Assignment 1

Mike Whitley 55503405

07/03/2021

Question 1

Use the data in the file, bodyfat.txt to explore what are useful predictors of body fat. The data is percentage of body fat, age, weight, height, and body circumference measurements (e.g., abdomen) are recorded for 252 men. Body fat, a measure of health, is estimated through an underwater weighing technique. This is time consuming and expensive to undertake and it would be preferable to be able to estimate it with easy-to-measure variables which use only scales or a measuring tape.

```
bodyfat <- read.delim("bodyfat.txt") #read in the bodyfat textfile
head(bodyfat)
```

```
##   Person BodyFat Age Weight Height Neck Chest Abdomen   Hip Thigh Knee Ank
le
## 1      1    12.6  23 154.25  67.75 36.2  93.1    85.2  94.5  59.0 37.3  21
.9
## 2      2     6.9  22 173.25  72.25 38.5  93.6    83.0  98.7  58.7 37.3  23
.4
## 3      3    24.6  22 154.00  66.25 34.0  95.8    87.9  99.2  59.6 38.9  24
.0
## 4      4    10.9  26 184.75  72.25 37.4 101.8    86.4 101.2  60.1 37.3  22
.8
## 5      5    27.8  24 184.25  71.25 34.4  97.3   100.0 101.9  63.2 42.2  24
.0
## 6      6    20.6  24 210.25  74.75 39.0 104.5    94.4 107.8  66.0 42.0  25
.6
##   Biceps Forearm Wrist
## 1   32.0    27.4  17.1
## 2   30.5    28.9  18.2
## 3   28.8    25.2  16.6
## 4   32.4    29.4  18.2
## 5   32.2    27.7  17.7
## 6   35.7    30.6  18.8
```

The variables in the file, bodyfat.txt, are: Person Number Percent body fat Age (yrs) Weight (lbs) Height (inches) Neck circumference (cm) Chest circumference (cm) Abdomen circumference (cm) Hip circumference (cm) Thigh circumference (cm) Knee circumference (cm) Ankle circumference (cm) Extended biceps circumference (cm) Forearm circumference (cm) Wrist circumference (cm)

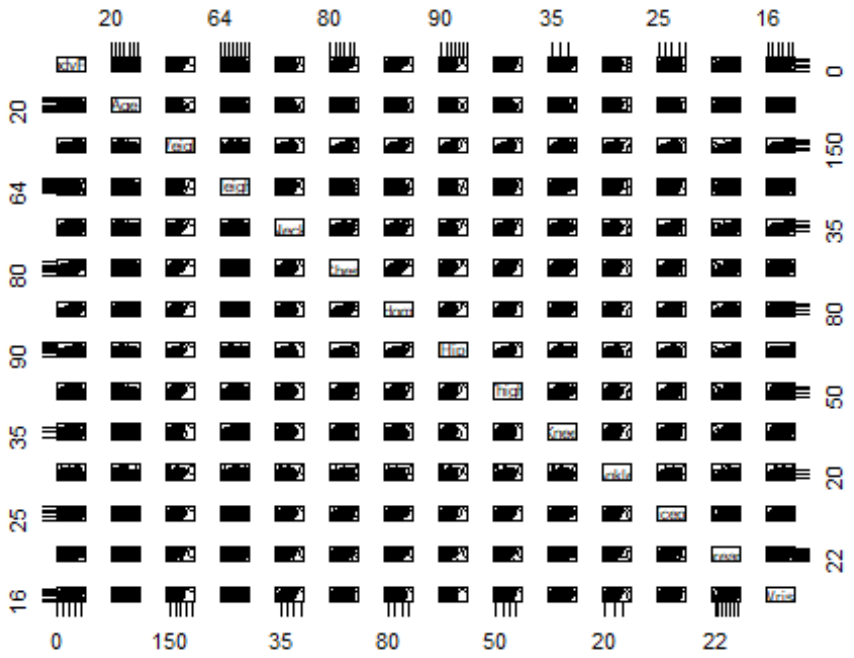
a. What measures are well correlated with body fat? Create a correlation and matrix plot to display this information.

```
cor(bodyfat[, -1]) # correlation matrix for bodyfat excluding the person fiel
d
```

```
##             BodyFat         Age      Weight      Height      Neck     Ches
t
## BodyFat  1.00000000  0.28917352  0.61315611 -0.02452467 0.4914889 0.702885
2
## Age      0.28917352  1.00000000 -0.01274609 -0.24521233 0.1135052 0.176449
7
## Weight   0.61315611 -0.01274609  1.00000000  0.48688800 0.8307162 0.894190
5
## Height  -0.02452467 -0.24521233  0.48688800  1.00000000 0.3211409 0.226828
6
## Neck     0.49148893  0.11350519  0.83071622  0.32114085 1.0000000 0.784835
0
## Chest    0.70288516  0.17644968  0.89419052  0.22682861 0.7848350 1.000000
0
## Abdomen  0.81370622  0.23040942  0.88799494  0.18976623 0.7540774 0.915827
7
## Hip      0.62569993 -0.05033212  0.94088412  0.37210602 0.7349579 0.829419
9
## Thigh    0.56128438 -0.20009576  0.86869354  0.33855758 0.6956973 0.729858
6
## Knee     0.50778587  0.01751569  0.85316739  0.50050052 0.6724050 0.719496
4
## Ankle    0.26678256 -0.10505810  0.61368542  0.39313147 0.4778924 0.482987
9
## Biceps   0.49303089 -0.04116212  0.80041593  0.31850749 0.7311459 0.727907
5
## Forearm  0.36327744 -0.08505555  0.63030143  0.32202734 0.6236603 0.580172
7
## Wrist    0.34757276  0.21353062  0.72977489  0.39777960 0.7448264 0.660162
3
##           Abdomen         Hip      Thigh       Knee      Ankle      Biceps
## BodyFat 0.8137062  0.62569993  0.5612844 0.50778587  0.2667826  0.49303089
## Age     0.2304094 -0.05033212 -0.2000958 0.01751569 -0.1050581 -0.04116212
## Weight  0.8879949  0.94088412  0.8686935 0.85316739  0.6136854  0.80041593
## Height  0.1897662  0.37210602  0.3385576 0.50050052  0.3931315  0.31850749
## Neck    0.7540774  0.73495788  0.6956973 0.67240498  0.4778924  0.73114592
## Chest   0.9158277  0.82941992  0.7298586 0.71949640  0.4829879  0.72790748
## Abdomen 1.0000000  0.87406618  0.7666239 0.73717888  0.4532227  0.68498272
## Hip     0.8740662  1.00000000  0.8964098 0.82347262  0.5583868  0.73927252
## Thigh   0.7666239  0.89640979  1.0000000 0.79917030  0.5397971  0.76147745
## Knee    0.7371789  0.82347262  0.7991703 1.00000000  0.6116082  0.67870883
## Ankle   0.4532227  0.55838682  0.5397971 0.61160820  1.0000000  0.48485454
```

```
## Biceps  0.6849827  0.73927252  0.7614774 0.67870883  0.4848545  1.00000000
## Forearm 0.5033161  0.54501412  0.5668422 0.55589819  0.4190500  0.67825513
## Wrist   0.6198324  0.63008954  0.5586848 0.66450729  0.5661946  0.63212642
##             Forearm     Wrist
## BodyFat  0.36327744 0.3475728
## Age     -0.08505555 0.2135306
## Weight   0.63030143 0.7297749
## Height   0.32202734 0.3977796
## Neck     0.62366027 0.7448264
## Chest    0.58017273 0.6601623
## Abdomen  0.50331609 0.6198324
## Hip      0.54501412 0.6300895
## Thigh    0.56684218 0.5586848
## Knee     0.55589819 0.6645073
## Ankle    0.41904999 0.5661946
## Biceps   0.67825513 0.6321264
## Forearm  1.00000000 0.5855883
## Wrist    0.58558825 1.0000000
```

```
pairs(bodyfat[, -1]) #matrix plot for bodyfat excluding the person field
```



