 | ankle\_diam height | 0.7491479 | 0.7443698 | 661.171331 |
| 38 | 31 | 2 | wrist\_girth height | 0.7474135 | 0.7426023 | 666.448164 |
| 24 | 32 | 2 | chest\_depth gender | 0.7402606 | 0.7353132 | 688.209555 |
| 27 | 33 | 2 | ankle\_diam wrist\_diam | 0.7320764 | 0.7269731 | 713.108357 |
| 26 | 34 | 2 | ankle\_diam wrist\_girth | 0.7300732 | 0.7249317 | 719.202866 |
| 22 | 35 | 2 | chest\_depth age | 0.7216916 | 0.7163905 | 744.702329 |
| 45 | 36 | 2 | height gender | 0.7084730 | 0.7029201 | 784.917496 |
| 36 | 37 | 2 | wrist\_girth wrist\_diam | 0.7018849 | 0.6962065 | 804.960446 |
| 30 | 38 | 2 | ankle\_diam gender | 0.6984320 | 0.6926879 | 815.465214 |
| 42 | 39 | 2 | wrist\_diam gender | 0.6794899 | 0.6733850 | 873.093075 |
| 28 | 40 | 2 | ankle\_diam age | 0.6788782 | 0.6727616 | 874.954095 |
| 39 | 41 | 2 | wrist\_girth gender | 0.6747190 | 0.6685232 | 887.607607 |
| 43 | 42 | 2 | age height | 0.6647213 | 0.6583350 | 918.024019 |
| 37 | 43 | 2 | wrist\_girth age | 0.6556133 | 0.6490535 | 945.733404 |
| 40 | 44 | 2 | wrist\_diam age | 0.6440550 | 0.6372751 | 980.897273 |
| 44 | 45 | 2 | age gender | 0.5384088 | 0.5296166 | 1302.306519 |
| 117 | 46 | 3 | waist\_girth age height | 0.9337240 | 0.9318121 | 101.632702 |
| 62 | 47 | 3 | chest\_diam waist\_girth height | 0.9309804 | 0.9289894 | 109.979598 |
| 119 | 48 | 3 | waist\_girth height gender | 0.9229523 | 0.9207297 | 134.403586 |
| 98 | 49 | 3 | ankle\_diam waist\_girth height | 0.9228973 | 0.9206731 | 134.570959 |
| 112 | 50 | 3 | waist\_girth wrist\_girth height | 0.9224027 | 0.9201643 | 136.075621 |
| 83 | 51 | 3 | chest\_depth waist\_girth height | 0.9207834 | 0.9184983 | 141.002008 |
| 115 | 52 | 3 | waist\_girth wrist\_diam height | 0.9198223 | 0.9175095 | 143.925913 |
| 53 | 53 | 3 | chest\_diam ankle\_diam waist\_girth | 0.9101826 | 0.9075917 | 173.253103 |
| 61 | 54 | 3 | chest\_diam waist\_girth age | 0.9038720 | 0.9010991 | 192.451759 |
| 97 | 55 | 3 | ankle\_diam waist\_girth age | 0.9032383 | 0.9004471 | 194.379718 |
| 59 | 56 | 3 | chest\_diam waist\_girth wrist\_girth | 0.9020358 | 0.8992099 | 198.038111 |
| 47 | 57 | 3 | chest\_diam chest\_depth waist\_girth | 0.9018337 | 0.8990019 | 198.653092 |
| 111 | 58 | 3 | waist\_girth wrist\_girth age | 0.8983821 | 0.8954508 | 209.153820 |
| 63 | 59 | 3 | chest\_diam waist\_girth gender | 0.8973232 | 0.8943614 | 212.375276 |
| 60 | 60 | 3 | chest\_diam waist\_girth wrist\_diam | 0.8952254 | 0.8922031 | 218.757355 |
| 51 | 61 | 3 | chest\_diam chest\_depth height | 0.8947332 | 0.8916967 | 220.254771 |
| 95 | 62 | 3 | ankle\_diam waist\_girth wrist\_girth | 0.8919153 | 0.8887975 | 228.827728 |
| 99 | 63 | 3 | ankle\_diam waist\_girth gender | 0.8884033 | 0.8851842 | 239.512455 |
| 74 | 64 | 3 | chest\_depth ankle\_diam waist\_girth | 0.8859786 | 0.8826895 | 246.889303 |
| 96 | 65 | 3 | ankle\_diam waist\_girth wrist\_diam | 0.8852017 | 0.8818902 | 249.252729 |
| 113 | 66 | 3 | waist\_girth wrist\_girth gender | 0.8826589 | 0.8792741 | 256.988716 |
| 46 | 67 | 3 | chest\_diam chest\_depth ankle\_diam | 0.8801531 | 0.8766959 | 264.612344 |
| 80 | 68 | 3 | chest\_depth waist\_girth wrist\_girth | 0.8795321 | 0.8760570 | 266.501554 |
| 114 | 69 | 3 | waist\_girth wrist\_diam age | 0.8795228 | 0.8760475 | 266.529762 |
| 52 | 70 | 3 | chest\_diam chest\_depth gender | 0.8791380 | 0.8756516 | 267.700486 |
| 50 | 71 | 3 | chest\_diam chest\_depth age | 0.8780673 | 0.8745501 | 270.957733 |
| 110 | 72 | 3 | waist\_girth wrist\_girth wrist\_diam | 0.8773480 | 0.8738100 | 273.146111 |
| 49 | 73 | 3 | chest\_diam chest\_depth wrist\_diam | 0.8749145 | 0.8713062 | 280.549761 |
| 82 | 74 | 3 | chest\_depth waist\_girth age | 0.8747128 | 0.8710988 | 281.163269 |
| 48 | 75 | 3 | chest\_diam chest\_depth wrist\_girth | 0.8726475 | 0.8689739 | 287.446641 |
| 81 | 76 | 3 | chest\_depth waist\_girth wrist\_diam | 0.8679082 | 0.8640979 | 301.865075 |
| 57 | 77 | 3 | chest\_diam ankle\_diam height | 0.8636659 | 0.8597332 | 314.771480 |
| 69 | 78 | 3 | chest\_diam wrist\_diam height | 0.8596690 | 0.8556210 | 326.931224 |
| 116 | 79 | 3 | waist\_girth wrist\_diam gender | 0.8570095 | 0.8528848 | 335.022384 |
| 66 | 80 | 3 | chest\_diam wrist\_girth height | 0.8556656 | 0.8515022 | 339.110781 |
| 58 | 81 | 3 | chest\_diam ankle\_diam gender | 0.8545798 | 0.8503850 | 342.414293 |
| 118 | 82 | 3 | waist\_girth age gender | 0.8544821 | 0.8502844 | 342.711615 |
| 73 | 83 | 3 | chest\_diam height gender | 0.8515085 | 0.8472251 | 351.758012 |
| 84 | 84 | 3 | chest\_depth waist\_girth gender | 0.8507874 | 0.8464831 | 353.952078 |
| 55 | 85 | 3 | chest\_diam ankle\_diam wrist\_diam | 0.8497970 | 0.8454642 | 356.964993 |
| 71 | 86 | 3 | chest\_diam age height | 0.8492422 | 0.8448934 | 358.653002 |
| 54 | 87 | 3 | chest\_diam ankle\_diam wrist\_girth | 0.8491558 | 0.8448045 | 358.915812 |
| 56 | 88 | 3 | chest\_diam ankle\_diam age | 0.8471190 | 0.8427090 | 365.112357 |
| 90 | 89 | 3 | chest\_depth wrist\_diam height | 0.8445742 | 0.8400907 | 372.854524 |
| 78 | 90 | 3 | chest\_depth ankle\_diam height | 0.8341539 | 0.8293699 | 404.556372 |
| 64 | 91 | 3 | chest\_diam wrist\_girth wrist\_diam | 0.8340926 | 0.8293068 | 404.742932 |
| 67 | 92 | 3 | chest\_diam wrist\_girth gender | 0.8334751 | 0.8286715 | 406.621424 |
| 87 | 93 | 3 | chest\_depth wrist\_girth height | 0.8321789 | 0.8273379 | 410.564804 |
| 70 | 94 | 3 | chest\_diam wrist\_diam gender | 0.8306205 | 0.8257345 | 415.306073 |
| 68 | 95 | 3 | chest\_diam wrist\_diam age | 0.8287887 | 0.8238499 | 420.879004 |
| 65 | 96 | 3 | chest\_diam wrist\_girth age | 0.8286850 | 0.8237432 | 421.194587 |
| 92 | 97 | 3 | chest\_depth age height | 0.8273246 | 0.8223436 | 425.333260 |
| 94 | 98 | 3 | chest\_depth height gender | 0.8242095 | 0.8191387 | 434.810195 |
| 76 | 99 | 3 | chest\_depth ankle\_diam wrist\_diam | 0.8061516 | 0.8005598 | 489.748202 |
| 72 | 100 | 3 | chest\_diam age gender | 0.8050502 | 0.7994267 | 493.098928 |
| 75 | 101 | 3 | chest\_depth ankle\_diam wrist\_girth | 0.7987932 | 0.7929892 | 512.134617 |
| 89 | 102 | 3 | chest\_depth wrist\_diam age | 0.7975824 | 0.7917434 | 515.818431 |
| 85 | 103 | 3 | chest\_depth wrist\_girth wrist\_diam | 0.7938355 | 0.7878884 | 527.217685 |
| 77 | 104 | 3 | chest\_depth ankle\_diam age | 0.7918665 | 0.7858626 | 533.208111 |
| 79 | 105 | 3 | chest\_depth ankle\_diam gender | 0.7873465 | 0.7812123 | 546.959178 |
| 91 | 106 | 3 | chest\_depth wrist\_diam gender | 0.7866919 | 0.7805388 | 548.950673 |
| 105 | 107 | 3 | ankle\_diam wrist\_diam height | 0.7854868 | 0.7792989 | 552.617014 |
| 86 | 108 | 3 | chest\_depth wrist\_girth age | 0.7805573 | 0.7742272 | 567.614279 |
| 121 | 109 | 3 | wrist\_girth wrist\_diam height | 0.7768537 | 0.7704168 | 578.881757 |
| 88 | 110 | 3 | chest\_depth wrist\_girth gender | 0.7751372 | 0.7686508 | 584.103683 |
| 102 | 111 | 3 | ankle\_diam wrist\_girth height | 0.7741678 | 0.7676534 | 587.053031 |
| 128 | 112 | 3 | wrist\_diam height gender | 0.7703598 | 0.7637355 | 598.638261 |
| 126 | 113 | 3 | wrist\_diam age height | 0.7655048 | 0.7587405 | 613.408749 |
| 109 | 114 | 3 | ankle\_diam height gender | 0.7571439 | 0.7501385 | 638.844981 |
| 93 | 115 | 3 | chest\_depth age gender | 0.7541138 | 0.7470210 | 648.063553 |
| 125 | 116 | 3 | wrist\_girth height gender | 0.7527511 | 0.7456189 | 652.209443 |
| 107 | 117 | 3 | ankle\_diam age height | 0.7510369 | 0.7438553 | 657.424488 |
| 123 | 118 | 3 | wrist\_girth age height | 0.7486551 | 0.7414048 | 664.670647 |
| 100 | 119 | 3 | ankle\_diam wrist\_girth wrist\_diam | 0.7468260 | 0.7395229 | 670.235531 |
| 106 | 120 | 3 | ankle\_diam wrist\_diam gender | 0.7366560 | 0.7290596 | 701.175714 |
| 103 | 121 | 3 | ankle\_diam wrist\_girth gender | 0.7326199 | 0.7249070 | 713.454884 |
| 104 | 122 | 3 | ankle\_diam wrist\_diam age | 0.7322273 | 0.7245031 | 714.649212 |
| 101 | 123 | 3 | ankle\_diam wrist\_girth age | 0.7301435 | 0.7223591 | 720.988967 |
| 122 | 124 | 3 | wrist\_girth wrist\_diam gender | 0.7100766 | 0.7017135 | 782.038646 |
| 129 | 125 | 3 | age height gender | 0.7085955 | 0.7001896 | 786.544665 |
| 120 | 126 | 3 | wrist\_girth wrist\_diam age | 0.7019484 | 0.6933507 | 806.767414 |
| 108 | 127 | 3 | ankle\_diam age gender | 0.6985786 | 0.6898838 | 817.019204 |
| 127 | 128 | 3 | wrist\_diam age gender | 0.6830985 | 0.6739571 | 864.114696 |
| 124 | 129 | 3 | wrist\_girth age gender | 0.6749694 | 0.6655935 | 888.845867 |
| 175 | 130 | 4 | chest\_diam waist\_girth height gender | 0.9472124 | 0.9451624 | 62.596596 |
| 173 | 131 | 4 | chest\_diam waist\_girth age height | 0.9452664 | 0.9431409 | 68.516842 |
| 244 | 132 | 4 | waist\_girth wrist\_girth age height | 0.9406773 | 0.9383735 | 82.478372 |
| 228 | 133 | 4 | ankle\_diam waist\_girth age height | 0.9404305 | 0.9381171 | 83.229343 |
| 208 | 134 | 4 | chest\_depth waist\_girth age height | 0.9401391 | 0.9378144 | 84.115910 |
| 247 | 135 | 4 | waist\_girth wrist\_diam age height | 0.9381249 | 0.9357220 | 90.243617 |
| 246 | 136 | 4 | waist\_girth wrist\_girth height gender | 0.9359698 | 0.9334832 | 96.799999 |
| 250 | 137 | 4 | waist\_girth age height gender | 0.9352096 | 0.9326935 | 99.112844 |
| 230 | 138 | 4 | ankle\_diam waist\_girth height gender | 0.9344082 | 0.9318610 | 101.550899 |
| 139 | 139 | 4 | chest\_diam chest\_depth waist\_girth height | 0.9339305 | 0.9313647 | 103.004288 |
| 154 | 140 | 4 | chest\_diam ankle\_diam waist\_girth height | 0.9335766 | 0.9309970 | 104.081127 |
| 168 | 141 | 4 | chest\_diam waist\_girth wrist\_girth height | 0.9320814 | 0.9294438 | 108.629859 |
| 171 | 142 | 4 | chest\_diam waist\_girth wrist\_diam height | 0.9312378 | 0.9285674 | 111.196328 |
| 155 | 143 | 4 | chest\_diam ankle\_diam waist\_girth gender | 0.9298356 | 0.9271107 | 115.462402 |
| 249 | 144 | 4 | waist\_girth wrist\_diam height gender | 0.9286979 | 0.9259289 | 118.923643 |
| 210 | 145 | 4 | chest\_depth waist\_girth height gender | 0.9283333 | 0.9255502 | 120.032654 |
| 153 | 146 | 4 | chest\_diam ankle\_diam waist\_girth age | 0.9259672 | 0.9230921 | 127.231357 |
