MVA.R

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```
#ggplot2 is used to plot the bar plot
#install.packages("ggplot2")
library("ggplot2")
#corrplot is used to plot the correlation matrix
#install.packages("corrplot")
library("corrplot")
```

```
## corrplot 0.84 loaded
```

```
#It is used to reshape a one-dimensional array into a two-dimensional array with one column and multiple arr
ays.
#install.packages("reshape")
library("reshape")
```

```
## Warning: package 'reshape' was built under R version 3.5.2
```

```
#Reading the dataset
breast_cancer <- read.csv("C:\\Users\\APEKSHA\\Downloads\\wisc_bc_data.csv")

#Displaying the dataset using head function
head(breast_cancer)
```

```
##         id diagnosis radius_mean texture_mean perimeter_mean area_mean
## 1 87139402         B       12.32        12.39          78.85     464.1
## 2  8910251         B       10.60        18.95          69.28     346.4
## 3   905520         B       11.04        16.83          70.92     373.2
## 4   868871         B       11.28        13.39          73.00     384.8
## 5  9012568         B       15.19        13.21          97.65     711.8
## 6   906539         B       11.57        19.04          74.20     409.7
##   smoothness_mean compactness_mean concavity_mean points_mean
## 1         0.10280          0.06981        0.03987     0.03700
## 2         0.09688          0.11470        0.06387     0.02642
## 3         0.10770          0.07804        0.03046     0.02480
## 4         0.11640          0.11360        0.04635     0.04796
## 5         0.07963          0.06934        0.03393     0.02657
## 6         0.08546          0.07722        0.05485     0.01428
##   symmetry_mean dimension_mean radius_se texture_se perimeter_se area_se
## 1        0.1959        0.05955    0.2360     0.6656        1.670   17.43
## 2        0.1922        0.06491    0.4505     1.1970        3.430   27.10
## 3        0.1714        0.06340    0.1967     1.3870        1.342   13.54
## 4        0.1771        0.06072    0.3384     1.3430        1.851   26.33
## 5        0.1721        0.05544    0.1783     0.4125        1.338   17.72
## 6        0.2031        0.06267    0.2864     1.4400        2.206   20.30
##   smoothness_se compactness_se concavity_se points_se symmetry_se
## 1      0.008045       0.011800      0.01683  0.012410     0.01924
## 2      0.007470       0.035810      0.03354  0.013650     0.03504
## 3      0.005158       0.009355      0.01056  0.007483     0.01718
## 4      0.011270       0.034980      0.02187  0.019650     0.01580
## 5      0.005012       0.014850      0.01551  0.009155     0.01647
## 6      0.007278       0.020470      0.04447  0.008799     0.01868
##   dimension_se radius_worst texture_worst perimeter_worst area_worst
## 1     0.002248        13.50         15.64           86.97      549.1
## 2     0.003318        11.88         22.94           78.28      424.8
## 3     0.002198        12.41         26.44           79.93      471.4
## 4     0.003442        11.92         15.77           76.53      434.0
## 5     0.001767        16.20         15.73          104.50      819.1
## 6     0.003339        13.07         26.98           86.43      520.5
##   smoothness_worst compactness_worst concavity_worst points_worst
## 1           0.1385            0.1266         0.12420      0.09391
## 2           0.1213            0.2515         0.19160      0.07926
## 3           0.1369            0.1482         0.10670      0.07431
## 4           0.1367            0.1822         0.08669      0.08611
## 5           0.1126            0.1737         0.13620      0.08178
## 6           0.1249            0.1937         0.25600      0.06664
##   symmetry_worst dimension_worst
## 1         0.2827         0.06771
## 2         0.2940         0.07587
## 3         0.2998         0.07881
## 4         0.2102         0.06784
## 5         0.2487         0.06766
## 6         0.3035         0.08284
```

```
#Displays structure of the dataset
str(breast_cancer)
```

```
## 'data.frame':    569 obs. of  32 variables:
##  $ id               : int  87139402 8910251 905520 868871 9012568 906539 925291 87880 862989 89827 ...
##  $ diagnosis        : Factor w/ 2 levels "B","M": 1 1 1 1 1 1 1 2 1 1 ...
##  $ radius_mean      : num  12.3 10.6 11 11.3 15.2 ...
##  $ texture_mean     : num  12.4 18.9 16.8 13.4 13.2 ...
##  $ perimeter_mean   : num  78.8 69.3 70.9 73 97.7 ...
##  $ area_mean        : num  464 346 373 385 712 ...
##  $ smoothness_mean  : num  0.1028 0.0969 0.1077 0.1164 0.0796 ...
##  $ compactness_mean : num  0.0698 0.1147 0.078 0.1136 0.0693 ...
##  $ concavity_mean   : num  0.0399 0.0639 0.0305 0.0464 0.0339 ...
##  $ points_mean      : num  0.037 0.0264 0.0248 0.048 0.0266 ...
##  $ symmetry_mean    : num  0.196 0.192 0.171 0.177 0.172 ...
##  $ dimension_mean   : num  0.0595 0.0649 0.0634 0.0607 0.0554 ...
##  $ radius_se        : num  0.236 0.451 0.197 0.338 0.178 ...
##  $ texture_se       : num  0.666 1.197 1.387 1.343 0.412 ...
##  $ perimeter_se     : num  1.67 3.43 1.34 1.85 1.34 ...
##  $ area_se          : num  17.4 27.1 13.5 26.3 17.7 ...
##  $ smoothness_se    : num  0.00805 0.00747 0.00516 0.01127 0.00501 ...
##  $ compactness_se   : num  0.0118 0.03581 0.00936 0.03498 0.01485 ...
##  $ concavity_se     : num  0.0168 0.0335 0.0106 0.0219 0.0155 ...
##  $ points_se        : num  0.01241 0.01365 0.00748 0.01965 0.00915 ...
##  $ symmetry_se      : num  0.0192 0.035 0.0172 0.0158 0.0165 ...
##  $ dimension_se     : num  0.00225 0.00332 0.0022 0.00344 0.00177 ...
##  $ radius_worst     : num  13.5 11.9 12.4 11.9 16.2 ...
##  $ texture_worst    : num  15.6 22.9 26.4 15.8 15.7 ...
##  $ perimeter_worst  : num  87 78.3 79.9 76.5 104.5 ...
##  $ area_worst       : num  549 425 471 434 819 ...
##  $ smoothness_worst : num  0.139 0.121 0.137 0.137 0.113 ...
##  $ compactness_worst: num  0.127 0.252 0.148 0.182 0.174 ...
##  $ concavity_worst  : num  0.1242 0.1916 0.1067 0.0867 0.1362 ...
##  $ points_worst     : num  0.0939 0.0793 0.0743 0.0861 0.0818 ...
##  $ symmetry_worst   : num  0.283 0.294 0.3 0.21 0.249 ...
##  $ dimension_worst  : num  0.0677 0.0759 0.0788 0.0678 0.0677 ...
```

```
#Displays the names of the columns
names(breast_cancer)
```

```
##  [1] "id"                "diagnosis"         "radius_mean"
##  [4] "texture_mean"      "perimeter_mean"    "area_mean"
##  [7] "smoothness_mean"   "compactness_mean"  "concavity_mean"
## [10] "points_mean"       "symmetry_mean"     "dimension_mean"
## [13] "radius_se"         "texture_se"        "perimeter_se"
## [16] "area_se"           "smoothness_se"     "compactness_se"
## [19] "concavity_se"      "points_se"         "symmetry_se"
## [22] "dimension_se"      "radius_worst"      "texture_worst"
## [25] "perimeter_worst"   "area_worst"        "smoothness_worst"
## [28] "compactness_worst" "concavity_worst"   "points_worst"
## [31] "symmetry_worst"    "dimension_worst"
```

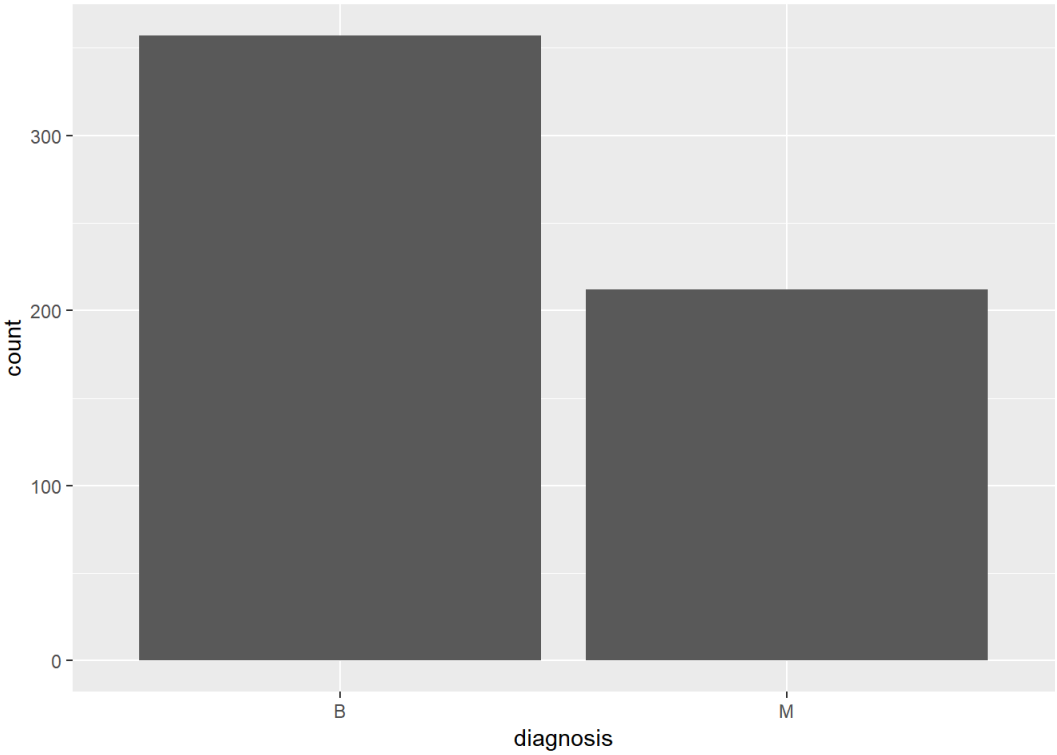
```
#Displays the summary of the dataset
summary(breast_cancer)
```

```
##        id            diagnosis  radius_mean      texture_mean
##  Min.   :     8670   B:357     Min.   : 6.981   Min.   : 9.71
##  1st Qu.:   869218   M:212     1st Qu.:11.700   1st Qu.:16.17
##  Median :   906024             Median :13.370   Median :18.84
##  Mean   : 30371831             Mean   :14.127   Mean   :19.29
##  3rd Qu.:  8813129             3rd Qu.:15.780   3rd Qu.:21.80
##  Max.   :911320502             Max.   :28.110   Max.   :39.28
##  perimeter_mean     area_mean      smoothness_mean   compactness_mean
##  Min.   : 43.79   Min.   : 143.5   Min.   :0.05263   Min.   :0.01938
##  1st Qu.: 75.17   1st Qu.: 420.3   1st Qu.:0.08637   1st Qu.:0.06492
##  Median : 86.24   Median : 551.1   Median :0.09587   Median :0.09263
##  Mean   : 91.97   Mean   : 654.9   Mean   :0.09636   Mean   :0.10434
##  3rd Qu.:104.10   3rd Qu.: 782.7   3rd Qu.:0.10530   3rd Qu.:0.13040
##  Max.   :188.50   Max.   :2501.0   Max.   :0.16340   Max.   :0.34540
##  concavity_mean     points_mean      symmetry_mean    dimension_mean
##  Min.   :0.00000   Min.   :0.00000   Min.   :0.1060   Min.   :0.04996
##  1st Qu.:0.02956   1st Qu.:0.02031   1st Qu.:0.1619   1st Qu.:0.05770
##  Median :0.06154   Median :0.03350   Median :0.1792   Median :0.06154
##  Mean   :0.08880   Mean   :0.04892   Mean   :0.1812   Mean   :0.06280
##  3rd Qu.:0.13070   3rd Qu.:0.07400   3rd Qu.:0.1957   3rd Qu.:0.06612
##  Max.   :0.42680   Max.   :0.20120   Max.   :0.3040   Max.   :0.09744
##    radius_se        texture_se      perimeter_se       area_se
##  Min.   :0.1115   Min.   :0.3602   Min.   : 0.757   Min.   :  6.802
##  1st Qu.:0.2324   1st Qu.:0.8339   1st Qu.: 1.606   1st Qu.: 17.850
##  Median :0.3242   Median :1.1080   Median : 2.287   Median : 24.530
##  Mean   :0.4052   Mean   :1.2169   Mean   : 2.866   Mean   : 40.337
##  3rd Qu.:0.4789   3rd Qu.:1.4740   3rd Qu.: 3.357   3rd Qu.: 45.190
##  Max.   :2.8730   Max.   :4.8850   Max.   :21.980   Max.   :542.200
##  smoothness_se      compactness_se      concavity_se
##  Min.   :0.001713   Min.   :0.002252   Min.   :0.00000
##  1st Qu.:0.005169   1st Qu.:0.013080   1st Qu.:0.01509
##  Median :0.006380   Median :0.020450   Median :0.02589
##  Mean   :0.007041   Mean   :0.025478   Mean   :0.03189
##  3rd Qu.:0.008146   3rd Qu.:0.032450   3rd Qu.:0.04205
##  Max.   :0.031130   Max.   :0.135400   Max.   :0.39600
##    points_se         symmetry_se        dimension_se        radius_worst
##  Min.   :0.000000   Min.   :0.007882   Min.   :0.0008948   Min.   : 7.93
##  1st Qu.:0.007638   1st Qu.:0.015160   1st Qu.:0.0022480   1st Qu.:13.01
##  Median :0.010930   Median :0.018730   Median :0.0031870   Median :14.97
##  Mean   :0.011796   Mean   :0.020542   Mean   :0.0037949   Mean   :16.27
##  3rd Qu.:0.014710   3rd Qu.:0.023480   3rd Qu.:0.0045580   3rd Qu.:18.79
##  Max.   :0.052790   Max.   :0.078950   Max.   :0.0298400   Max.   :36.04
##  texture_worst   perimeter_worst    area_worst     smoothness_worst
##  Min.   :12.02   Min.   : 50.41   Min.   : 185.2   Min.   :0.07117
##  1st Qu.:21.08   1st Qu.: 84.11   1st Qu.: 515.3   1st Qu.:0.11660
##  Median :25.41   Median : 97.66   Median : 686.5   Median :0.13130
##  Mean   :25.68   Mean   :107.26   Mean   : 880.6   Mean   :0.13237
##  3rd Qu.:29.72   3rd Qu.:125.40   3rd Qu.:1084.0   3rd Qu.:0.14600
##  Max.   :49.54   Max.   :251.20   Max.   :4254.0   Max.   :0.22260
##  compactness_worst concavity_worst   points_worst     symmetry_worst
##  Min.   :0.02729   Min.   :0.0000   Min.   :0.00000   Min.   :0.1565
##  1st Qu.:0.14720   1st Qu.:0.1145   1st Qu.:0.06493   1st Qu.:0.2504
##  Median :0.21190   Median :0.2267   Median :0.09993   Median :0.2822
##  Mean   :0.25427   Mean   :0.2722   Mean   :0.11461   Mean   :0.2901
##  3rd Qu.:0.33910   3rd Qu.:0.3829   3rd Qu.:0.16140   3rd Qu.:0.3179
##  Max.   :1.05800   Max.   :1.2520   Max.   :0.29100   Max.   :0.6638
##  dimension_worst
##  Min.   :0.05504
##  1st Qu.:0.07146
##  Median :0.08004
##  Mean   :0.08395
##  3rd Qu.:0.09208
##  Max.   :0.20750
```

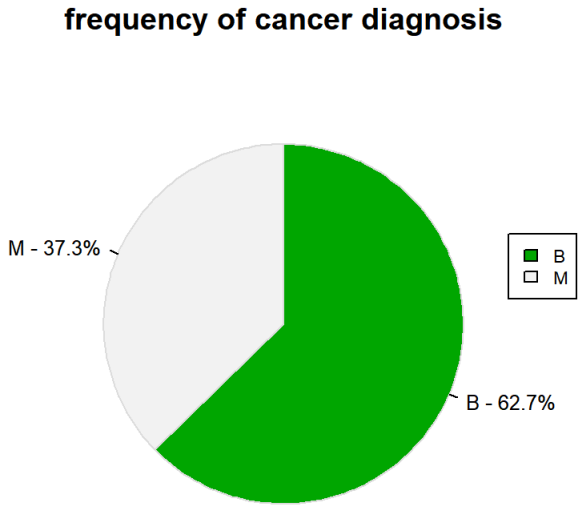
```
#To display the frequency table
diagnosis.table <- table(breast_cancer$diagnosis)

#Displays the table
#This shows how many patients are benign and malignant
diagnosis.table
```

```
##
##   B   M
## 357 212
```

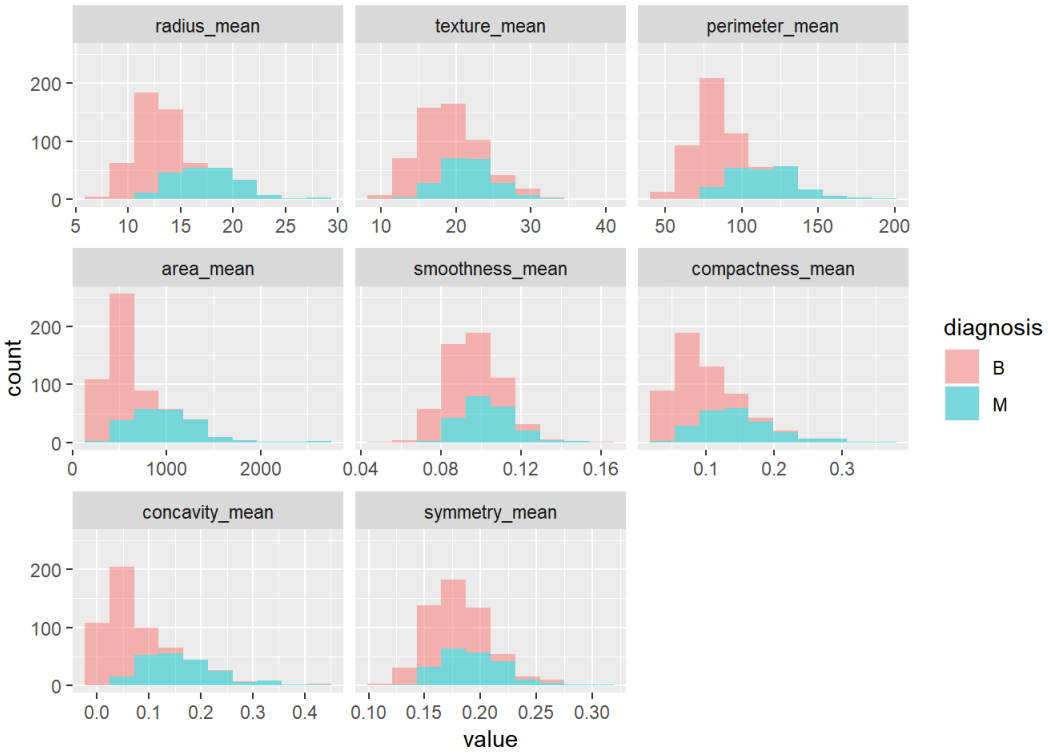
```
#Generate barplot
ggplot(data=breast_cancer, aes(x=diagnosis)) + geom_bar(stat = "count")
```



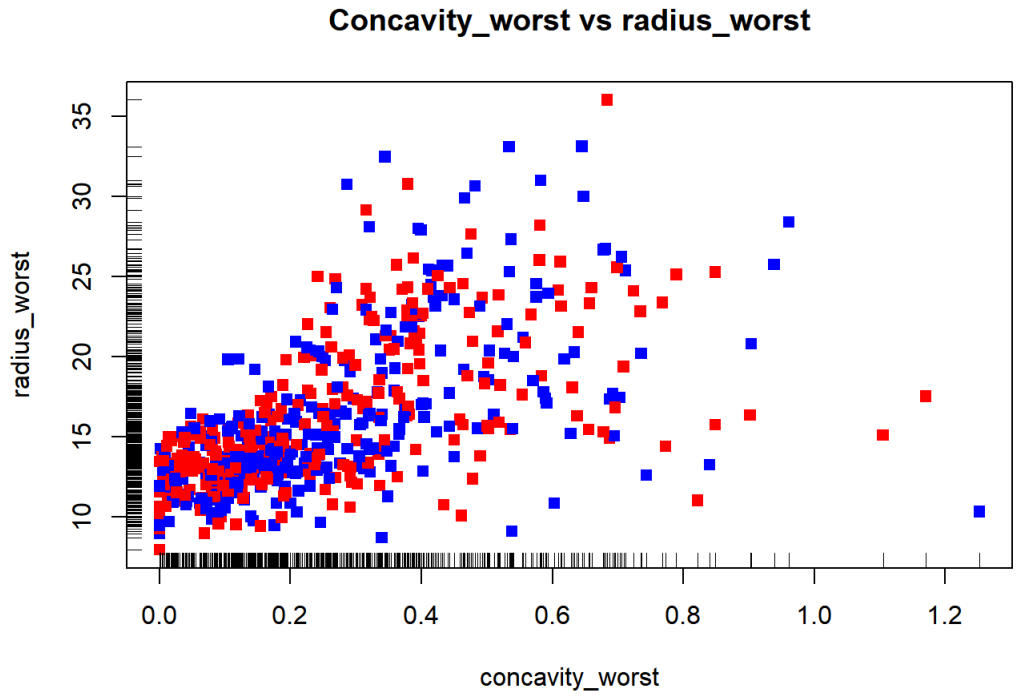

