BodyFat

S18809

2024-04-04

```
# Load the Libraries
library(psych) # Factor Analysis
library(lavaan) # Confirmatory Analysis
```

```
## This is lavaan 0.6-17
## lavaan is FREE software! Please report any bugs.
```

```
##
## Attaching package: 'lavaan'
```

```
## The following object is masked from 'package:psych':
##
##     cor2cov
```

```
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```
# Load the data set
dat <- read.csv(file.choose(),header = TRUE)
head(dat,10)
```

```
##    Density BodyFat Age Weight Height Neck Chest Abdomen   Hip Thigh Knee Ankle
## 1   1.0708    12.3  23 154.25  67.75 36.2  93.1    85.2  94.5  59.0 37.3  21.9
## 2   1.0853     6.1  22 173.25  72.25 38.5  93.6    83.0  98.7  58.7 37.3  23.4
## 3   1.0414    25.3  22 154.00  66.25 34.0  95.8    87.9  99.2  59.6 38.9  24.0
## 4   1.0751    10.4  26 184.75  72.25 37.4 101.8    86.4 101.2  60.1 37.3  22.8
## 5   1.0340    28.7  24 184.25  71.25 34.4  97.3   100.0 101.9  63.2 42.2  24.0
## 6   1.0502    20.9  24 210.25  74.75 39.0 104.5    94.4 107.8  66.0 42.0  25.6
## 7   1.0549    19.2  26 181.00  69.75 36.4 105.1    90.7 100.3  58.4 38.3  22.9
## 8   1.0704    12.4  25 176.00  72.50 37.8  99.6    88.5  97.1  60.0 39.4  23.2
## 9   1.0900     4.1  25 191.00  74.00 38.1 100.9    82.5  99.9  62.9 38.3  23.8
## 10  1.0722    11.7  23 198.25  73.50 42.1  99.6    88.6 104.1  63.1 41.7  25.0
##    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
## 7    31.9    27.8  17.7
## 8    30.5    29.0  18.8
## 9    35.9    31.1  18.2
## 10   35.6    30.0  19.2
```

```r
# Check the null value
sum(is.na(dat))
```

```
## [1] 0
```

```r
str(dat)
```

```
## 'data.frame':    252 obs. of  15 variables:
##  $ Density: num  1.07 1.09 1.04 1.08 1.03 ...
##  $ BodyFat: num  12.3 6.1 25.3 10.4 28.7 20.9 19.2 12.4 4.1 11.7 ...
##  $ Age    : int  23 22 22 26 24 24 26 25 25 23 ...
##  $ Weight : num  154 173 154 185 184 ...
##  $ Height : num  67.8 72.2 66.2 72.2 71.2 ...
##  $ Neck   : num  36.2 38.5 34 37.4 34.4 39 36.4 37.8 38.1 42.1 ...
##  $ Chest  : num  93.1 93.6 95.8 101.8 97.3 ...
##  $ Abdomen: num  85.2 83 87.9 86.4 100 94.4 90.7 88.5 82.5 88.6 ...
##  $ Hip    : num  94.5 98.7 99.2 101.2 101.9 ...
##  $ Thigh  : num  59 58.7 59.6 60.1 63.2 66 58.4 60 62.9 63.1 ...
##  $ Knee   : num  37.3 37.3 38.9 37.3 42.2 42 38.3 39.4 38.3 41.7 ...
##  $ Ankle  : num  21.9 23.4 24 22.8 24 25.6 22.9 23.2 23.8 25 ...
##  $ Biceps : num  32 30.5 28.8 32.4 32.2 35.7 31.9 30.5 35.9 35.6 ...
##  $ Forearm: num  27.4 28.9 25.2 29.4 27.7 30.6 27.8 29 31.1 30 ...
##  $ Wrist  : num  17.1 18.2 16.6 18.2 17.7 18.8 17.7 18.8 18.2 19.2 ...
```

```r
# Find the dimension of the data set
dim(dat)
```

```
## [1] 252  15
```

```r
# Find the Summary of the data set
summary(dat)
```

```