| 223 | 147 | 4 | ankle\_diam waist\_girth wrist\_girth height | 0.9245900 | 0.9216614 | 131.421107 |
| 189 | 148 | 4 | chest\_depth ankle\_diam waist\_girth height | 0.9241587 | 0.9212134 | 132.733280 |
| 203 | 149 | 4 | chest\_depth waist\_girth wrist\_girth height | 0.9236359 | 0.9206703 | 134.323724 |
| 226 | 150 | 4 | ankle\_diam waist\_girth wrist\_diam height | 0.9232356 | 0.9202544 | 135.541741 |
| 242 | 151 | 4 | waist\_girth wrist\_girth wrist\_diam height | 0.9225010 | 0.9194913 | 137.776626 |
| 206 | 152 | 4 | chest\_depth waist\_girth wrist\_diam height | 0.9223510 | 0.9193355 | 138.232822 |
| 169 | 153 | 4 | chest\_diam waist\_girth wrist\_girth gender | 0.9198639 | 0.9167518 | 145.799498 |
| 138 | 154 | 4 | chest\_diam chest\_depth waist\_girth age | 0.9196452 | 0.9165246 | 146.464716 |
| 167 | 155 | 4 | chest\_diam waist\_girth wrist\_girth age | 0.9186272 | 0.9154671 | 149.561883 |
| 222 | 156 | 4 | ankle\_diam waist\_girth wrist\_girth age | 0.9135541 | 0.9101970 | 164.995839 |
| 140 | 157 | 4 | chest\_diam chest\_depth waist\_girth gender | 0.9134897 | 0.9101300 | 165.191803 |
| 130 | 158 | 4 | chest\_diam chest\_depth ankle\_diam waist\_girth | 0.9129739 | 0.9095942 | 166.761028 |
| 151 | 159 | 4 | chest\_diam ankle\_diam waist\_girth wrist\_girth | 0.9116785 | 0.9082485 | 170.701977 |
| 170 | 160 | 4 | chest\_diam waist\_girth wrist\_diam age | 0.9111467 | 0.9076961 | 172.319943 |
| 152 | 161 | 4 | chest\_diam ankle\_diam waist\_girth wrist\_diam | 0.9101848 | 0.9066969 | 175.246141 |
| 150 | 162 | 4 | chest\_diam chest\_depth height gender | 0.9086425 | 0.9050947 | 179.938333 |
| 188 | 163 | 4 | chest\_depth ankle\_diam waist\_girth age | 0.9085431 | 0.9049914 | 180.240717 |
| 225 | 164 | 4 | ankle\_diam waist\_girth wrist\_diam age | 0.9066693 | 0.9030448 | 185.941544 |
| 136 | 165 | 4 | chest\_diam chest\_depth waist\_girth wrist\_girth | 0.9063656 | 0.9027293 | 186.865446 |
| 174 | 166 | 4 | chest\_diam waist\_girth age gender | 0.9057679 | 0.9021084 | 188.683883 |
| 172 | 167 | 4 | chest\_diam waist\_girth wrist\_diam gender | 0.9055568 | 0.9018891 | 189.326038 |
| 229 | 168 | 4 | ankle\_diam waist\_girth age gender | 0.9043117 | 0.9005956 | 193.114209 |
| 224 | 169 | 4 | ankle\_diam waist\_girth wrist\_girth gender | 0.9042515 | 0.9005331 | 193.297268 |
| 202 | 170 | 4 | chest\_depth waist\_girth wrist\_girth age | 0.9040541 | 0.9003281 | 193.897703 |
| 137 | 171 | 4 | chest\_diam chest\_depth waist\_girth wrist\_diam | 0.9037092 | 0.8999697 | 194.947225 |
| 166 | 172 | 4 | chest\_diam waist\_girth wrist\_girth wrist\_diam | 0.9020753 | 0.8982724 | 199.917787 |
| 148 | 173 | 4 | chest\_diam chest\_depth age height | 0.9009742 | 0.8971285 | 203.267866 |
| 241 | 174 | 4 | waist\_girth wrist\_girth wrist\_diam age | 0.9001373 | 0.8962591 | 205.814081 |
| 245 | 175 | 4 | waist\_girth wrist\_girth age gender | 0.9000211 | 0.8961384 | 206.167450 |
| 135 | 176 | 4 | chest\_diam chest\_depth ankle\_diam gender | 0.8962280 | 0.8921980 | 217.707288 |
| 146 | 177 | 4 | chest\_diam chest\_depth wrist\_diam height | 0.8961331 | 0.8920995 | 217.995873 |
| 134 | 178 | 4 | chest\_diam chest\_depth ankle\_diam height | 0.8960793 | 0.8920436 | 218.159566 |
| 205 | 179 | 4 | chest\_depth waist\_girth wrist\_diam age | 0.8953673 | 0.8913039 | 220.325872 |
| 143 | 180 | 4 | chest\_diam chest\_depth wrist\_girth height | 0.8947458 | 0.8906582 | 222.216710 |
| 186 | 181 | 4 | chest\_depth ankle\_diam waist\_girth wrist\_girth | 0.8927167 | 0.8885504 | 228.389623 |
| 221 | 182 | 4 | ankle\_diam waist\_girth wrist\_girth wrist\_diam | 0.8919218 | 0.8877245 | 230.808221 |
| 227 | 183 | 4 | ankle\_diam waist\_girth wrist\_diam gender | 0.8917891 | 0.8875868 | 231.211753 |
| 190 | 184 | 4 | chest\_depth ankle\_diam waist\_girth gender | 0.8917539 | 0.8875502 | 231.318941 |
| 133 | 185 | 4 | chest\_diam chest\_depth ankle\_diam age | 0.8876482 | 0.8832851 | 243.809607 |
| 187 | 186 | 4 | chest\_depth ankle\_diam waist\_girth wrist\_diam | 0.8876276 | 0.8832637 | 243.872311 |
| 147 | 187 | 4 | chest\_diam chest\_depth wrist\_diam gender | 0.8871963 | 0.8828155 | 245.184625 |
| 204 | 188 | 4 | chest\_depth waist\_girth wrist\_girth gender | 0.8861848 | 0.8817648 | 248.261792 |
| 144 | 189 | 4 | chest\_diam chest\_depth wrist\_girth gender | 0.8854300 | 0.8809807 | 250.558129 |
| 145 | 190 | 4 | chest\_diam chest\_depth wrist\_diam age | 0.8844265 | 0.8799383 | 253.611012 |
| 243 | 191 | 4 | waist\_girth wrist\_girth wrist\_diam gender | 0.8839860 | 0.8794807 | 254.951163 |
| 149 | 192 | 4 | chest\_diam chest\_depth age gender | 0.8826401 | 0.8780824 | 259.045956 |
| 132 | 193 | 4 | chest\_diam chest\_depth ankle\_diam wrist\_diam | 0.8809379 | 0.8763142 | 264.224443 |
| 201 | 194 | 4 | chest\_depth waist\_girth wrist\_girth wrist\_diam | 0.8804938 | 0.8758528 | 265.575696 |
| 142 | 195 | 4 | chest\_diam chest\_depth wrist\_girth age | 0.8803567 | 0.8757103 | 265.992815 |
| 131 | 196 | 4 | chest\_diam chest\_depth ankle\_diam wrist\_girth | 0.8801683 | 0.8755146 | 266.565992 |
| 248 | 197 | 4 | waist\_girth wrist\_diam age gender | 0.8799008 | 0.8752368 | 267.379686 |
| 209 | 198 | 4 | chest\_depth waist\_girth age gender | 0.8772834 | 0.8725178 | 275.342585 |
| 141 | 199 | 4 | chest\_diam chest\_depth wrist\_girth wrist\_diam | 0.8750800 | 0.8702287 | 282.046146 |
| 165 | 200 | 4 | chest\_diam ankle\_diam height gender | 0.8727357 | 0.8677934 | 289.178232 |
| 207 | 201 | 4 | chest\_depth waist\_girth wrist\_diam gender | 0.8694316 | 0.8643610 | 299.230305 |
| 161 | 202 | 4 | chest\_diam ankle\_diam wrist\_diam height | 0.8665706 | 0.8613888 | 307.934596 |
| 184 | 203 | 4 | chest\_diam wrist\_diam height gender | 0.8661354 | 0.8609368 | 309.258426 |
| 158 | 204 | 4 | chest\_diam ankle\_diam wrist\_girth height | 0.8645465 | 0.8592862 | 314.092305 |
| 163 | 205 | 4 | chest\_diam ankle\_diam age height | 0.8639907 | 0.8587088 | 315.783226 |
| 181 | 206 | 4 | chest\_diam wrist\_girth height gender | 0.8627415 | 0.8574111 | 319.583716 |
| 159 | 207 | 4 | chest\_diam ankle\_diam wrist\_girth gender | 0.8606305 | 0.8552181 | 326.006108 |
| 177 | 208 | 4 | chest\_diam wrist\_girth wrist\_diam height | 0.8604725 | 0.8550539 | 326.486938 |
| 182 | 209 | 4 | chest\_diam wrist\_diam age height | 0.8602988 | 0.8548736 | 327.015147 |
| 162 | 210 | 4 | chest\_diam ankle\_diam wrist\_diam gender | 0.8597500 | 0.8543034 | 328.684759 |
| 179 | 211 | 4 | chest\_diam wrist\_girth age height | 0.8558267 | 0.8502278 | 340.620742 |
| 164 | 212 | 4 | chest\_diam ankle\_diam age gender | 0.8547090 | 0.8490667 | 344.021065 |
| 217 | 213 | 4 | chest\_depth wrist\_diam age height | 0.8524397 | 0.8467092 | 350.925274 |
| 185 | 214 | 4 | chest\_diam age height gender | 0.8520804 | 0.8463359 | 352.018244 |
| 160 | 215 | 4 | chest\_diam ankle\_diam wrist\_diam age | 0.8511054 | 0.8453231 | 354.984589 |
| 156 | 216 | 4 | chest\_diam ankle\_diam wrist\_girth wrist\_diam | 0.8506300 | 0.8448292 | 356.430806 |
| 157 | 217 | 4 | chest\_diam ankle\_diam wrist\_girth age | 0.8500308 | 0.8442068 | 358.253748 |
| 196 | 218 | 4 | chest\_depth ankle\_diam wrist\_diam height | 0.8465745 | 0.8406162 | 368.768967 |
| 219 | 219 | 4 | chest\_depth wrist\_diam height gender | 0.8454741 | 0.8394731 | 372.116763 |
| 212 | 220 | 4 | chest\_depth wrist\_girth wrist\_diam height | 0.8447352 | 0.8387055 | 374.364655 |
| 178 | 221 | 4 | chest\_diam wrist\_girth wrist\_diam gender | 0.8404698 | 0.8342745 | 387.341231 |
| 198 | 222 | 4 | chest\_depth ankle\_diam age height | 0.8384787 | 0.8322060 | 393.398989 |
| 193 | 223 | 4 | chest\_depth ankle\_diam wrist\_girth height | 0.8373428 | 0.8310260 | 396.854760 |
| 214 | 224 | 4 | chest\_depth wrist\_girth age height | 0.8368332 | 0.8304966 | 398.405130 |
| 176 | 225 | 4 | chest\_diam wrist\_girth wrist\_diam age | 0.8351860 | 0.8287854 | 403.416379 |
| 200 | 226 | 4 | chest\_depth ankle\_diam height gender | 0.8342477 | 0.8278107 | 406.271043 |
| 180 | 227 | 4 | chest\_diam wrist\_girth age gender | 0.8335626 | 0.8270990 | 408.355278 |
| 216 | 228 | 4 | chest\_depth wrist\_girth height gender | 0.8323731 | 0.8258634 | 411.973982 |
| 183 | 229 | 4 | chest\_diam wrist\_diam age gender | 0.8307683 | 0.8241961 | 416.856527 |
| 220 | 230 | 4 | chest\_depth age height gender | 0.8297193 | 0.8231065 | 420.047735 |
| 195 | 231 | 4 | chest\_depth ankle\_diam wrist\_diam age | 0.8160058 | 0.8088604 | 461.768540 |
| 191 | 232 | 4 | chest\_depth ankle\_diam wrist\_girth wrist\_diam | 0.8084673 | 0.8010291 | 484.703097 |
| 197 | 233 | 4 | chest\_depth ankle\_diam wrist\_diam gender | 0.8062418 | 0.7987172 | 491.473650 |
| 192 | 234 | 4 | chest\_depth ankle\_diam wrist\_girth age | 0.8050621 | 0.7974917 | 495.062843 |
| 211 | 235 | 4 | chest\_depth wrist\_girth wrist\_diam age | 0.8046449 | 0.7970583 | 496.332146 |
| 218 | 236 | 4 | chest\_depth wrist\_diam age gender | 0.8016272 | 0.7939234 | 505.512724 |
| 194 | 237 | 4 | chest\_depth ankle\_diam wrist\_girth gender | 0.7988855 | 0.7910753 | 513.853852 |
| 199 | 238 | 4 | chest\_depth ankle\_diam age gender | 0.7951731 | 0.7872187 | 525.148203 |
| 213 | 239 | 4 | chest\_depth wrist\_girth wrist\_diam gender | 0.7938508 | 0.7858450 | 529.171237 |
| 232 | 240 | 4 | ankle\_diam wrist\_girth wrist\_diam height | 0.7899803 | 0.7818242 | 540.946328 |
| 239 | 241 | 4 | ankle\_diam wrist\_diam height gender | 0.7862211 | 0.7779190 | 552.383014 |
| 237 | 242 | 4 | ankle\_diam wrist\_diam age height | 0.7855323 | 0.7772034 | 554.478685 |
| 215 | 243 | 4 | chest\_depth wrist\_girth age gender | 0.7841529 | 0.7757705 | 558.675247 |
| 253 | 244 | 4 | wrist\_girth wrist\_diam height gender | 0.7780328 | 0.7694127 | 577.294508 |
| 251 | 245 | 4 | wrist\_girth wrist\_diam age height | 0.7768680 | 0.7682026 | 580.838251 |
| 236 | 246 | 4 | ankle\_diam wrist\_girth height gender | 0.7749229 | 0.7661820 | 586.755871 |
| 234 | 247 | 4 | ankle\_diam wrist\_girth age height | 0.7743936 | 0.7656322 | 588.365994 |