```
#Generate Pie chart represented in frequency
diagnosis.prop.table <- prop.table(diagnosis.table)*100
diagnosis.prop.df <- as.data.frame(diagnosis.prop.table)
pielabels <- sprintf("%s - %3.1f%s", diagnosis.prop.df[,1], diagnosis.prop.table, "%")
colors <- terrain.colors(2)
pie(diagnosis.prop.table,
    labels=pielabels,
    clockwise=TRUE,
    col=colors,
    border="gainsboro",
    radius=0.8,
    cex=0.8,
    main="frequency of cancer diagnosis")
legend(1, .4, legend=diagnosis.prop.df[,1], cex = 0.7, fill = colors)
```



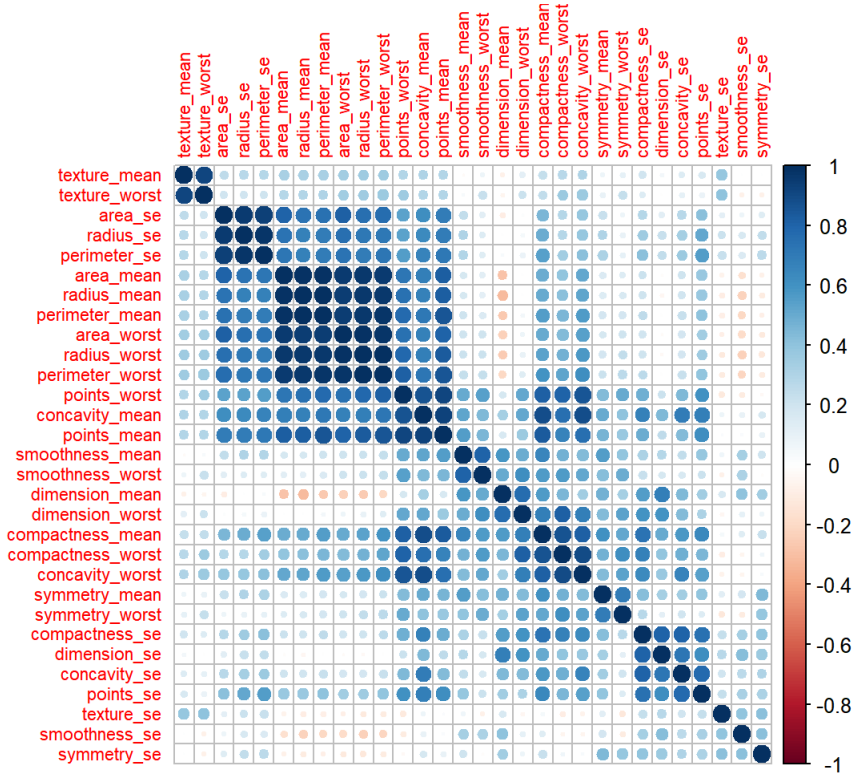

```
#To Plot histograms of "mean" variables group by diagnosis
data_mean <- breast_cancer[ ,c("diagnosis", "radius_mean", "texture_mean","perimeter_mean", "area_mean", "smoothness_mean", "compactness_mean", "concavity_mean", "symmetry_mean" )]

#Plot histograms
ggplot(data = melt(data_mean, id.var = "diagnosis"), mapping = aes(x = value)) +
  geom_histogram(bins = 10, aes(fill=diagnosis), alpha=0.5) + facet_wrap(~variable, scales ='free_x')
```



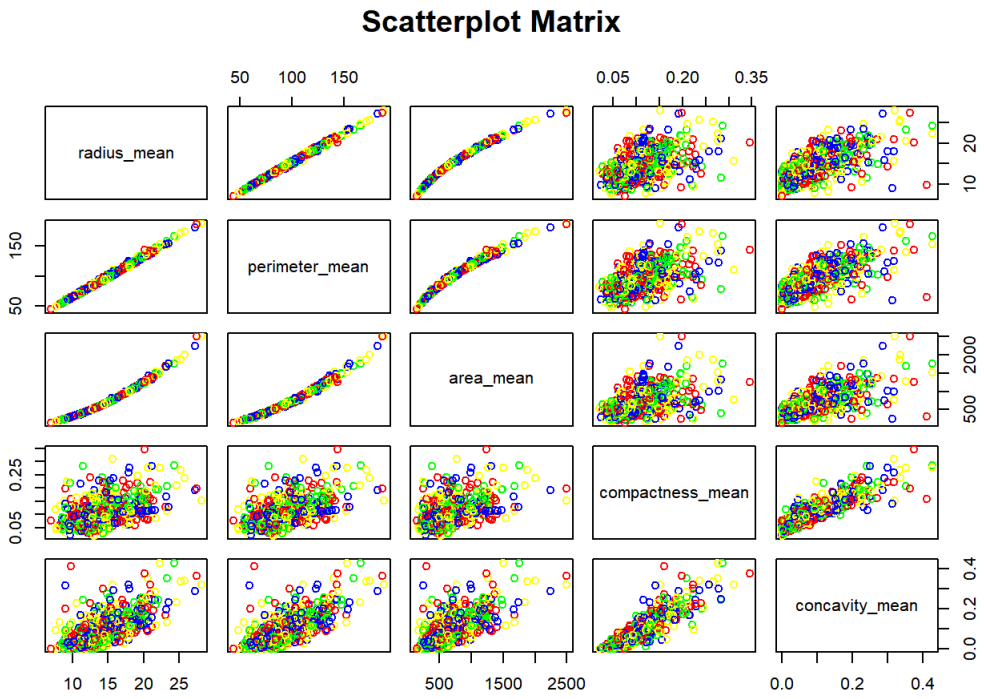
```
#Generate a Scatter plot of two varaible ie. concavity against radius
data <- breast_cancer[,c('concavity_worst','radius_worst')]
plot(x = breast_cancer$concavity_worst,y = breast_cancer$radius_worst,
     xlab = "concavity_worst",
     ylab = "radius_worst",
     main = "Concavity_worst vs radius_worst",
     pch=15,
     col = c("red","blue")
     )
rug(breast_cancer$concavity_worst, side = 1)
rug(breast_cancer$radius_worst, side = 2)
```




```
#Generate Corelation Matrix of columns
corMatMy <- cor(breast_cancer[,3:32])
corrplot(corMatMy, order = "hclust", tl.cex = 0.7)
```



```
#Generate Scatterplot Matrix
pairs(~radius_mean+perimeter_mean+area_mean+compactness_mean+concavity_mean,data = breast_cancer,main = "Scatterplot Matrix",col=c("red","blue","green","yellow"))
```




```
#Multivariate analysis
#t-tEST
with(data=breast_cancer,t.test(radius_mean[diagnosis=="B"],radius_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
##  Two Sample t-test
##
## data:  radius_mean[diagnosis == "B"] and radius_mean[diagnosis == "M"]
## t = -25.436, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -5.726832 -4.905781
## sample estimates:
## mean of x mean of y
##  12.14652  17.46283
```

```
with(data=breast_cancer,t.test(texture_mean[diagnosis=="B"],texture_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
##  Two Sample t-test
##
## data:  texture_mean[diagnosis == "B"] and texture_mean[diagnosis == "M"]
## t = -10.867, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -4.357107 -3.023181
## sample estimates:
## mean of x mean of y
##  17.91476  21.60491
```

```
with(data=breast_cancer,t.test(perimeter_mean[diagnosis=="B"],perimeter_mean[diagnosis=="M"],var.equal=TRUE)
)
```

```
##
##  Two Sample t-test
##
## data:  perimeter_mean[diagnosis == "B"] and perimeter_mean[diagnosis == "M"]
## t = -26.405, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -40.06379 -34.51615
## sample estimates:
## mean of x mean of y
##  78.07541 115.36538
```

```
with(data=breast_cancer,t.test(area_mean[diagnosis=="B"],area_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
##  Two Sample t-test
##
## data:  area_mean[diagnosis == "B"] and area_mean[diagnosis == "M"]
## t = -23.939, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -557.8898 -473.2826
## sample estimates:
## mean of x mean of y
##  462.7902  978.3764
```

```
with(data=breast_cancer,t.test(smoothness_mean[diagnosis=="B"],smoothness_mean[diagnosis=="M"],var.equal=TRU
E))
```

```
##
##  Two Sample t-test
##
## data:  smoothness_mean[diagnosis == "B"] and smoothness_mean[diagnosis == "M"]
## t = -9.1461, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.012658756 -0.008182931
## sample estimates:
##  mean of x  mean of y
## 0.09247765 0.10289849
```

```
with(data=breast_cancer,t.test(compactness_mean[diagnosis=="B"],compactness_mean[diagnosis=="M"],var.equal=T
RUE))
```

```
##
##  Two Sample t-test
##
## data:  compactness_mean[diagnosis == "B"] and compactness_mean[diagnosis == "M"]
## t = -17.698, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.07232827 -0.05787805
## sample estimates:
##  mean of x  mean of y
## 0.08008462 0.14518778
```

```
with(data=breast_cancer,t.test(concavity_mean[diagnosis=="B"],concavity_mean[diagnosis=="M"],var.equal=TRUE)
)
```

```
##
##  Two Sample t-test
##
## data:  concavity_mean[diagnosis == "B"] and concavity_mean[diagnosis == "M"]
## t = -23.104, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.1244696 -0.1049646
## sample estimates:
##  mean of x  mean of y
## 0.04605762 0.16077472
```

```
with(data=breast_cancer,t.test(points_mean[diagnosis=="B"],points_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
##  Two Sample t-test
##
## data:  points_mean[diagnosis == "B"] and points_mean[diagnosis == "M"]
## t = -29.354, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.06643938 -0.05810581
## sample estimates:
##  mean of x  mean of y
## 0.02571741 0.08799000
```

```
with(data=breast_cancer,t.test(symmetry_mean[diagnosis=="B"],symmetry_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
##  Two Sample t-test
##
## data:  symmetry_mean[diagnosis == "B"] and symmetry_mean[diagnosis == "M"]
## t = -8.3383, df = 567, p-value = 5.733e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.02313331 -0.01431262
## sample estimates:
## mean of x mean of y
##  0.174186  0.192909
```

```
with(data=breast_cancer,t.test(dimension_mean[diagnosis=="B"],dimension_mean[diagnosis=="M"],var.equal=TRUE)
)
```

```
##
##  Two Sample t-test
##
## data:  dimension_mean[diagnosis == "B"] and dimension_mean[diagnosis == "M"]
## t = 0.30571, df = 567, p-value = 0.7599
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.001016083  0.001390684
## sample estimates:
##  mean of x  mean of y
## 0.06286739 0.06268009
```

```
#Hotelling's T2 test
#install.packages("Hotelling")
library(Hotelling)
```

```
## Warning: package 'Hotelling' was built under R version 3.5.2
```

```
## Loading required package: corpcor
```

```
## Warning: package 'corpcor' was built under R version 3.5.2
```

```
t2testcan <- hotelling.test(radius_mean + texture_mean + perimeter_mean + area_mean + smoothness_mean + comp
actness_mean + concavity_mean + points_mean + symmetry_mean + dimension_mean ~ diagnosis, data=breast_cancer
)
# Output of the function hotelling.test is given
cat("T2 statistic =",t2testcan$stat[[1]],"\n")
```

```
## T2 statistic = 1220.313
```

```
print(t2testcan)
```

```
## Test stat:  120.09
## Numerator df:  10
## Denominator df:  558
## P-value:  0
```

```
#  T2 statistic is located in the first element of the list "stat"
#View(t2testcan)
#View(breast_cancer)


#Levene's tests based on absolute differences around means using t-tests. Standarizing the data set with sca
le()
matstand <- scale(breast_cancer[,3:10])
head(matstand)
```

```
##      radius_mean texture_mean perimeter_mean  area_mean smoothness_mean
## [1,]  -0.5128453  -1.60418301     -0.5399006 -0.5421468       0.4578825
## [2,]  -1.0009202  -0.07896900     -0.9337442 -0.8766033       0.0369535
## [3,]  -0.8760638  -0.57187353     -0.8662517 -0.8004484       0.8062867
## [4,]  -0.8079604  -1.37168088     -0.7806514 -0.7674858       1.4248817
## [5,]   0.3015589  -1.41353126      0.2337944  0.1617181      -1.1895712
## [6,]  -0.7256686  -0.05804381     -0.7312666 -0.6967299      -0.7750414
##      compactness_mean concavity_mean points_mean
## [1,]       -0.6538379     -0.6137661 -0.30717196
## [2,]        0.1961461     -0.3127117 -0.57983238
## [3,]       -0.4980044     -0.7318045 -0.62158190
## [4,]        0.1753178     -0.5324814 -0.02471844
## [5,]       -0.6627373     -0.6882771 -0.57596668
## [6,]       -0.5135309     -0.4258580 -0.89269604
```

```
matben <- matstand[breast_cancer$diagnosis =="B",]
head(matben)
```

```
##      radius_mean texture_mean perimeter_mean  area_mean smoothness_mean
## [1,]  -0.5128453  -1.60418301     -0.5399006 -0.5421468       0.4578825
## [2,]  -1.0009202  -0.07896900     -0.9337442 -0.8766033       0.0369535
## [3,]  -0.8760638  -0.57187353     -0.8662517 -0.8004484       0.8062867
## [4,]  -0.8079604  -1.37168088     -0.7806514 -0.7674858       1.4248817
## [5,]   0.3015589  -1.41353126      0.2337944  0.1617181      -1.1895712
## [6,]  -0.7256686  -0.05804381     -0.7312666 -0.6967299      -0.7750414
##      compactness_mean concavity_mean points_mean
## [1,]       -0.6538379     -0.6137661 -0.30717196
## [2,]        0.1961461     -0.3127117 -0.57983238
## [3,]       -0.4980044     -0.7318045 -0.62158190
## [4,]        0.1753178     -0.5324814 -0.02471844
## [5,]       -0.6627373     -0.6882771 -0.57596668
## [6,]       -0.5135309     -0.4258580 -0.89269604
```

```
matmalign <- matstand[breast_cancer$diagnosis == "M",]
vecmedianben <- apply(matben, 2, median)
# in the above 2 represents column. Hence, we are asking for column median
vecmedianben
```

```
##      radius_mean     texture_mean   perimeter_mean        area_mean
##       -0.5468970       -0.4416723       -0.5674737       -0.5583439
##  smoothness_mean compactness_mean   concavity_mean      points_mean
##       -0.3981961       -0.5500751       -0.6486382       -0.6566309
```

```
vecmedianmalign <- apply(matmalign, 2, median)
matabsdevben <- abs(matben - matrix(rep(vecmedianben,nrow(matben)),nrow=nrow(matben), byrow=TRUE))

matabsdevmalign <- abs(matmalign - matrix(rep(vecmedianmalign,nrow(matmalign)),nrow=nrow(matmalign), byrow=T
RUE))

head(matabsdevmalign)
```

```
##      radius_mean texture_mean perimeter_mean area_mean smoothness_mean
## [1,]   0.9974323   0.53242989      0.9317263 0.9496635      2.14019666
## [2,]   0.9264911   0.05115047      0.9712341 1.1025417      0.44794814
## [3,]   0.6427266   0.82305756      0.5555789 0.7359750      0.07110288
## [4,]   0.7846089   0.55800512      0.8436568 0.8951047      0.41239670
## [5,]   1.0002699   1.31828711      0.9782303 0.9885934      0.10665432
## [6,]   0.5746231   0.88583314      0.4856171 0.5671838      0.42661727
##      compactness_mean concavity_mean points_mean
## [1,]       0.84165269     0.05582051  0.14122676
## [2,]       0.60686094     0.84608833  0.66541513
## [3,]       0.63696730     0.17749666  0.11210518
## [4,]       0.97419643     0.96525570  1.07517890
## [5,]       0.08236646     0.92147737  0.91720079
## [6,]       0.70721548     0.21261968  0.03169871
```

```
matabsdev.all <- rbind(matabsdevben,matabsdevmalign)
matabsdev.all <- data.frame(breast_cancer$diagnosis, matabsdev.all)

t.test(matabsdev.all$radius_mean[breast_cancer$diagnosis == "B"],matabsdev.all$radius_mean[breast_cancer$dia
gnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  matabsdev.all$radius_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$radius_mean[breast_can
cer$diagnosis == "M"]
## t = 0.32562, df = 567, p-value = 0.6276
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##        -Inf 0.07485419
## sample estimates:
## mean of x mean of y
## 0.5301158 0.5177632
```

```
t.test(matabsdev.all$texture_mean[breast_cancer$diagnosis == "B"],matabsdev.all$texture_mean[breast_cancer$d
iagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  matabsdev.all$texture_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$texture_mean[breast_c
ancer$diagnosis == "M"]
## t = -2.1618, df = 567, p-value = 0.01553
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##         -Inf -0.02723094
## sample estimates:
## mean of x mean of y
## 0.6364762 0.7509490
```

```
t.test(matabsdev.all$perimeter_mean[breast_cancer$diagnosis == "B"],matabsdev.all$perimeter_mean[breast_canc
er$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  matabsdev.all$perimeter_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$perimeter_mean[brea
st_cancer$diagnosis == "M"]
## t = 0.2439, df = 567, p-value = 0.5963
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##        -Inf 0.07148672
## sample estimates:
## mean of x mean of y
## 0.5125724 0.5033541
```

```
t.test(matabsdev.all$area_mean[breast_cancer$diagnosis == "B"],matabsdev.all$area_mean[breast_cancer$diagnos
is == "M"], alternative="less",var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  matabsdev.all$area_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$area_mean[breast_cancer$
diagnosis == "M"]
## t = 0.40112, df = 567, p-value = 0.6558
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##       -Inf 0.0909786
## sample estimates:
## mean of x mean of y
## 0.4981297 0.4803166
```

```
t.test(matabsdev.all$smoothness_mean[breast_cancer$diagnosis == "B"],matabsdev.all$smoothness_mean[breast_ca
ncer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  matabsdev.all$smoothness_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$smoothness_mean[br
east_cancer$diagnosis == "M"]
## t = 1.6742, df = 567, p-value = 0.9527
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf 0.167207
## sample estimates:
## mean of x mean of y
## 0.7680704 0.6837950
```

```
t.test(matabsdev.all$compactness_mean[breast_cancer$diagnosis == "B"],matabsdev.all$compactness_mean[breast_
cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  matabsdev.all$compactness_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$compactness_mean[
breast_cancer$diagnosis == "M"]
## t = 1.8406, df = 567, p-value = 0.9669
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##       -Inf 0.1710355
## sample estimates:
## mean of x mean of y
## 0.6249227 0.5346711
```

```
t.test(matabsdev.all$concavity_mean[breast_cancer$diagnosis == "B"],matabsdev.all$concavity_mean[breast_canc
er$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  matabsdev.all$concavity_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$concavity_mean[brea
st_cancer$diagnosis == "M"]
## t = 1.0995, df = 567, p-value = 0.864
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##       -Inf 0.1302286
## sample estimates:
## mean of x mean of y
## 0.4977532 0.4456302
```

```
t.test(matabsdev.all$points_mean[breast_cancer$diagnosis == "B"],matabsdev.all$points_mean[breast_cancer$dia
gnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  matabsdev.all$points_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$points_mean[breast_can
cer$diagnosis == "M"]
## t = 0.31387, df = 567, p-value = 0.6231
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##        -Inf 0.07740908
## sample estimates:
## mean of x mean of y
## 0.4434506 0.4310634
```