##     Density         BodyFat          Age            Weight
##  Min.   :0.995   Min.   : 0.00   Min.   :22.00   Min.   :118.5
##  1st Qu.:1.041   1st Qu.:12.47   1st Qu.:35.75   1st Qu.:159.0
##  Median :1.055   Median :19.20   Median :43.00   Median :176.5
##  Mean   :1.056   Mean   :19.15   Mean   :44.88   Mean   :178.9
##  3rd Qu.:1.070   3rd Qu.:25.30   3rd Qu.:54.00   3rd Qu.:197.0
##  Max.   :1.109   Max.   :47.50   Max.   :81.00   Max.   :363.1
##      Height           Neck           Chest           Abdomen
##  Min.   :29.50   Min.   :31.10   Min.   : 79.30   Min.   : 69.40
##  1st Qu.:68.25   1st Qu.:36.40   1st Qu.: 94.35   1st Qu.: 84.58
##  Median :70.00   Median :38.00   Median : 99.65   Median : 90.95
##  Mean   :70.15   Mean   :37.99   Mean   :100.82   Mean   : 92.56
##  3rd Qu.:72.25   3rd Qu.:39.42   3rd Qu.:105.38   3rd Qu.: 99.33
##  Max.   :77.75   Max.   :51.20   Max.   :136.20   Max.   :148.10
##       Hip            Thigh            Knee           Ankle          Biceps
##  Min.   : 85.0   Min.   :47.20   Min.   :33.00   Min.   :19.1   Min.   :24.80
##  1st Qu.: 95.5   1st Qu.:56.00   1st Qu.:36.98   1st Qu.:22.0   1st Qu.:30.20
##  Median : 99.3   Median :59.00   Median :38.50   Median :22.8   Median :32.05
##  Mean   : 99.9   Mean   :59.41   Mean   :38.59   Mean   :23.1   Mean   :32.27
##  3rd Qu.:103.5   3rd Qu.:62.35   3rd Qu.:39.92   3rd Qu.:24.0   3rd Qu.:34.33
##  Max.   :147.7   Max.   :87.30   Max.   :49.10   Max.   :33.9   Max.   :45.00
##     Forearm          Wrist
##  Min.   :21.00   Min.   :15.80
##  1st Qu.:27.30   1st Qu.:17.60
```

```
##  Median :28.70   Median :18.30
##  Mean   :28.66   Mean   :18.23
##  3rd Qu.:30.00   3rd Qu.:18.80
##  Max.   :34.90   Max.   :21.40
```

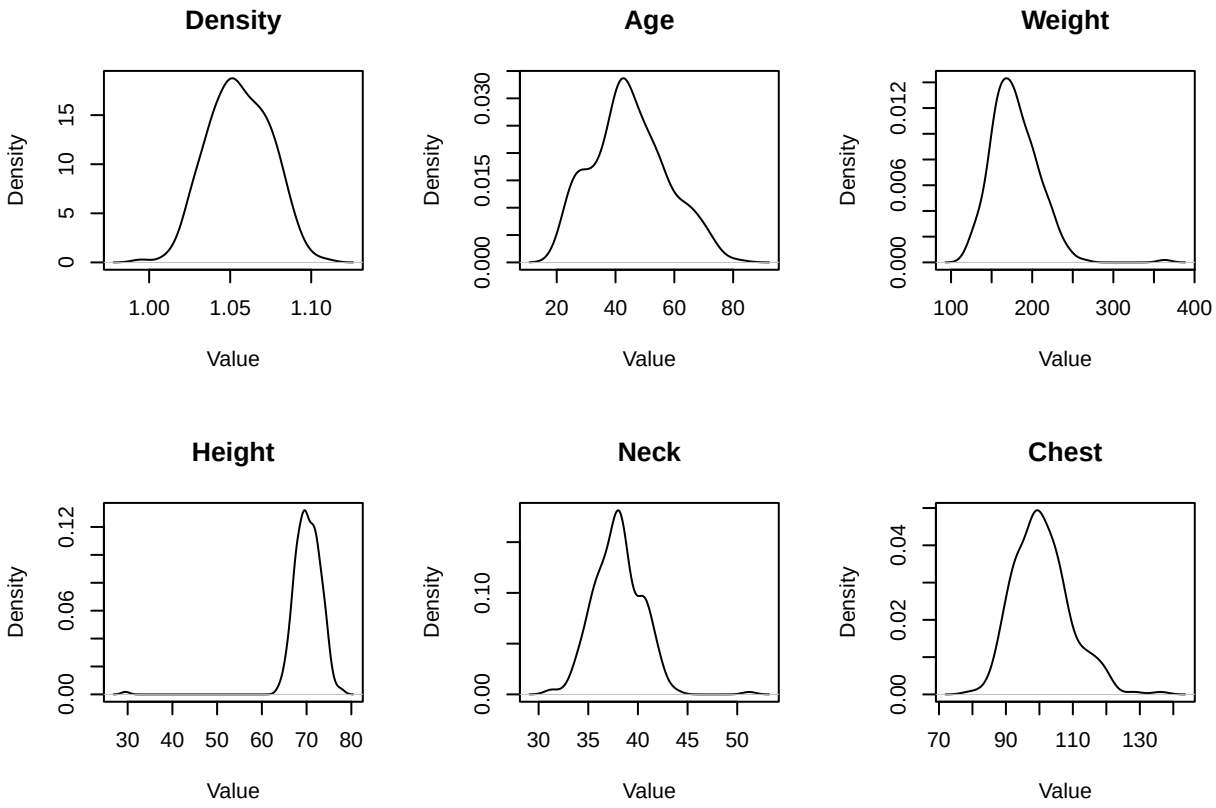
```
bodyFat <- dat[,-2]
```

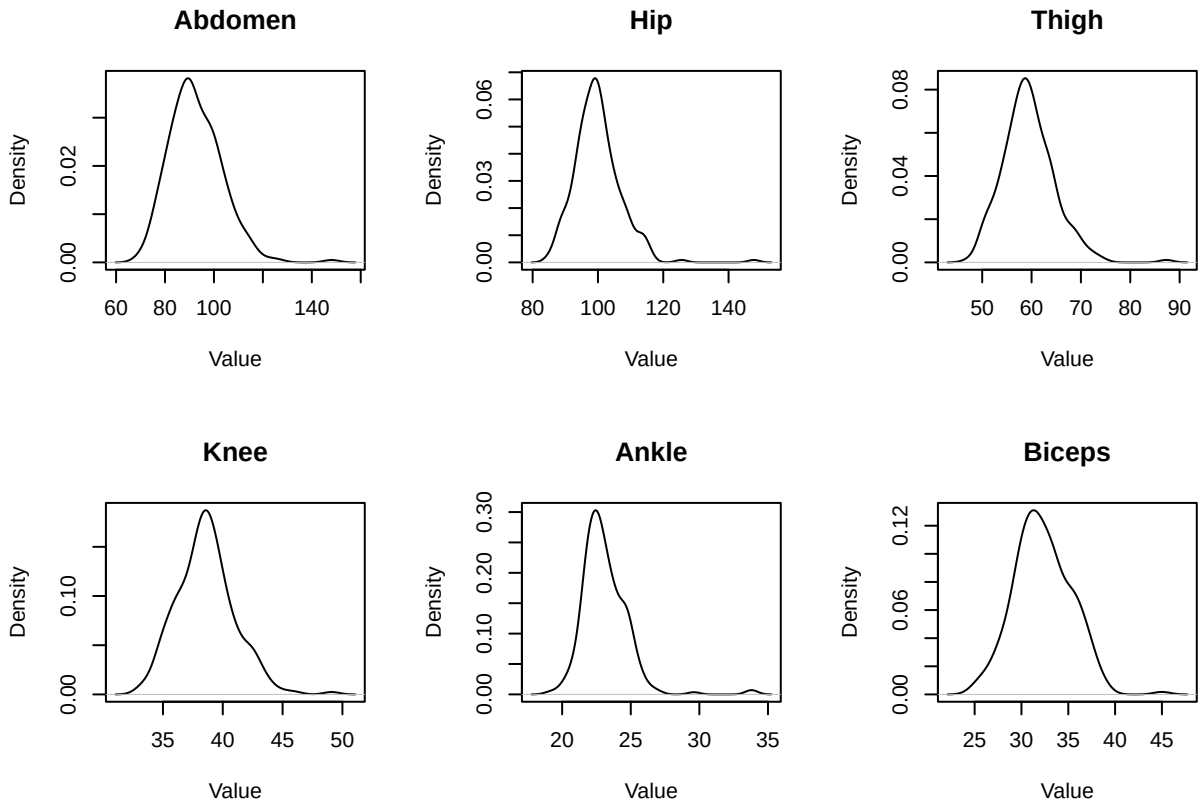
```
head(bodyFat)
```

```
##   Density Age Weight Height Neck Chest Abdomen   Hip Thigh Knee Ankle Biceps
## 1  1.0708  23 154.25  67.75 36.2  93.1    85.2  94.5  59.0 37.3  21.9   32.0
## 2  1.0853  22 173.25  72.25 38.5  93.6    83.0  98.7  58.7 37.3  23.4   30.5
## 3  1.0414  22 154.00  66.25 34.0  95.8    87.9  99.2  59.6 38.9  24.0   28.8
## 4  1.0751  26 184.75  72.25 37.4 101.8    86.4 101.2  60.1 37.3  22.8   32.4
## 5  1.0340  24 184.25  71.25 34.4  97.3   100.0 101.9  63.2 42.2  24.0   32.2
## 6  1.0502  24 210.25  74.75 39.0 104.5    94.4 107.8  66.0 42.0  25.6   35.7
##   Forearm Wrist
## 1    27.4  17.1
## 2    28.9  18.2
## 3    25.2  16.6
## 4    29.4  18.2
## 5    27.7  17.7
## 6    30.6  18.8
```

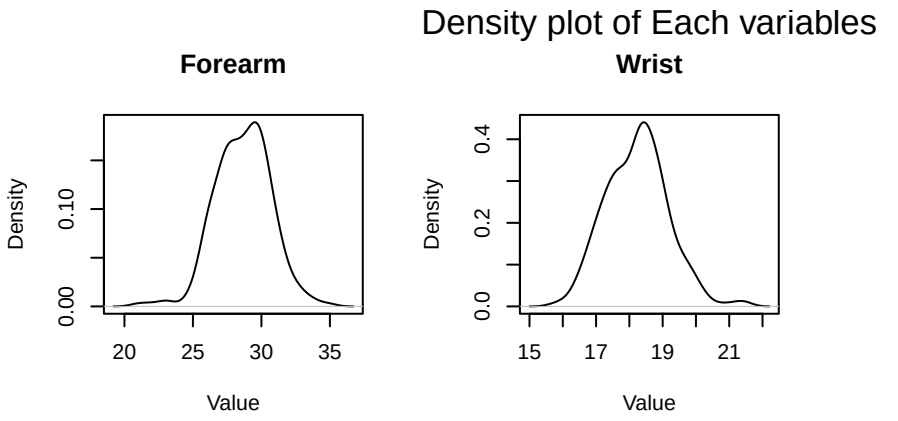
Exploratory Data Analysis

```
#  Draw the Density plot
par(mfrow = c(2,3))
for (col in names(bodyFat)) {
  plot(density(bodyFat[[col]]),
       main = col,
       xlab = "Value",
       ylab = "Density")
}
```


Density
Density
0
5
10
15
1.00
1.05
1.10
Value
Age
Density
0.000
0.015
0.030
20
40
60
80
Value
Weight
Density
0.000
0.006
0.012
100
200
300
400
Value
Height
Density
0.00
0.06
0.12
30
40
50
60
70
80
Value
Neck
Density
0.00
0.10
30
35
40
45
50
Value
Chest
Density
0.00
0.02
0.04
70
90
110