b. By looking at the graphs and correlations, what are the two most useful measures of body fat?

Chest, abdomen, hip, thigh, weight - these look quite linear when looking graphically

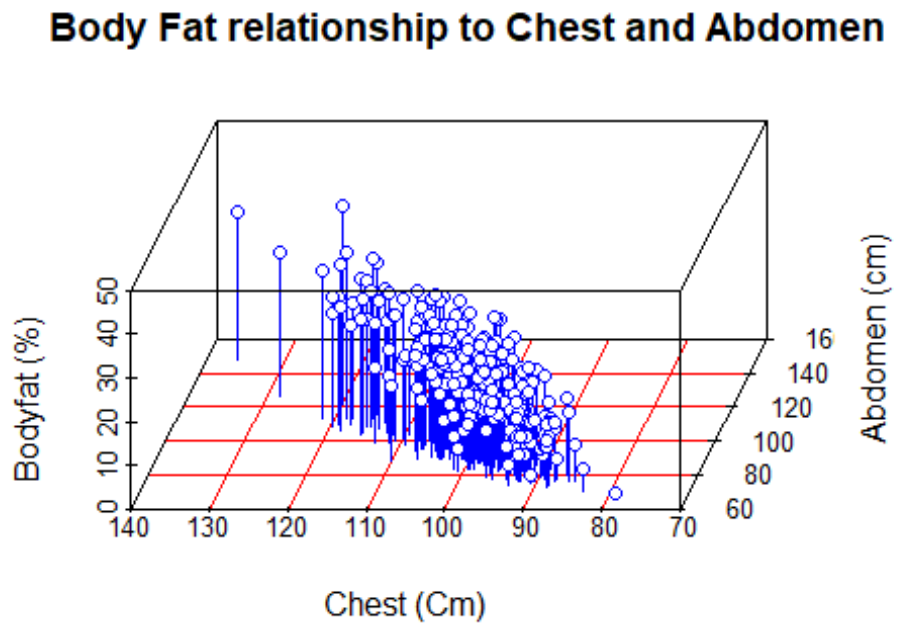
by looking at the matrix plot we can identity these following variables visually show a stronger correlation to body fat

chest 0.70288516 abdomen 0.81370622 hip 0.62569993 thigh 0.56128438 weight 0.61315611