```
head(matstand)
```

```
##      radius_mean texture_mean perimeter_mean  area_mean smoothness_mean
## [1,]  -0.5128453  -1.60418301     -0.5399006 -0.5421468       0.4578825
## [2,]  -1.0009202  -0.07896900     -0.9337442 -0.8766033       0.0369535
## [3,]  -0.8760638  -0.57187353     -0.8662517 -0.8004484       0.8062867
## [4,]  -0.8079604  -1.37168088     -0.7806514 -0.7674858       1.4248817
## [5,]   0.3015589  -1.41353126      0.2337944  0.1617181      -1.1895712
## [6,]  -0.7256686  -0.05804381     -0.7312666 -0.6967299      -0.7750414
##      compactness_mean concavity_mean points_mean
## [1,]       -0.6538379     -0.6137661 -0.30717196
## [2,]        0.1961461     -0.3127117 -0.57983238
## [3,]       -0.4980044     -0.7318045 -0.62158190
## [4,]        0.1753178     -0.5324814 -0.02471844
## [5,]       -0.6627373     -0.6882771 -0.57596668
## [6,]       -0.5135309     -0.4258580 -0.89269604
```

```
matstand.all <- data.frame(breast_cancer$diagnosis, matstand)
head(matstand.all)
```

```
##   breast_cancer.diagnosis radius_mean texture_mean perimeter_mean
## 1                       B  -0.5128453  -1.60418301     -0.5399006
## 2                       B  -1.0009202  -0.07896900     -0.9337442
## 3                       B  -0.8760638  -0.57187353     -0.8662517
## 4                       B  -0.8079604  -1.37168088     -0.7806514
## 5                       B   0.3015589  -1.41353126      0.2337944
## 6                       B  -0.7256686  -0.05804381     -0.7312666
##    area_mean smoothness_mean compactness_mean concavity_mean points_mean
## 1 -0.5421468       0.4578825       -0.6538379     -0.6137661 -0.30717196
## 2 -0.8766033       0.0369535        0.1961461     -0.3127117 -0.57983238
## 3 -0.8004484       0.8062867       -0.4980044     -0.7318045 -0.62158190
## 4 -0.7674858       1.4248817        0.1753178     -0.5324814 -0.02471844
## 5  0.1617181      -1.1895712       -0.6627373     -0.6882771 -0.57596668
## 6 -0.6967299      -0.7750414       -0.5135309     -0.4258580 -0.89269604
```

```
colnames(matstand.all) <- colnames(breast_cancer[2:10])
t2testcan <- hotelling.test(radius_mean + texture_mean + perimeter_mean + area_mean + smoothness_mean + comp
actness_mean + concavity_mean + points_mean + symmetry_mean + dimension_mean ~ diagnosis, data=breast_cancer
)
cat("T2 statistic =",t2testcan$stat[[1]],"\n")
```

```
## T2 statistic = 1220.313
```

```
print(t2testcan)
```

```
## Test stat:  120.09
## Numerator df:  10
## Denominator df:  558
## P-value:  0
```

```
# In the above we standardized using scale function
head(matabsdev.all)
```

```
##   breast_cancer.diagnosis radius_mean texture_mean perimeter_mean
## 1                       B  0.03405174    1.1625107     0.02757317
## 2                       B  0.45402322    0.3627033     0.36627050
## 3                       B  0.32916684    0.1302012     0.29877796
## 4                       B  0.26106335    0.9300085     0.21317766
## 5                       B  0.84845589    0.9718589     0.80126817
## 6                       B  0.17877164    0.3836285     0.16379288
##    area_mean smoothness_mean compactness_mean concavity_mean points_mean
## 1 0.01619713       0.8560787       0.10376281     0.03487214  0.34945891
## 2 0.31825946       0.4351496       0.74622121     0.33592655  0.07679849
## 3 0.24210452       1.2044828       0.05207075     0.08316628  0.03504898
## 4 0.20914193       1.8230778       0.72539291     0.11615683  0.63191243
## 5 0.72006202       0.7913750       0.11266217     0.03963883  0.08066419
## 6 0.13838603       0.3768453       0.03654420     0.22278026  0.23606517
```

```
#install.packages("car")
library(car)
```

```
## Warning: package 'car' was built under R version 3.5.2
```

```
## Loading required package: carData
```

```
#leveneTest() produces a two-sided test
# Leverne test is used to verify Homoscedasticity. It tests if the variance of two samples are # #equal. Lev
ene's test is an inferential statistic used to assess the equality of variances for a #variable calculated f
or two or more groups.[1] Some common statistical procedures assume that #variances of the populations from
which different samples are drawn are equal. Levene's test #assesses this assumption.
leveneTest(radius_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group   1  90.477 < 2.2e-16 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(texture_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value Pr(>F)
## group   1   0.684 0.4086
##       567
```

```
leveneTest(perimeter_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group   1  91.237 < 2.2e-16 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(area_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group   1  170.21 < 2.2e-16 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(smoothness_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value Pr(>F)
## group   1  0.8377 0.3604
##       567
```

```
leveneTest(compactness_mean~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group   1  39.892 5.428e-10 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(concavity_mean~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group   1  70.484 3.723e-16 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(points_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group   1  94.906 < 2.2e-16 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(symmetry_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value Pr(>F)
## group   1   2.036 0.1542
##       567
```

```
leveneTest(dimension_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value  Pr(>F)
## group   1   6.113 0.01371 *
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#PCA

dim(breast_cancer)
```

```
## [1] 569  32
```

```
attach(breast_cancer)
head(breast_cancer)
```

```
##         id diagnosis radius_mean texture_mean perimeter_mean area_mean
## 1 87139402         B       12.32        12.39          78.85     464.1
## 2  8910251         B       10.60        18.95          69.28     346.4
## 3   905520         B       11.04        16.83          70.92     373.2
## 4   868871         B       11.28        13.39          73.00     384.8
## 5  9012568         B       15.19        13.21          97.65     711.8
## 6   906539         B       11.57        19.04          74.20     409.7
##   smoothness_mean compactness_mean concavity_mean points_mean
## 1         0.10280          0.06981        0.03987     0.03700
## 2         0.09688          0.11470        0.06387     0.02642
## 3         0.10770          0.07804        0.03046     0.02480
## 4         0.11640          0.11360        0.04635     0.04796
## 5         0.07963          0.06934        0.03393     0.02657
## 6         0.08546          0.07722        0.05485     0.01428
##   symmetry_mean dimension_mean radius_se texture_se perimeter_se area_se
## 1        0.1959         0.05955    0.2360     0.6656        1.670   17.43
## 2        0.1922         0.06491    0.4505     1.1970        3.430   27.10
## 3        0.1714         0.06340    0.1967     1.3870        1.342   13.54
## 4        0.1771         0.06072    0.3384     1.3430        1.851   26.33
## 5        0.1721         0.05544    0.1783     0.4125        1.338   17.72
## 6        0.2031         0.06267    0.2864     1.4400        2.206   20.30
##   smoothness_se compactness_se concavity_se points_se symmetry_se
## 1      0.008045       0.011800      0.01683  0.012410     0.01924
## 2      0.007470       0.035810      0.03354  0.013650     0.03504
## 3      0.005158       0.009355      0.01056  0.007483     0.01718
## 4      0.011270       0.034980      0.02187  0.019650     0.01580
## 5      0.005012       0.014850      0.01551  0.009155     0.01647
## 6      0.007278       0.020470      0.04447  0.008799     0.01868
##   dimension_se radius_worst texture_worst perimeter_worst area_worst
## 1     0.002248        13.50         15.64           86.97      549.1
## 2     0.003318        11.88         22.94           78.28      424.8
## 3     0.002198        12.41         26.44           79.93      471.4
## 4     0.003442        11.92         15.77           76.53      434.0
## 5     0.001767        16.20         15.73          104.50      819.1
## 6     0.003339        13.07         26.98           86.43      520.5
##   smoothness_worst compactness_worst concavity_worst points_worst
## 1           0.1385            0.1266         0.12420      0.09391
## 2           0.1213            0.2515         0.19160      0.07926
## 3           0.1369            0.1482         0.10670      0.07431
## 4           0.1367            0.1822         0.08669      0.08611
## 5           0.1126            0.1737         0.13620      0.08178
## 6           0.1249            0.1937         0.25600      0.06664
##   symmetry_worst dimension_worst
## 1         0.2827         0.06771
## 2         0.2940         0.07587
## 3         0.2998         0.07881
## 4         0.2102         0.06784
## 5         0.2487         0.06766
## 6         0.3035         0.08284
```

```
#Get the Correlations between the measurements
cor(breast_cancer[-2])
```

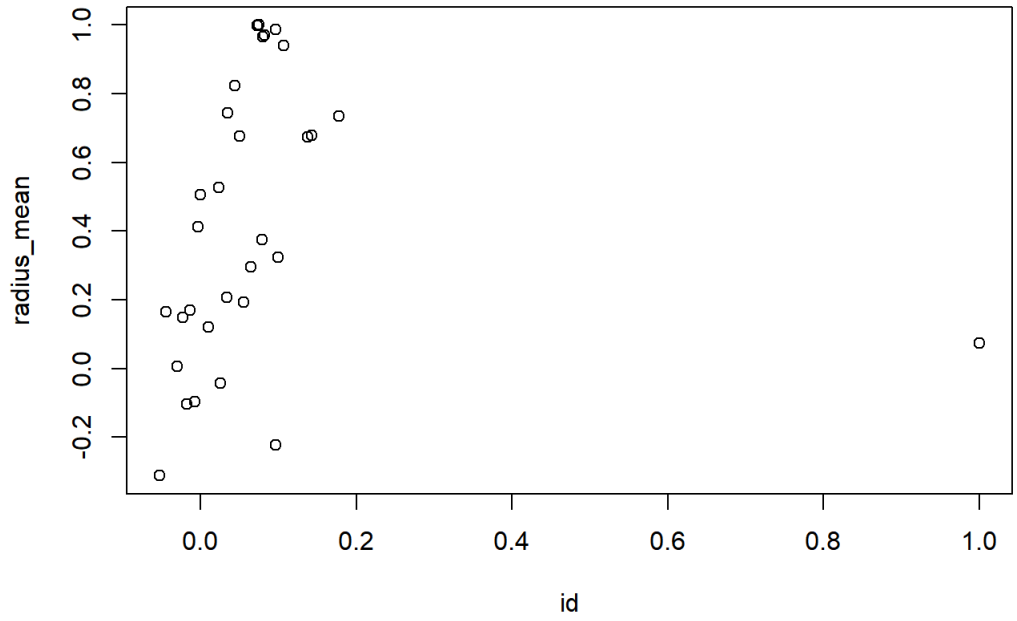
```
##                             id  radius_mean texture_mean perimeter_mean
## id                 1.0000000000  0.074626470  0.099769891    0.073159412
## radius_mean        0.0746264697  1.000000000  0.323781891    0.997855281
## texture_mean       0.0997698912  0.323781891  1.000000000    0.329533059
## perimeter_mean     0.0731594119  0.997855281  0.329533059    1.000000000
## area_mean          0.0968928233  0.987357170  0.321085696    0.986506804
## smoothness_mean   -0.0129681975  0.170581187 -0.023388516    0.207278164
## compactness_mean   0.0000957011  0.506123578  0.236702222    0.556936211
## concavity_mean     0.0500799532  0.676763550  0.302417828    0.716135650
## points_mean        0.0441580956  0.822528522  0.293464051    0.850977041
## symmetry_mean     -0.0221140609  0.147741242  0.071400980    0.183027212
## dimension_mean    -0.0525114476 -0.311630826 -0.076437183   -0.261476908
## radius_se          0.1430475814  0.679090388  0.275868676    0.691765014
## texture_se        -0.0075261904 -0.097317443  0.386357623   -0.086761078
## perimeter_se       0.1373310660  0.674171616  0.281673115    0.693134890
## area_se            0.1777419152  0.735863663  0.259844987    0.744982694
## smoothness_se      0.0967805739 -0.222600125  0.006613777   -0.202694026
## compactness_se     0.0339609721  0.205999980  0.191974611    0.250743681
## concavity_se       0.0552393174  0.194203623  0.143293077    0.228082345
## points_se          0.0787680711  0.376168956  0.163851025    0.407216916
## symmetry_se       -0.0173062948 -0.104320881  0.009127168   -0.081629327
## dimension_se       0.0257253243 -0.042641269  0.054457520   -0.005523391
## radius_worst       0.0824053373  0.969538973  0.352572947    0.969476363
## texture_worst      0.0647195454  0.297007644  0.912044589    0.303038372
## perimeter_worst    0.0799858731  0.965136514  0.358039575    0.970386887
## area_worst         0.1071865233  0.941082460  0.343545947    0.941549808
## smoothness_worst   0.0103380343  0.119616140  0.077503359    0.150549404
## compactness_worst -0.0029680998  0.413462823  0.277829592    0.455774228
## concavity_worst    0.0232027439  0.526911462  0.301025224    0.563879263
## points_worst       0.0351735794  0.744214198  0.295315843    0.771240789
## symmetry_worst    -0.0442242529  0.163953335  0.105007910    0.189115040
## dimension_worst   -0.0298656360  0.007065886  0.119205351    0.051018530
##                    area_mean smoothness_mean compactness_mean
## id                 0.096892823     -0.01296820     0.0000957011
## radius_mean        0.987357170      0.17058119     0.5061235775
## texture_mean       0.321085696     -0.02338852     0.2367022221
## perimeter_mean     0.986506804      0.20727816     0.5569362109
## area_mean          1.000000000      0.17702838     0.4985016822
## smoothness_mean    0.177028377      1.00000000     0.6591232152
## compactness_mean   0.498501682      0.65912322     1.0000000000
## concavity_mean     0.685982829      0.52198377     0.8831206702
## points_mean        0.823268869      0.55369517     0.8311350431
## symmetry_mean      0.151293079      0.55777479     0.6026410484
## dimension_mean    -0.283109812      0.58479200     0.5653686634
## radius_se          0.732562227      0.30146710     0.4974734461
## texture_se        -0.066280214      0.06840645     0.0462048307
## perimeter_se       0.726628328      0.29609193     0.5489052646
## area_se            0.800085921      0.24655243     0.4556528520
## smoothness_se     -0.166776667      0.33237544     0.1352992677
## compactness_se     0.212582551      0.31894330     0.7387217897
## concavity_se       0.207660060      0.24839568     0.5705168715
## points_se          0.372320282      0.38067569     0.6422618510
## symmetry_se       -0.072496588      0.20077438     0.2299765908
## dimension_se      -0.019886963      0.28360670     0.5073181269
## radius_worst       0.962746086      0.21312014     0.5353153982
## texture_worst      0.287488627      0.03607180     0.2481328333
## perimeter_worst    0.959119574      0.23885263     0.5902104277
## area_worst         0.959213326      0.20671836     0.5096038056
## smoothness_worst   0.123522939      0.80532420     0.5655411664
## compactness_worst  0.390410309      0.47246844     0.8658090398
## concavity_worst    0.512605920      0.43492571     0.8162752498
## points_worst       0.722016626      0.50305335     0.8155732236
## symmetry_worst     0.143569914      0.39430948     0.5102234299
## dimension_worst    0.003737597      0.49931637     0.6873823228
##                   concavity_mean points_mean symmetry_mean dimension_mean
## id                    0.05007995  0.04415810   -0.02211406  -0.0525114476
## radius_mean           0.67676355  0.82252852    0.14774124  -0.3116308263
## texture_mean          0.30241783  0.29346405    0.07140098  -0.0764371834
## perimeter_mean        0.71613565  0.85097704    0.18302721  -0.2614769081
## area_mean             0.68598283  0.82326887    0.15129308  -0.2831098117
## smoothness_mean       0.52198377  0.55369517    0.55777479   0.5847920019
## compactness_mean      0.88312067  0.83113504    0.60264105   0.5653686634
```

```
## concavity_mean        1.00000000  0.92139103    0.50066662   0.3367833594
## points_mean           0.92139103  1.00000000    0.46249739   0.1669173832
## symmetry_mean         0.50066662  0.46249739    1.00000000   0.4799213301
## dimension_mean        0.33678336  0.16691738    0.47992133   1.0000000000
## radius_se             0.63192482  0.69804983    0.30337926   0.0001109951
## texture_se            0.07621835  0.02147958    0.12805293   0.1641739659
## perimeter_se          0.66039079  0.71064987    0.31389276   0.0398299316
## area_se               0.61742681  0.69029854    0.22397022  -0.0901702475
## smoothness_se         0.09856375  0.02765331    0.18732117   0.4019644254
## compactness_se        0.67027882  0.49042425    0.42165915   0.5598366906
## concavity_se          0.69127021  0.43916707    0.34262702   0.4466303217
## points_se             0.68325992  0.61563413    0.39329787   0.3411980444
## symmetry_se           0.17800921  0.09535079    0.44913654   0.3450073971
## dimension_se          0.44930075  0.25758375    0.33178615   0.6881315775
## radius_worst          0.68823641  0.83031763    0.18572775  -0.2536914949
## texture_worst         0.29987889  0.29275171    0.09065069  -0.0512692020
## perimeter_worst       0.72956492  0.85592313    0.21916856  -0.2051512113
## area_worst            0.67598723  0.80962962    0.17719338  -0.2318544512
## smoothness_worst      0.44882204  0.45275305    0.42667503   0.5049420754
## compactness_worst     0.75496802  0.66745368    0.47320001   0.4587981567
## concavity_worst       0.88410264  0.75239950    0.43372101   0.3462338763
## points_worst          0.86132303  0.91015531    0.43029661   0.1753254492
## symmetry_worst        0.40946413  0.37574415    0.69982580   0.3340186839
## dimension_worst       0.51492989  0.36866113    0.43841350   0.7672967792
##                       radius_se  texture_se perimeter_se     area_se
## id                 0.1430475814 -0.00752619   0.13733107  0.17774192
## radius_mean        0.6790903880 -0.09731744   0.67417162  0.73586366
## texture_mean       0.2758686762  0.38635762   0.28167311  0.25984499
## perimeter_mean     0.6917650135 -0.08676108   0.69313489  0.74498269
## area_mean          0.7325622270 -0.06628021   0.72662833  0.80008592
## smoothness_mean    0.3014670983  0.06840645   0.29609193  0.24655243
## compactness_mean   0.4974734461  0.04620483   0.54890526  0.45565285
## concavity_mean     0.6319248221  0.07621835   0.66039079  0.61742681
## points_mean        0.6980498336  0.02147958   0.71064987  0.69029854
## symmetry_mean      0.3033792632  0.12805293   0.31389276  0.22397022
## dimension_mean     0.0001109951  0.16417397   0.03982993 -0.09017025
## radius_se          1.0000000000  0.21324734   0.97279368  0.95183011
## texture_se         0.2132473373  1.00000000   0.22317073  0.11156725
## perimeter_se       0.9727936770  0.22317073   1.00000000  0.93765541
## area_se            0.9518301121  0.11156725   0.93765541  1.00000000
## smoothness_se      0.1645142198  0.39724285   0.15107533  0.07515034
## compactness_se     0.3560645755  0.23169970   0.41632237  0.28484006
## concavity_se       0.3323575376  0.19499846   0.36248158  0.27089473
## points_se          0.5133464414  0.23028340   0.55626408  0.41572957
## symmetry_se        0.2405673625  0.41162068   0.26648709  0.13410898
## dimension_se       0.2277535327  0.27972275   0.24414277  0.12707090
## radius_worst       0.7150651951 -0.11169031   0.69720059  0.75737319
## texture_worst      0.1947985568  0.40900277   0.20037085  0.19649665
## perimeter_worst    0.7196838037 -0.10224192   0.72103131  0.76121264
## area_worst         0.7515484761 -0.08319499   0.73071297  0.81140796
## smoothness_worst   0.1419185529 -0.07365766   0.13005439  0.12538943
## compactness_worst  0.2871031656 -0.09243935   0.34191945  0.28325654
## concavity_worst    0.3805846346 -0.06895622   0.41889882  0.38510014
## points_worst       0.5310623278 -0.11963752   0.55489723  0.53816631
## symmetry_worst     0.0945428304 -0.12821476   0.10993043  0.07412629
## dimension_worst    0.0495594325 -0.04565457   0.08543257  0.01753930
##                   smoothness_se compactness_se concavity_se  points_se
## id                  0.096780574     0.03396097   0.05523932 0.07876807
## radius_mean        -0.222600125     0.20599998   0.19420362 0.37616896
## texture_mean        0.006613777     0.19197461   0.14329308 0.16385103
## perimeter_mean     -0.202694026     0.25074368   0.22808235 0.40721692
## area_mean          -0.166776667     0.21258255   0.20766006 0.37232028
## smoothness_mean     0.332375443     0.31894330   0.24839568 0.38067569
## compactness_mean    0.135299268     0.73872179   0.57051687 0.64226185
## concavity_mean      0.098563746     0.67027882   0.69127021 0.68325992
## points_mean         0.027653308     0.49042425   0.43916707 0.61563413
## symmetry_mean       0.187321165     0.42165915   0.34262702 0.39329787
## dimension_mean      0.401964425     0.55983669   0.44663032 0.34119804
## radius_se           0.164514220     0.35606458   0.33235754 0.51334644
## texture_se          0.397242853     0.23169970   0.19499846 0.23028340
## perimeter_se        0.151075331     0.41632237   0.36248158 0.55626408
## area_se             0.075150338     0.28484006   0.27089473 0.41572957
## smoothness_se       1.000000000     0.33669608   0.26868476 0.32842950
```