130
Value




```
mtext("Density plot of Each variables",side = 3,line = 3,cex = 1.1)
```

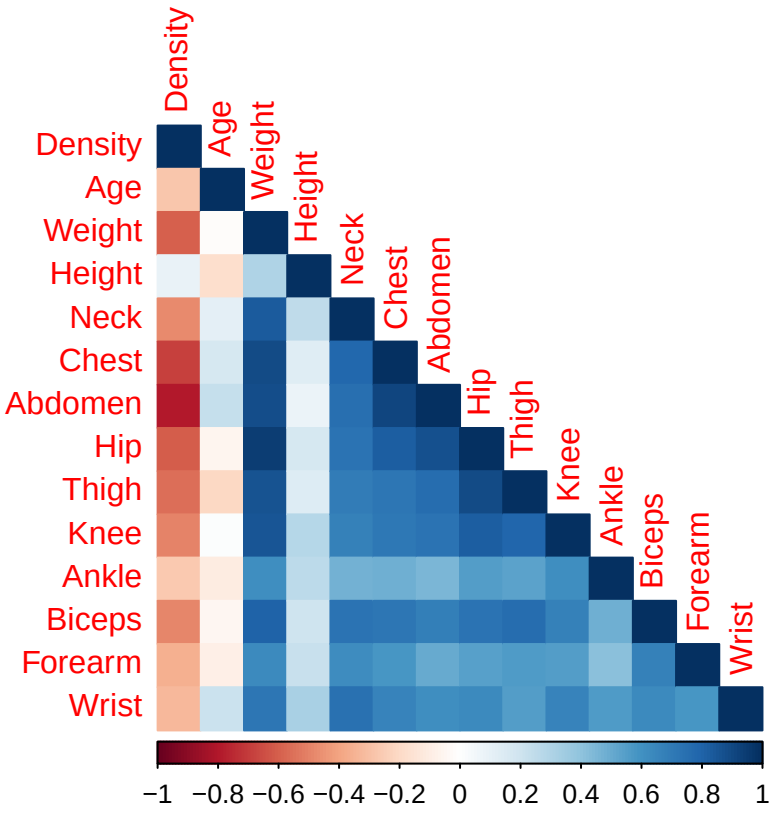



```
# Find the Correlation between each variables
bodyFat.corr <- cor(bodyFat)
bodyFat.corr
```

```
##             Density         Age      Weight      Height       Neck      Chest
## Density  1.00000000 -0.27763721 -0.59406188  0.09788114 -0.4729664 -0.6825987
## Age     -0.27763721  1.00000000 -0.01274609 -0.17164514  0.1135052  0.1764497
## Weight  -0.59406188 -0.01274609  1.00000000  0.30827854  0.8307162  0.8941905
## Height   0.09788114 -0.17164514  0.30827854  1.00000000  0.2537099  0.1348918
## Neck    -0.47296636  0.11350519  0.83071622  0.25370988  1.0000000  0.7848350
## Chest   -0.68259865  0.17644968  0.89419052  0.13489181  0.7848350  1.0000000
## Abdomen -0.79895463  0.23040942  0.88799494  0.08781291  0.7540774  0.9158277
## Hip     -0.60933143 -0.05033212  0.94088412  0.17039426  0.7349579  0.8294199
## Thigh   -0.55309098 -0.20009576  0.86869354  0.14843561  0.6956973  0.7298586
## Knee    -0.49504035  0.01751569  0.85316739  0.28605321  0.6724050  0.7194964
## Ankle   -0.26489003 -0.10505810  0.61368542  0.26474369  0.4778924  0.4829879
## Biceps  -0.48710872 -0.04116212  0.80041593  0.20781557  0.7311459  0.7279075
## Forearm -0.35164842 -0.08505555  0.63030143  0.22864922  0.6236603  0.5801727
## Wrist   -0.32571598  0.21353062  0.72977489  0.32206533  0.7448264  0.6601623
##              Abdomen         Hip      Thigh       Knee      Ankle      Biceps
## Density -0.79895463 -0.60933143 -0.5530910 -0.49504035 -0.2648900 -0.48710872
## Age      0.23040942 -0.05033212 -0.2000958  0.01751569 -0.1050581 -0.04116212
## Weight   0.88799494  0.94088412  0.8686935  0.85316739  0.6136854  0.80041593
## Height   0.08781291  0.17039426  0.1484356  0.28605321  0.2647437  0.20781557
## Neck     0.75407737  0.73495788  0.6956973  0.67240498  0.4778924  0.73114592
## Chest    0.91582767  0.82941992  0.7298586  0.71949640  0.4829879  0.72790748
```

```
## Abdomen  1.00000000  0.87406618  0.7666239  0.73717888  0.4532227  0.68498272
## Hip      0.87406618  1.00000000  0.8964098  0.82347262  0.5583868  0.73927252
## Thigh    0.76662393  0.89640979  1.0000000  0.79917030  0.5397971  0.76147745
## Knee     0.73717888  0.82347262  0.7991703  1.00000000  0.6116082  0.67870883
## Ankle    0.45322269  0.55838682  0.5397971  0.61160820  1.0000000  0.48485454
## Biceps   0.68498272  0.73927252  0.7614774  0.67870883  0.4848545  1.00000000
## Forearm  0.50331609  0.54501412  0.5668422  0.55589819  0.4190500  0.67825513
## Wrist    0.61983243  0.63008954  0.5586848  0.66450729  0.5661946  0.63212642
##             Forearm      Wrist
## Density -0.35164842 -0.3257160
## Age     -0.08505555  0.2135306
## Weight   0.63030143  0.7297749
## Height   0.22864922  0.3220653
## 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
```

```r
# Draw the Corr plots
corrplot(bodyFat.corr,