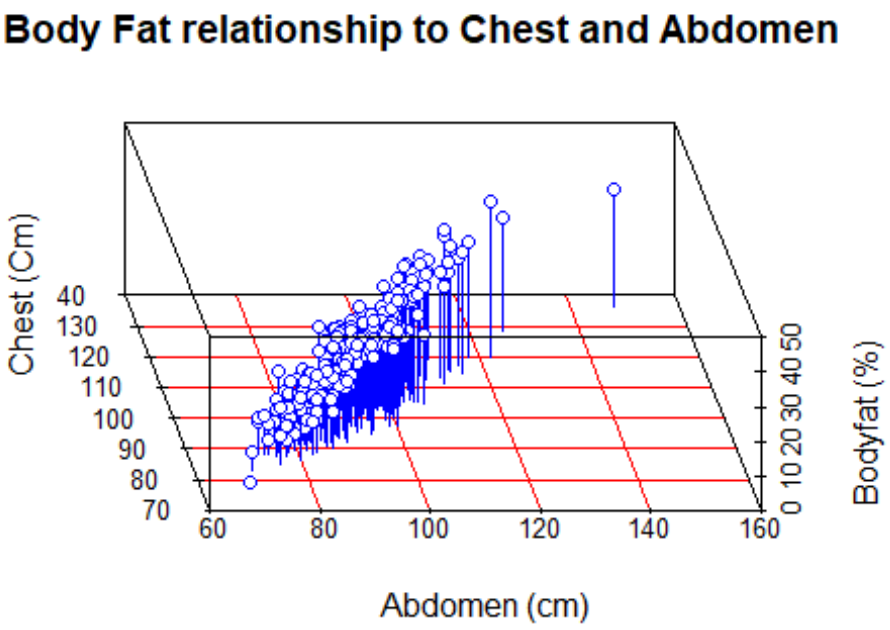
Looking at these specific variables using the correlation matrix we can see the variables of abdomen and chest show the highest strong positive correlation to body fat

c. Create a sensible 3-D plot with these two measures and body fat. Describe what information is in the graph.

```
library(scatterplot3d)
with(bodyfat, scatterplot3d(Abdomen, Chest, BodyFat, type = "h", color="blue"
, angle = 250, pch = 21,xlab="Abdomen (cm)", ylab="Chest (Cm)",zlab = "Bodyfa
t (%)", col.grid = "red",main="Body Fat relationship to Chest and Abdomen"))
# angle 1
```




```
with(bodyfat, scatterplot3d(Abdomen, Chest, BodyFat, type = "h", color="blue"
, angle = 100, pch = 21,xlab="Abdomen (cm)", ylab="Chest (Cm)",zlab = "Bodyfa
t (%)",col.grid = "red",main="Body Fat relationship to Chest and Abdomen")) #
angle 2
```

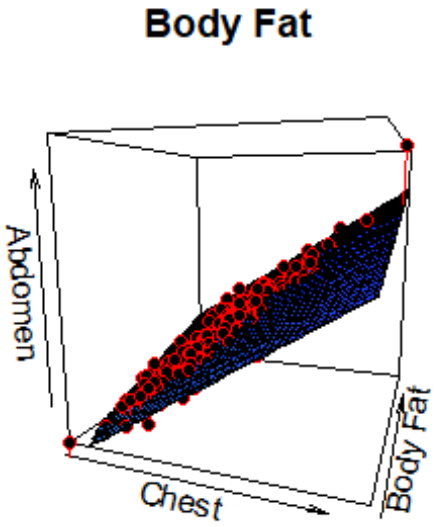



```
with(bodyfat, scatterplot3d(Abdomen, Chest, BodyFat, type = "h", color="blue"
, angle = 50, pch = 21,xlab="Abdomen (cm)", ylab="Chest (Cm)",zlab = "Bodyfat
(%)",col.grid = "red",main="Body Fat relationship to Chest and Abdomen")) # a
ngle 3

#two different angles to for clarity simple to understand an increasing trend
for bodyfat % increase with relation to chest and abdomen size
```

In this graph we can see a close linear trend as the size of the chest and abdomen increase the body fat in turn increases

```
library("plot3D")

#3D Regression Plotting

#code taken from https://rpubs.com/pjozefek/576206

# set the x, y, and z variables
x <- bodyfat$Chest
y <- bodyfat$BodyFat
z <- bodyfat$Abdomen

# Compute the linear regression
fit <- lm(z ~ x + y)

# create a grid from the x and y values (min to max) and predict values for e
very point
```

```
# this will become the regression plane
grid.lines = 40
x.pred <- seq(min(x), max(x), length.out = grid.lines)
y.pred <- seq(min(y), max(y), length.out = grid.lines)
xy <- expand.grid( x = x.pred, y = y.pred)
z.pred <- matrix(predict(fit, newdata = xy),
                 nrow = grid.lines, ncol = grid.lines)

# create the fitted points for droplines to the surface
fitpoints <- predict(fit)

# scatter plot with regression plane
scatter3D(x, y, z, pch = 21, cex = 1,colvar = NULL, col="red",
          theta = 20, phi = 10, bty="b",
          xlab = "Chest", ylab = "Body Fat", zlab = "Abdomen",
          surf = list(x = x.pred, y = y.pred, z = z.pred,
                      facets = TRUE, fit = fitpoints, col=ramp.col (col = c("
dodgerblue3","blue"), n = 300, alpha=0.9), border="black"), main = "Body Fat"
)
```




```
#another 3D plot given with with a 3D regression line shows overall increase
```

d. Use the variable age to group the data into two age-groups (you can choose what these groups are). Use side-by-side box plots, or some better graphic, to compare body fat between the two age-groups.

```
#split in to two age groups one being below the age of 45 where middle age st
arts and the other middle age and higher this also gives around half to each
split
fortyfive_or_younger <- subset(bodyfat, Age < 45) #gives me a df of all the a
ges 45 and lower for interest
summary(fortyfive_or_younger)
```