| 255 | 248 | 4 | wrist\_diam age height gender | 0.7709040 | 0.7620070 | 598.982593 |
| 240 | 249 | 4 | ankle\_diam age height gender | 0.7571906 | 0.7477611 | 640.703176 |
| 254 | 250 | 4 | wrist\_girth age height gender | 0.7527957 | 0.7431956 | 654.073589 |
| 233 | 251 | 4 | ankle\_diam wrist\_girth wrist\_diam gender | 0.7477762 | 0.7379811 | 669.344613 |
| 231 | 252 | 4 | ankle\_diam wrist\_girth wrist\_diam age | 0.7471366 | 0.7373167 | 671.290463 |
| 238 | 253 | 4 | ankle\_diam wrist\_diam age gender | 0.7381407 | 0.7279714 | 698.658748 |
| 235 | 254 | 4 | ankle\_diam wrist\_girth age gender | 0.7327500 | 0.7223714 | 715.058936 |
| 252 | 255 | 4 | wrist\_girth wrist\_diam age gender | 0.7119058 | 0.7007177 | 778.473603 |
| 300 | 256 | 5 | chest\_diam ankle\_diam waist\_girth height gender | 0.9559948 | 0.9538377 | 37.877800 |
| 316 | 257 | 5 | chest\_diam waist\_girth wrist\_girth height gender | 0.9541234 | 0.9518746 | 43.571115 |
| 320 | 258 | 5 | chest\_diam waist\_girth age height gender | 0.9536440 | 0.9513716 | 45.029696 |
| 280 | 259 | 5 | chest\_diam chest\_depth waist\_girth height gender | 0.9536013 | 0.9513269 | 45.159415 |
| 278 | 260 | 5 | chest\_diam chest\_depth waist\_girth age height | 0.9509397 | 0.9485348 | 53.256849 |
| 319 | 261 | 5 | chest\_diam waist\_girth wrist\_diam height gender | 0.9493286 | 0.9468447 | 58.158549 |
| 298 | 262 | 5 | chest\_diam ankle\_diam waist\_girth age height | 0.9489104 | 0.9464060 | 59.430612 |
| 314 | 263 | 5 | chest\_diam waist\_girth wrist\_girth age height | 0.9476734 | 0.9451084 | 63.193931 |
| 379 | 264 | 5 | waist\_girth wrist\_girth age height gender | 0.9473583 | 0.9447778 | 64.152649 |
| 317 | 265 | 5 | chest\_diam waist\_girth wrist\_diam age height | 0.9465265 | 0.9439052 | 66.683430 |
| 370 | 266 | 5 | ankle\_diam waist\_girth age height gender | 0.9455727 | 0.9429046 | 69.585212 |
| 349 | 267 | 5 | chest\_depth waist\_girth wrist\_girth age height | 0.9436443 | 0.9408818 | 75.451874 |
| 333 | 268 | 5 | chest\_depth ankle\_diam waist\_girth age height | 0.9436156 | 0.9408516 | 75.539291 |
| 352 | 269 | 5 | chest\_depth waist\_girth wrist\_diam age height | 0.9431101 | 0.9403214 | 77.077038 |
| 364 | 270 | 5 | ankle\_diam waist\_girth wrist\_girth age height | 0.9430942 | 0.9403047 | 77.125495 |
| 355 | 271 | 5 | chest\_depth waist\_girth age height gender | 0.9427368 | 0.9399298 | 78.212784 |
| 380 | 272 | 5 | waist\_girth wrist\_diam age height gender | 0.9417226 | 0.9388659 | 81.298172 |
| 367 | 273 | 5 | ankle\_diam waist\_girth wrist\_diam age height | 0.9415866 | 0.9387232 | 81.712004 |
| 376 | 274 | 5 | waist\_girth wrist\_girth wrist\_diam age height | 0.9411801 | 0.9382968 | 82.948679 |
| 366 | 275 | 5 | ankle\_diam waist\_girth wrist\_girth height gender | 0.9408913 | 0.9379938 | 83.827524 |
| 351 | 276 | 5 | chest\_depth waist\_girth wrist\_girth height gender | 0.9375481 | 0.9344867 | 93.998517 |
| 299 | 277 | 5 | chest\_diam ankle\_diam waist\_girth age gender | 0.9367053 | 0.9336026 | 96.562546 |
| 335 | 278 | 5 | chest\_depth ankle\_diam waist\_girth height gender | 0.9363740 | 0.9332551 | 97.570491 |
| 378 | 279 | 5 | waist\_girth wrist\_girth wrist\_diam height gender | 0.9363354 | 0.9332146 | 97.687718 |
| 294 | 280 | 5 | chest\_diam ankle\_diam waist\_girth wrist\_girth gender | 0.9359954 | 0.9328579 | 98.722337 |
| 369 | 281 | 5 | ankle\_diam waist\_girth wrist\_diam height gender | 0.9359104 | 0.9327688 | 98.980768 |
| 259 | 282 | 5 | chest\_diam chest\_depth ankle\_diam waist\_girth height | 0.9351477 | 0.9319687 | 101.301122 |
| 260 | 283 | 5 | chest\_diam chest\_depth ankle\_diam waist\_girth gender | 0.9344350 | 0.9312211 | 103.469395 |
| 273 | 284 | 5 | chest\_diam chest\_depth waist\_girth wrist\_girth height | 0.9341309 | 0.9309020 | 104.394718 |
| 276 | 285 | 5 | chest\_diam chest\_depth waist\_girth wrist\_diam height | 0.9339767 | 0.9307403 | 104.863697 |
| 293 | 286 | 5 | chest\_diam ankle\_diam waist\_girth wrist\_girth height | 0.9337397 | 0.9304917 | 105.584781 |
| 296 | 287 | 5 | chest\_diam ankle\_diam waist\_girth wrist\_diam height | 0.9336021 | 0.9303473 | 106.003569 |
| 354 | 288 | 5 | chest\_depth waist\_girth wrist\_diam height gender | 0.9328506 | 0.9295590 | 108.289682 |
| 312 | 289 | 5 | chest\_diam waist\_girth wrist\_girth wrist\_diam height | 0.9320856 | 0.9287565 | 110.616969 |
| 258 | 290 | 5 | chest\_diam chest\_depth ankle\_diam waist\_girth age | 0.9311948 | 0.9278220 | 113.327156 |
| 297 | 291 | 5 | chest\_diam ankle\_diam waist\_girth wrist\_diam gender | 0.9301826 | 0.9267601 | 116.406740 |
| 292 | 292 | 5 | chest\_diam ankle\_diam waist\_girth wrist\_girth age | 0.9286660 | 0.9251693 | 121.020464 |
| 315 | 293 | 5 | chest\_diam waist\_girth wrist\_girth age gender | 0.9280641 | 0.9245378 | 122.851766 |
| 295 | 294 | 5 | chest\_diam ankle\_diam waist\_girth wrist\_diam age | 0.9263364 | 0.9227254 | 128.108060 |
| 274 | 295 | 5 | chest\_diam chest\_depth waist\_girth wrist\_girth gender | 0.9257224 | 0.9220813 | 129.976046 |
| 272 | 296 | 5 | chest\_diam chest\_depth waist\_girth wrist\_girth age | 0.9254553 | 0.9218011 | 130.788591 |
| 328 | 297 | 5 | chest\_depth ankle\_diam waist\_girth wrist\_girth height | 0.9252788 | 0.9216160 | 131.325405 |
| 362 | 298 | 5 | ankle\_diam waist\_girth wrist\_girth wrist\_diam height | 0.9245916 | 0.9208951 | 133.416181 |
| 331 | 299 | 5 | chest\_depth ankle\_diam waist\_girth wrist\_diam height | 0.9244552 | 0.9207520 | 133.831171 |
| 279 | 300 | 5 | chest\_diam chest\_depth waist\_girth age gender | 0.9244026 | 0.9206968 | 133.991363 |
| 347 | 301 | 5 | chest\_depth waist\_girth wrist\_girth wrist\_diam height | 0.9237677 | 0.9200308 | 135.922771 |
| 275 | 302 | 5 | chest\_diam chest\_depth waist\_girth wrist\_diam age | 0.9233484 | 0.9195909 | 137.198488 |
| 313 | 303 | 5 | chest\_diam waist\_girth wrist\_girth wrist\_diam gender | 0.9200384 | 0.9161187 | 147.268614 |
| 311 | 304 | 5 | chest\_diam waist\_girth wrist\_girth wrist\_diam age | 0.9190283 | 0.9150591 | 150.341605 |
| 365 | 305 | 5 | ankle\_diam waist\_girth wrist\_girth age gender | 0.9189293 | 0.9149552 | 150.642779 |
| 277 | 306 | 5 | chest\_diam chest\_depth waist\_girth wrist\_diam gender | 0.9183426 | 0.9143398 | 152.427563 |
| 327 | 307 | 5 | chest\_depth ankle\_diam waist\_girth wrist\_girth age | 0.9159557 | 0.9118359 | 159.689243 |
| 318 | 308 | 5 | chest\_diam waist\_girth wrist\_diam age gender | 0.9153577 | 0.9112086 | 161.508590 |
| 361 | 309 | 5 | ankle\_diam waist\_girth wrist\_girth wrist\_diam age | 0.9136713 | 0.9094395 | 166.639301 |
| 256 | 310 | 5 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth | 0.9136009 | 0.9093657 | 166.853271 |
| 270 | 311 | 5 | chest\_diam chest\_depth ankle\_diam height gender | 0.9134468 | 0.9092040 | 167.322279 |
| 257 | 312 | 5 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_diam | 0.9129748 | 0.9087089 | 168.758183 |
| 289 | 313 | 5 | chest\_diam chest\_depth wrist\_diam height gender | 0.9127383 | 0.9084608 | 169.477669 |
| 291 | 314 | 5 | chest\_diam ankle\_diam waist\_girth wrist\_girth wrist\_diam | 0.9119768 | 0.9076620 | 171.794389 |
| 330 | 315 | 5 | chest\_depth ankle\_diam waist\_girth wrist\_diam age | 0.9117521 | 0.9074262 | 172.478026 |
| 290 | 316 | 5 | chest\_diam chest\_depth age height gender | 0.9103406 | 0.9059455 | 176.772325 |
| 334 | 317 | 5 | chest\_depth ankle\_diam waist\_girth age gender | 0.9098944 | 0.9054774 | 178.129844 |
| 286 | 318 | 5 | chest\_diam chest\_depth wrist\_girth height gender | 0.9097113 | 0.9052854 | 178.686774 |
| 368 | 319 | 5 | ankle\_diam waist\_girth wrist\_diam age gender | 0.9085981 | 0.9041176 | 182.073596 |
| 271 | 320 | 5 | chest\_diam chest\_depth waist\_girth wrist\_girth wrist\_diam | 0.9064300 | 0.9018433 | 188.669437 |
| 346 | 321 | 5 | chest\_depth waist\_girth wrist\_girth wrist\_diam age | 0.9061267 | 0.9015251 | 189.592177 |
| 350 | 322 | 5 | chest\_depth waist\_girth wrist\_girth age gender | 0.9058179 | 0.9012011 | 190.531795 |
| 329 | 323 | 5 | chest\_depth ankle\_diam waist\_girth wrist\_girth gender | 0.9050667 | 0.9004131 | 192.817156 |
| 363 | 324 | 5 | ankle\_diam waist\_girth wrist\_girth wrist\_diam gender | 0.9042531 | 0.8995596 | 195.292423 |
| 287 | 325 | 5 | chest\_diam chest\_depth wrist\_diam age height | 0.9035984 | 0.8988729 | 197.284088 |
| 268 | 326 | 5 | chest\_diam chest\_depth ankle\_diam age height | 0.9024696 | 0.8976887 | 200.718407 |
| 377 | 327 | 5 | waist\_girth wrist\_girth wrist\_diam age gender | 0.9020404 | 0.8972385 | 202.024092 |
| 284 | 328 | 5 | chest\_diam chest\_depth wrist\_girth age height | 0.9009744 | 0.8961202 | 205.267309 |
| 269 | 329 | 5 | chest\_diam chest\_depth ankle\_diam age gender | 0.8983219 | 0.8933376 | 213.337065 |
| 267 | 330 | 5 | chest\_diam chest\_depth ankle\_diam wrist\_diam gender | 0.8982606 | 0.8932734 | 213.523370 |
| 264 | 331 | 5 | chest\_diam chest\_depth ankle\_diam wrist\_girth gender | 0.8973923 | 0.8923625 | 216.165075 |
| 282 | 332 | 5 | chest\_diam chest\_depth wrist\_girth wrist\_diam height | 0.8967742 | 0.8917142 | 218.045430 |
| 266 | 333 | 5 | chest\_diam chest\_depth ankle\_diam wrist\_diam height | 0.8967353 | 0.8916733 | 218.163909 |
| 263 | 334 | 5 | chest\_diam chest\_depth ankle\_diam wrist\_girth height | 0.8963722 | 0.8912925 | 219.268422 |
| 353 | 335 | 5 | chest\_depth waist\_girth wrist\_diam age gender | 0.8953745 | 0.8902458 | 222.303915 |
| 332 | 336 | 5 | chest\_depth ankle\_diam waist\_girth wrist\_diam gender | 0.8949785 | 0.8898303 | 223.508766 |
| 326 | 337 | 5 | chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam | 0.8927168 | 0.8874578 | 230.389481 |
| 288 | 338 | 5 | chest\_diam chest\_depth wrist\_diam age gender | 0.8916701 | 0.8863598 | 233.573944 |
| 265 | 339 | 5 | chest\_diam chest\_depth ankle\_diam wrist\_diam age | 0.8895076 | 0.8840913 | 240.152723 |
| 283 | 340 | 5 | chest\_diam chest\_depth wrist\_girth wrist\_diam gender | 0.8888946 | 0.8834483 | 242.017786 |