         method = "color",
         type = "lower")
```




```
# Find the mean of the each variables
apply(bodyFat,2,mean)
```

```
##    Density        Age     Weight     Height       Neck      Chest    Abdomen
##   1.055574  44.884921 178.924405  70.148810  37.992063 100.824206  92.555952
##        Hip      Thigh       Knee      Ankle     Biceps    Forearm      Wrist
##  99.904762  59.405952  38.590476  23.102381  32.273413  28.663889  18.229762
```

```
# Find the Standard deviation of the data
apply(bodyFat,2,var)
```

```
##      Density          Age       Weight       Height         Neck        Chest
## 3.621955e-04 1.588114e+02 8.637227e+02 1.341651e+01 5.909339e+00 7.107292e+01
##      Abdomen          Hip        Thigh         Knee        Ankle       Biceps
## 1.162747e+02 5.132372e+01 2.756200e+01 5.816801e+00 2.872664e+00 9.128095e+00
##      Forearm        Wrist
## 4.083193e+00 8.715808e-01
```

```
# Standardize the data Frame
bodyFat.scale <- apply(bodyFat,2,scale)
head(bodyFat.scale)
```

```
##         Density       Age     Weight     Height       Neck      Chest
## [1,]  0.8000548 -1.736617 -0.8395750 -0.6549014 -0.7371976 -0.9162243
## [2,]  1.5619522 -1.815970 -0.1930782  0.5736482  0.2089488 -0.8569156
## [3,] -0.7447578 -1.815970 -0.8480816 -1.0644180 -1.6422073 -0.5959576
## [4,]  1.0259968 -1.498561  0.1982226  0.5736482 -0.2435560  0.1157460
## [5,] -1.1335882 -1.657265  0.1812095  0.3006371 -1.4776601 -0.4180317
```

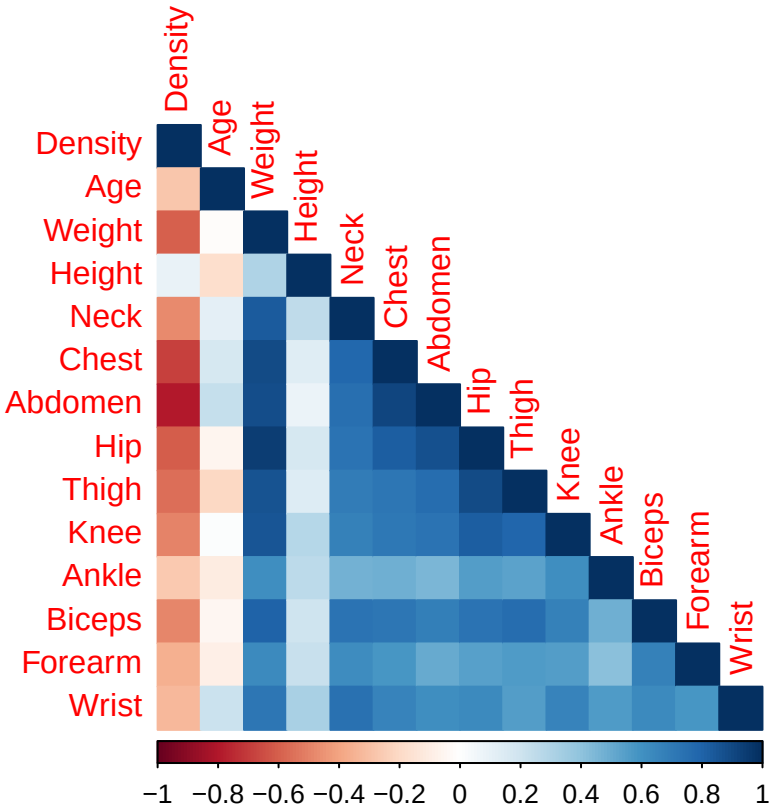
```
## [6,] -0.2823649 -1.657265  1.0658894  1.2561757  0.4146329  0.4360126
##         Abdomen         Hip       Thigh       Knee      Ankle      Biceps
## [1,] -0.6821756 -0.75442747 -0.07732497 -0.5350666 -0.7094139 -0.09049584
## [2,] -0.8861990 -0.16816753 -0.13446835 -0.5350666  0.1755975 -0.58697518
## [3,] -0.4317833 -0.09837468  0.03696179  0.1283370  0.5296021 -1.14965176
## [4,] -0.5708902  0.18079672  0.13220075 -0.5350666 -0.1784071  0.04189865
## [5,]  0.6903454  0.27850671  0.72268234  1.4966071  0.5296021 -0.02429859
## [6,]  0.1710131  1.10206233  1.25602055  1.4136816  1.4736142  1.13415320
##         Forearm       Wrist
## [1,] -0.6254736 -1.21013297
## [2,]  0.1168467 -0.03187916
## [3,] -1.7142099 -1.74570289
## [4,]  0.3642868 -0.03187916
## [5,] -0.4770095 -0.56744908
## [6,]  0.9581430  0.61080474
```

```r
# Find the correlation between each variable in standardized data frame
bodyFat.scale.corr <- cor(bodyFat.scale)
bodyFat.scale.corr
```

```
##             Density         Age      Weight      Height       Neck      Chest
## Density  1.00000000 -0.27763721 -0.59406188  0.09788114 -0.4729664 -0.6825987
## Age     -0.27763721  1.00000000 -0.01274609 -0.17164514  0.1135052  0.1764497
## Weight  -0.59406188 -0.01274609  1.00000000  0.30827854  0.8307162  0.8941905
## Height   0.09788114 -0.17164514  0.30827854  1.00000000  0.2537099  0.1348918
## Neck    -0.47296636  0.11350519  0.83071622  