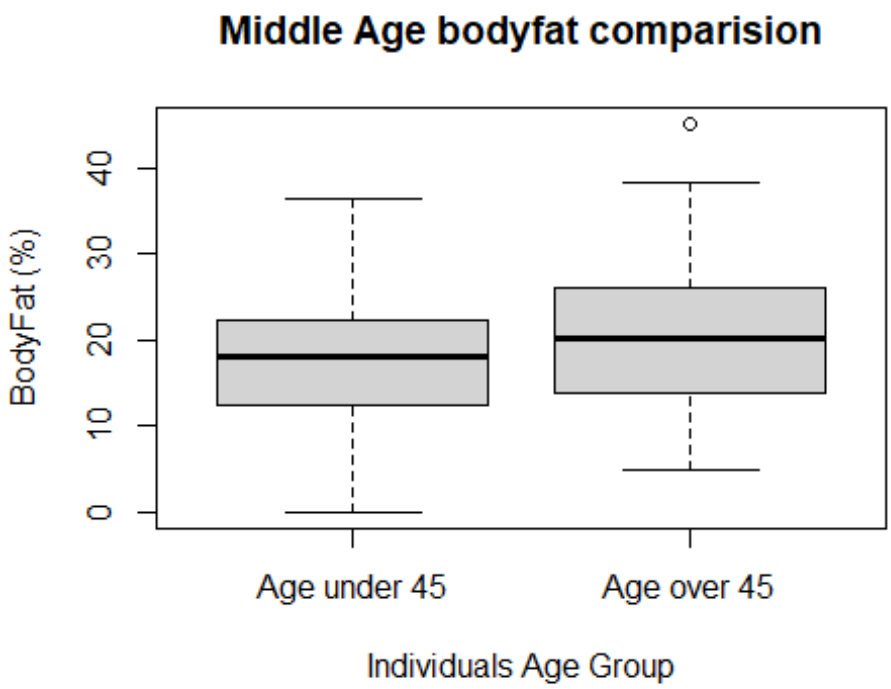
```
##      Person          BodyFat           Age            Weight
##  Min.   :  1.00   Min.   : 0.00   Min.   :22.00   Min.   :118.5
##  1st Qu.: 34.75   1st Qu.:12.38   1st Qu.:28.75   1st Qu.:159.6
##  Median :137.50   Median :18.00   Median :37.50   Median :177.2
##  Mean   :115.13   Mean   :17.80   Mean   :35.52   Mean   :179.3
##  3rd Qu.:173.25   3rd Qu.:22.40   3rd Qu.:41.25   3rd Qu.:198.8
##  Max.   :207.00   Max.   :36.50   Max.   :44.00   Max.   :247.2
##      Height           Neck           Chest           Abdomen
##  Min.   :64.75   Min.   :31.10   Min.   : 79.30   Min.   : 69.40
##  1st Qu.:69.00   1st Qu.:36.20   1st Qu.: 93.50   1st Qu.: 83.58
##  Median :70.75   Median :37.85   Median : 99.10   Median : 90.30
##  Mean   :70.75   Mean   :37.76   Mean   : 99.74   Mean   : 90.93
##  3rd Qu.:72.50   3rd Qu.:39.12   3rd Qu.:104.67   3rd Qu.: 98.22
##  Max.   :77.50   Max.   :43.90   Max.   :121.60   Max.   :115.90
##       Hip             Thigh           Knee           Ankle
##  Min.   : 85.00   Min.   :47.2   Min.   :33.50   Min.   :20.20
##  1st Qu.: 96.03   1st Qu.:57.3   1st Qu.:36.80   1st Qu.:22.10
##  Median : 99.85   Median :60.0   Median :38.70   Median :23.00
##  Mean   :100.21   Mean   :60.3   Mean   :38.64   Mean   :23.23
##  3rd Qu.:104.15   3rd Qu.:63.5   3rd Qu.:40.00   3rd Qu.:24.10
##  Max.   :116.10   Max.   :74.4   Max.   :45.00   Max.   :33.90
##      Biceps          Forearm          Wrist
##  Min.   :24.80   Min.   :21.00   Min.   :16.10
##  1st Qu.:30.50   1st Qu.:27.40   1st Qu.:17.40
##  Median :32.15   Median :28.70   Median :18.10
##  Mean   :32.42   Mean   :28.76   Mean   :18.06
##  3rd Qu.:34.33   3rd Qu.:30.10   3rd Qu.:18.70
##  Max.   :39.10   Max.   :34.90   Max.   :20.10
```

```
fortyfive_or_older <- subset(bodyfat, Age >= 45) #gives me a df of all the ag
es 45 and over for interest
summary(fortyfive_or_older)
```

```
##      Person          BodyFat           Age            Weight
##  Min.   : 36.00   Min.   : 5.00   Min.   :45.00   Min.   :125.0
##  1st Qu.: 73.75   1st Qu.:13.95   1st Qu.:49.00   1st Qu.:157.8
##  Median :110.50   Median :20.10   Median :54.00   Median :174.9
##  Mean   :139.83   Mean   :20.28   Mean   :55.86   Mean   :178.5
##  3rd Qu.:223.25   3rd Qu.:26.02   3rd Qu.:62.00   3rd Qu.:196.8
##  Max.   :252.00   Max.   :45.10   Max.   :81.00   Max.   :363.1
##      Height           Neck           Chest           Abdomen
##  Min.   :64.00   Min.   :32.80   Min.   : 83.40   Min.   : 70.40
##  1st Qu.:67.50   1st Qu.:36.67   1st Qu.: 95.95   1st Qu.: 86.47
```

```
##  Median :69.75   Median :38.00   Median :100.55   Median : 93.65
##  Mean   :69.79   Mean   :38.26   Mean   :102.10   Mean   : 94.46
##  3rd Qu.:71.81   3rd Qu.:40.20   3rd Qu.:106.53   3rd Qu.:100.00
##  Max.   :77.75   Max.   :51.20   Max.   :136.20   Max.   :148.10
##       Hip             Thigh           Knee           Ankle
##  Min.   : 87.20   Min.   :49.30   Min.   :33.00   Min.   :19.10
##  1st Qu.: 94.95   1st Qu.:55.00   1st Qu.:37.17   1st Qu.:21.98
##  Median : 98.35   Median :58.15   Median :38.30   Median :22.65
##  Mean   : 99.55   Mean   :58.36   Mean   :38.53   Mean   :22.95
##  3rd Qu.:102.28   3rd Qu.:61.00   3rd Qu.:39.62   3rd Qu.:23.52
##  Max.   :147.70   Max.   :87.30   Max.   :49.10   Max.   :33.70
##      Biceps          Forearm         Wrist
##  Min.   :25.30   Min.   :22.00   Min.   :15.80
##  1st Qu.:29.77   1st Qu.:27.30   1st Qu.:17.88
##  Median :31.75   Median :28.75   Median :18.40
##  Mean   :32.10   Mean   :28.55   Mean   :18.43
##  3rd Qu.:34.33   3rd Qu.:29.90   3rd Qu.:19.00
##  Max.   :45.00   Max.   :32.70   Max.   :21.40
```

```
# box-plot of CBL for each Island using formula interface
with(bodyfat, boxplot(BodyFat ~ Age >= 45, names=c("Age under 45","Age over 4
5" ),main="Middle Age bodyfat comparision",xlab="Individuals Age Group",ylab=
"BodyFat (%)"))
```