| 285 | 341 | 5 | chest\_diam chest\_depth wrist\_girth age gender | 0.8882134 | 0.8827336 | 244.090299 |
| 348 | 342 | 5 | chest\_depth waist\_girth wrist\_girth wrist\_diam gender | 0.8876969 | 0.8821918 | 245.661708 |
| 262 | 343 | 5 | chest\_diam chest\_depth ankle\_diam wrist\_girth age | 0.8876962 | 0.8821911 | 245.663671 |
| 281 | 344 | 5 | chest\_diam chest\_depth wrist\_girth wrist\_diam age | 0.8844820 | 0.8788193 | 255.442434 |
| 261 | 345 | 5 | chest\_diam chest\_depth ankle\_diam wrist\_girth wrist\_diam | 0.8810117 | 0.8751789 | 266.000164 |
| 309 | 346 | 5 | chest\_diam ankle\_diam wrist\_diam height gender | 0.8775962 | 0.8715960 | 276.391120 |
| 306 | 347 | 5 | chest\_diam ankle\_diam wrist\_girth height gender | 0.8759790 | 0.8698996 | 281.311007 |
| 310 | 348 | 5 | chest\_diam ankle\_diam age height gender | 0.8731362 | 0.8669174 | 289.959918 |
| 323 | 349 | 5 | chest\_diam wrist\_girth wrist\_diam height gender | 0.8688731 | 0.8624453 | 302.929500 |
| 307 | 350 | 5 | chest\_diam ankle\_diam wrist\_diam age height | 0.8674665 | 0.8609697 | 307.208940 |
| 302 | 351 | 5 | chest\_diam ankle\_diam wrist\_girth wrist\_diam height | 0.8666132 | 0.8600746 | 309.804980 |
| 325 | 352 | 5 | chest\_diam wrist\_diam age height gender | 0.8661564 | 0.8595954 | 311.194696 |
| 304 | 353 | 5 | chest\_diam ankle\_diam wrist\_girth age height | 0.8650233 | 0.8584068 | 314.641859 |
| 324 | 354 | 5 | chest\_diam wrist\_girth age height gender | 0.8631631 | 0.8564554 | 320.301165 |
| 303 | 355 | 5 | chest\_diam ankle\_diam wrist\_girth wrist\_diam gender | 0.8625130 | 0.8557735 | 322.278937 |
| 321 | 356 | 5 | chest\_diam wrist\_girth wrist\_diam age height | 0.8611754 | 0.8543703 | 326.348341 |
| 305 | 357 | 5 | chest\_diam ankle\_diam wrist\_girth age gender | 0.8607373 | 0.8539107 | 327.681233 |
| 308 | 358 | 5 | chest\_diam ankle\_diam wrist\_diam age gender | 0.8597501 | 0.8528751 | 330.684580 |
| 342 | 359 | 5 | chest\_depth ankle\_diam wrist\_diam age height | 0.8541318 | 0.8469814 | 347.777251 |
| 356 | 360 | 5 | chest\_depth wrist\_girth wrist\_diam age height | 0.8525263 | 0.8452972 | 352.661529 |
| 360 | 361 | 5 | chest\_depth wrist\_diam age height gender | 0.8524608 | 0.8452285 | 352.860802 |
| 301 | 362 | 5 | chest\_diam ankle\_diam wrist\_girth wrist\_diam age | 0.8519940 | 0.8447388 | 354.281154 |
| 344 | 363 | 5 | chest\_depth ankle\_diam wrist\_diam height gender | 0.8482178 | 0.8407775 | 365.769451 |
| 337 | 364 | 5 | chest\_depth ankle\_diam wrist\_girth wrist\_diam height | 0.8465866 | 0.8390664 | 370.732025 |
| 358 | 365 | 5 | chest\_depth wrist\_girth wrist\_diam height gender | 0.8459361 | 0.8383840 | 372.711040 |
| 339 | 366 | 5 | chest\_depth ankle\_diam wrist\_girth age height | 0.8421323 | 0.8343937 | 384.283363 |
| 322 | 367 | 5 | chest\_diam wrist\_girth wrist\_diam age gender | 0.8404898 | 0.8326706 | 389.280609 |
| 345 | 368 | 5 | chest\_depth ankle\_diam age height gender | 0.8386524 | 0.8307432 | 394.870350 |
| 341 | 369 | 5 | chest\_depth ankle\_diam wrist\_girth height gender | 0.8382176 | 0.8302871 | 396.193242 |
| 359 | 370 | 5 | chest\_depth wrist\_girth age height gender | 0.8369172 | 0.8289230 | 400.149474 |
| 336 | 371 | 5 | chest\_depth ankle\_diam wrist\_girth wrist\_diam age | 0.8179291 | 0.8090041 | 457.917271 |
| 343 | 372 | 5 | chest\_depth ankle\_diam wrist\_diam age gender | 0.8164168 | 0.8074176 | 462.518181 |
| 338 | 373 | 5 | chest\_depth ankle\_diam wrist\_girth wrist\_diam gender | 0.8089835 | 0.7996199 | 485.132672 |
| 357 | 374 | 5 | chest\_depth wrist\_girth wrist\_diam age gender | 0.8059385 | 0.7964257 | 494.396531 |
| 340 | 375 | 5 | chest\_depth ankle\_diam wrist\_girth age gender | 0.8053631 | 0.7958221 | 496.147099 |
| 371 | 376 | 5 | ankle\_diam wrist\_girth wrist\_diam age height | 0.7900842 | 0.7797942 | 542.630283 |
| 373 | 377 | 5 | ankle\_diam wrist\_girth wrist\_diam height gender | 0.7900486 | 0.7797568 | 542.738752 |
| 375 | 378 | 5 | ankle\_diam wrist\_diam age height gender | 0.7865359 | 0.7760720 | 553.425286 |
| 381 | 379 | 5 | wrist\_girth wrist\_diam age height gender | 0.7783401 | 0.7674744 | 578.359553 |
| 374 | 380 | 5 | ankle\_diam wrist\_girth age height gender | 0.7749470 | 0.7639150 | 588.682468 |
| 372 | 381 | 5 | ankle\_diam wrist\_girth wrist\_diam age gender | 0.7487136 | 0.7363956 | 668.492805 |
| 426 | 382 | 6 | chest\_diam ankle\_diam waist\_girth age height gender | 0.9619753 | 0.9597164 | 21.683061 |
| 411 | 383 | 6 | chest\_diam chest\_depth waist\_girth age height gender | 0.9616112 | 0.9593307 | 22.790771 |
| 435 | 384 | 6 | chest\_diam waist\_girth wrist\_girth age height gender | 0.9606679 | 0.9583313 | 25.660737 |
| 391 | 385 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth height gender | 0.9589994 | 0.9565637 | 30.736825 |
| 422 | 386 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_girth height gender | 0.9588253 | 0.9563793 | 31.266369 |
| 407 | 387 | 6 | chest\_diam chest\_depth waist\_girth wrist\_girth height gender | 0.9572266 | 0.9546856 | 36.130191 |
| 436 | 388 | 6 | chest\_diam waist\_girth wrist\_diam age height gender | 0.9564813 | 0.9538961 | 38.397598 |
| 425 | 389 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_diam height gender | 0.9561595 | 0.9535551 | 39.376607 |
| 410 | 390 | 6 | chest\_diam chest\_depth waist\_girth wrist\_diam height gender | 0.9548632 | 0.9521818 | 43.320404 |
| 434 | 391 | 6 | chest\_diam waist\_girth wrist\_girth wrist\_diam height gender | 0.9541490 | 0.9514252 | 45.493183 |
| 389 | 392 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth age height | 0.9523803 | 0.9495514 | 50.874235 |
| 462 | 393 | 6 | ankle\_diam waist\_girth wrist\_girth age height gender | 0.9517339 | 0.9488666 | 52.840668 |
| 408 | 394 | 6 | chest\_diam chest\_depth waist\_girth wrist\_diam age height | 0.9515403 | 0.9486615 | 53.429652 |
| 405 | 395 | 6 | chest\_diam chest\_depth waist\_girth wrist\_girth age height | 0.9515099 | 0.9486293 | 53.522191 |
| 456 | 396 | 6 | chest\_depth waist\_girth wrist\_girth age height gender | 0.9503265 | 0.9473756 | 57.122547 |
| 420 | 397 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_girth age height | 0.9495957 | 0.9466014 | 59.345876 |
| 447 | 398 | 6 | chest\_depth ankle\_diam waist\_girth age height gender | 0.9490798 | 0.9460549 | 60.915281 |
| 423 | 399 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_diam age height | 0.9490646 | 0.9460387 | 60.961584 |
| 465 | 400 | 6 | waist\_girth wrist\_girth wrist\_diam age height gender | 0.9480858 | 0.9450018 | 63.939417 |
| 432 | 401 | 6 | chest\_diam waist\_girth wrist\_girth wrist\_diam age height | 0.9478028 | 0.9447020 | 64.800408 |
| 457 | 402 | 6 | chest\_depth waist\_girth wrist\_diam age height gender | 0.9477494 | 0.9446454 | 64.962895 |
| 463 | 403 | 6 | ankle\_diam waist\_girth wrist\_diam age height gender | 0.9476775 | 0.9445692 | 65.181695 |
| 441 | 404 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_girth age height | 0.9451672 | 0.9419098 | 72.818803 |
| 444 | 405 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_diam age height | 0.9447120 | 0.9414276 | 74.203477 |
| 453 | 406 | 6 | chest\_depth waist\_girth wrist\_girth wrist\_diam age height | 0.9443006 | 0.9409918 | 75.455104 |
| 459 | 407 | 6 | ankle\_diam waist\_girth wrist\_girth wrist\_diam age height | 0.9432163 | 0.9398430 | 78.754083 |
| 421 | 408 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_girth age gender | 0.9430629 | 0.9396805 | 79.220715 |
| 390 | 409 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth age gender | 0.9428548 | 0.9394601 | 79.853742 |
| 443 | 410 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_girth height gender | 0.9415880 | 0.9381180 | 83.707834 |
| 461 | 411 | 6 | ankle\_diam waist\_girth wrist\_girth wrist\_diam height gender | 0.9409014 | 0.9373906 | 85.796619 |
| 385 | 412 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth gender | 0.9384088 | 0.9347499 | 93.379871 |
| 455 | 413 | 6 | chest\_depth waist\_girth wrist\_girth wrist\_diam height gender | 0.9379905 | 0.9343068 | 94.652523 |
| 446 | 414 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_diam height gender | 0.9378127 | 0.9341184 | 95.193585 |
| 424 | 415 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_diam age gender | 0.9374616 | 0.9337464 | 96.261725 |
| 419 | 416 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_girth wrist\_diam gender | 0.9362641 | 0.9324778 | 99.904814 |
| 406 | 417 | 6 | chest\_diam chest\_depth waist\_girth wrist\_girth age gender | 0.9355719 | 0.9317445 | 102.010731 |
| 387 | 418 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_diam height | 0.9351936 | 0.9313437 | 103.161478 |
| 384 | 419 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth height | 0.9351530 | 0.9313007 | 103.285199 |
| 388 | 420 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_diam gender | 0.9347001 | 0.9308209 | 104.662866 |
| 403 | 421 | 6 | chest\_diam chest\_depth waist\_girth wrist\_girth wrist\_diam height | 0.9341312 | 0.9302182 | 106.393658 |
| 418 | 422 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_girth wrist\_diam height | 0.9338807 | 0.9299528 | 107.155878 |
| 383 | 423 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth age | 0.9323487 | 0.9283298 | 111.816647 |
| 386 | 424 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_diam age | 0.9314936 | 0.9274240 | 114.418024 |
| 409 | 425 | 6 | chest\_diam chest\_depth waist\_girth wrist\_diam age gender | 0.9301860 | 0.9260386 | 118.396425 |
| 417 | 426 | 6 | chest\_diam ankle\_diam waist\_girth wrist\_girth wrist\_diam age | 0.9286789 | 0.9244420 | 122.981240 |
| 433 | 427 | 6 | chest\_diam waist\_girth wrist\_girth wrist\_diam age gender | 0.9285412 | 0.9242962 | 123.400199 |
| 402 | 428 | 6 | chest\_diam chest\_depth waist\_girth wrist\_girth wrist\_diam age | 0.9260013 | 0.9216054 | 131.127324 |
| 404 | 429 | 6 | chest\_diam chest\_depth waist\_girth wrist\_girth wrist\_diam gender | 0.9259644 | 0.9215662 | 131.239754 |