0.25370988  1.0000000  0.7848350
## Chest   -0.68259865  0.17644968  0.89419052  0.13489181  0.7848350  1.0000000
## Abdomen -0.79895463  0.23040942  0.88799494  0.08781291  0.7540774  0.9158277
## Hip     -0.60933143 -0.05033212  0.94088412  0.17039426  0.7349579  0.8294199
## Thigh   -0.55309098 -0.20009576  0.86869354  0.14843561  0.6956973  0.7298586
## Knee    -0.49504035  0.01751569  0.85316739  0.28605321  0.6724050  0.7194964
## Ankle   -0.26489003 -0.10505810  0.61368542  0.26474369  0.4778924  0.4829879
## Biceps  -0.48710872 -0.04116212  0.80041593  0.20781557  0.7311459  0.7279075
## Forearm -0.35164842 -0.08505555  0.63030143  0.22864922  0.6236603  0.5801727
## Wrist   -0.32571598  0.21353062  0.72977489  0.32206533  0.7448264  0.6601623
##             Abdomen         Hip       Thigh        Knee      Ankle      Biceps
## Density -0.79895463 -0.60933143 -0.5530910 -0.49504035 -0.2648900 -0.48710872
## Age      0.23040942 -0.05033212 -0.2000958  0.01751569 -0.1050581 -0.04116212
## Weight   0.88799494  0.94088412  0.8686935  0.85316739  0.6136854  0.80041593
## Height   0.08781291  0.17039426  0.1484356  0.28605321  0.2647437  0.20781557
## Neck     0.75407737  0.73495788  0.6956973  0.67240498  0.4778924  0.73114592
## Chest    0.91582767  0.82941992  0.7298586  0.71949640  0.4829879  0.72790748
## Abdomen  1.00000000  0.87406618  0.7666239  0.73717888  0.4532227  0.68498272
## Hip      0.87406618  1.00000000  0.8964098  0.82347262  0.5583868  0.73927252
## Thigh    0.76662393  0.89640979  1.0000000  0.79917030  0.5397971  0.76147745
## Knee     0.73717888  0.82347262  0.7991703  1.00000000  0.6116082  0.67870883
## Ankle    0.45322269  0.55838682  0.5397971  0.61160820  1.0000000  0.48485454
## Biceps   0.68498272  0.73927252  0.7614774  0.67870883  0.4848545  1.00000000
## Forearm  0.50331609  0.54501412  0.5668422  0.55589819  0.4190500  0.67825513
## Wrist    0.61983243  0.63008954  0.5586848  0.66450729  0.5661946  0.63212642
##             Forearm      Wrist
## Density -0.35164842 -0.3257160
## Age     -0.08505555  0.2135306
## Weight   0.63030143  0.7297749
## Height   0.22864922  0.3220653
```

```
## 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
```

```
# Draw Corr plot for standardized data
corrplot(bodyFat.scale.corr,
         method = "color",
         type = "lower")
```




```
# Calculate the eigen value for standardized data
bodyFat.eigen <- eigen(bodyFat.scale.corr)
bodyFat.eigen
```

```
## eigen() decomposition
## $values
##  [1] 8.43784115 1.57270697 1.04790534 0.67442069 0.62473644 0.42578716
##  [7] 0.30447636 0.26159009 0.19916570 0.17927597 0.13067508 0.07689434
## [13] 0.04114629 0.02337843
##
## $vectors
```

```