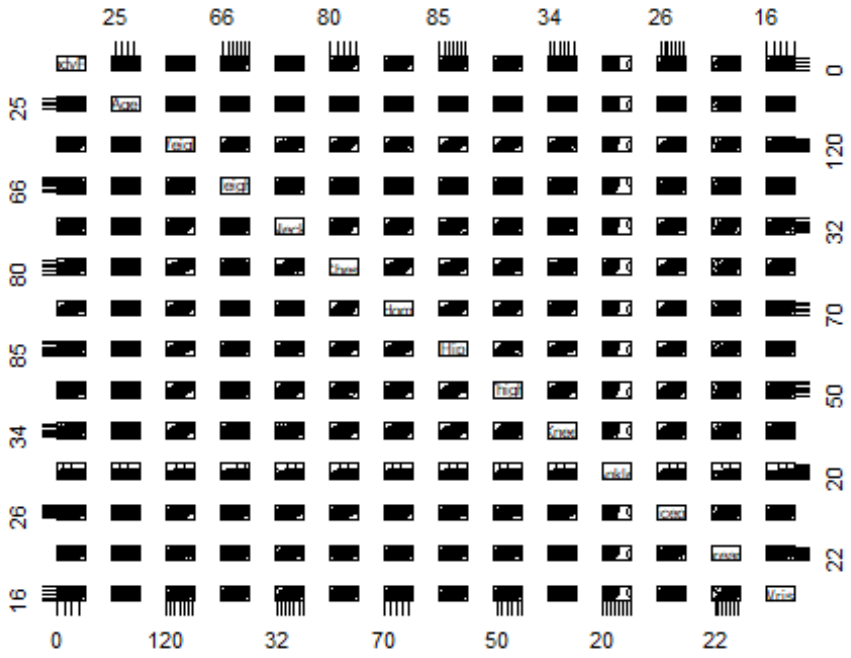


We can see that people aged over 45 in general have higher body fat % compared to those under the age of 45