| 439 | 430 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam height | 0.9252805 | 0.9208417 | 133.320432 |
| 442 | 431 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_girth age gender | 0.9210715 | 0.9163827 | 146.125413 |
| 460 | 432 | 6 | ankle\_diam waist\_girth wrist\_girth wrist\_diam age gender | 0.9190622 | 0.9142540 | 152.238418 |
| 438 | 433 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam age | 0.9162236 | 0.9112468 | 160.874394 |
| 400 | 434 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_diam height gender | 0.9153162 | 0.9102855 | 163.634858 |
| 416 | 435 | 6 | chest\_diam chest\_depth wrist\_diam age height gender | 0.9150371 | 0.9099898 | 164.483918 |
| 401 | 436 | 6 | chest\_diam chest\_depth ankle\_diam age height gender | 0.9147793 | 0.9097167 | 165.268306 |
| 445 | 437 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_diam age gender | 0.9140137 | 0.9089056 | 167.597621 |
| 382 | 438 | 6 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam | 0.9137838 | 0.9086620 | 168.297022 |
| 397 | 439 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_girth height gender | 0.9136230 | 0.9084917 | 168.786143 |
| 414 | 440 | 6 | chest\_diam chest\_depth wrist\_girth wrist\_diam height gender | 0.9127508 | 0.9075677 | 171.439532 |
| 415 | 441 | 6 | chest\_diam chest\_depth wrist\_girth age height gender | 0.9112662 | 0.9059948 | 175.956420 |
| 454 | 442 | 6 | chest\_depth waist\_girth wrist\_girth wrist\_diam age gender | 0.9081930 | 0.9027391 | 185.306038 |
| 440 | 443 | 6 | chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam gender | 0.9050831 | 0.8994445 | 194.767124 |
| 412 | 444 | 6 | chest\_diam chest\_depth wrist\_girth wrist\_diam age height | 0.9044128 | 0.8987344 | 196.806456 |
| 398 | 445 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_diam age height | 0.9040432 | 0.8983428 | 197.930947 |
| 395 | 446 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_girth age height | 0.9026541 | 0.8968712 | 202.157067 |
| 399 | 447 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_diam age gender | 0.9009780 | 0.8950955 | 207.256188 |
| 396 | 448 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_girth age gender | 0.8993411 | 0.8933614 | 212.236146 |
| 394 | 449 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_girth wrist\_diam gender | 0.8985664 | 0.8925407 | 214.593078 |
| 393 | 450 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_girth wrist\_diam height | 0.8976797 | 0.8916013 | 217.290722 |
| 413 | 451 | 6 | chest\_diam chest\_depth wrist\_girth wrist\_diam age gender | 0.8926998 | 0.8863255 | 232.441267 |
| 392 | 452 | 6 | chest\_diam chest\_depth ankle\_diam wrist\_girth wrist\_diam age | 0.8896570 | 0.8831020 | 241.698308 |
| 429 | 453 | 6 | chest\_diam ankle\_diam wrist\_girth wrist\_diam height gender | 0.8785242 | 0.8713078 | 275.567939 |
| 431 | 454 | 6 | chest\_diam ankle\_diam wrist\_diam age height gender | 0.8776732 | 0.8704063 | 278.156778 |
| 430 | 455 | 6 | chest\_diam ankle\_diam wrist\_girth age height gender | 0.8763271 | 0.8689802 | 282.252159 |
| 437 | 456 | 6 | chest\_diam wrist\_girth wrist\_diam age height gender | 0.8689303 | 0.8611440 | 304.755403 |
| 427 | 457 | 6 | chest\_diam ankle\_diam wrist\_girth wrist\_diam age height | 0.8675239 | 0.8596540 | 309.034308 |
| 428 | 458 | 6 | chest\_diam ankle\_diam wrist\_girth wrist\_diam age gender | 0.8625216 | 0.8543546 | 324.252754 |
| 452 | 459 | 6 | chest\_depth ankle\_diam wrist\_diam age height gender | 0.8543495 | 0.8456970 | 349.114934 |
| 448 | 460 | 6 | chest\_depth ankle\_diam wrist\_girth wrist\_diam age height | 0.8541325 | 0.8454671 | 349.775083 |
| 458 | 461 | 6 | chest\_depth wrist\_girth wrist\_diam age height gender | 0.8525848 | 0.8438274 | 354.483749 |
| 450 | 462 | 6 | chest\_depth ankle\_diam wrist\_girth wrist\_diam height gender | 0.8483950 | 0.8393887 | 367.230435 |
| 451 | 463 | 6 | chest\_depth ankle\_diam wrist\_girth age height gender | 0.8421778 | 0.8328022 | 386.145147 |
| 449 | 464 | 6 | chest\_depth ankle\_diam wrist\_girth wrist\_diam age gender | 0.8179957 | 0.8071836 | 459.714654 |
| 464 | 465 | 6 | ankle\_diam wrist\_girth wrist\_diam age height gender | 0.7902488 | 0.7777883 | 544.129622 |
| 475 | 466 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth age height gender | 0.9661907 | 0.9638241 | 10.858469 |
| 490 | 467 | 7 | chest\_diam ankle\_diam waist\_girth wrist\_girth age height gender | 0.9649811 | 0.9625297 | 14.538722 |
| 484 | 468 | 7 | chest\_diam chest\_depth waist\_girth wrist\_girth age height gender | 0.9649292 | 0.9624742 | 14.696532 |
| 485 | 469 | 7 | chest\_diam chest\_depth waist\_girth wrist\_diam age height gender | 0.9633998 | 0.9608378 | 19.349453 |
| 491 | 470 | 7 | chest\_diam ankle\_diam waist\_girth wrist\_diam age height gender | 0.9624247 | 0.9597944 | 22.315947 |
| 493 | 471 | 7 | chest\_diam waist\_girth wrist\_girth wrist\_diam age height gender | 0.9608357 | 0.9580942 | 27.150180 |
| 471 | 472 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth height gender | 0.9606613 | 0.9579076 | 27.680759 |
| 474 | 473 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_diam height gender | 0.9591224 | 0.9562610 | 32.362638 |
| 489 | 474 | 7 | chest\_diam ankle\_diam waist\_girth wrist\_girth wrist\_diam height gender | 0.9589438 | 0.9560699 | 32.905884 |
| 483 | 475 | 7 | chest\_diam chest\_depth waist\_girth wrist\_girth wrist\_diam height gender | 0.9572765 | 0.9542859 | 37.978343 |
| 497 | 476 | 7 | chest\_depth ankle\_diam waist\_girth wrist\_girth age height gender | 0.9534843 | 0.9502283 | 49.515337 |
| 469 | 477 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth age height | 0.9525136 | 0.9491895 | 52.468728 |
| 472 | 478 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_diam age height | 0.9525029 | 0.9491781 | 52.501094 |
| 501 | 479 | 7 | ankle\_diam waist\_girth wrist\_girth wrist\_diam age height gender | 0.9518770 | 0.9485083 | 54.405528 |
| 481 | 480 | 7 | chest\_diam chest\_depth waist\_girth wrist\_girth wrist\_diam age height | 0.9517143 | 0.9483343 | 54.900394 |
| 500 | 481 | 7 | chest\_depth waist\_girth wrist\_girth wrist\_diam age height gender | 0.9512374 | 0.9478240 | 56.351288 |
| 498 | 482 | 7 | chest\_depth ankle\_diam waist\_girth wrist\_diam age height gender | 0.9511312 | 0.9477104 | 56.674282 |
| 487 | 483 | 7 | chest\_diam ankle\_diam waist\_girth wrist\_girth wrist\_diam age height | 0.9495972 | 0.9460690 | 61.341146 |
| 470 | 484 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth age gender | 0.9466340 | 0.9428983 | 70.356356 |
| 494 | 485 | 7 | chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam age height | 0.9454297 | 0.9416098 | 74.020156 |
| 473 | 486 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_diam age gender | 0.9435183 | 0.9395646 | 79.835176 |
| 488 | 487 | 7 | chest\_diam ankle\_diam waist\_girth wrist\_girth wrist\_diam age gender | 0.9431155 | 0.9391335 | 81.060773 |
| 496 | 488 | 7 | chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam height gender | 0.9416214 | 0.9375348 | 85.606317 |
| 468 | 489 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam gender | 0.9385569 | 0.9342559 | 94.929437 |
| 482 | 490 | 7 | chest\_diam chest\_depth waist\_girth wrist\_girth wrist\_diam age gender | 0.9362179 | 0.9317531 | 102.045402 |
| 467 | 491 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam height | 0.9352286 | 0.9306946 | 105.054981 |
| 466 | 492 | 7 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam age | 0.9323553 | 0.9276202 | 113.796605 |
| 495 | 493 | 7 | chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam age gender | 0.9213523 | 0.9158469 | 147.271254 |
| 480 | 494 | 7 | chest\_diam chest\_depth ankle\_diam wrist\_diam age height gender | 0.9171323 | 0.9113315 | 160.109890 |
| 478 | 495 | 7 | chest\_diam chest\_depth ankle\_diam wrist\_girth wrist\_diam height gender | 0.9153375 | 0.9094111 | 165.570056 |
| 486 | 496 | 7 | chest\_diam chest\_depth wrist\_girth wrist\_diam age height gender | 0.9150414 | 0.9090943 | 166.470838 |
| 479 | 497 | 7 | chest\_diam chest\_depth ankle\_diam wrist\_girth age height gender | 0.9149208 | 0.9089653 | 166.837743 |
| 476 | 498 | 7 | chest\_diam chest\_depth ankle\_diam wrist\_girth wrist\_diam age height | 0.9051513 | 0.8985119 | 196.559666 |
| 477 | 499 | 7 | chest\_diam chest\_depth ankle\_diam wrist\_girth wrist\_diam age gender | 0.9011156 | 0.8941937 | 208.837638 |
| 492 | 500 | 7 | chest\_diam ankle\_diam wrist\_girth wrist\_diam age height gender | 0.8786304 | 0.8701345 | 277.244827 |
| 499 | 501 | 7 | chest\_depth ankle\_diam wrist\_girth wrist\_diam age height gender | 0.8543722 | 0.8441782 | 351.045977 |
| 505 | 502 | 8 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth age height gender | 0.9677793 | 0.9651757 | 8.025419 |
| 506 | 503 | 8 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_diam age height gender | 0.9665896 | 0.9638898 | 11.644982 |
| 508 | 504 | 8 | chest\_diam chest\_depth waist\_girth wrist\_girth wrist\_diam age height gender | 0.9651872 | 0.9623741 | 15.911414 |
| 509 | 505 | 8 | chest\_diam ankle\_diam waist\_girth wrist\_girth wrist\_diam age height gender | 0.9649869 | 0.9621576 | 16.520862 |
| 504 | 506 | 8 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam height gender | 0.9607138 | 0.9575392 | 29.520997 |
| 510 | 507 | 8 | chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam age height gender | 0.9537630 | 0.9500267 | 50.667587 |
| 502 | 508 | 8 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam age height | 0.9525581 | 0.9487244 | 54.333206 |
| 503 | 509 | 8 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam age gender | 0.9466354 | 0.9423231 | 72.352051 |
| 507 | 510 | 8 | chest\_diam chest\_depth ankle\_diam wrist\_girth wrist\_diam age height gender | 0.9172127 | 0.9105229 | 161.865037 |
| 511 | 511 | 9 | chest\_diam chest\_depth ankle\_diam waist\_girth wrist\_girth wrist\_diam age height gender | 0.9677877 | 0.9648294 | 10.000000 |