##              [,1]         [,2]          [,3]        [,4]        [,5]
##  [1,]  0.22581343 -0.429113998 -0.1948279800 -0.14316740  0.23272017
##  [2,] -0.01797477  0.595410151 -0.5998437495  0.04613923  0.09056328
##  [3,] -0.33570802 -0.044571158  0.0308432587  0.09380523 -0.08082890
##  [4,] -0.08978746 -0.500233190 -0.4753434353  0.28889732 -0.59502540
##  [5,] -0.29632742  0.001593207 -0.1710017560 -0.21724661 -0.04669105
##  [6,] -0.31227481  0.171785361 -0.0042676326 -0.00490568 -0.10560396
##  [7,] -0.31157419  0.257369548  0.0576403884  0.13842379 -0.15514673
##  [8,] -0.31897312  0.006329201  0.1967515192  0.16362895 -0.04551544
##  [9,] -0.30258774 -0.087660408  0.3243036852  0.05763244 -0.01656506
## [10,] -0.29928615 -0.080353729 -0.0006119755  0.22565683  0.07849416
## [11,] -0.22038585 -0.249229127 -0.0744833535  0.39045954  0.67979373
## [12,] -0.29075906 -0.074463875  0.0601612566 -0.33021519 -0.02706441
## [13,] -0.24076352 -0.165878188 -0.0540358813 -0.68011038  0.05038676
## [14,] -0.26751888 -0.063399809 -0.4321726281 -0.11689352  0.25641783
##               [,6]         [,7]        [,8]         [,9]        [,10]
##  [1,]  0.566493180 -0.089572071 -0.03423348 -0.447229906  0.222671787
##  [2,] -0.005725449 -0.269437621  0.18578892 -0.235328657 -0.069471718
##  [3,]  0.116375454  0.046392377 -0.06409035 -0.127574454  0.134103152
##  [4,] -0.218618692  0.006905608  0.08094767 -0.006485188 -0.008640938
##  [5,]  0.304840429  0.443871280 -0.08986951 -0.131947186 -0.700392695
##  [6,]  0.024674094  0.278208392 -0.13986122 -0.353373461  0.450188169
##  [7,] -0.006988353  0.128416094 -0.13387964 -0.060216126  0.153054391
##  [8,]  0.201156485 -0.094150397 -0.10345006 -0.047491369  0.172133213
##  [9,]  0.181528729 -0.208641221  0.07943017  0.141032422 -0.208755434
## [10,]  0.084832948 -0.676539973 -0.09834184 -0.105635193 -0.217398660
## [11,] -0.392710001  0.251524351  0.11841667 -0.155894886 -0.063519220
## [12,]  0.023884933 -0.013938665  0.85777886  0.009600890  0.139080614
## [13,] -0.481536823 -0.227130084 -0.32311506 -0.159844681  0.018072762
## [14,]  0.238426917  0.033456015 -0.16491331  0.706491053  0.258286832
##              [,11]        [,12]         [,13]        [,14]
##  [1,]  0.13261278  0.03981938  0.228205105  0.036051663
##  [2,]  0.30845609  0.06678730 -0.079522831 -0.041691546
##  [3,]  0.04199084 -0.16930732 -0.101016522 -0.879963062
##  [4,]  0.11153649  0.05907146 -0.005338364  0.088132334
##  [5,] -0.10027469 -0.08497406 -0.050440141  0.088113838
##  [6,] -0.31579674  0.45580434 -0.299297661  0.199006079
##  [7,]  0.06027680 -0.12152347  0.834867580  0.114927506
##  [8,]  0.40222552 -0.54709686 -0.366377821  0.378695635
##  [9,]  0.48046351  0.64310718  0.034283313 -0.010871300
## [10,] -0.55270250 -0.03603854  0.035667152  0.076435202
## [11,]  0.08354997  0.01047322  0.029054868  0.037529330
## [12,] -0.13976117 -0.12046140  0.060305390  0.053428087
## [13,]  0.17436836 -0.03524349  0.032793638  0.006371429
## [14,] -0.06797409  0.04460931 -0.001411374  0.024687619
```

```r
# Find the total proportion of explained by each factor
total_var = sum(bodyFat.eigen$values)
cat("Total Varience of this data set: " ,total_var)