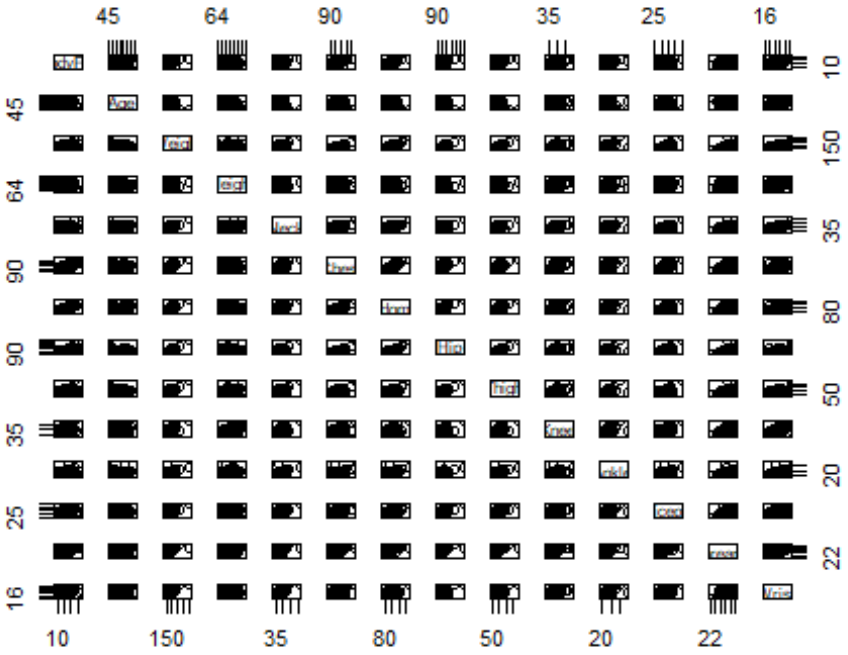
e. Revisit your correlation analysis when the data was looked at altogether, and repeat this analysis for the two groups separately. Do any of your findings change when the age groups were looked at separately?

repeated steps a and b with the seperated data using our two variables fortyfive_or_younger and fortyfive_or_older and defined above

```
pairs(fortyfive_or_younger[, -1]) #matrix plot for bodyfat excluding the pers
on field for the grouping age of 45 or younger
```




```
pairs(fortyfive_or_older[, -1]) #matrix plot for bodyfat excluding the person
field  for the grouping age of 45 or older
```



we can see for the the grouping of under 45 it is easier to tell which 2 variables have the closet relationship as we can see that chest, abdomen, thigh and weight are all very similar in a more linear pattern where as with over the age of 45 grouping its slightly different with weight, neck, chest abdomen, hip, thigh all looking very similar.

```
cor(fortyfive_or_younger[, -1]) # correlation matrix for bodyfat excluding th
e person field for the grouping age of 45 or younger
```

```
##             BodyFat         Age     Weight      Height       Neck     Chest
## BodyFat   1.0000000  0.30658047 0.59136605  0.05009620 0.40521850 0.6354107
## Age       0.3065805  1.00000000 0.04322493 -0.08275698 0.03102424 0.1220892
## Weight    0.5913661  0.04322493 1.00000000  0.58092696 0.81246134 0.9027067
## Height    0.0500962 -0.08275698 0.58092696  1.00000000 0.39145289 0.3391483
## Neck      0.4052185  0.03102424 0.81246134  0.39145289 1.00000000 0.7750238
## Chest     0.6354107  0.12208923 0.90270667  0.33914828 0.77502377 1.0000000
## Abdomen   0.7957190  0.20580608 0.89097468  0.31029713 0.70536555 0.8893188
## Hip       0.6248136  0.01538198 0.94428440  0.47837237 0.71548448 0.8463877
## Thigh     0.6384637 -0.02692919 0.89021991  0.38053074 0.69815284 0.7927079
## Knee      0.5509987  0.05928264 0.88024783  0.53656713 0.64500364 0.7658975
## Ankle     0.2306279 -0.09329161 0.62202205  0.49727921 0.45227998 0.5125657
## Biceps    0.5015663  0.04546803 0.84547591  0.40087518 0.75648276 0.7613843
## Forearm   0.3148923 -0.06068804 0.61460748  0.31882205 0.60534023 0.5384155
## Wrist     0.2285023 -0.01499604 0.76887295  0.50317918 0.72259181 0.6611071
##             Abdomen        Hip       Thigh       Knee       Ankle     Biceps
## BodyFat   0.7957190 0.62481364  0.63846370 0.55099870  0.23062794 0.50156634
## Age       0.2058061 0.01538198 -0.02692919 0.05928264 -0.09329161 0.04546803
## Weight    0.8909747 0.94428440  0.89021991 0.88024783  0.62202205 0.84547591
```

```
## Height  0.3102971 0.47837237  0.38053074 0.53656713  0.49727921 0.40087518
## Neck    0.7053655 0.71548448  0.69815284 0.64500364  0.45227998 0.75648276
## Chest   0.8893188 0.84638775  0.79270790 0.76589748  0.51256574 0.76138427
## Abdomen 1.0000000 0.88880610  0.84965988 0.80316576  0.45827802 0.71384441
## Hip     0.8888061 1.00000000  0.92324335 0.87767185  0.56701671 0.78508826
## Thigh   0.8496599 0.92324335  1.00000000 0.82893763  0.52601565 0.81193551
## Knee    0.8031658 0.87767185  0.82893763 1.00000000  0.61758912 0.75516547
## Ankle   0.4582780 0.56701671  0.52601565 0.61758912  1.00000000 0.51381600
## Biceps  0.7138444 0.78508826  0.81193551 0.75516547  0.51381600 1.00000000
## Forearm 0.4780608 0.52885118  0.52266656 0.51653912  0.39604648 0.62855914
## Wrist   0.5805400 0.67541800  0.63142764 0.66399569  0.63481884 0.68507234
##             Forearm       Wrist
## BodyFat  0.31489230  0.22850230
## Age     -0.06068804 -0.01499604
## Weight   0.61460748  0.76887295
## Height   0.31882205  0.50317918
## Neck     0.60534023  0.72259181
## Chest    0.53841551  0.66110712
## Abdomen  0.47806084  0.58054003
## Hip      0.52885118  0.67541800
## Thigh    0.52266656  0.63142764
## Knee     0.51653912  0.66399569
## Ankle    0.39604648  0.63481884
## Biceps   0.62855914  0.68507234
## Forearm  1.00000000  0.56129923
## Wrist    0.56129923  1.00000000
```

```
cor(fortyfive_or_older[, -1]) # correlation matrix for bodyfat excluding the
person field for the grouping age of 45 or older
```