```
## compactness_se      0.336696081     1.00000000   0.80126834 0.74408267
## concavity_se        0.268684760     0.80126834   1.00000000 0.77180399
## points_se           0.328429499     0.74408267   0.77180399 1.00000000
## symmetry_se         0.413506125     0.39471283   0.30942858 0.31278022
## dimension_se        0.427374207     0.80326882   0.72737218 0.61104414
## radius_worst       -0.230690710     0.20460717   0.18690352 0.35812667
## texture_worst      -0.074742965     0.14300258   0.10024098 0.08674121
## perimeter_worst    -0.217303755     0.26051584   0.22668043 0.39499925
## area_worst         -0.182195478     0.19937133   0.18835265 0.34227116
## smoothness_worst    0.314457456     0.22739423   0.16848132 0.21535060
## compactness_worst  -0.055558139     0.67878035   0.48485780 0.45288838
## concavity_worst    -0.058298387     0.63914670   0.66256413 0.54959238
## points_worst       -0.102006796     0.48320833   0.44047226 0.60244961
## symmetry_worst     -0.107342098     0.27787843   0.19778782 0.14311567
## dimension_worst     0.101480315     0.59097276   0.43932927 0.31065455
##                    symmetry_se dimension_se radius_worst texture_worst
## id                -0.017306295  0.025725324   0.08240534   0.064719545
## radius_mean       -0.104320881 -0.042641269   0.96953897   0.297007644
## texture_mean       0.009127168  0.054457520   0.35257295   0.912044589
## perimeter_mean    -0.081629327 -0.005523391   0.96947636   0.303038372
## area_mean         -0.072496588 -0.019886963   0.96274609   0.287488627
## smoothness_mean    0.200774376  0.283606699   0.21312014   0.036071799
## compactness_mean   0.229976591  0.507318127   0.53531540   0.248132833
## concavity_mean     0.178009208  0.449300749   0.68823641   0.299878889
## points_mean        0.095350787  0.257583746   0.83031763   0.292751713
## symmetry_mean      0.449136542  0.331786146   0.18572775   0.090650688
## dimension_mean     0.345007397  0.688131577  -0.25369149  -0.051269202
## radius_se          0.240567362  0.227753533   0.71506520   0.194798557
## texture_se         0.411620680  0.279722748  -0.11169031   0.409002766
## perimeter_se       0.266487092  0.244142773   0.69720059   0.200370854
## area_se            0.134108980  0.127070903   0.75737319   0.196496649
## smoothness_se      0.413506125  0.427374207  -0.23069071  -0.074742965
## compactness_se     0.394712835  0.803268818   0.20460717   0.143002583
## concavity_se       0.309428578  0.727372184   0.18690352   0.100240984
## points_se          0.312780223  0.611044139   0.35812667   0.086741210
## symmetry_se        1.000000000  0.369078083  -0.12812077  -0.077473420
## dimension_se       0.369078083  1.000000000  -0.03748762  -0.003195029
## radius_worst      -0.128120769 -0.037487618   1.00000000   0.359920754
## texture_worst     -0.077473420 -0.003195029   0.35992075   1.000000000
## perimeter_worst   -0.103753044 -0.001000398   0.99370792   0.365098245
## area_worst        -0.110342743 -0.022736147   0.98401456   0.345842283
## smoothness_worst  -0.012661800  0.170568316   0.21657443   0.225429415
## compactness_worst  0.060254879  0.390158842   0.47582004   0.360832339
## concavity_worst    0.037119049  0.379974661   0.57397471   0.368365607
## points_worst      -0.030413396  0.215204013   0.78742385   0.359754610
## symmetry_worst     0.389402485  0.111093956   0.24352920   0.233027461
## dimension_worst    0.078079476  0.591328066   0.09349198   0.219122425
##                   perimeter_worst  area_worst smoothness_worst
## id                    0.079985873  0.10718652       0.01033803
## radius_mean           0.965136514  0.94108246       0.11961614
## texture_mean          0.358039575  0.34354595       0.07750336
## perimeter_mean        0.970386887  0.94154981       0.15054940
## area_mean             0.959119574  0.95921333       0.12352294
## smoothness_mean       0.238852626  0.20671836       0.80532420
## compactness_mean      0.590210428  0.50960381       0.56554117
## concavity_mean        0.729564917  0.67598723       0.44882204
## points_mean           0.855923128  0.80962962       0.45275305
## symmetry_mean         0.219168559  0.17719338       0.42667503
## dimension_mean       -0.205151211 -0.23185445       0.50494208
## radius_se             0.719683804  0.75154848       0.14191855
## texture_se           -0.102241922 -0.08319499      -0.07365766
## perimeter_se          0.721031310  0.73071297       0.13005439
## area_se               0.761212636  0.81140796       0.12538943
## smoothness_se        -0.217303755 -0.18219548       0.31445746
## compactness_se        0.260515840  0.19937133       0.22739423
## concavity_se          0.226680426  0.18835265       0.16848132
## points_se             0.394999252  0.34227116       0.21535060
## symmetry_se          -0.103753044 -0.11034274      -0.01266180
## dimension_se         -0.001000398 -0.02273615       0.17056832
## radius_worst          0.993707916  0.98401456       0.21657443
## texture_worst         0.365098245  0.34584228       0.22542941
## perimeter_worst       1.000000000  0.97757809       0.23677460
## area_worst            0.977578091  1.00000000       0.20914533
```

```
## area_worst            0.977578091  1.00000000       0.20914533
## smoothness_worst      0.236774604  0.20914533       1.00000000
## compactness_worst     0.529407690  0.43829628       0.56818652
## concavity_worst       0.618344080  0.54333053       0.51852329
## points_worst          0.816322102  0.74741880       0.54769090
## symmetry_worst        0.269492769  0.20914551       0.49383833
## dimension_worst       0.138956862  0.07964703       0.61762419
##                   compactness_worst concavity_worst points_worst
## id                      -0.00296810      0.02320274   0.03517358
## radius_mean              0.41346282      0.52691146   0.74421420
## texture_mean             0.27782959      0.30102522   0.29531584
## perimeter_mean           0.45577423      0.56387926   0.77124079
## area_mean                0.39041031      0.51260592   0.72201663
## smoothness_mean          0.47246844      0.43492571   0.50305335
## compactness_mean         0.86580904      0.81627525   0.81557322
## concavity_mean           0.75496802      0.88410264   0.86132303
## points_mean              0.66745368      0.75239950   0.91015531
## symmetry_mean            0.47320001      0.43372101   0.43029661
## dimension_mean           0.45879816      0.34623388   0.17532545
## radius_se                0.28710317      0.38058463   0.53106233
## texture_se              -0.09243935     -0.06895622  -0.11963752
## perimeter_se             0.34191945      0.41889882   0.55489723
## area_se                  0.28325654      0.38510014   0.53816631
## smoothness_se           -0.05555814     -0.05829839  -0.10200680
## compactness_se           0.67878035      0.63914670   0.48320833
## concavity_se             0.48485780      0.66256413   0.44047226
## points_se                0.45288838      0.54959238   0.60244961
## symmetry_se              0.06025488      0.03711905  -0.03041340
## dimension_se             0.39015884      0.37997466   0.21520401
## radius_worst             0.47582004      0.57397471   0.78742385
## texture_worst            0.36083234      0.36836561   0.35975461
## perimeter_worst          0.52940769      0.61834408   0.81632210
## area_worst               0.43829628      0.54333053   0.74741880
## smoothness_worst         0.56818652      0.51852329   0.54769090
## compactness_worst        1.00000000      0.89226090   0.80108036
## concavity_worst          0.89226090      1.00000000   0.85543386
## points_worst             0.80108036      0.85543386   1.00000000
## symmetry_worst           0.61444050      0.53251973   0.50252849
## dimension_worst          0.81045486      0.68651092   0.51111415
##                   symmetry_worst dimension_worst
## id                   -0.04422425    -0.029865636
## radius_mean           0.16395333     0.007065886
## texture_mean          0.10500791     0.119205351
## perimeter_mean        0.18911504     0.051018530
## area_mean             0.14356991     0.003737597
## smoothness_mean       0.39430948     0.499316369
## compactness_mean      0.51022343     0.687382323
## concavity_mean        0.40946413     0.514929891
## points_mean           0.37574415     0.368661134
## symmetry_mean         0.69982580     0.438413498
## dimension_mean        0.33401868     0.767296779
## radius_se             0.09454283     0.049559432
## texture_se           -0.12821476    -0.045654569
## perimeter_se          0.10993043     0.085432572
## area_se               0.07412629     0.017539295
## smoothness_se        -0.10734210     0.101480315
## compactness_se        0.27787843     0.590972763
## concavity_se          0.19778782     0.439329269
## points_se             0.14311567     0.310654551
## symmetry_se           0.38940248     0.078079476
## dimension_se          0.11109396     0.591328066
## radius_worst          0.24352920     0.093491979
## texture_worst         0.23302746     0.219122425
## perimeter_worst       0.26949277     0.138956862
## area_worst            0.20914551     0.079647034
## smoothness_worst      0.49383833     0.617624192
## compactness_worst     0.61444050     0.810454856
## concavity_worst       0.53251973     0.686510921
## points_worst          0.50252849     0.511114146
## symmetry_worst        1.00000000     0.537848206
## dimension_worst       0.53784821     1.000000000
```

```
c <- (cor(breast_cancer[-2]))
plot(c)
```




```
# Using prcomp to compute the principal components (eigenvalues and eigenvectors). With scale=TRUE, variable means are set to zero, and variances set to one
breast_cancer_pca <- prcomp(breast_cancer[,-2],scale=TRUE)
breast_cancer_pca
```

```
## Standard deviations (1, .., p=31):
##  [1] 3.64527878 2.38679814 1.68386313 1.40760690 1.28406203 1.11115827
##  [7] 0.98907696 0.81960537 0.67881693 0.63492763 0.59089337 0.54211662
## [13] 0.51102537 0.49125372 0.39619900 0.30680373 0.28250655 0.24299439
## [19] 0.22932770 0.22163467 0.17626907 0.17303527 0.16562163 0.15572098
## [25] 0.13431069 0.12441756 0.09039745 0.08305482 0.03986650 0.02735646
## [31] 0.01153431
##
## Rotation (n x k) = (31 x 31):
##                             PC1          PC2          PC3          PC4
## id                 -0.02291216  0.034068491  0.096938436 -0.026598045
## radius_mean        -0.21891302  0.233271401 -0.011393786  0.042187950
## texture_mean       -0.10384388  0.060044199  0.066892342 -0.602954308
## perimeter_mean     -0.22753491  0.214589002 -0.012124791  0.042752797
## area_mean          -0.22104577  0.230668816  0.026293150  0.054114724
## smoothness_mean    -0.14241471 -0.186422211 -0.103182400  0.158098177
## compactness_mean   -0.23906730 -0.152454726 -0.074768623  0.031818117
## concavity_mean     -0.25828025 -0.060541625  0.001758736  0.019497124
## points_mean        -0.26073811  0.034167392 -0.027579607  0.065785353
## symmetry_mean      -0.13797774 -0.190684979 -0.040962032  0.067502543
## dimension_mean     -0.06414779 -0.366531055 -0.020817875  0.047957856
## radius_se          -0.20611747  0.105935702  0.266917221  0.099114446
## texture_se         -0.01741339 -0.089547789  0.371439885 -0.356497230
## perimeter_se       -0.21144652  0.089807043  0.264925682  0.090293055
## area_se            -0.20307642  0.152771289  0.215790250  0.108568705
## smoothness_se      -0.01467821 -0.203189876  0.311787845  0.044368664
## compactness_se     -0.17028840 -0.232503362  0.154557465 -0.026425360
## concavity_se       -0.15354367 -0.196846081  0.176560052  0.002248291
## points_se          -0.18340675 -0.129965181  0.223850479  0.075252232
## symmetry_se        -0.04241552 -0.183558627  0.285265066  0.046936126
## dimension_se       -0.10249607 -0.279584139  0.211893354  0.016212450
## radius_worst       -0.22800935  0.219296044 -0.049406340  0.015659705
## texture_worst      -0.10451545  0.045501223 -0.039828934 -0.633119655
## perimeter_worst    -0.23663734  0.199295985 -0.050431945  0.014068572
## area_worst         -0.22493214  0.218985461 -0.013188891  0.025970672
## smoothness_worst   -0.12782441 -0.172562959 -0.255328751  0.014523359
```

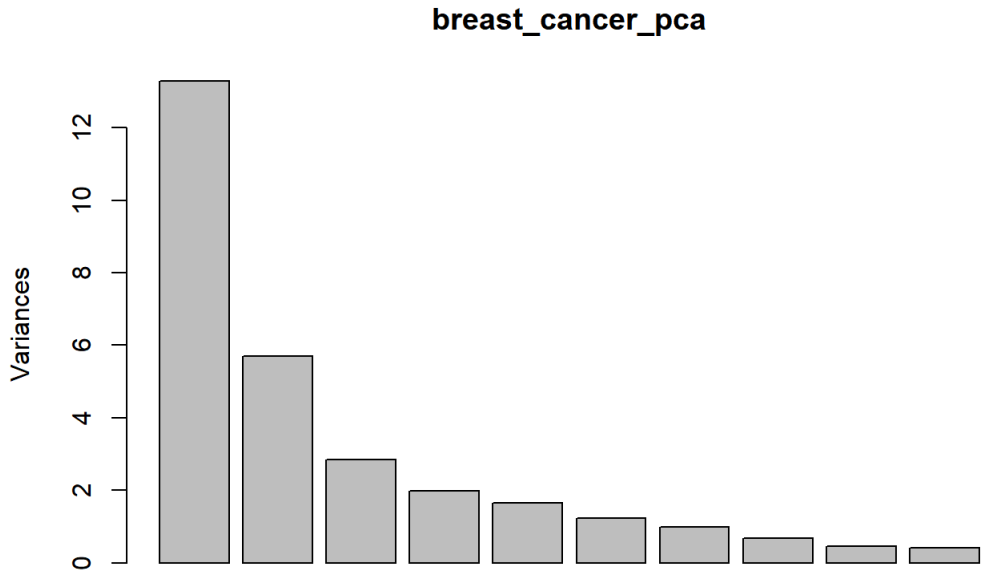
```
## compactness_worst -0.20988456 -0.144253637 -0.234513609 -0.092562168
## concavity_worst   -0.22860218 -0.098526524 -0.172024941 -0.074807188
## points_worst      -0.25074620  0.007534367 -0.170480673  0.005305980
## symmetry_worst    -0.12267993 -0.142619436 -0.270515902 -0.037129466
## dimension_worst   -0.13156024 -0.275702077 -0.229474476 -0.078971489
##                          PC5          PC6           PC7          PC8
## id                 0.011327587 -0.316733438  0.9071156324 -0.096362415
## radius_mean       -0.038129861  0.029588521 -0.0422987777 -0.116427419
## texture_mean       0.049091450 -0.031394323  0.0149935618  0.001875482
## perimeter_mean    -0.037715592  0.028394008 -0.0435888242 -0.106272097
## area_mean         -0.010562229  0.006113155 -0.0289256668 -0.047414568
## smoothness_mean    0.365750055 -0.262508993 -0.1403403617 -0.123541189
## compactness_mean  -0.011786637 -0.004903894 -0.0453031106  0.043145968
## concavity_mean    -0.086512506 -0.002356338 -0.0325530646 -0.102436021
## points_mean        0.043667412 -0.034509273 -0.0814216298 -0.136923237
## symmetry_mean      0.305378893  0.335082168  0.1182592361 -0.098874531
## dimension_mean     0.044767906 -0.112784169 -0.0410588768  0.306499872
## radius_se          0.154254367 -0.023261199  0.0167882718  0.307415709
## texture_se         0.190001500  0.022856912 -0.1902676469 -0.052632477
## perimeter_se       0.120703357  0.003820151  0.0195081762  0.311265679
## area_se            0.127765023 -0.051958835  0.0565606078  0.334287959
## smoothness_se      0.232745603 -0.330867850 -0.0678348099 -0.260833914
## compactness_se    -0.280298048  0.066788120  0.0222220211  0.021001944
## concavity_se      -0.354164595  0.049699104  0.0336810725 -0.219193299
## points_se         -0.195758558 -0.023197526 -0.0378517870 -0.370217167
## symmetry_se        0.251331178  0.477530515  0.1184032606 -0.084854768
## dimension_se      -0.263395188 -0.048462373 -0.0157602244  0.194418818
## radius_worst       0.004280034  0.004521737 -0.0166458140 -0.007508307
## texture_worst      0.092551860 -0.045174516 -0.0094601240  0.006617640
## perimeter_worst   -0.007599144  0.012921166 -0.0145260986  0.002162488
## area_worst         0.027413595 -0.024033338 -0.0007372602  0.066173186
## smoothness_worst   0.325860028 -0.365048687 -0.0670682168 -0.116496117
## compactness_worst -0.121503371  0.034042714  0.0507556727  0.136509363
## concavity_worst   -0.188280510  0.017962040  0.0352007117 -0.067085744
## points_worst      -0.043123573 -0.029549100 -0.0207238959 -0.166500918
## symmetry_worst     0.244245936  0.451404312  0.2340143294 -0.041439633
## dimension_worst   -0.093699078 -0.092479698  0.0347167538  0.372034479
##                          PC9         PC10          PC11         PC12
## id                 0.149115642 -0.16926751  0.058188997 -0.006721252
## radius_mean       -0.046270835 -0.22402704 -0.079466081 -0.042213788
## texture_mean      -0.088727168  0.11945674 -0.253258091  0.304032359
## perimeter_mean    -0.036230738 -0.22634517 -0.069865929 -0.017573055
## area_mean         -0.080649856 -0.18600385 -0.062795372 -0.110760120
## smoothness_mean    0.278996404 -0.06133822  0.084661549  0.135321954
## compactness_mean   0.099214048 -0.19518602  0.005172841  0.307036205
## concavity_mean     0.075750464  0.03395563  0.134664686 -0.124553100
## points_mean        0.116569072 -0.14261678  0.006124860  0.071564686
## symmetry_mean      0.315150303  0.13561452 -0.574417320 -0.161058144
## dimension_mean     0.130639482 -0.15848117 -0.066456112  0.037318709
## radius_se          0.026200456  0.26504403  0.025847282  0.027030250
## texture_se         0.372989606 -0.31521084  0.323158815 -0.348396233
## perimeter_se       0.052860114  0.23789288  0.094867442  0.168501485
## area_se           -0.030627892  0.24966405  0.071991560 -0.050731496
## smoothness_se     -0.580789293 -0.01015980 -0.179568831 -0.081753374
## compactness_se    -0.148593714 -0.11518343 -0.038615749  0.206959272
## concavity_se       0.034715098  0.36592141  0.113536362 -0.348342358
## points_se          0.189022962  0.21518752 -0.094066850  0.342855186
## symmetry_se       -0.292785738 -0.22049558  0.328314881  0.185998712
## dimension_se      -0.060203202 -0.22637997 -0.353844543 -0.250428852
## radius_worst      -0.070224590 -0.09981025 -0.073013014 -0.105030701
## texture_worst     -0.008571809  0.10669296 -0.038561250 -0.012490348
## perimeter_worst   -0.058854223 -0.09821693 -0.045750979 -0.051125158
## area_worst        -0.097034650 -0.06179787 -0.068822329 -0.184460981
## smoothness_worst  -0.173257498  0.16912753  0.109278029 -0.142996001
## compactness_worst -0.111218083 -0.06445290  0.175401648  0.196805544
## concavity_worst   -0.035467377  0.19661986  0.295581609 -0.184959562
## points_worst       0.052322473  0.05121611  0.075496752  0.117518361
## symmetry_worst    -0.188266324  0.10308901  0.019223451 -0.157210098
## dimension_worst   -0.087222442 -0.11291399 -0.007071634 -0.118625115
##                         PC13         PC14          PC15         PC16
## id                -0.004841084 -0.006500099  0.006885943 -0.002753492
## radius_mean        0.050603927 -0.012496988 -0.059054553  0.050789156
```