```

```
## Total Varience of this data set:  14
```

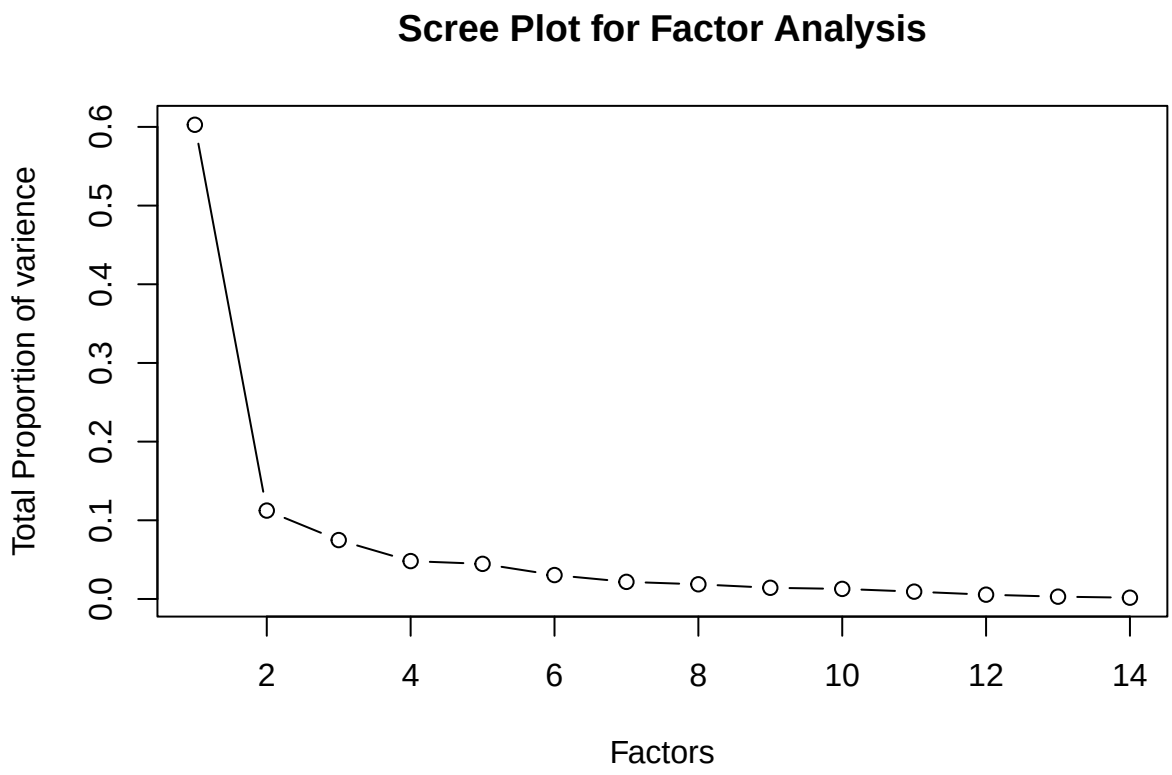
```r
bodyFat.PVE <- bodyFat.eigen$values/total_var
round(bodyFat.PVE,digits = 3)
```

```
##  [1] 0.603 0.112 0.075 0.048 0.045 0.030 0.022 0.019 0.014 0.013 0.009 0.005
## [13] 0.003 0.002
```

```
# Cumulative variance of Each Factor
cumsum(bodyFat.eigen$values)/total_var
```

```
##  [1] 0.6027029 0.7150392 0.7898895 0.8380624 0.8826865 0.9130998 0.9348482
##  [8] 0.9535332 0.9677593 0.9805647 0.9898986 0.9953911 0.9983301 1.0000000
```

```
# Draw the Scree plot
plot(1:length(bodyFat.PVE),bodyFat.PVE,
     type = "b",
     xlab = "Factors",
     ylab = " Total Proportion of varience ",
     main = "Scree Plot for Factor Analysis")
```



n_factors = 3

```
?factanal
```

```
## starting httpd help server ... done
```

```
# Fit the Factor model with 3factor using maximum-likelihood method
bodyFat.ml <- factanal(bodyFat.scale,
                       factors = 3,
                       rotation = "none")
```

```
bodyFat.ml
```

```
##
## Call:
```

```
## factanal(x = bodyFat.scale, factors = 3, rotation = "none")
##
## Uniquenesses:
## Density     Age  Weight  Height    Neck   Chest Abdomen     Hip   Thigh    Knee
##   0.280   0.474   0.017   0.707   0.234   0.116   0.005   0.059   0.127   0.253
##   Ankle  Biceps Forearm   Wrist
##   0.565   0.332   0.532   0.277
##
## Loadings:
##         Factor1 Factor2 Factor3
## Density -0.755   0.367   0.123
## Age      0.155  -0.551   0.446
## Weight   0.944   0.302
## Height   0.152   0.442   0.273
## Neck     0.798   0.232   0.274
## Chest    0.931           0.130
## Abdomen  0.987  -0.144
## Hip      0.921   0.248  -0.176
## Thigh    0.826   0.344  -0.268
## Knee     0.796   0.337
## Ankle    0.518   0.401
## Biceps   0.744   0.331
## Forearm  0.562   0.341   0.190
## Wrist    0.672   0.295   0.428
##
##                Factor1 Factor2 Factor3
## SS loadings      7.740   1.567   0.716
## Proportion Var   0.553   0.112   0.051
## Cumulative Var   0.553   0.665   0.716
##
## Test of the hypothesis that 3 factors are sufficient.
## The chi square statistic is 263.05 on 52 degrees of freedom.
## The p-value is 5.69e-30
```

```
# Fit the Factor model with 3 factor using maximum-likelihood method
bodyFat.ml.vari <- factanal(bodyFat.scale,
                        factors = 3,
                        scores = "regression",
                        rotation = "varimax")
```

```
bodyFat.ml.vari
```

```
##
## Call:
## factanal(x = bodyFat.scale, factors = 3, scores = "regression",     rotation = "varimax")
##
## Uniquenesses:
## Density     Age  Weight  Height    Neck   Chest Abdomen     Hip   Thigh    Knee
##   0.280   0.474   0.017   0.707   0.234   0.116   0.005   0.059   0.127   0.253
##   Ankle  Biceps Forearm   Wrist
##   0.565   0.332   0.532   0.277
##
## Loadings:
##         Factor1 Factor2 Factor3
## Density -0.788          -0.309
```