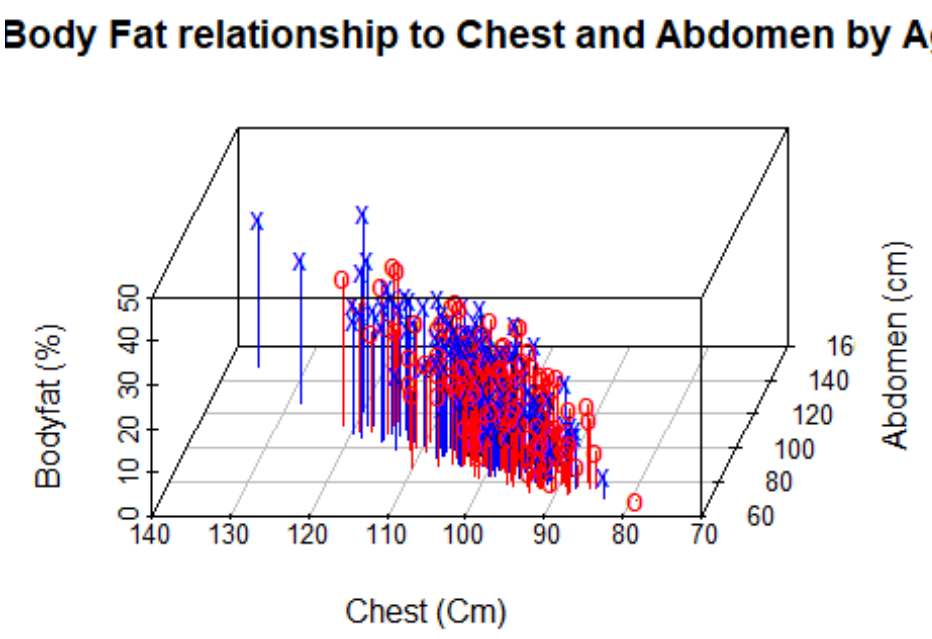
```
##             BodyFat         Age      Weight      Height       Neck      Ch
est
## BodyFat  1.00000000  0.24548759  0.65537231 -0.04112611 0.56531679 0.75472
836
## Age      0.24548759  1.00000000 -0.04121463 -0.24572663 0.06930127 0.09820
099
## Weight   0.65537231 -0.04121463  1.00000000  0.40733573 0.86174368 0.90768
028
## Height  -0.04112611 -0.24572663  0.40733573  1.00000000 0.30296753 0.18527
250
## Neck     0.56531679  0.06930127  0.86174368  0.30296753 1.00000000 0.79098
442
## Chest    0.75472836  0.09820099  0.90768028  0.18527250 0.79098442 1.00000
000
## Abdomen  0.82221938  0.13760004  0.91323970  0.14771800 0.79685523 0.93576
494
## Hip      0.65964638 -0.05392815  0.93960021  0.27321662 0.77432032 0.84389
365
## Thigh    0.57704749 -0.15559100  0.87930340  0.24121746 0.77368223 0.76897
046
```

```
## Knee     0.48347731  0.06510145  0.82762639  0.47118991 0.71604740 0.69848
910
## Ankle    0.34032466 -0.03565497  0.60792558  0.27238964 0.53110358 0.49182
283
## Biceps   0.51660925 -0.03387835  0.75782173  0.22594383 0.72661458 0.72883
462
## Forearm  0.45677634 -0.09009426  0.65842712  0.32114771 0.67326836 0.66835
405
## Wrist    0.42598489  0.20230120  0.72581871  0.39530149 0.76342873 0.64384
469
##           Abdomen         Hip      Thigh       Knee       Ankle      Bicep
s
## BodyFat 0.8222194  0.65964638  0.5770475 0.48347731  0.34032466  0.5166092
5
## Age     0.1376000 -0.05392815 -0.1555910 0.06510145 -0.03565497 -0.0338783
5
## Weight  0.9132397  0.93960021  0.8793034 0.82762639  0.60792558  0.7578217
3
## Height  0.1477180  0.27321662  0.2412175 0.47118991  0.27238964  0.2259438
3
## Neck    0.7968552  0.77432032  0.7736822 0.71604740  0.53110358  0.7266145
8
## Chest   0.9357649  0.84389365  0.7689705 0.69848910  0.49182283  0.7288346
2
## Abdomen 1.0000000  0.89964757  0.8008177 0.70257587  0.49145223  0.6963269
3
## Hip     0.8996476  1.00000000  0.8992280 0.77684008  0.54962909  0.6984315
7
## Thigh   0.8008177  0.89922796  1.0000000 0.78542289  0.54915826  0.7148044
9
## Knee    0.7025759  0.77684008  0.7854229 1.00000000  0.60642366  0.5958357
2
## Ankle   0.4914522  0.54962909  0.5491583 0.60642366  1.00000000  0.4508551
7
## Biceps  0.6963269  0.69843157  0.7148045 0.59583572  0.45085517  1.0000000
0
## Forearm 0.5759921  0.57326686  0.6321221 0.60904990  0.44628383  0.7438943
4
## Wrist   0.6334876  0.63226201  0.6029853 0.70250050  0.55681770  0.6266655
8
##             Forearm     Wrist
## BodyFat  0.45677634 0.4259849
## Age     -0.09009426 0.2023012
## Weight   0.65842712 0.7258187
## Height   0.32114771 0.3953015
## Neck     0.67326836 0.7634287
## Chest    0.66835405 0.6438447
## Abdomen  0.57599214 0.6334876
## Hip      0.57326686 0.6322620
## Thigh    0.63212213 0.6029853
```

```
## Knee     0.60904990 0.7025005
## Ankle    0.44628383 0.5568177
## Biceps   0.74389434 0.6266656
## Forearm  1.00000000 0.6709860
## Wrist    0.67098598 1.0000000
```