```
## texture_mean       0.256273666 -0.201876125  0.020701124  0.108089530
## perimeter_mean     0.038470392 -0.044684430 -0.048019221  0.039590476
## area_mean          0.065047550 -0.067879244 -0.010152279 -0.014636050
## smoothness_mean    0.315872261 -0.046461624 -0.444044654  0.117493291
## compactness_mean  -0.104264618 -0.230005458 -0.007661166 -0.230759682
## concavity_mean     0.065723393 -0.387349680  0.189733740  0.128386008
## points_mean        0.042253113 -0.132637847  0.245219266  0.217299938
## symmetry_mean     -0.288054252 -0.189570545 -0.030903840  0.073950596
## dimension_mean     0.236120382 -0.106390748  0.377436108 -0.518333769
## radius_se         -0.015625578  0.069635807 -0.011959877  0.111103952
## texture_se        -0.308499115  0.165408488  0.012614192 -0.033389049
## perimeter_se      -0.100597125  0.038865462  0.044358477  0.008991734
## area_se           -0.017226446 -0.055687709 -0.083203050  0.045171638
## smoothness_se     -0.293287983 -0.149148603  0.200139961 -0.018414232
## compactness_se    -0.263398426 -0.010320713 -0.491903153 -0.167886977
## concavity_se       0.251864823 -0.157777595 -0.135322845 -0.250292522
## points_se         -0.006430584  0.494527095  0.199547389 -0.062548716
## symmetry_se        0.319874237 -0.010836031  0.047340593  0.113219397
## dimension_se       0.275943072  0.240767973 -0.145958050  0.353782637
## radius_worst       0.039582217  0.138036550 -0.023526025 -0.166213790
## texture_worst      0.080142089  0.080737140 -0.053897961 -0.100862417
## perimeter_worst   -0.009084762  0.097004376 -0.012559001 -0.182407021
## area_worst         0.047986766  0.101235629  0.006646192 -0.315142865
## smoothness_worst   0.056931408  0.206026671 -0.163389545 -0.045226715
## compactness_worst -0.371991007 -0.013117334 -0.165941776  0.049613607
## concavity_worst   -0.086870368 -0.218055908  0.066854662  0.204743734
## points_worst      -0.068367254  0.254345228  0.276401728  0.169597618
## symmetry_worst     0.043937722  0.256766084 -0.005448734 -0.139913723
## dimension_worst   -0.035134642  0.172524501  0.212520491  0.255448214
##                         PC17         PC18         PC19         PC20
## id                -0.007779983 -0.019707372  0.005442248  0.020454908
## radius_mean        0.150008977  0.209908003 -0.156773206  0.211821385
## texture_mean       0.159152972 -0.034161758  0.040048687  0.029931705
## perimeter_mean     0.113792993  0.201233658 -0.168413120  0.227079273
## area_mean          0.130173978  0.251460456 -0.269145594 -0.045499625
## smoothness_mean    0.203117911  0.168171613  0.354463321 -0.160358262
## compactness_mean  -0.170379447 -0.016302860 -0.014259132  0.292092522
## concavity_mean    -0.270010606 -0.005071590  0.027973937  0.007197446
## points_mean       -0.381111880  0.028741889  0.087065594 -0.153991624
## symmetry_mean      0.165691481 -0.194702559 -0.169168737 -0.058503329
## dimension_mean     0.039119713  0.046298986 -0.086779501 -0.062879947
## radius_se         -0.055118880 -0.124562479  0.231233991  0.181436577
## texture_se         0.032768777  0.041652813  0.009177450  0.038681291
## perimeter_se      -0.023929011 -0.009084130  0.014508488  0.364045783
## area_se           -0.045538238  0.313148246 -0.296273515 -0.433949999
## smoothness_se      0.058326686  0.145306166  0.228819703 -0.013932678
## compactness_se    -0.190065826 -0.015610691 -0.094108380 -0.250216687
## concavity_se       0.126034946  0.092345618 -0.005794297  0.119490304
## points_se          0.197671940  0.106747906 -0.046944796 -0.015851066
## symmetry_se        0.158541381 -0.279918359 -0.180195394 -0.084242460
## dimension_se      -0.267180143 -0.122002438  0.059970839  0.097082660
## radius_worst       0.083459877 -0.235215809  0.218781792  0.027741137
## texture_worst     -0.185972310  0.065992656 -0.057250572 -0.080880841
## perimeter_worst    0.056649279 -0.228493742  0.189279122  0.105666112
## area_worst         0.090325036 -0.286471546  0.158722686 -0.393681440
## smoothness_worst  -0.142781922 -0.276751162 -0.504565504  0.228506719
## compactness_worst  0.153347954 -0.003683424  0.073627229  0.025544372
## concavity_worst    0.216302398 -0.190307542  0.107894455 -0.035839305
## points_worst      -0.178353485 -0.085180057 -0.067182996 -0.261323873
## symmetry_worst    -0.260033510  0.436706158  0.269313654  0.111738683
## dimension_worst    0.404957673  0.162920272 -0.026674889 -0.022516600
##                         PC21         PC22         PC23         PC24
## id                 0.009870917  0.006195707  0.003190337 -0.010289027
## radius_mean        0.046009507  0.070394387 -0.073021974 -0.098704322
## texture_mean       0.264801220 -0.436269565 -0.095890704  0.001311285
## perimeter_mean     0.015122205  0.070963404 -0.074821704 -0.040500943
## area_mean          0.087345298  0.021672998 -0.097428804  0.009396470
## smoothness_mean   -0.023842011  0.117945821 -0.063741313 -0.020088204
## compactness_mean  -0.476395571 -0.213187888  0.094254664  0.058295270
## concavity_mean     0.037771062 -0.001270114  0.188862925  0.321062737
## points_mean        0.231546040  0.017493297  0.313280824 -0.057974684
## symmetry_mean     -0.030776761  0.085067786  0.018331111 -0.052004767
## dimension_mean     0.172565576  0.085104005 -0.286892578 -0.084701081
```

```
## radius_se          0.090564458 -0.085660592  0.147793165 -0.263799753
## texture_se         0.083589382 -0.212168357 -0.048761201 -0.001150858
## perimeter_se       0.169586632  0.317246026 -0.153859020  0.081384223
## area_se           -0.270679518 -0.207916141 -0.068745790  0.110258620
## smoothness_se     -0.095370809  0.066602974 -0.051852247 -0.057154068
## compactness_se     0.451033960  0.159332265  0.048970757  0.003993806
## concavity_se      -0.070203251 -0.071023842  0.200850815 -0.388573085
## points_se         -0.064848884 -0.035557778  0.074494143  0.354040783
## symmetry_se       -0.112133933  0.092193625  0.084324570 -0.043455477
## dimension_se      -0.214213177 -0.069171668 -0.245408452  0.089594196
## radius_worst       0.006481267 -0.007068180  0.096292694 -0.057768458
## texture_worst     -0.330244412  0.578095532  0.111968438 -0.009473435
## perimeter_worst   -0.010544107  0.094457678 -0.014952244  0.058698441
## area_worst        -0.053510824 -0.149328216  0.096798702  0.193293235
## smoothness_worst   0.140127867 -0.156936236  0.069660581  0.091134610
## compactness_worst -0.220884131 -0.191897773 -0.033373706 -0.145389941
## concavity_worst    0.047166544  0.139729448 -0.456817799  0.290302924
## points_worst      -0.039740929 -0.006870640 -0.305694162 -0.563297713
## symmetry_worst     0.125617213 -0.155827542 -0.096426675  0.122996111
## dimension_worst    0.095366679  0.092769737  0.470358007  0.002775112
##                         PC25        PC26         PC27         PC28
## id                -0.004233388 -0.00132610 -0.002571324 -0.001623875
## radius_mean       -0.183664583  0.01859418  0.128713229  0.131697326
## texture_mean       0.099441545 -0.08442059  0.024821224  0.017622634
## perimeter_mean    -0.117262178 -0.02743488  0.124670225  0.115650274
## area_mean          0.070557041  0.21057100 -0.361014547 -0.467489167
## smoothness_mean    0.068940049 -0.02876100  0.037372832 -0.069482805
## compactness_mean  -0.102198309 -0.39651346 -0.262695425 -0.098624638
## concavity_mean     0.045550527  0.09717977  0.550227716 -0.363040016
## points_mean        0.082349955  0.18630114 -0.389316679  0.453345398
## symmetry_mean      0.018841491  0.02451053  0.015910368  0.015157593
## dimension_mean    -0.134601525  0.20670502  0.096796804  0.101343150
## radius_se         -0.561133900  0.17339784 -0.050411953 -0.213735821
## texture_se         0.023938591 -0.05709165  0.010893175  0.009925699
## perimeter_se       0.516048248 -0.07217201 -0.103485879 -0.041989200
## area_se           -0.018546693 -0.13093723  0.155929011  0.314758068
## smoothness_se      0.016193934 -0.03100551  0.008066566  0.009312365
## compactness_se    -0.122457873 -0.17364984  0.049404535 -0.046651501
## concavity_se       0.186159613 -0.01600952 -0.091931364  0.083824645
## points_se         -0.107166573  0.12999049  0.018674110  0.011675700
## symmetry_se        0.002613811  0.01936313  0.016991197  0.019891112
## dimension_se       0.076177800  0.08458109 -0.035156906  0.012141785
## radius_worst      -0.158114412 -0.07144112  0.195812320  0.178796461
## texture_worst     -0.118609952  0.11802219 -0.036347107 -0.021473842
## perimeter_worst    0.236463109 -0.11790535  0.243266456  0.241658719
## area_worst         0.146339946  0.03921251 -0.229813188 -0.237323945
## smoothness_worst  -0.011224935  0.04787154 -0.012860335  0.040730207
## compactness_worst  0.185437121  0.62471727  0.100772153  0.071087434
## concavity_worst   -0.286701322 -0.11586768 -0.267236886  0.142148446
## points_worst       0.105286798 -0.26352782  0.133749940 -0.230794105
## symmetry_worst    -0.013193455 -0.04505357 -0.027824916 -0.022695808
## dimension_worst    0.037882167 -0.28015574 -0.004500884 -0.060081371
##                         PC29          PC30          PC31
## id                -1.891724e-05 -0.0006852263 -7.122581e-05
## radius_mean        2.111968e-01 -0.2114371011 -7.024325e-01
## texture_mean      -6.362507e-05  0.0106165839 -2.644366e-04
## perimeter_mean     8.434280e-02 -0.3838889617  6.898676e-01
## area_mean         -2.725167e-01  0.4227208085  3.297173e-02
## smoothness_mean    1.480038e-03  0.0034638648  4.850746e-03
## compactness_mean  -5.466656e-03  0.0409079834 -4.468229e-02
## concavity_mean     4.554138e-02  0.0101122808 -2.512860e-02
## points_mean       -8.885707e-03  0.0041142627  1.067984e-03
## symmetry_mean      1.432581e-03  0.0075571475  1.279594e-03
## dimension_mean    -6.312291e-03 -0.0073311823  4.751885e-03
## radius_se         -1.922290e-01 -0.1186768422  8.679321e-03
## texture_se        -5.624974e-03  0.0086942153  1.063104e-03
## perimeter_se       2.631905e-01  0.0060612569 -1.373310e-02
## area_se           -4.205668e-02  0.0863645419 -1.054698e-03
## smoothness_se      9.795835e-03 -0.0016737982  1.618711e-03
## compactness_se    -1.539757e-02 -0.0032295613 -1.923037e-03
## concavity_se       5.819985e-03 -0.0161202167  8.921294e-03
## points_se         -2.900497e-02  0.0241014722  2.178643e-03
## symmetry_se       -7.637856e-03  0.0051771158 -3.338380e-04
```

```
## dimension_se       1.975791e-02  0.0083971145 -1.792802e-03
## radius_worst       4.126296e-01  0.6356796555  1.356846e-01
## texture_worst     -3.896988e-04 -0.0172219636 -1.020237e-03
## perimeter_worst   -7.286790e-01 -0.0228830657 -7.974244e-02
## area_worst         2.389679e-01 -0.4448733182 -3.976788e-02
## smoothness_worst  -1.535941e-03 -0.0074142082 -4.586820e-03
## compactness_worst  4.869512e-02  0.0001075081  1.285262e-02
## concavity_worst   -1.764174e-02  0.0126547542 -4.031809e-04
## points_worst       2.247340e-02 -0.0353341030  2.276561e-03
## symmetry_worst     4.922100e-03 -0.0133523613 -3.910451e-04
## dimension_worst   -2.356283e-02 -0.0115053741 -1.897779e-03
```

```
plot(breast_cancer_pca)
```




```
summary(breast_cancer_pca)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6
## Standard deviation     3.6453 2.3868 1.68386 1.40761 1.28406 1.11116
## Proportion of Variance 0.4286 0.1838 0.09146 0.06391 0.05319 0.03983
## Cumulative Proportion  0.4286 0.6124 0.70388 0.76779 0.82098 0.86081
##                           PC7     PC8     PC9    PC10    PC11    PC12
## Standard deviation     0.98908 0.81961 0.67882 0.6349 0.59089 0.54212
## Proportion of Variance 0.03156 0.02167 0.01486 0.0130 0.01126 0.00948
## Cumulative Proportion  0.89237 0.91404 0.92890 0.9419 0.95317 0.96265
##                           PC13    PC14    PC15    PC16    PC17   PC18
## Standard deviation     0.51103 0.49125 0.39620 0.30680 0.28251 0.2430
## Proportion of Variance 0.00842 0.00778 0.00506 0.00304 0.00257 0.0019
## Cumulative Proportion  0.97107 0.97886 0.98392 0.98696 0.98953 0.9914
##                           PC19    PC20   PC21    PC22    PC23    PC24
## Standard deviation     0.2293 0.22163 0.1763 0.17304 0.16562 0.15572
## Proportion of Variance 0.0017 0.00158 0.0010 0.00097 0.00088 0.00078
## Cumulative Proportion  0.9931 0.99472 0.9957 0.99669 0.99757 0.99835
##                           PC25   PC26    PC27    PC28    PC29    PC30
## Standard deviation     0.13431 0.1244 0.09040 0.08305 0.03987 0.02736
## Proportion of Variance 0.00058 0.0005 0.00026 0.00022 0.00005 0.00002
## Cumulative Proportion  0.99893 0.9994 0.99970 0.99992 0.99997 1.00000
##                           PC31
## Standard deviation     0.01153
## Proportion of Variance 0.00000
## Cumulative Proportion  1.00000
```

```
#View(breast_cancer_pca)
head(breast_cancer_pca$x)
```

```
##            PC1         PC2        PC3        PC4         PC5        PC6
## [1,] 2.501946 -0.09694805 -0.4489597  2.3341176  0.69771548 -0.2430058
## [2,] 1.467439 -1.68630059  1.1542039  0.3362109  0.45962538  1.2308248
## [3,] 2.929028 -0.38319924 -0.8955891 -0.1164828  0.98441377 -0.2587872
## [4,] 1.995342 -1.33046592  1.1172876  2.0502761  0.25303846 -1.5539634
## [5,] 2.500252  2.01035097 -0.7584035  1.9862169 -1.13537096  0.5940361
## [6,] 2.018308 -0.78242095  0.1125197 -0.6532280  0.01841577  0.6914453
##             PC7         PC8        PC9        PC10       PC11        PC12
## [1,]  0.5092015 -1.11423307  0.2840243  0.32463197 -0.3245353  0.04981306
## [2,]  0.2937434  0.10000461 -0.0668399  0.42612180  0.4564029  1.19357566
## [3,] -0.3303385  0.03599041  0.8734350  0.02222192  0.4208602 -0.06687286
## [4,] -0.9692185 -1.31852134  0.6254396  0.05666470 -0.0691646  0.97082409
## [5,]  0.1198201 -0.48279704 -0.2727816 -0.29439485 -0.3577533  0.03266208
## [6,]  0.1454026  0.06214539  0.2342454  0.73681239 -0.3671239 -0.77029743
##             PC13        PC14         PC15        PC16        PC17
## [1,] -0.19760220  0.1134403 -0.059302558  0.16637723 -0.04286656
## [2,]  0.01807424 -0.2824292 -0.204858888 -0.07067959  0.03088787
## [3,]  0.37435458  0.2585457 -0.330274216 -0.13000189 -0.24616091
## [4,] -0.90968379  0.2179117 -0.665825669  0.10213387 -0.10289446
## [5,] -0.35547138 -0.1480140 -0.005540503 -0.06495881  0.22273309
## [6,] -0.49542291 -0.2992431  0.049952835 -0.20161083  0.14920422
##              PC18        PC19        PC20        PC21        PC22
## [1,] -0.104542766 -0.03484189 -0.09691187 -0.02846306 -0.00673628
## [2,] -0.405534243 -0.02886103 -0.05262226 -0.05987170  0.05868642
## [3,]  0.327711259  0.15937793 -0.13804895 -0.13489743  0.10080029
## [4,]  0.197085181  0.36251771 -0.40018239 -0.10302093 -0.28821708
## [5,] -0.129129156 -0.35877054  0.08515543 -0.08500541 -0.06332008
## [6,] -0.002229379 -0.08178568  0.18970936 -0.06872875  0.09669594
##              PC23         PC24         PC25        PC26         PC27
## [1,] -0.038971937  0.062212075  0.088438866  0.04872948 -0.007000724
## [2,]  0.070978613 -0.030822339 -0.016741580  0.04173030 -0.059332996
## [3,]  0.053909008  0.085484364  0.038277664 -0.04151896 -0.035546410
## [4,]  0.182045907  0.222848059 -0.115720065 -0.03676948 -0.148171674
## [5,]  0.043591030  0.008165322  0.002738052  0.05983731  0.046167735
## [6,] -0.001458054 -0.031338348  0.042784223 -0.08646068 -0.030944690
##             PC28         PC29         PC30         PC31
## [1,]  0.05356131  0.015184882  0.015985406  0.001396101
## [2,] -0.18696553  0.027011311 -0.000803330  0.008096490
## [3,] -0.07653067 -0.014640388  0.010307894  0.009074601
## [4,] -0.01711665 -0.047828494  0.023862995  0.000265075
## [5,]  0.03835364  0.032450800 -0.002312178 -0.002563269
## [6,]  0.00955434 -0.004403431  0.003869919 -0.002931194
```

```
# sample scores stored in breast_cancer_pca$x
# singular values (square roots of eigenvalues) stored in breast_cancer_pca$sdev
# loadings (eigenvectors) are stored in breast_cancer_pca$rotation
# variable means stored in breast_cancer_pca$center
# variable standard deviations stored in sparrows_pca$scale
# A table containing eigenvalues and %'s accounted, follows
# Eigenvalues are sdev^2
(eigen_breast_cancer <- breast_cancer_pca$sdev^2) ## brackets for print
```

```
##  [1] 1.328806e+01 5.696805e+00 2.835395e+00 1.981357e+00 1.648815e+00
##  [6] 1.234673e+00 9.782732e-01 6.717530e-01 4.607924e-01 4.031331e-01
## [11] 3.491550e-01 2.938904e-01 2.611469e-01 2.413302e-01 1.569736e-01
## [16] 9.412853e-02 7.980995e-02 5.904627e-02 5.259119e-02 4.912193e-02
## [21] 3.107078e-02 2.994121e-02 2.743052e-02 2.424902e-02 1.803936e-02
## [26] 1.547973e-02 8.171699e-03 6.898103e-03 1.589338e-03 7.483761e-04
## [31] 1.330402e-04
```

```
names(eigen_breast_cancer) <- paste("PC",1:31,sep="")
eigen_breast_cancer
```

```
##          PC1          PC2          PC3          PC4          PC5
## 1.328806e+01 5.696805e+00 2.835395e+00 1.981357e+00 1.648815e+00
##          PC6          PC7          PC8          PC9         PC10
## 1.234673e+00 9.782732e-01 6.717530e-01 4.607924e-01 4.031331e-01
##         PC11         PC12         PC13         PC14         PC15
## 3.491550e-01 2.938904e-01 2.611469e-01 2.413302e-01 1.569736e-01
##         PC16         PC17         PC18         PC19         PC20
## 9.412853e-02 7.980995e-02 5.904627e-02 5.259119e-02 4.912193e-02
##         PC21         PC22         PC23         PC24         PC25
## 3.107078e-02 2.994121e-02 2.743052e-02 2.424902e-02 1.803936e-02
##         PC26         PC27         PC28         PC29         PC30
## 1.547973e-02 8.171699e-03 6.898103e-03 1.589338e-03 7.483761e-04
##         PC31
## 1.330402e-04
```