```
## Age                      0.722
## Weight   0.817   0.562
## Height           0.532
## Neck     0.602   0.614   0.163
## Chest    0.806   0.421   0.240
## Abdomen  0.927   0.246   0.273
## Hip      0.880   0.385  -0.134
## Thigh    0.814   0.361  -0.282
## Knee     0.692   0.507  -0.106
## Ankle    0.393   0.512  -0.136
## Biceps   0.616   0.535
## Forearm  0.401   0.554
## Wrist    0.420   0.711   0.202
##
##                Factor1 Factor2 Factor3
## SS loadings      5.950   3.116   0.958
## Proportion Var   0.425   0.223   0.068
## Cumulative Var   0.425   0.648   0.716
##
## Test of the hypothesis that 3 factors are sufficient.
## The chi square statistic is 263.05 on 52 degrees of freedom.
## The p-value is 5.69e-30
```

```
# Factor Loading
bodyFat.ml.vari$loadings
```

```
##
## Loadings:
##         Factor1 Factor2 Factor3
## Density -0.788          -0.309
## Age                      0.722
## Weight   0.817   0.562
## Height           0.532
## Neck     0.602   0.614   0.163
## Chest    0.806   0.421   0.240
## Abdomen  0.927   0.246   0.273
## Hip      0.880   0.385  -0.134
## Thigh    0.814   0.361  -0.282
## Knee     0.692   0.507  -0.106
## Ankle    0.393   0.512  -0.136
## Biceps   0.616   0.535
## Forearm  0.401   0.554
## Wrist    0.420   0.711   0.202
##
##                Factor1 Factor2 Factor3
## SS loadings      5.950   3.116   0.958
## Proportion Var   0.425   0.223   0.068
## Cumulative Var   0.425   0.648   0.716
```

```
head(bodyFat.ml.vari$scores)
```

```
##         Factor1    Factor2    Factor3
## [1,] -0.2569666 -1.0315342 -0.8167028
## [2,] -0.7683310  0.6622875 -1.2598962
## [3,]  0.4940794 -2.1227871 -1.3507320
```

```
## [4,] -0.4213582  0.7455651 -1.2441042
## [5,]  1.2910107 -1.5386545 -0.7008818
## [6,]  0.4260346  1.1500328 -1.7665407
```

Confirmatory Factor Analysis

```
bodyFat.ml.vari$loadings
```

```
##
## Loadings:
##         Factor1 Factor2 Factor3
## Density -0.788          -0.309
## Age                      0.722
## Weight   0.817   0.562
## Height           0.532
## Neck     0.602   0.614   0.163
## Chest    0.806   0.421   0.240
## Abdomen  0.927   0.246   0.273
## Hip      0.880   0.385  -0.134
## Thigh    0.814   0.361  -0.282
## Knee     0.692   0.507  -0.106
## Ankle    0.393   0.512  -0.136
## Biceps   0.616   0.535
## Forearm  0.401   0.554
## Wrist    0.420   0.711   0.202
##
##                Factor1 Factor2 Factor3
## SS loadings      5.950   3.116   0.958
## Proportion Var   0.425   0.223   0.068
## Cumulative Var   0.425   0.648   0.716
```

Factor1 - Body Composition Factor -> (Density,Weight,Neck,Chest,Abdomen,Hip,Thigh,Knee,Biceps) - BCF

Facor2 - Muscularity Factor -> (Weight,Height,Neck,Knee,Ankle,Biceps,Forearm,Wrist) - MF

Factor3 - Age Factor -> (Age) - AF

```
colnames(bodyFat)
```

```
##  [1] "Density" "Age"     "Weight"  "Height"  "Neck"    "Chest"   "Abdomen"
##  [8] "Hip"     "Thigh"   "Knee"    "Ankle"   "Biceps"  "Forearm" "Wrist"
```

```
# Create the Mode confirmatory Model
bodyFat.cfa.model <- '
BCF = ~Density+ Weight+ Neck+ Chest+ Abdomen+ Hip+ Thigh+ Knee+ Biceps
MF = ~Weight+ Height+ Neck+ Knee+ Ankle+ Biceps+ Forearm+ Wrist
AF = ~Age
'
```

```
# Fit the CFA Model
bodyFat.cfa.est <- cfa(bodyFat.cfa.model,bodyFat.scale)
```

```
summary(bodyFat.cfa.est,fit = TRUE )
```

```
## lavaan 0.6.17 ended normally after 70 iterations
##
##   Estimator                                         ML
```

```
##   Optimization method                           NLMINB
##   Number of model parameters                        34
##
##   Number of observations                           252
##
## Model Test User Model:
##
##   Test statistic                               831.146
##   Degrees of freedom                                71
##   P-value (Chi-square)                           0.000
##
## Model Test Baseline Model:
##
##   Test statistic                              4156.825
##   Degrees of freedom                                91
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.813
##   Tucker-Lewis Index (TLI)                       0.760
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -3336.162
##   Loglikelihood unrestricted model (H1)      -2920.589
##
##   Akaike (AIC)                                6740.324
##   Bayesian (BIC)                              6860.324
##   Sample-size adjusted Bayesian (SABIC)       6752.539
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.206
##   90 Percent confidence interval - lower         0.194
##   90 Percent confidence interval - upper         0.219
##   P-value H_0: RMSEA <= 0.050                    0.000
##   P-value H_0: RMSEA >= 0.080                    1.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.083
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   BCF =~
##     Density           1.000
##     Weight           -1.124    0.092  -12.266    0.000
```

```
##     Neck             -0.516    0.116   -4.456    0.000
##     Chest            -1.356    0.106  -12.831    0.000
##     Abdomen          -1.388    0.106  -13.073    0.000
##     Hip              -1.450    0.107  -13.538    0.000
##     Thigh            -1.337    0.105  -12.679    0.000
##     Knee             -0.881    0.118   -7.473    0.000
##     Biceps           -0.637    0.123   -5.197    0.000
##   MF =~
##     Weight            1.000
##     Height            1.416    0.256    5.529    0.000
##     Neck              1.957    0.276    7.099    0.000
##     Knee              1.105    0.233    4.743    0.000
##     Ankle             2.272    0.296    7.681    0.000
##     Biceps            1.543    0.275    5.613    0.000
##     Forearm           2.465    0.307    8.037    0.000
##     Wrist             2.905    0.337    8.618    0.000
##   AF =~
##     Age               1.000
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)
##   BCF ~~
##     MF              -0.151    0.025   -5.941    0.000
##     AF              -0.005    0.042   -0.127    0.899
##   MF ~~
##     AF               0.005    0.019    0.248    0.804
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)
##    .Density           0.557    0.050   11.052    0.000
##    .Weight            0.018    0.004    4.362    0.000
##    .Neck              0.255    0.026    9.796    0.000
##    .Chest             0.188    0.018   10.255    0.000
##    .Abdomen           0.150    0.015    9.940    0.000
##    .Hip               0.073    0.009    8.156    0.000
##    .Thigh             0.211    0.020   10.390    0.000
##    .Knee              0.260    0.024   10.777    0.000
##    .Biceps            0.323    0.031   10.581    0.000
##    .Height            0.829    0.075   11.010    0.000
##    .Ankle             0.567    0.055   10.395    0.000
##    .Forearm           0.491    0.049   10.080    0.000
##    .Wrist             0.294    0.035    8.340    0.000
##    .Age               0.000
##     BCF               0.439    0.074    5.928    0.000
##     MF                0.083    0.019    4.486    0.000
##     AF                0.996    0.089   11.225    0.000
```