plot(bd.all)

## Warning: It is deprecated to specify `guide = FALSE` to remove a guide. Please  
## use `guide = "none"` instead.  
  
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## use `guide = "none"` instead.  
  
## Warning: It is deprecated to specify `guide = FALSE` to remove a guide. Please  
## use `guide = "none"` instead.



#check models with 5 variables  
body\_5 <- subset(bd.all,n==5)   
summary(body\_5)

## mindex n predictors rsquare   
## Min. :256.0 Min. :5 Length:126 Min. :0.7487   
## 1st Qu.:287.2 1st Qu.:5 Class :character 1st Qu.:0.8678   
## Median :318.5 Median :5 Mode :character Median :0.9092   
## Mean :318.5 Mean :5 Mean :0.8972   
## 3rd Qu.:349.8 3rd Qu.:5 3rd Qu.:0.9334   
## Max. :381.0 Max. :5 Max. :0.9560   
## adjr predrsq cp aic   
## Min. :0.7364 Min. :0.7125 Min. : 37.88 Min. :562.2   
## 1st Qu.:0.8613 1st Qu.:0.8523 1st Qu.:106.58 1st Qu.:606.9   
## Median :0.9047 Median :0.8974 Median :180.38 Median :640.4   
## Mean :0.8921 Mean :0.8843 Mean :216.81 Mean :644.4   
## 3rd Qu.:0.9302 3rd Qu.:0.9254 3rd Qu.:306.14 3rd Qu.:681.0   
## Max. :0.9538 Max. :0.9505 Max. :668.49 Max. :750.3   
## sbic sbc msep fpe   
## Min. :253.3 Min. :580.9 Min. :1072 Min. :10.47   
## 1st Qu.:294.4 1st Qu.:625.7 1st Qu.:1622 1st Qu.:15.85   
## Median :325.9 Median :659.2 Median :2213 Median :21.62   
## Mean :330.1 Mean :663.2 Mean :2505 Mean :24.47   
## 3rd Qu.:364.6 3rd Qu.:699.7 3rd Qu.:3220 3rd Qu.:31.46   
## Max. :432.1 Max. :769.1 Max. :6122 Max. :59.81   
## apc hsp   
## Min. :0.04918 Min. :0.09825   
## 1st Qu.:0.07442 1st Qu.:0.14867   
## Median :0.10153 Median :0.20283   
## Mean :0.11492 Mean :0.22957   
## 3rd Qu.:0.14773 3rd Qu.:0.29513   
## Max. :0.28085 Max. :0.56105

#check models with 6 variables  
body\_6 <- subset(bd.all,n==6)  
summary(body\_6)