```
sumlambdas <- sum(eigen_breast_cancer)
sumlambdas
```

```
## [1] 31
```

```
propvar <- eigen_breast_cancer/sumlambdas
propvar
```

```
##          PC1          PC2          PC3          PC4          PC5
## 4.286470e-01 1.837679e-01 9.146436e-02 6.391475e-02 5.318759e-02
##          PC6          PC7          PC8          PC9         PC10
## 3.982815e-02 3.155720e-02 2.166945e-02 1.486427e-02 1.300429e-02
##         PC11         PC12         PC13         PC14         PC15
## 1.126306e-02 9.480337e-03 8.424094e-03 7.784846e-03 5.063666e-03
##         PC16         PC17         PC18         PC19         PC20
## 3.036404e-03 2.574514e-03 1.904718e-03 1.696490e-03 1.584578e-03
##         PC21         PC22         PC23         PC24         PC25
## 1.002283e-03 9.658453e-04 8.848556e-04 7.822265e-04 5.819149e-04
##         PC26         PC27         PC28         PC29         PC30
## 4.993461e-04 2.636032e-04 2.225194e-04 5.126895e-05 2.414116e-05
##         PC31
## 4.291620e-06
```

```
summary(eigen_breast_cancer)
```

```
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
##  0.000133  0.025840  0.094129  1.000000  0.566273 13.288057
```

```
summary(breast_cancer_pca)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6
## Standard deviation     3.6453 2.3868 1.68386 1.40761 1.28406 1.11116
## Proportion of Variance 0.4286 0.1838 0.09146 0.06391 0.05319 0.03983
## Cumulative Proportion  0.4286 0.6124 0.70388 0.76779 0.82098 0.86081
##                           PC7     PC8     PC9    PC10    PC11    PC12
## Standard deviation     0.98908 0.81961 0.67882 0.6349 0.59089 0.54212
## Proportion of Variance 0.03156 0.02167 0.01486 0.0130 0.01126 0.00948
## Cumulative Proportion  0.89237 0.91404 0.92890 0.9419 0.95317 0.96265
##                           PC13    PC14    PC15    PC16    PC17   PC18
## Standard deviation     0.51103 0.49125 0.39620 0.30680 0.28251 0.2430
## Proportion of Variance 0.00842 0.00778 0.00506 0.00304 0.00257 0.0019
## Cumulative Proportion  0.97107 0.97886 0.98392 0.98696 0.98953 0.9914
##                           PC19    PC20   PC21    PC22    PC23    PC24
## Standard deviation     0.2293 0.22163 0.1763 0.17304 0.16562 0.15572
## Proportion of Variance 0.0017 0.00158 0.0010 0.00097 0.00088 0.00078
## Cumulative Proportion  0.9931 0.99472 0.9957 0.99669 0.99757 0.99835
##                           PC25   PC26    PC27    PC28    PC29    PC30
## Standard deviation     0.13431 0.1244 0.09040 0.08305 0.03987 0.02736
## Proportion of Variance 0.00058 0.0005 0.00026 0.00022 0.00005 0.00002
## Cumulative Proportion  0.99893 0.9994 0.99970 0.99992 0.99997 1.00000
##                           PC31
## Standard deviation     0.01153
## Proportion of Variance 0.00000
## Cumulative Proportion  1.00000
```

```
cumvar_breast_cancer <- cumsum(propvar)
cumvar_breast_cancer
```

```
##       PC1       PC2       PC3       PC4       PC5       PC6       PC7
## 0.4286470 0.6124149 0.7038793 0.7677940 0.8209816 0.8608098 0.8923670
##       PC8       PC9      PC10      PC11      PC12      PC13      PC14
## 0.9140364 0.9289007 0.9419050 0.9531681 0.9626484 0.9710725 0.9788573
##      PC15      PC16      PC17      PC18      PC19      PC20      PC21
## 0.9839210 0.9869574 0.9895319 0.9914366 0.9931331 0.9947177 0.9957200
##      PC22      PC23      PC24      PC25      PC26      PC27      PC28
## 0.9966858 0.9975707 0.9983529 0.9989348 0.9994342 0.9996978 0.9999203
##      PC29      PC30      PC31
## 0.9999716 0.9999957 1.0000000
```

```
matlambdas <- rbind(eigen_breast_cancer,propvar,cumvar_breast_cancer)
rownames(matlambdas) <- c("Eigenvalues","Prop. variance","Cum. prop. variance")
round(matlambdas,4)
```

```
##                          PC1    PC2    PC3    PC4    PC5    PC6    PC7
## Eigenvalues          13.2881 5.6968 2.8354 1.9814 1.6488 1.2347 0.9783
## Prop. variance        0.4286 0.1838 0.0915 0.0639 0.0532 0.0398 0.0316
## Cum. prop. variance   0.4286 0.6124 0.7039 0.7678 0.8210 0.8608 0.8924
##                          PC8    PC9   PC10   PC11   PC12   PC13   PC14
## Eigenvalues          0.6718 0.4608 0.4031 0.3492 0.2939 0.2611 0.2413
## Prop. variance       0.0217 0.0149 0.0130 0.0113 0.0095 0.0084 0.0078
## Cum. prop. variance 0.9140 0.9289 0.9419 0.9532 0.9626 0.9711 0.9789
##                         PC15   PC16   PC17   PC18   PC19   PC20   PC21
## Eigenvalues          0.1570 0.0941 0.0798 0.0590 0.0526 0.0491 0.0311
## Prop. variance       0.0051 0.0030 0.0026 0.0019 0.0017 0.0016 0.0010
## Cum. prop. variance 0.9839 0.9870 0.9895 0.9914 0.9931 0.9947 0.9957
##                         PC22   PC23   PC24   PC25   PC26   PC27   PC28
## Eigenvalues          0.0299 0.0274 0.0242 0.0180 0.0155 0.0082 0.0069
## Prop. variance       0.0010 0.0009 0.0008 0.0006 0.0005 0.0003 0.0002
## Cum. prop. variance 0.9967 0.9976 0.9984 0.9989 0.9994 0.9997 0.9999
##                         PC29  PC30  PC31
## Eigenvalues          0.0016 7e-04 1e-04
## Prop. variance       0.0001 0e+00 0e+00
## Cum. prop. variance 1.0000 1e+00 1e+00
```

```
summary(breast_cancer_pca)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6
## Standard deviation     3.6453 2.3868 1.68386 1.40761 1.28406 1.11116
## Proportion of Variance 0.4286 0.1838 0.09146 0.06391 0.05319 0.03983
## Cumulative Proportion  0.4286 0.6124 0.70388 0.76779 0.82098 0.86081
##                           PC7     PC8     PC9    PC10    PC11    PC12
## Standard deviation     0.98908 0.81961 0.67882 0.6349 0.59089 0.54212
## Proportion of Variance 0.03156 0.02167 0.01486 0.0130 0.01126 0.00948
## Cumulative Proportion  0.89237 0.91404 0.92890 0.9419 0.95317 0.96265
##                           PC13    PC14    PC15    PC16    PC17   PC18
## Standard deviation     0.51103 0.49125 0.39620 0.30680 0.28251 0.2430
## Proportion of Variance 0.00842 0.00778 0.00506 0.00304 0.00257 0.0019
## Cumulative Proportion  0.97107 0.97886 0.98392 0.98696 0.98953 0.9914
##                           PC19    PC20   PC21    PC22    PC23    PC24
## Standard deviation     0.2293 0.22163 0.1763 0.17304 0.16562 0.15572
## Proportion of Variance 0.0017 0.00158 0.0010 0.00097 0.00088 0.00078
## Cumulative Proportion  0.9931 0.99472 0.9957 0.99669 0.99757 0.99835
##                           PC25   PC26    PC27    PC28    PC29    PC30
## Standard deviation     0.13431 0.1244 0.09040 0.08305 0.03987 0.02736
## Proportion of Variance 0.00058 0.0005 0.00026 0.00022 0.00005 0.00002
## Cumulative Proportion  0.99893 0.9994 0.99970 0.99992 0.99997 1.00000
##                           PC31
## Standard deviation     0.01153
## Proportion of Variance 0.00000
## Cumulative Proportion  1.00000
```

```
breast_cancer_pca$rotation
```

```
##                             PC1           PC2           PC3           PC4
## id                 -0.02291216  0.034068491  0.096938436 -0.026598045
## radius_mean        -0.21891302  0.233271401 -0.011393786  0.042187950
## texture_mean       -0.10384388  0.060044199  0.066892342 -0.602954308
## perimeter_mean     -0.22753491  0.214589002 -0.012124791  0.042752797
## area_mean          -0.22104577  0.230668816  0.026293150  0.054114724
## smoothness_mean    -0.14241471 -0.186422211 -0.103182400  0.158098177
## compactness_mean   -0.23906730 -0.152454726 -0.074768623  0.031818117
## concavity_mean     -0.25828025 -0.060541625  0.001758736  0.019497124
## points_mean        -0.26073811  0.034167392 -0.027579607  0.065785353
## symmetry_mean      -0.13797774 -0.190684979 -0.040962032  0.067502543
## dimension_mean     -0.06414779 -0.366531055 -0.020817875  0.047957856
## radius_se          -0.20611747  0.105935702  0.266917221  0.099114446
## texture_se         -0.01741339 -0.089547789  0.371439885 -0.356497230
## perimeter_se       -0.21144652  0.089807043  0.264925682  0.090293055
## area_se            -0.20307642  0.152771289  0.215790250  0.108568705
## smoothness_se      -0.01467821 -0.203189876  0.311787845  0.044368664
## compactness_se     -0.17028840 -0.232503362  0.154557465 -0.026425360
## concavity_se       -0.15354367 -0.196846081  0.176560052  0.002248291
## points_se          -0.18340675 -0.129965181  0.223850479  0.075252232
## symmetry_se        -0.04241552 -0.183558627  0.285265066  0.046936126
## dimension_se       -0.10249607 -0.279584139  0.211893354  0.016212450
## radius_worst       -0.22800935  0.219296044 -0.049406340  0.015659705
## texture_worst      -0.10451545  0.045501223 -0.039828934 -0.633119655
## perimeter_worst    -0.23663734  0.199295985 -0.050431945  0.014068572
## area_worst         -0.22493214  0.218985461 -0.013188891  0.025970672
## smoothness_worst   -0.12782441 -0.172562959 -0.255328751  0.014523359
## compactness_worst  -0.20988456 -0.144253637 -0.234513609 -0.092562168
## concavity_worst    -0.22860218 -0.098526524 -0.172024941 -0.074807188
## points_worst       -0.25074620  0.007534367 -0.170480673  0.005305980
## symmetry_worst     -0.12267993 -0.142619436 -0.270515902 -0.037129466
## dimension_worst    -0.13156024 -0.275702077 -0.229474476 -0.078971489
##                             PC5           PC6           PC7           PC8
## id                  0.011327587 -0.316733438  0.9071156324 -0.096362415
## radius_mean        -0.038129861  0.029588521 -0.0422987777 -0.116427419
## texture_mean        0.049091450 -0.031394323  0.0149935618  0.001875482
## perimeter_mean     -0.037715592  0.028394008 -0.0435888242 -0.106272097
## area_mean          -0.010562229  0.006113155 -0.0289256668 -0.047414568
## smoothness_mean     0.365750055 -0.262508993 -0.1403403617 -0.123541189
## compactness_mean   -0.011786637 -0.004903894 -0.0453031106  0.043145968
## concavity_mean     -0.086512506 -0.002356338 -0.0325530646 -0.102436021
## points_mean         0.043667412 -0.034509273 -0.0814216298 -0.136923237
## symmetry_mean       0.305378893  0.335082168  0.1182592361 -0.098874531
```

```
## dimension_mean     0.044767906 -0.112784169 -0.0410588768  0.306499872
## radius_se          0.154254367 -0.023261199  0.0167882718  0.307415709
## texture_se         0.190001500  0.022856912 -0.1902676469 -0.052632477
## perimeter_se       0.120703357  0.003820151  0.0195081762  0.311265679
## area_se            0.127765023 -0.051958835  0.0565606078  0.334287959
## smoothness_se      0.232745603 -0.330867850 -0.0678348099 -0.260833914
## compactness_se    -0.280298048  0.066788120  0.0222220211  0.021001944
## concavity_se      -0.354164595  0.049699104  0.0336810725 -0.219193299
## points_se         -0.195758558 -0.023197526 -0.0378517870 -0.370217167
## symmetry_se        0.251331178  0.477530515  0.1184032606 -0.084854768
## dimension_se      -0.263395188 -0.048462373 -0.0157602244  0.194418818
## radius_worst       0.004280034  0.004521737 -0.0166458140 -0.007508307
## texture_worst      0.092551860 -0.045174516 -0.0094601240  0.006617640
## perimeter_worst   -0.007599144  0.012921166 -0.0145260986  0.002162488
## area_worst         0.027413595 -0.024033338 -0.0007372602  0.066173186
## smoothness_worst   0.325860028 -0.365048687 -0.0670682168 -0.116496117
## compactness_worst -0.121503371  0.034042714  0.0507556727  0.136509363
## concavity_worst   -0.188280510  0.017962040  0.0352007117 -0.067085744
## points_worst      -0.043123573 -0.029549100 -0.0207238959 -0.166500918
## symmetry_worst     0.244245936  0.451404312  0.2340143294 -0.041439633
## dimension_worst   -0.093699078 -0.092479698  0.0347167538  0.372034479
##                           PC9        PC10         PC11         PC12
## id                 0.149115642 -0.16926751  0.058188997 -0.006721252
## radius_mean       -0.046270835 -0.22402704 -0.079466081 -0.042213788
## texture_mean      -0.088727168  0.11945674 -0.253258091  0.304032359
## perimeter_mean    -0.036230738 -0.22634517 -0.069865929 -0.017573055
## area_mean         -0.080649856 -0.18600385 -0.062795372 -0.110760120
## smoothness_mean    0.278996404 -0.06133822  0.084661549  0.135321954
## compactness_mean   0.099214048 -0.19518602  0.005172841  0.307036205
## concavity_mean     0.075750464  0.03395563  0.134664686 -0.124553100
## points_mean        0.116569072 -0.14261678  0.006124860  0.071564686
## symmetry_mean      0.315150303  0.13561452 -0.574417320 -0.161058144
## dimension_mean     0.130639482 -0.15848117 -0.066456112  0.037318709
## radius_se          0.026200456  0.26504403  0.025847282  0.027030250
## texture_se         0.372989606 -0.31521084  0.323158815 -0.348396233
## perimeter_se       0.052860114  0.23789288  0.094867442  0.168501485
## area_se           -0.030627892  0.24966405  0.071991560 -0.050731496
## smoothness_se     -0.580789293 -0.01015980 -0.179568831 -0.081753374
## compactness_se    -0.148593714 -0.11518343 -0.038615749  0.206959272
## concavity_se       0.034715098  0.36592141  0.113536362 -0.348342358
## points_se          0.189022962  0.21518752 -0.094066850  0.342855186
## symmetry_se       -0.292785738 -0.22049558  0.328314881  0.185998712
## dimension_se      -0.060203202 -0.22637997 -0.353844543 -0.250428852
## radius_worst      -0.070224590 -0.09981025 -0.073013014 -0.105030701
## texture_worst     -0.008571809  0.10669296 -0.038561250 -0.012490348
## perimeter_worst   -0.058854223 -0.09821693 -0.045750979 -0.051125158
## area_worst        -0.097034650 -0.06179787 -0.068822329 -0.184460981
## smoothness_worst  -0.173257498  0.16912753  0.109278029 -0.142996001
## compactness_worst -0.111218083 -0.06445290  0.175401648  0.196805544
## concavity_worst   -0.035467377  0.19661986  0.295581609 -0.184959562
## points_worst       0.052322473  0.05121611  0.075496752  0.117518361
## symmetry_worst    -0.188266324  0.10308901  0.019223451 -0.157210098
## dimension_worst   -0.087222442 -0.11291399 -0.007071634 -0.118625115
##                          PC13         PC14         PC15         PC16
## id                -0.004841084 -0.006500099  0.006885943 -0.002753492
## radius_mean        0.050603927 -0.012496988 -0.059054553  0.050789156
## texture_mean       0.256273666 -0.201876125  0.020701124  0.108089530
## perimeter_mean     0.038470392 -0.044684430 -0.048019221  0.039590476
## area_mean          0.065047550 -0.067879244 -0.010152279 -0.014636050
## smoothness_mean    0.315872261 -0.046461624 -0.444044654  0.117493291
## compactness_mean  -0.104264618 -0.230005458 -0.007661166 -0.230759682
## concavity_mean     0.065723393 -0.387349680  0.189733740  0.128386008
## points_mean        0.042253113 -0.132637847  0.245219266  0.217299938
## symmetry_mean     -0.288054252 -0.189570545 -0.030903840  0.073950596
## dimension_mean     0.236120382 -0.106390748  0.377436108 -0.518333769
## radius_se         -0.015625578  0.069635807 -0.011959877  0.111103952
## texture_se        -0.308499115  0.165408488  0.012614192 -0.033389049
## perimeter_se      -0.100597125  0.038865462  0.044358477  0.008991734
## area_se           -0.017226446 -0.055687709 -0.083203050  0.045171638
## smoothness_se     -0.293287983 -0.149148603  0.200139961 -0.018414232
## compactness_se    -0.263398426 -0.010320713 -0.491903153 -0.167886977
## concavity_se       0.251864823 -0.157777595 -0.135322845 -0.250292522
## points_se         -0.006430584  0.494527095  0.199547389 -0.062548716
```

```
## points_se          -0.000430584  0.494527095  0.199547389 -0.062548716
## symmetry_se         0.319874237 -0.010836031  0.047340593  0.113219397
## dimension_se        0.275943072  0.240767973 -0.145958050  0.353782637
## radius_worst        0.039582217  0.138036550 -0.023526025 -0.166213790
## texture_worst       0.080142089  0.080737140 -0.053897961 -0.100862417
## perimeter_worst    -0.009084762  0.097004376 -0.012559001 -0.182407021
## area_worst          0.047986766  0.101235629  0.006646192 -0.315142865
## smoothness_worst    0.056931408  0.206026671 -0.163389545 -0.045226715
## compactness_worst -0.371991007 -0.013117334 -0.165941776  0.049613607
## concavity_worst    -0.086870368 -0.218055908  0.066854662  0.204743734
## points_worst       -0.068367254  0.254345228  0.276401728  0.169597618
## symmetry_worst      0.043937722  0.256766084 -0.005448734 -0.139913723
## dimension_worst    -0.035134642  0.172524501  0.212520491  0.255448214
##                           PC17         PC18         PC19         PC20
## id                 -0.007779983 -0.019707372  0.005442248  0.020454908
## radius_mean         0.150008977  0.209908003 -0.156773206  0.211821385
## texture_mean        0.159152972 -0.034161758  0.040048687  0.029931705
## perimeter_mean      0.113792993  0.201233658 -0.168413120  0.227079273
## area_mean           0.130173978  0.251460456 -0.269145594 -0.045499625
## smoothness_mean     0.203117911  0.168171613  0.354463321 -0.160358262
## compactness_mean   -0.170379447 -0.016302860 -0.014259132  0.292092522
## concavity_mean     -0.270010606 -0.005071590  0.027973937  0.007197446
## points_mean        -0.381111880  0.028741889  0.087065594 -0.153991624
## symmetry_mean       0.165691481 -0.194702559 -0.169168737 -0.058503329
## dimension_mean      0.039119713  0.046298986 -0.086779501 -0.062879947
## radius_se          -0.055118880 -0.124562479  0.231233991  0.181436577
## texture_se          0.032768777  0.041652813  0.009177450  0.038681291
## perimeter_se       -0.023929011 -0.009084130  0.014508488  0.364045783
## area_se            -0.045538238  0.313148246 -0.296273515 -0.433949999
## smoothness_se       0.058326686  0.145306166  0.228819703 -0.013932678
## compactness_se     -0.190065826 -0.015610691 -0.094108380 -0.250216687
## concavity_se        0.126034946  0.092345618 -0.005794297  0.119490304
## points_se           0.197671940  0.106747906 -0.046944796 -0.015851066
## symmetry_se         0.158541381 -0.279918359 -0.180195394 -0.084242460
## dimension_se       -0.267180143 -0.122002438  0.059970839  0.097082660
## radius_worst        0.083459877 -0.235215809  0.218781792  0.027741137
## texture_worst      -0.185972310  0.065992656 -0.057250572 -0.080880841
## perimeter_worst     0.056649279 -0.228493742  0.189279122  0.105666112
## area_worst          0.090325036 -0.286471546  0.158722686 -0.393681440
## smoothness_worst   -0.142781922 -0.276751162 -0.504565504  0.228506719
## compactness_worst   0.153347954 -0.003683424  0.073627229  0.025544372
## concavity_worst     0.216302398 -0.190307542  0.107894455 -0.035839305
## points_worst       -0.178353485 -0.085180057 -0.067182996 -0.261323873
## symmetry_worst     -0.260033510  0.436706158  0.269313654  0.111738683
## dimension_worst     0.404957673  0.162920272 -0.026674889 -0.022516600
##                           PC21         PC22         PC23         PC24
## id                  0.009870917  0.006195707  0.003190337 -0.010289027
## radius_mean         0.046009507  0.070394387 -0.073021974 -0.098704322
## texture_mean        0.264801220 -0.436269565 -0.095890704  0.001311285
## perimeter_mean      0.015122205  0.070963404 -0.074821704 -0.040500943
## area_mean           0.087345298  0.021672998 -0.097428804  0.009396470
## smoothness_mean    -0.023842011  0.117945821 -0.063741313 -0.020088204
## compactness_mean   -0.476395571 -0.213187888  0.094254664  0.058295270
## concavity_mean      0.037771062 -0.001270114  0.188862925  0.321062737
## points_mean         0.231546040  0.017493297  0.313280824 -0.057974684
## symmetry_mean      -0.030776761  0.085067786  0.018331111 -0.052004767
## dimension_mean      0.172565576  0.085104005 -0.286892578 -0.084701081
## radius_se           0.090564458 -0.085660592  0.147793165 -0.263799753
## texture_se          0.083589382 -0.212168357 -0.048761201 -0.001150858
## perimeter_se        0.169586632  0.317246026 -0.153859020  0.081384223
## area_se            -0.270679518 -0.207916141 -0.068745790  0.110258620
## smoothness_se      -0.095370809  0.066602974 -0.051852247 -0.057154068
## compactness_se      0.451033960  0.159332265  0.048970757  0.003993806
## concavity_se       -0.070203251 -0.071023842  0.200850815 -0.388573085
## points_se          -0.064848884 -0.035557778  0.074494143  0.354040783
## symmetry_se        -0.112133933  0.092193625  0.084324570 -0.043455477
## dimension_se       -0.214213177 -0.069171668 -0.245408452  0.089594196
## radius_worst        0.006481267 -0.007068180  0.096292694 -0.057768458
## texture_worst      -0.330244412  0.578095532  0.111968438 -0.009473435
## perimeter_worst    -0.010544107  0.094457678 -0.014952244  0.058698441
## area_worst         -0.053510824 -0.149328216  0.096798702  0.193293235
## smoothness_worst    0.140127867 -0.156936236  0.069660581  0.091134610
## compactness_worst  -0.220884131 -0.191897773 -0.033373706 -0.145389941
```