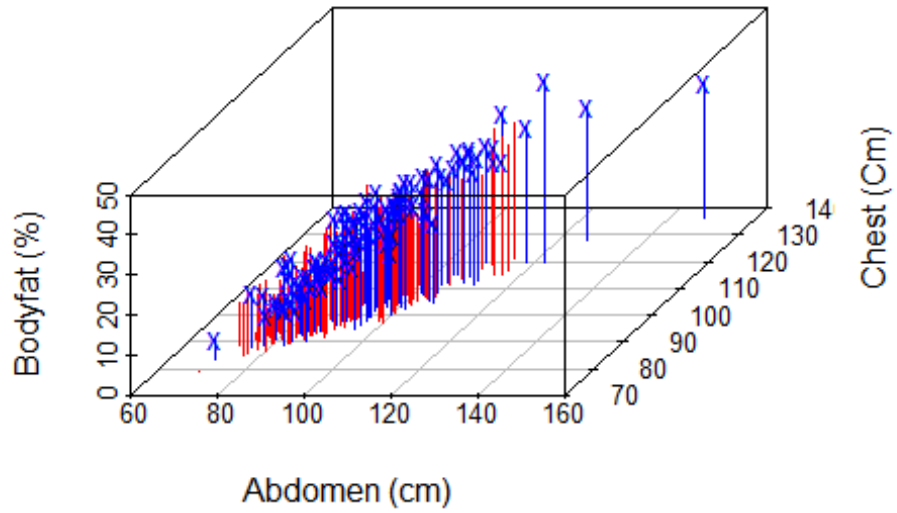
Looking at the identified variables for the grouping of under the age of 45. Abdomen and Thigh are the two variables with the highest correlation however, Chest is very close to thigh with a difference of only 0.003053. for the over the age of 45 grouping Abdomen and Chest are the two variables with the highest correlation. This indicates that for the original data it is being skewed by the individuals over the age of 45 for the chest measurement.

```
bodyfat$underAge45 <- with(bodyfat, ifelse(Age<45, 1, 0)) #if the individual
is in the group of under 45 assign a 1 else assign a 0

# if they are under 45 its red else its blue
with(bodyfat, scatterplot3d(Abdomen, Chest, BodyFat, type = "h", angle = 250,
xlab="Abdomen (cm)", ylab="Chest (Cm)",zlab = "Bodyfat (%)", main="Body Fat r
elationship to Chest and Abdomen by Age", #plot 3
color = ifelse(underAge45 == 1, "red", "blue"),
pch = ifelse(underAge45 == 1, "o", "x")))
```




```
with(bodyfat, scatterplot3d(Abdomen, Chest, BodyFat, type = "h", angle = 60,x
lab="Abdomen (cm)", ylab="Chest (Cm)",zlab = "Bodyfat (%)",main="Body Fat rel
ationship to Chest and Abdomen by Age", #plot 3
color = ifelse(underAge45 == 1, "red", "blue"),
pch = ifelse(underAge45 == 1, "", "x")))
```

Body Fat relationship to Chest and Abdomen by Age




```
#two different angles given for clarity
```

we can see that there is a slight difference when we split by age groupings but this is more evident with an increase in bodyfat % for ages over 45 fitting with conventional logic of losing muscle mass as we age. However, the trend of splitting ages fits the same as the overall trend of our combined data.