## mindex n predictors rsquare   
## Min. :382.0 Min. :6 Length:84 Min. :0.7902   
## 1st Qu.:402.8 1st Qu.:6 Class :character 1st Qu.:0.9043   
## Median :423.5 Median :6 Mode :character Median :0.9319   
## Mean :423.5 Mean :6 Mean :0.9204   
## 3rd Qu.:444.2 3rd Qu.:6 3rd Qu.:0.9477   
## Max. :465.0 Max. :6 Max. :0.9620   
## adjr predrsq cp aic   
## Min. :0.7778 Min. :0.7553 Min. : 21.68 Min. :548.4   
## 1st Qu.:0.8986 1st Qu.:0.8905 1st Qu.: 65.13 1st Qu.:582.8   
## Median :0.9279 Median :0.9235 Median :113.12 Median :611.3   
## Mean :0.9156 Mean :0.9085 Mean :148.30 Mean :619.2   
## 3rd Qu.:0.9446 3rd Qu.:0.9393 3rd Qu.:197.09 3rd Qu.:648.0   
## Max. :0.9597 Max. :0.9564 Max. :544.13 Max. :732.8   
## sbic sbc msep fpe   
## Min. :241.0 Min. :569.8 Min. : 935.7 Min. : 9.221   
## 1st Qu.:271.6 1st Qu.:604.3 1st Qu.:1287.1 1st Qu.:12.684   
## Median :297.6 Median :632.7 Median :1675.2 Median :16.509   
## Mean :305.5 Mean :640.7 Mean :1959.8 Mean :19.313   
## 3rd Qu.:332.0 3rd Qu.:669.5 3rd Qu.:2354.4 3rd Qu.:23.202   
## Max. :413.3 Max. :754.3 Max. :5161.4 Max. :50.864   
## apc hsp   
## Min. :0.04330 Min. :0.0866   
## 1st Qu.:0.05955 1st Qu.:0.1191   
## Median :0.07752 Median :0.1550   
## Mean :0.09068 Mean :0.1814   
## 3rd Qu.:0.10894 3rd Qu.:0.2179   
## Max. :0.23883 Max. :0.4777

#check models with 7 variables  
body\_7 <- subset(bd.all,n==7)   
summary(body\_7)

## mindex n predictors rsquare   
## Min. :466.0 Min. :7 Length:36 Min. :0.8544   
## 1st Qu.:474.8 1st Qu.:7 Class :character 1st Qu.:0.9296   
## Median :483.5 Median :7 Mode :character Median :0.9481   
## Mean :483.5 Mean :7 Mean :0.9394   
## 3rd Qu.:492.2 3rd Qu.:7 3rd Qu.:0.9577   
## Max. :501.0 Max. :7 Max. :0.9662   
## adjr predrsq cp aic   
## Min. :0.8442 Min. :0.8269 Min. : 10.86 Min. :537.7   
## 1st Qu.:0.9247 1st Qu.:0.9187 1st Qu.: 36.71 1st Qu.:561.9   
## Median :0.9445 Median :0.9398 Median : 65.85 Median :583.9   
## Mean :0.9352 Mean :0.9288 Mean : 92.35 Mean :593.1   
## 3rd Qu.:0.9547 3rd Qu.:0.9499 3rd Qu.:122.17 3rd Qu.:616.7   
## Max. :0.9638 Max. :0.9601 Max. :351.05 Max. :695.4   
## sbic sbc msep fpe   
## Min. :232.0 Min. :561.8 Min. : 840.4 Min. : 8.353   
## 1st Qu.:252.8 1st Qu.:586.0 1st Qu.:1051.6 1st Qu.:10.452   
## Median :272.2 Median :608.1 Median :1289.6 Median :12.818   
## Mean :280.9 Mean :617.2 Mean :1506.2 Mean :14.970   
## 3rd Qu.:301.8 3rd Qu.:640.8 3rd Qu.:1749.7 3rd Qu.:17.391   
## Max. :375.7 Max. :719.6 Max. :3619.7 Max. :35.978   
## apc hsp   
## Min. :0.03922 Min. :0.07855   
## 1st Qu.:0.04908 1st Qu.:0.09829   
## Median :0.06019 Median :0.12055   
## Mean :0.07029 Mean :0.14079   
## 3rd Qu.:0.08166 3rd Qu.:0.16356   
## Max. :0.16893 Max. :0.33835

#check models with 8 variables  
body\_8 <- subset(bd.all,n==8)   
summary(body\_8)

## mindex n predictors rsquare adjr   
## Min. :502 Min. :8 Length:9 Min. :0.9172 Min. :0.9105   
## 1st Qu.:504 1st Qu.:8 Class :character 1st Qu.:0.9526 1st Qu.:0.9487   
## Median :506 Median :8 Mode :character Median :0.9607 Median :0.9575   
## Mean :506 Mean :8 Mean :0.9550 Mean :0.9514   
## 3rd Qu.:508 3rd Qu.:8 3rd Qu.:0.9652 3rd Qu.:0.9624   
## Max. :510 Max. :8 Max. :0.9678 Max. :0.9652   
## predrsq cp aic sbic   
## Min. :0.8994 Min. : 8.025 Min. :534.5 Min. :229.8   
## 1st Qu.:0.9441 1st Qu.: 15.911 1st Qu.:542.9 1st Qu.:236.7   
## Median :0.9525 Median : 29.521 Median :555.9 Median :247.7   
## Mean :0.9460 Mean : 46.760 Mean :565.6 Mean :256.4   
## 3rd Qu.:0.9580 3rd Qu.: 54.333 3rd Qu.:576.3 3rd Qu.:265.1   
## Max. :0.9612 Max. :161.865 Max. :636.4 Max. :319.0   
## sbc msep fpe apc   
## Min. :561.3 Min. : 809.0 Min. : 8.110 Min. :0.03808   
## 1st Qu.:569.7 1st Qu.: 874.1 1st Qu.: 8.762 1st Qu.:0.04114   
## Median :582.7 Median : 986.5 Median : 9.888 Median :0.04643   
## Mean :592.4 Mean :1128.7 Mean :11.315 Mean :0.05313   
## 3rd Qu.:603.1 3rd Qu.:1191.2 3rd Qu.:11.941 3rd Qu.:0.05607   
## Max. :663.2 Max. :2078.7 Max. :20.838 Max. :0.09784   
## hsp   
## Min. :0.07639   
## 1st Qu.:0.08253   
## Median :0.09314   
## Mean :0.10657   
## 3rd Qu.:0.11248   
## Max. :0.19627

The best model predicting weight using adjusted R2 value as a selection criteria, is the model using the eight predictors of chest\_diam, chest\_depth, ankle\_diam, waist\_girth, wrist\_girth, age, height, and gender (adjusted R2=0.9651757). However, the question specifically asks about the best models using 5, 6, and 7 predictors, which have lower adjusted R2 values of 0.9538377, 0.9597164, and 0.9638241, respectively. All of the adjusted R2 values of these models (5, 6, 7, and 8 predictor models) are close in terms of adjusted R2, and close to the models derived from forward selection and backward elimination (both also with 8 predictors) that had adjusted R2 values of 0.9648 and 0.9652, respectively.

**Question 3.**

city = read.csv("hw3\_city\_temps.csv", header=T)  
  
#fit linear regression model  
city.lm =lm(High\_F~Latitude, data=city)  
summary(city.lm)

##   
## Call:  
## lm(formula = High\_F ~ Latitude, data = city)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -6.975 -4.153 -2.571 1.021 24.073   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 133.3425 7.2663 18.35 < 2e-16 \*\*\*  
## Latitude -2.2772 0.1932 -11.79 6.53e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 6.773 on 49 degrees of freedom  
## Multiple R-squared: 0.7393, Adjusted R-squared: 0.7339   
## F-statistic: 138.9 on 1 and 49 DF, p-value: 6.526e-16

#RMSE

rss1 = c(crossprod(city.lm$residuals))

mse1 = rss1 / length(city.lm$residuals)

rmse1 = sqrt(mse1)

cat("RMSE: ", rmse1)

##RMSE: 6.638825

#scatter plot of High\_F vs Latitude with linear model  
ggplot(city, aes(Latitude, High\_F)) + geom\_smooth(method="lm", color='red', size=0.5, fill='red', alpha=0.2) + geom\_point(aes(Latitude, High\_F), shape=21, size=2, fill='white') + labs(x = "Latitude (decimal degrees)", y = "Temperature (Fahrenheit)") + theme(text = element\_text(size = 15), plot.title=element\_text(hjust=0.5)) + ggtitle("Average High January Temperature vs. Latitude")

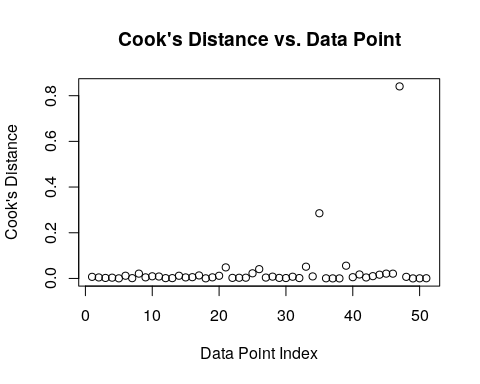
## Warning: Duplicated aesthetics after name standardisation: colour

## `geom\_smooth()` using formula 'y ~ x'

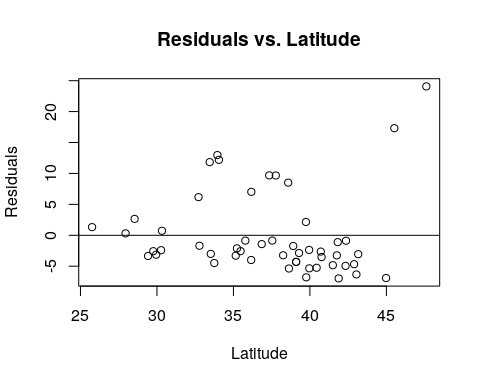
Chart, scatter chart

Description automatically generated

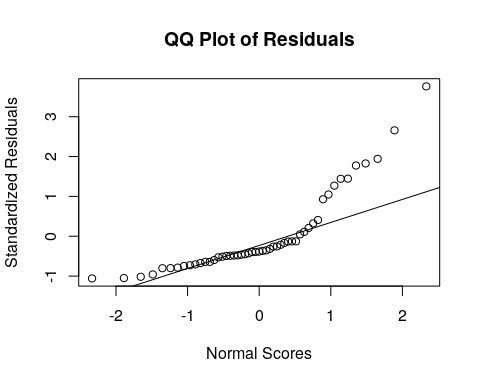
#Cook's distance to detect influential observations  
cooksd = cooks.distance(city.lm)  
plot(cooksd, ylab="Cook's Distance", xlab="Data Point Index", main="Cook's Distance vs. Data Point")



#residuals  
city.res = resid(city.lm)  
plot(city$Latitude, city.res,  
 ylab="Residuals", xlab="Latitude",  
 main="Residuals vs. Latitude")  
abline(0,0)



#QQ plot  
city.stres = rstandard(city.lm)  
qqnorm(city.stres,  
 ylab="Standardized Residuals",  
 xlab = "Normal Scores",  
 main = "QQ Plot of Residuals")  
qqline(city.stres)



**3A.** The linear regression model for predicting the highest average January temperature as a response of latitude is given by the general single linear regression equation:

*yi = b0 + b1x1i + ei*

*yi*= response variable; average high January temperature of city in degrees Fahrenheit (High\_F) for the *i*th observation

*b0* = y intercept; the value of the response variable when the predictor variable is 0

*b1* = regression coefficient for predictor variable Latitude

*x1i* = predictor variable at *i*th observation; latitude of city in decimal degrees (Latitude) at *i*th observation

*ei* = residual error; difference between observed value at *i*th observation and expected value (model value)

**3B.** The fitted linear regression model of average high January temperature as a response of latitude is given by the equation:

*High\_F = 133.3425 - 2.2772(Latitude)*

*High\_F* = response variable at *i*th observation; average highest January temperature of city in Fahrenheit

*133.3425* = y-intercept; degrees Fahrenheit of average high January temperature of city at 0 degrees latitude, as predicted by regression model

*-2.2772* = regression coefficient for predictor variable Latitude of regression model

*Latitude* = latitude of city in decimal degrees at *i*th observation

The fitted regression shows a negative association between average high January temperature (High\_F) and latitude (Latitude), where temperature decreases 2.2772 degrees Fahrenheit for every degree of latitude increase above/below the equator (Latitude=0 degrees). The model also shows that at the equator (Latitude=0 degrees), the predicted mean temperature would be 133 degrees Fahrenheit; however, this seems unrealistic and could be explained by the dataset only consisting of selected cities in the United States and not close to the equator. The calculated coefficients of the y-intercept and slope are significant, as shown by their high t values (and low P values) of 18.35 (< 2e-16) and -11.79 (6.53e-16), respectively.