```
## concavity_worst    0.047166544  0.139729448 -0.456817799  0.290302924
## points_worst      -0.039740929 -0.006870640 -0.305694162 -0.563297713
## symmetry_worst     0.125617213 -0.155827542 -0.096426675  0.122996111
## dimension_worst    0.095366679  0.092769737  0.470358007  0.002775112
##                         PC25         PC26         PC27         PC28
## id                -0.004233388 -0.00132610 -0.002571324 -0.001623875
## radius_mean       -0.183664583  0.01859418  0.128713229  0.131697326
## texture_mean       0.099441545 -0.08442059  0.024821224  0.017622634
## perimeter_mean    -0.117262178 -0.02743488  0.124670225  0.115650274
## area_mean          0.070557041  0.21057100 -0.361014547 -0.467489167
## smoothness_mean    0.068940049 -0.02876100  0.037372832 -0.069482805
## compactness_mean  -0.102198309 -0.39651346 -0.262695425 -0.098624638
## concavity_mean     0.045550527  0.09717977  0.550227716 -0.363040016
## points_mean        0.082349955  0.18630114 -0.389316679  0.453345398
## symmetry_mean      0.018841491  0.02451053  0.015910368  0.015157593
## dimension_mean    -0.134601525  0.20670502  0.096796804  0.101343150
## radius_se         -0.561133900  0.17339784 -0.050411953 -0.213735821
## texture_se         0.023938591 -0.05709165  0.010893175  0.009925699
## perimeter_se       0.516048248 -0.07217201 -0.103485879 -0.041989200
## area_se           -0.018546693 -0.13093723  0.155929011  0.314758068
## smoothness_se      0.016193934 -0.03100551  0.008066566  0.009312365
## compactness_se    -0.122457873 -0.17364984  0.049404535 -0.046651501
## concavity_se       0.186159613 -0.01600952 -0.091931364  0.083824645
## points_se         -0.107166573  0.12999049  0.018674110  0.011675700
## symmetry_se        0.002613811  0.01936313  0.016991197  0.019891112
## dimension_se       0.076177800  0.08458109 -0.035156906  0.012141785
## radius_worst      -0.158114412 -0.07144112  0.195812320  0.178796461
## texture_worst     -0.118609952  0.11802219 -0.036347107 -0.021473842
## perimeter_worst    0.236463109 -0.11790535  0.243266456  0.241658719
## area_worst         0.146339946  0.03921251 -0.229813188 -0.237323945
## smoothness_worst  -0.011224935  0.04787154 -0.012860335  0.040730207
## compactness_worst  0.185437121  0.62471727  0.100772153  0.071087434
## concavity_worst   -0.286701322 -0.11586768 -0.267236886  0.142148446
## points_worst       0.105286798 -0.26352782  0.133749940 -0.230794105
## symmetry_worst    -0.013193455 -0.04505357 -0.027824916 -0.022695808
## dimension_worst    0.037882167 -0.28015574 -0.004500884 -0.060081371
##                         PC29          PC30          PC31
## id                -1.891724e-05 -0.0006852263 -7.122581e-05
## radius_mean        2.111968e-01 -0.2114371011 -7.024325e-01
## texture_mean      -6.362507e-05  0.0106165839 -2.644366e-04
## perimeter_mean     8.434280e-02 -0.3838889617  6.898676e-01
## area_mean         -2.725167e-01  0.4227208085  3.297173e-02
## smoothness_mean    1.480038e-03  0.0034638648  4.850746e-03
## compactness_mean  -5.466656e-03  0.0409079834 -4.468229e-02
## concavity_mean     4.554138e-02  0.0101122808 -2.512860e-02
## points_mean       -8.885707e-03  0.0041142627  1.067984e-03
## symmetry_mean      1.432581e-03  0.0075571475  1.279594e-03
## dimension_mean    -6.312291e-03 -0.0073311823  4.751885e-03
## radius_se         -1.922290e-01 -0.1186768422  8.679321e-03
## texture_se        -5.624974e-03  0.0086942153  1.063104e-03
## perimeter_se       2.631905e-01  0.0060612569 -1.373310e-02
## area_se           -4.205668e-02  0.0863645419 -1.054698e-03
## smoothness_se      9.795835e-03 -0.0016737982  1.618711e-03
## compactness_se    -1.539757e-02 -0.0032295613 -1.923037e-03
## concavity_se       5.819985e-03 -0.0161202167  8.921294e-03
## points_se         -2.900497e-02  0.0241014722  2.178643e-03
## symmetry_se       -7.637856e-03  0.0051771158 -3.338380e-04
## dimension_se       1.975791e-02  0.0083971145 -1.792802e-03
## radius_worst       4.126296e-01  0.6356796555  1.356846e-01
## texture_worst     -3.896988e-04 -0.0172219636 -1.020237e-03
## perimeter_worst   -7.286790e-01 -0.0228830657 -7.974244e-02
## area_worst         2.389679e-01 -0.4448733182 -3.976788e-02
## smoothness_worst  -1.535941e-03 -0.0074142082 -4.586820e-03
## compactness_worst  4.869512e-02  0.0001075081  1.285262e-02
## concavity_worst   -1.764174e-02  0.0126547542 -4.031809e-04
## points_worst       2.247340e-02 -0.0353341030  2.276561e-03
## symmetry_worst     4.922100e-03 -0.0133523613 -3.910451e-04
## dimension_worst   -2.356283e-02 -0.0115053741 -1.897779e-03
```

```
print(breast_cancer_pca)
```

```
## Standard deviations (1,      p=31):
```

```
## Standard deviations (1, ..., p=31):
##  [1] 3.64527878 2.38679814 1.68386313 1.40760690 1.28406203 1.11115827
##  [7] 0.98907696 0.81960537 0.67881693 0.63492763 0.59089337 0.54211662
## [13] 0.51102537 0.49125372 0.39619900 0.30680373 0.28250655 0.24299439
## [19] 0.22932770 0.22163467 0.17626907 0.17303527 0.16562163 0.15572098
## [25] 0.13431069 0.12441756 0.09039745 0.08305482 0.03986650 0.02735646
## [31] 0.01153431
##
## Rotation (n x k) = (31 x 31):
##                             PC1          PC2          PC3          PC4
## id                  -0.02291216  0.034068491  0.096938436 -0.026598045
## radius_mean         -0.21891302  0.233271401 -0.011393786  0.042187950
## texture_mean        -0.10384388  0.060044199  0.066892342 -0.602954308
## perimeter_mean      -0.22753491  0.214589002 -0.012124791  0.042752797
## area_mean           -0.22104577  0.230668816  0.026293150  0.054114724
## smoothness_mean     -0.14241471 -0.186422211 -0.103182400  0.158098177
## compactness_mean    -0.23906730 -0.152454726 -0.074768623  0.031818117
## concavity_mean      -0.25828025 -0.060541625  0.001758736  0.019497124
## points_mean         -0.26073811  0.034167392 -0.027579607  0.065785353
## symmetry_mean       -0.13797774 -0.190684979 -0.040962032  0.067502543
## dimension_mean      -0.06414779 -0.366531055 -0.020817875  0.047957856
## radius_se           -0.20611747  0.105935702  0.266917221  0.099114446
## texture_se          -0.01741339 -0.089547789  0.371439885 -0.356497230
## perimeter_se        -0.21144652  0.089807043  0.264925682  0.090293055
## area_se             -0.20307642  0.152771289  0.215790250  0.108568705
## smoothness_se       -0.01467821 -0.203189876  0.311787845  0.044368664
## compactness_se      -0.17028840 -0.232503362  0.154557465 -0.026425360
## concavity_se        -0.15354367 -0.196846081  0.176560052  0.002248291
## points_se           -0.18340675 -0.129965181  0.223850479  0.075252232
## symmetry_se         -0.04241552 -0.183558627  0.285265066  0.046936126
## dimension_se        -0.10249607 -0.279584139  0.211893354  0.016212450
## radius_worst        -0.22800935  0.219296044 -0.049406340  0.015659705
## texture_worst       -0.10451545  0.045501223 -0.039828934 -0.633119655
## perimeter_worst     -0.23663734  0.199295985 -0.050431945  0.014068572
## area_worst          -0.22493214  0.218985461 -0.013188891  0.025970672
## smoothness_worst    -0.12782441 -0.172562959 -0.255328751  0.014523359
## compactness_worst   -0.20988456 -0.144253637 -0.234513609 -0.092562168
## concavity_worst     -0.22860218 -0.098526524 -0.172024941 -0.074807188
## points_worst        -0.25074620  0.007534367 -0.170480673  0.005305980
## symmetry_worst      -0.12267993 -0.142619436 -0.270515902 -0.037129466
## dimension_worst     -0.13156024 -0.275702077 -0.229474476 -0.078971489
##                             PC5          PC6           PC7          PC8
## id                   0.011327587 -0.316733438  0.9071156324 -0.096362415
## radius_mean         -0.038129861  0.029588521 -0.0422987777 -0.116427419
## texture_mean         0.049091450 -0.031394323  0.0149935618  0.001875482
## perimeter_mean      -0.037715592  0.028394008 -0.0435888242 -0.106272097
## area_mean           -0.010562229  0.006113155 -0.0289256668 -0.047414568
## smoothness_mean      0.365750055 -0.262508993 -0.1403403617 -0.123541189
## compactness_mean    -0.011786637 -0.004903894 -0.0453031106  0.043145968
## concavity_mean      -0.086512506 -0.002356338 -0.0325530646 -0.102436021
## points_mean          0.043667412 -0.034509273 -0.0814216298 -0.136923237
## symmetry_mean        0.305378893  0.335082168  0.1182592361 -0.098874531
## dimension_mean       0.044767906 -0.112784169 -0.0410588768  0.306499872
## radius_se            0.154254367 -0.023261199  0.0167882718  0.307415709
## texture_se           0.190001500  0.022856912 -0.1902676469 -0.052632477
## perimeter_se         0.120703357  0.003820151  0.0195081762  0.311265679
## area_se              0.127765023 -0.051958835  0.0565606078  0.334287959
## smoothness_se        0.232745603 -0.330867850 -0.0678348099 -0.260833914
## compactness_se      -0.280298048  0.066788120  0.0222220211  0.021001944
## concavity_se        -0.354164595  0.049699104  0.0336810725 -0.219193299
## points_se           -0.195758558 -0.023197526 -0.0378517870 -0.370217167
## symmetry_se          0.251331178  0.477530515  0.1184032606 -0.084854768
## dimension_se        -0.263395188 -0.048462373 -0.0157602244  0.194418818
## radius_worst         0.004280034  0.004521737 -0.0166458140 -0.007508307
## texture_worst        0.092551860 -0.045174516 -0.0094601240  0.006617640
## perimeter_worst     -0.007599144  0.012921166 -0.0145260986  0.002162488
## area_worst           0.027413595 -0.024033338 -0.0007372602  0.066173186
## smoothness_worst     0.325860028 -0.365048687 -0.0670682168 -0.116496117
## compactness_worst   -0.121503371  0.034042714  0.0507556727  0.136509363
## concavity_worst     -0.188280510  0.017962040  0.0352007117 -0.067085744
## points_worst        -0.043123573 -0.029549100 -0.0207238959 -0.166500918
## symmetry_worst       0.244245936  0.451404312  0.2340143294 -0.041439633
## dimension_worst     -0.093699078 -0.092479698  0.0347167538  0.372034479
```

```
##                             PC9         PC10          PC11          PC12
## id                   0.149115642 -0.16926751  0.058188997 -0.006721252
## radius_mean         -0.046270835 -0.22402704 -0.079466081 -0.042213788
## texture_mean        -0.088727168  0.11945674 -0.253258091  0.304032359
## perimeter_mean      -0.036230738 -0.22634517 -0.069865929 -0.017573055
## area_mean           -0.080649856 -0.18600385 -0.062795372 -0.110760120
## smoothness_mean      0.278996404 -0.06133822  0.084661549  0.135321954
## compactness_mean     0.099214048 -0.19518602  0.005172841  0.307036205
## concavity_mean       0.075750464  0.03395563  0.134664686 -0.124553100
## points_mean          0.116569072 -0.14261678  0.006124860  0.071564686
## symmetry_mean        0.315150303  0.13561452 -0.574417320 -0.161058144
## dimension_mean       0.130639482 -0.15848117 -0.066456112  0.037318709
## radius_se            0.026200456  0.26504403  0.025847282  0.027030250
## texture_se           0.372989606 -0.31521084  0.323158815 -0.348396233
## perimeter_se         0.052860114  0.23789288  0.094867442  0.168501485
## area_se             -0.030627892  0.24966405  0.071991560 -0.050731496
## smoothness_se       -0.580789293 -0.01015980 -0.179568831 -0.081753374
## compactness_se      -0.148593714 -0.11518343 -0.038615749  0.206959272
## concavity_se         0.034715098  0.36592141  0.113536362 -0.348342358
## points_se            0.189022962  0.21518752 -0.094066850  0.342855186
## symmetry_se         -0.292785738 -0.22049558  0.328314881  0.185998712
## dimension_se        -0.060203202 -0.22637997 -0.353844543 -0.250428852
## radius_worst        -0.070224590 -0.09981025 -0.073013014 -0.105030701
## texture_worst       -0.008571809  0.10669296 -0.038561250 -0.012490348
## perimeter_worst     -0.058854223 -0.09821693 -0.045750979 -0.051125158
## area_worst          -0.097034650 -0.06179787 -0.068822329 -0.184460981
## smoothness_worst    -0.173257498  0.16912753  0.109278029 -0.142996001
## compactness_worst   -0.111218083 -0.06445290  0.175401648  0.196805544
## concavity_worst     -0.035467377  0.19661986  0.295581609 -0.184959562
## points_worst         0.052322473  0.05121611  0.075496752  0.117518361
## symmetry_worst      -0.188266324  0.10308901  0.019223451 -0.157210098
## dimension_worst     -0.087222442 -0.11291399 -0.007071634 -0.118625115
##                            PC13         PC14          PC15          PC16
## id                  -0.004841084 -0.006500099  0.006885943 -0.002753492
## radius_mean          0.050603927 -0.012496988 -0.059054553  0.050789156
## texture_mean         0.256273666 -0.201876125  0.020701124  0.108089530
## perimeter_mean       0.038470392 -0.044684430 -0.048019221  0.039590476
## area_mean            0.065047550 -0.067879244 -0.010152279 -0.014636050
## smoothness_mean      0.315872261 -0.046461624 -0.444044654  0.117493291
## compactness_mean    -0.104264618 -0.230005458 -0.007661166 -0.230759682
## concavity_mean       0.065723393 -0.387349680  0.189733740  0.128386008
## points_mean          0.042253113 -0.132637847  0.245219266  0.217299938
## symmetry_mean       -0.288054252 -0.189570545 -0.030903840  0.073950596
## dimension_mean       0.236120382 -0.106390748  0.377436108 -0.518333769
## radius_se           -0.015625578  0.069635807 -0.011959877  0.111103952
## texture_se          -0.308499115  0.165408488  0.012614192 -0.033389049
## perimeter_se        -0.100597125  0.038865462  0.044358477  0.008991734
## area_se             -0.017226446 -0.055687709 -0.083203050  0.045171638
## smoothness_se       -0.293287983 -0.149148603  0.200139961 -0.018414232
## compactness_se      -0.263398426 -0.010320713 -0.491903153 -0.167886977
## concavity_se         0.251864823 -0.157777595 -0.135322845 -0.250292522
## points_se           -0.006430584  0.494527095  0.199547389 -0.062548716
## symmetry_se          0.319874237 -0.010836031  0.047340593  0.113219397
## dimension_se         0.275943072  0.240767973 -0.145958050  0.353782637
## radius_worst         0.039582217  0.138036550 -0.023526025 -0.166213790
## texture_worst        0.080142089  0.080737140 -0.053897961 -0.100862417
## perimeter_worst     -0.009084762  0.097004376 -0.012559001 -0.182407021
## area_worst           0.047986766  0.101235629  0.006646192 -0.315142865
## smoothness_worst     0.056931408  0.206026671 -0.163389545 -0.045226715
## compactness_worst   -0.371991007 -0.013117334 -0.165941776  0.049613607
## concavity_worst     -0.086870368 -0.218055908  0.066854662  0.204743734
## points_worst        -0.068367254  0.254345228  0.276401728  0.169597618
## symmetry_worst       0.043937722  0.256766084 -0.005448734 -0.139913723
## dimension_worst     -0.035134642  0.172524501  0.212520491  0.255448214
##                            PC17         PC18          PC19          PC20
## id                  -0.007779983 -0.019707372  0.005442248  0.020454908
## radius_mean          0.150008977  0.209908003 -0.156773206  0.211821385
## texture_mean         0.159152972 -0.034161758  0.040048687  0.029931705
## perimeter_mean       0.113792993  0.201233658 -0.168413120  0.227079273
## area_mean            0.130173978  0.251460456 -0.269145594 -0.045499625
## smoothness_mean      0.203117911  0.168171613  0.354463321 -0.160358262
## compactness_mean    -0.170379447 -0.016302860 -0.014259132  0.292092522
## concavity_mean      -0.270010606 -0.005071590  0.027973937  0.007197446
```