**3C.** The four assumptions for a least squares regression analysis are (1) mean linearity, where the average value of errors is 0 regardless of values of any predictors of the response, (2) homoscedasticity, where variance is equally distributed around 0 on residual plot, (3) independence, where errors are uncorrelated, and (4) error normality, where errors are normally distributed. Assumptions 1, 2, and 4 are not met according to the summary of the linear model, “Residuals vs Latitude” plot, and “QQ Plot of Residuals” plot, found above. The mean linearity deviates negatively from zero, as can be seen by the median of -2.571, the Q1 -4.153, and the Q3 of 1.021. Examination of the “Residuals vs. Latitude” plot shows that most of the data points lie below zero. Assumption 2 of homoscedasticity is also not met. The “Residuals vs Latitude” plot above, shows highly positive values in the middle between 30 and 40 degrees Latitude, and very highly positive data points above 45 degrees Latitude. However, negative residuals are approximately evenly distributed. Assumption 4 of error normality is also not satisfied. The median of -2.571, the Q1 -4.153, and the Q3 of 1.021 suggest a positively skewed dataset, the “Residuals vs Latitude” plot shows a positively skewed dataset, and the “QQ Plot of Residuals” clearly does not produce a straight line that would be suggestive of a normal distribution. Finally, assumption 3 does appear to be satisfied. Although the high January temperature does appear to respond to Latitude above the equator, the associated errors are not affected and therefore independent. Overall, the assumptions are not met and the data needs to be examined in more detail before moving forward.

**Question 4.**

**4A.** These two points have both an unusual y and unusual x, and can be classified as both outliers (unusual y) and influential points (unusual x). The y values of the two points are both well above where data would be predicted to occur at those latitudes. Additionally, the x values are beyond the rest of the dataset, giving these two points the most extreme x values (two most northern cities in the data set). We should also look at the Cook’s Distance of each data point (plot above in question 3), which measures the change of parameter estimates if that specific data point (xi) is removed. For these two points we see that Cook’s D is ~0.3 and 0.8 for Portland, OR and Seattle, WA, respectively, and are well above the remaining datapoints that average around ~0.05. Both points change the parameter estimates by a significant amount when removed.

**4B.**

#modified city\_temps data without Seattle, WA and Portland, OR  
city\_2 = city[-c(35,47), ]  
  
#fit new linear regression model  
city\_2.lm =lm(High\_F~Latitude, data = city\_2)  
summary(city\_2.lm)

##   
## Call:  
## lm(formula = High\_F ~ Latitude, data = city\_2)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -5.4109 -3.1086 -1.8758 0.2318 12.6632   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 146.8260 5.7478 25.55 <2e-16 \*\*\*  
## Latitude -2.6654 0.1545 -17.25 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 5.001 on 47 degrees of freedom  
## Multiple R-squared: 0.8636, Adjusted R-squared: 0.8607   
## F-statistic: 297.5 on 1 and 47 DF, p-value: < 2.2e-16

#new RMSE

rss2 = c(crossprod(city\_2.lm$residuals))

mse2 = rss2 / length(city\_2.lm$residuals)

rmse2 = sqrt(mse2)

cat("RMSE (new model): ", rmse2)

##RMSE (new model): 4.898205

#scatter plot of High\_F vs Latitude with linear model  
ggplot(city\_2, aes(High\_F, Latitude)) + geom\_smooth(method="lm", col=1, color='red', size=0.5, fill='red', alpha=0.2) + geom\_point(aes(High\_F, Latitude), shape=21, size=2, fill='white') + labs(x = "Latitude (decimal degrees)", y = "Temperature (Fahrenheit)") + theme(text = element\_text(size = 15), plot.title=element\_text(hjust=0.5), plot.subtitle=element\_text(hjust = 0.5, face="italic", size=10)) + ggtitle("Average High January Temperature vs. Latitude", subtitle=("(exluding Portland, OR and Seattle, WA)"))

## Warning: Duplicated aesthetics after name standardisation: colour

## `geom\_smooth()` using formula 'y ~ x'

Chart, scatter chart

Description automatically generated

After refitting the linear regression to a modified dataset that excludes Portland, OR and Seattle, WA, we see a much better fit of the model, which can be seen by the comparison of several values:

***Original Model New model (excluding Portland and Seattle)***

***F value*** *138.9 on 1 and 49 DF, p-value: 6.526e-16 297.5 on 1 and 47 DF, p-value: < 2.2e-16*

***Root MSE*** *6.638825 4.898205*

***R2*** *0.7393 0.8636*

***Adjusted R2***  *0.7339 0.8607*

***t value of predictor*** *-11.79 -17.25*

***P value of predictor*** *6.53e-16 <2e-16*

The F value of the old model increase from 138.9 to 297.5 in the new model, and the associated P values decrease from 6.526e-16 to < 2.2e-16, respectively. The R2 value of the old model increases from 0.7393 to 0.8636 in the new model. The adjusted R2 value of the old model increases from 0.7339 to 0.8607 in the new model. The t value of the Latitude predictor variable increases from -11.79 in the old model to -17.25 in the new model, and the associated P value decreases from 6.53e-16 to <2e-16 in the new model. The root MSE value of the old model decreases from 6.638825 to 4.898205 in the new model.

All of these changes are expected with modifying a dataset to remove outliers and influential points, which result in a more accurate and precise model: (1) the F value of the overall model should increase, signaling a stronger significance of the model (and the associated P value decreases); (2) the R2 value increases, which signals that the model accounts for more variation; (3) the adjusted R2 value increases, which signals a better fit compared to the old model; (4) the t value of the predictor parameter estimate increases, which shows that the new regression is a better fit to the dataset (and the associated P value decreases); (5) and the RMSE decreases, which shows that the standard deviation of the residuals decreases and that the new model is a better fit to the observed data points.

**Question 5.**

#add indicator based on first letter of city name  
 #create new indicator variable  
earlyind1 = c(substr(city$City,0, 1) < "M")   
 #create new dataset with new indicator variable earlyind1  
city\_3 = data.frame(city, earlyind = earlyind1)  
  
#fit linear regression model  
city\_3.lm = lm(High\_F~Latitude + earlyind, data = city\_3)  
summary(city\_3.lm)

##   
## Call:  
## lm(formula = High\_F ~ Latitude + earlyind, data = city\_3)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -8.606 -4.223 -2.202 1.158 22.356   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 134.5624 7.0777 19.012 < 2e-16 \*\*\*  
## Latitude -2.2667 0.1876 -12.085 3.61e-16 \*\*\*  
## earlyindTRUE -3.7319 1.8591 -2.007 0.0504 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 6.573 on 48 degrees of freedom  
## Multiple R-squared: 0.7594, Adjusted R-squared: 0.7494   
## F-statistic: 75.77 on 2 and 48 DF, p-value: 1.409e-15

*#f test for overall model*

fcv5 = qf(p=0.05, df1=2, df2=48, lower.tail=F)

cat("F0.05,2,48 critical value for MLR: ", fcv5)

##F0.05,2,48 critical value for MLR: 3.190727

#scatter plot of High\_F vs Latitude with linear model  
ggplot(city\_3, aes(High\_F, Latitude)) + geom\_smooth(method="lm", col=1, color='red', size=0.5, fill='red', alpha=0.2) + geom\_point(aes(High\_F, Latitude), shape=21, size=2, fill='white') + labs(x = "Latitude (decimal degrees)", y = "Temperature (Fahrenheit)") + theme(text = element\_text(size = 15), plot.title=element\_text(hjust=0.5), plot.subtitle=element\_text(hjust = 0.5, face="italic", size=10)) + ggtitle("Average High January Temperature vs. Latitude", subtitle=("(exluding Portland, OR and Seattle, WA)"))

## Warning: Duplicated aesthetics after name standardisation: colour

## `geom\_smooth()` using formula 'y ~ x'

Chart, scatter chart

Description automatically generated

**5A.** To test the significance of the overall fit of the regression model, we will use a right-tailed F test with a null hypothesis (H0) of B1=B2=0, an alternative hypothesis (HA) of Bk≠0 for some k (at least one predictor not equal to 0). We are not given a significance level, but I will assume a significance level of a=0.05. If the F value of the model is beyond the F critical value, we will reject the null hypothesis. Otherwise we will fail to reject the null hypothesis.

Here see that the F value of the model is 75.77 and the F0.05,2,48 critical value is 3.190727. The F value of the model is well beyond the critical value, and we reject the null hypothesis. We can conclude that at least one predictor is not equal to zero and that the overall fit of the MLR model relating average high January temperatures (response) to Latitude and first letter of the city's name (predictors) is significant.

The R2 value for this MLR is 0.7594, which indicates that over 75% of the variance of the average high January temperature is explained by this model. For reference, the original model has an R2 value of 0.7393 and an adjusted R2 value of 0.7339, and this new MLR model has an adjusted R2 of 0.7494.

**5B.** Again, we are not given a significance level criterion for assessing variable significance, but I will assume a significance level of a=0.05. Within this context, the only significant variable is Latitude, which has a P value of 3.61e-16 that is well below the significance level of 0.05 assumed here. This implies that Latitude, while keeping the other predictor constant, significantly changes the mean response of average high January temperature. More specifically, we can be 95% confident that the average high January temperature decreases by -2.2667 degrees Fahrenheit for each degree that Latitude increases above the equator (or decreases below the equator if using extreme extrapolation).

On the other hand, the other predictor, earlyindTRUE, has a P value of 0.0504, higher than our assumed significance level 0.05. This implies that the beginning letter of each city does not significantly change the mean response of average high January temperature, while keeping Latitude constant. If we used a larger significance level, say a=0.1, then this parameter estimate would be significant and we could be 90% confident that first letters of city names (first half of the alphabet vs. second half of alphabet), do affect the predicted average high January temperature.

**5C.** Statistically, the beginning letter of city names could be considered useful for predicting average high January temperatures, IF a reasonably high confidence level were used for the assessment. However, this makes absolutely no sense, as the physical effects of climate are in no way related to arbitrary city names.

If the city name indicator variable were used and did show significance with your chose level of significance for the study, it would be to an underlying, confounding variable. In this example, we see that that both groups have similar mean latitudes, where A to M is 37.4 degrees and N to Z is 37.1 degrees. However, we can also see that cities located near oceans (which greatly affects seasonal temperatures) is unevenly distributed, with the A to M group having five cities near an ocean, and the N to Z group having 13 cities near the ocean. Other examples could include very large sample sizes and/or low sample variance, both of which, could result in statistical significance, but no real practical significance.

To reiterate, this makes zero practical sense, but may mistakenly make statistical sense in some cases.