```
##                          -_
## points_mean        -0.381111880  0.028741889  0.087065594 -0.153991624
## symmetry_mean       0.165691481 -0.194702559 -0.169168737 -0.058503329
## dimension_mean      0.039119713  0.046298986 -0.086779501 -0.062879947
## radius_se          -0.055118880 -0.124562479  0.231233991  0.181436577
## texture_se          0.032768777  0.041652813  0.009177450  0.038681291
## perimeter_se       -0.023929011 -0.009084130  0.014508488  0.364045783
## area_se            -0.045538238  0.313148246 -0.296273515 -0.433949999
## smoothness_se       0.058326686  0.145306166  0.228819703 -0.013932678
## compactness_se     -0.190065826 -0.015610691 -0.094108380 -0.250216687
## concavity_se        0.126034946  0.092345618 -0.005794297  0.119490304
## points_se           0.197671940  0.106747906 -0.046944796 -0.015851066
## symmetry_se         0.158541381 -0.279918359 -0.180195394 -0.084242460
## dimension_se       -0.267180143 -0.122002438  0.059970839  0.097082660
## radius_worst        0.083459877 -0.235215809  0.218781792  0.027741137
## texture_worst      -0.185972310  0.065992656 -0.057250572 -0.080880841
## perimeter_worst     0.056649279 -0.228493742  0.189279122  0.105666112
## area_worst          0.090325036 -0.286471546  0.158722686 -0.393681440
## smoothness_worst   -0.142781922 -0.276751162 -0.504565504  0.228506719
## compactness_worst   0.153347954 -0.003683424  0.073627229  0.025544372
## concavity_worst     0.216302398 -0.190307542  0.107894455 -0.035839305
## points_worst       -0.178353485 -0.085180057 -0.067182996 -0.261323873
## symmetry_worst     -0.260033510  0.436706158  0.269313654  0.111738683
## dimension_worst     0.404957673  0.162920272 -0.026674889 -0.022516600
##                           PC21         PC22         PC23         PC24
## id                  0.009870917  0.006195707  0.003190337 -0.010289027
## radius_mean         0.046009507  0.070394387 -0.073021974 -0.098704322
## texture_mean        0.264801220 -0.436269565 -0.095890704  0.001311285
## perimeter_mean      0.015122205  0.070963404 -0.074821704 -0.040500943
## area_mean           0.087345298  0.021672998 -0.097428804  0.009396470
## smoothness_mean    -0.023842011  0.117945821 -0.063741313 -0.020088204
## compactness_mean   -0.476395571 -0.213187888  0.094254664  0.058295270
## concavity_mean      0.037771062 -0.001270114  0.188862925  0.321062737
## points_mean         0.231546040  0.017493297  0.313280824 -0.057974684
## symmetry_mean      -0.030776761  0.085067786  0.018331111 -0.052004767
## dimension_mean      0.172565576  0.085104005 -0.286892578 -0.084701081
## radius_se           0.090564458 -0.085660592  0.147793165 -0.263799753
## texture_se          0.083589382 -0.212168357 -0.048761201 -0.001150858
## perimeter_se        0.169586632  0.317246026 -0.153859020  0.081384223
## area_se            -0.270679518 -0.207916141 -0.068745790  0.110258620
## smoothness_se      -0.095370809  0.066602974 -0.051852247 -0.057154068
## compactness_se      0.451033960  0.159332265  0.048970757  0.003993806
## concavity_se       -0.070203251 -0.071023842  0.200850815 -0.388573085
## points_se          -0.064848884 -0.035557778  0.074494143  0.354040783
## symmetry_se        -0.112133933  0.092193625  0.084324570 -0.043455477
## dimension_se       -0.214213177 -0.069171668 -0.245408452  0.089594196
## radius_worst        0.006481267 -0.007068180  0.096292694 -0.057768458
## texture_worst      -0.330244412  0.578095532  0.111968438 -0.009473435
## perimeter_worst    -0.010544107  0.094457678 -0.014952244  0.058698441
## area_worst         -0.053510824 -0.149328216  0.096798702  0.193293235
## smoothness_worst    0.140127867 -0.156936236  0.069660581  0.091134610
## compactness_worst  -0.220884131 -0.191897773 -0.033373706 -0.145389941
## concavity_worst     0.047166544  0.139729448 -0.456817799  0.290302924
## points_worst       -0.039740929 -0.006870640 -0.305694162 -0.563297713
## symmetry_worst      0.125617213 -0.155827542 -0.096426675  0.122996111
## dimension_worst     0.095366679  0.092769737  0.470358007  0.002775112
##                           PC25         PC26         PC27         PC28
## id                 -0.004233388 -0.00132610 -0.002571324 -0.001623875
## radius_mean        -0.183664583  0.01859418  0.128713229  0.131697326
## texture_mean        0.099441545 -0.08442059  0.024821224  0.017622634
## perimeter_mean     -0.117262178 -0.02743488  0.124670225  0.115650274
## area_mean           0.070557041  0.21057100 -0.361014547 -0.467489167
## smoothness_mean     0.068940049 -0.02876100  0.037372832 -0.069482805
## compactness_mean   -0.102198309 -0.39651346 -0.262695425 -0.098624638
## concavity_mean      0.045550527  0.09717977  0.550227716 -0.363040016
## points_mean         0.082349955  0.18630114 -0.389316679  0.453345398
## symmetry_mean       0.018841491  0.02451053  0.015910368  0.015157593
## dimension_mean     -0.134601525  0.20670502  0.096796804  0.101343150
## radius_se          -0.561133900  0.17339784 -0.050411953 -0.213735821
## texture_se          0.023938591 -0.05709165  0.010893175  0.009925699
## perimeter_se        0.516048248 -0.07217201 -0.103485879 -0.041989200
## area_se            -0.018546693 -0.13093723  0.155929011  0.314758068
## smoothness_se       0.016193934 -0.03100551  0.008066566  0.009312365
## compactness_se     -0.122457873 -0.17364984  0.049404535 -0.046651501
```

```
## compactness_se    -0.122457875 -0.17564984  0.049404535 -0.046651501
## concavity_se       0.186159613 -0.01600952 -0.091931364  0.083824645
## points_se         -0.107166573  0.12999049  0.018674110  0.011675700
## symmetry_se        0.002613811  0.01936313  0.016991197  0.019891112
## dimension_se       0.076177800  0.08458109 -0.035156906  0.012141785
## radius_worst      -0.158114412 -0.07144112  0.195812320  0.178796461
## texture_worst     -0.118609952  0.11802219 -0.036347107 -0.021473842
## perimeter_worst    0.236463109 -0.11790535  0.243266456  0.241658719
## area_worst         0.146339946  0.03921251 -0.229813188 -0.237323945
## smoothness_worst  -0.011224935  0.04787154 -0.012860335  0.040730207
## compactness_worst  0.185437121  0.62471727  0.100772153  0.071087434
## concavity_worst   -0.286701322 -0.11586768 -0.267236886  0.142148446
## points_worst       0.105286798 -0.26352782  0.133749940 -0.230794105
## symmetry_worst    -0.013193455 -0.04505357 -0.027824916 -0.022695808
## dimension_worst    0.037882167 -0.28015574 -0.004500884 -0.060081371
##                           PC29          PC30          PC31
## id                -1.891724e-05 -0.0006852263 -7.122581e-05
## radius_mean        2.111968e-01 -0.2114371011 -7.024325e-01
## texture_mean      -6.362507e-05  0.0106165839 -2.644366e-04
## perimeter_mean     8.434280e-02 -0.3838889617  6.898676e-01
## area_mean         -2.725167e-01  0.4227208085  3.297173e-02
## smoothness_mean    1.480038e-03  0.0034638648  4.850746e-03
## compactness_mean  -5.466656e-03  0.0409079834 -4.468229e-02
## concavity_mean     4.554138e-02  0.0101122808 -2.512860e-02
## points_mean       -8.885707e-03  0.0041142627  1.067984e-03
## symmetry_mean      1.432581e-03  0.0075571475  1.279594e-03
## dimension_mean    -6.312291e-03 -0.0073311823  4.751885e-03
## radius_se         -1.922290e-01 -0.1186768422  8.679321e-03
## texture_se        -5.624974e-03  0.0086942153  1.063104e-03
## perimeter_se       2.631905e-01  0.0060612569 -1.373310e-02
## area_se           -4.205668e-02  0.0863645419 -1.054698e-03
## smoothness_se      9.795835e-03 -0.0016737982  1.618711e-03
## compactness_se    -1.539757e-02 -0.0032295613 -1.923037e-03
## concavity_se       5.819985e-03 -0.0161202167  8.921294e-03
## points_se         -2.900497e-02  0.0241014722  2.178643e-03
## symmetry_se       -7.637856e-03  0.0051771158 -3.338380e-04
## dimension_se       1.975791e-02  0.0083971145 -1.792802e-03
## radius_worst       4.126296e-01  0.6356796555  1.356846e-01
## texture_worst     -3.896988e-04 -0.0172219636 -1.020237e-03
## perimeter_worst   -7.286790e-01 -0.0228830657 -7.974244e-02
## area_worst         2.389679e-01 -0.4448733182 -3.976788e-02
## smoothness_worst  -1.535941e-03 -0.0074142082 -4.586820e-03
## compactness_worst  4.869512e-02  0.0001075081  1.285262e-02
## concavity_worst   -1.764174e-02  0.0126547542 -4.031809e-04
## points_worst       2.247340e-02 -0.0353341030  2.276561e-03
## symmetry_worst     4.922100e-03 -0.0133523613 -3.910451e-04
## dimension_worst   -2.356283e-02 -0.0115053741 -1.897779e-03
```

```
# Sample scores stored in breast_cancer_pca$x
head(breast_cancer_pca$x)
```

```
##            PC1         PC2        PC3        PC4         PC5        PC6
## [1,] 2.501946 -0.09694805 -0.4489597  2.3341176  0.69771548 -0.2430058
## [2,] 1.467439 -1.68630059  1.1542039  0.3362109  0.45962538  1.2308248
## [3,] 2.929028 -0.38319924 -0.8955891 -0.1164828  0.98441377 -0.2587872
## [4,] 1.995342 -1.33046592  1.1172876  2.0502761  0.25303846 -1.5539634
## [5,] 2.500252  2.01035097 -0.7584035  1.9862169 -1.13537096  0.5940361
## [6,] 2.018308 -0.78242095  0.1125197 -0.6532280  0.01841577  0.6914453
##             PC7         PC8        PC9        PC10       PC11        PC12
## [1,]  0.5092015 -1.11423307  0.2840243  0.32463197 -0.3245353  0.04981306
## [2,]  0.2937434  0.10000461 -0.0668399  0.42612180  0.4564029  1.19357566
## [3,] -0.3303385  0.03599041  0.8734350  0.02222192  0.4208602 -0.06687286
## [4,] -0.9692185 -1.31852134  0.6254396  0.05666470 -0.0691646  0.97082409
## [5,]  0.1198201 -0.48279704 -0.2727816 -0.29439485 -0.3577533  0.03266208
## [6,]  0.1454026  0.06214539  0.2342454  0.73681239 -0.3671239 -0.77029743
##             PC13       PC14         PC15        PC16        PC17
## [1,] -0.19760220  0.1134403 -0.059302558  0.16637723 -0.04286656
## [2,]  0.01807424 -0.2824292 -0.204858888 -0.07067959  0.03088787
## [3,]  0.37435458  0.2585457 -0.330274216 -0.13000189 -0.24616091
## [4,] -0.90968379  0.2179117 -0.665825669  0.10213387 -0.10289446
## [5,] -0.35547138 -0.1480140 -0.005540503 -0.06495881  0.22273309
## [6,] -0.49542291 -0.2992431  0.049952835 -0.20161083  0.14920422
##              PC18        PC19        PC20        PC21        PC22
## [1,] -0.104542766 -0.03484189 -0.09691187 -0.02846306 -0.00673628
## [2,] -0.405534243 -0.02886103 -0.05262226 -0.05987170  0.05868642
## [3,]  0.327711259  0.15937793 -0.13804895 -0.13489743  0.10080029
## [4,]  0.197085181  0.36251771 -0.40018239 -0.10302093 -0.28821708
## [5,] -0.129129156 -0.35877054  0.08515543 -0.08500541 -0.06332008
## [6,] -0.002229379 -0.08178568  0.18970936 -0.06872875  0.09669594
##              PC23         PC24         PC25        PC26         PC27
## [1,] -0.038971937  0.062212075  0.088438866  0.04872948 -0.007000724
## [2,]  0.070978613 -0.030822339 -0.016741580  0.04173030 -0.059332996
## [3,]  0.053909008  0.085484364  0.038277664 -0.04151896 -0.035546410
## [4,]  0.182045907  0.222848059 -0.115720065 -0.03676948 -0.148171674
## [5,]  0.043591030  0.008165322  0.002738052  0.05983731  0.046167735
## [6,] -0.001458054 -0.031338348  0.042784223 -0.08646068 -0.030944690
##             PC28         PC29         PC30         PC31
## [1,]  0.05356131  0.015184882  0.015985406  0.001396101
## [2,] -0.18696553  0.027011311 -0.000803330  0.008096490
## [3,] -0.07653067 -0.014640388  0.010307894  0.009074601
## [4,] -0.01711665 -0.047828494  0.023862995  0.000265075
## [5,]  0.03835364  0.032450800 -0.002312178 -0.002563269
## [6,]  0.00955434 -0.004403431  0.003869919 -0.002931194
```

```
# Identifying the scores by their diagnosis
diag_pca <- cbind(data.frame(diagnosis),breast_cancer_pca$x)
head(diag_pca)
```

```
##   diagnosis      PC1         PC2        PC3        PC4         PC5
## 1         B 2.501946 -0.09694805 -0.4489597  2.3341176  0.69771548
## 2         B 1.467439 -1.68630059  1.1542039  0.3362109  0.45962538
## 3         B 2.929028 -0.38319924 -0.8955891 -0.1164828  0.98441377
## 4         B 1.995342 -1.33046592  1.1172876  2.0502761  0.25303846
## 5         B 2.500252  2.01035097 -0.7584035  1.9862169 -1.13537096
## 6         B 2.018308 -0.78242095  0.1125197 -0.6532280  0.01841577
##          PC6        PC7         PC8        PC9        PC10       PC11
## 1 -0.2430058  0.5092015 -1.11423307  0.2840243  0.32463197 -0.3245353
## 2  1.2308248  0.2937434  0.10000461 -0.0668399  0.42612180  0.4564029
## 3 -0.2587872 -0.3303385  0.03599041  0.8734350  0.02222192  0.4208602
## 4 -1.5539634 -0.9692185 -1.31852134  0.6254396  0.05666470 -0.0691646
## 5  0.5940361  0.1198201 -0.48279704 -0.2727816 -0.29439485 -0.3577533
## 6  0.6914453  0.1454026  0.06214539  0.2342454  0.73681239 -0.3671239
##          PC12        PC13       PC14         PC15        PC16        PC17
## 1  0.04981306 -0.19760220  0.1134403 -0.059302558  0.16637723 -0.04286656
## 2  1.19357566  0.01807424 -0.2824292 -0.204858888 -0.07067959  0.03088787
## 3 -0.06687286  0.37435458  0.2585457 -0.330274216 -0.13000189 -0.24616091
## 4  0.97082409 -0.90968379  0.2179117 -0.665825669  0.10213387 -0.10289446
## 5  0.03266208 -0.35547138 -0.1480140 -0.005540503 -0.06495881  0.22273309
## 6 -0.77029743 -0.49542291 -0.2992431  0.049952835 -0.20161083  0.14920422
##           PC18        PC19        PC20        PC21        PC22
## 1 -0.104542766 -0.03484189 -0.09691187 -0.02846306 -0.00673628
## 2 -0.405534243 -0.02886103 -0.05262226 -0.05987170  0.05868642
## 3  0.327711259  0.15937793 -0.13804895 -0.13489743  0.10080029
## 4  0.197085181  0.36251771 -0.40018239 -0.10302093 -0.28821708
## 5 -0.129129156 -0.35877054  0.08515543 -0.08500541 -0.06332008
## 6 -0.002229379 -0.08178568  0.18970936 -0.06872875  0.09669594
##           PC23         PC24         PC25        PC26         PC27
## 1 -0.038971937  0.062212075  0.088438866  0.04872948 -0.007000724
## 2  0.070978613 -0.030822339 -0.016741580  0.04173030 -0.059332996
## 3  0.053909008  0.085484364  0.038277664 -0.04151896 -0.035546410
## 4  0.182045907  0.222848059 -0.115720065 -0.03676948 -0.148171674
## 5  0.043591030  0.008165322  0.002738052  0.05983731  0.046167735
## 6 -0.001458054 -0.031338348  0.042784223 -0.08646068 -0.030944690
##          PC28         PC29         PC30         PC31
## 1  0.05356131  0.015184882  0.015985406  0.001396101
## 2 -0.18696553  0.027011311 -0.000803330  0.008096490
## 3 -0.07653067 -0.014640388  0.010307894  0.009074601
## 4 -0.01711665 -0.047828494  0.023862995  0.000265075
## 5  0.03835364  0.032450800 -0.002312178 -0.002563269
## 6  0.00955434 -0.004403431  0.003869919 -0.002931194
```

```
# Means of scores for all the PC's classified by diagnosis status
tabmeansPC <- aggregate(diag_pca[,2:31],by=list(diagnosis=breast_cancer$diagnosis),mean)
tabmeansPC
```

```
##   diagnosis       PC1         PC2        PC3        PC4         PC5
## 1         B  2.204253 -0.3436398  0.2160542  0.1384470 -0.09800974
## 2         M -3.711879  0.5786765 -0.3638272 -0.2331395  0.16504470
##             PC6         PC7         PC8         PC9        PC10
## 1  0.004373132  0.01691799  0.04905754  0.03377092 -0.01002704
## 2 -0.007364189 -0.02848926 -0.08261104 -0.05686895  0.01688516
##             PC11         PC12         PC13        PC14        PC15
## 1 -0.0007888591  0.006017621  0.003305282 -0.03736471 -0.02453152
## 2  0.0013284090 -0.010133446 -0.005565970  0.06292076  0.04131016
##           PC16          PC17         PC18        PC19         PC20
## 1 -0.02516699  0.0001112917  0.006103777 -0.01307695 -0.009733891
## 2  0.04238026 -0.0001874111 -0.010278530  0.02202108  0.016391505
##           PC21         PC22         PC23         PC24         PC25
## 1 -0.008359794 -0.006225063 -0.003024993  0.002609428  0.007813479
## 2  0.014077577  0.010482771  0.005093974 -0.004394179 -0.013157604
##           PC26         PC27         PC28          PC29          PC30
## 1 -0.000879209 -0.003967725 -0.001909259 -0.0003418423 -0.0009838392
## 2  0.001480555  0.006681499  0.003215121  0.0005756496  0.0016567480
```

```
tabmeansPC <- tabmeansPC[rev(order(tabmeansPC$diagnosis)),]
tabmeansPC
```

```
##   diagnosis       PC1        PC2        PC3        PC4         PC5
## 2         M -3.711879  0.5786765 -0.3638272 -0.2331395  0.16504470
## 1         B  2.204253 -0.3436398  0.2160542  0.1384470 -0.09800974
##             PC6          PC7         PC8         PC9        PC10
## 2 -0.007364189 -0.02848926 -0.08261104 -0.05686895  0.01688516
## 1  0.004373132  0.01691799  0.04905754  0.03377092 -0.01002704
##            PC11          PC12         PC13        PC14        PC15
## 2  0.0013284090 -0.010133446 -0.005565970  0.06292076  0.04131016
## 1 -0.0007888591  0.006017621  0.003305282 -0.03736471 -0.02453152
##           PC16           PC17         PC18        PC19         PC20
## 2  0.04238026 -0.0001874111 -0.010278530  0.02202108  0.016391505
## 1 -0.02516699  0.0001112917  0.006103777 -0.01307695 -0.009733891
##            PC21         PC22         PC23         PC24         PC25
## 2  0.014077577  0.010482771  0.005093974 -0.004394179 -0.013157604
## 1 -0.008359794 -0.006225063 -0.003024993  0.002609428  0.007813479
##            PC26         PC27         PC28          PC29          PC30
## 2  0.001480555  0.006681499  0.003215121  0.0005756496  0.0016567480
## 1 -0.000879209 -0.003967725 -0.001909259 -0.0003418423 -0.0009838392
```

```
tabfmeans <- t(tabmeansPC[,-1])
tabfmeans
```

```
##                  2             1
## PC1  -3.7118786952  2.2042528946
## PC2   0.5786764540 -0.3436397990
## PC3  -0.3638271826  0.2160542373
## PC4  -0.2331394896  0.1384469798
## PC5   0.1650447018 -0.0980097389
## PC6  -0.0073641886  0.0043731316
## PC7  -0.0284892608  0.0169179924
## PC8  -0.0826110415  0.0490575373
## PC9  -0.0568689505  0.0337709174
## PC10  0.0168851623 -0.0100270432
## PC11  0.0013284090 -0.0007888591
## PC12 -0.0101334459  0.0060176205
## PC13 -0.0055659702  0.0033052820
## PC14  0.0629207582 -0.0373647080
## PC15  0.0413101623 -0.0245315249
## PC16  0.0423802589 -0.0251669885
## PC17 -0.0001874111  0.0001112917
## PC18 -0.0102785304  0.0061037771
## PC19  0.0220210837 -0.0130769461
## PC20  0.0163915046 -0.0097338907
## PC21  0.0140775772 -0.0083597937
## PC22  0.0104827709 -0.0062250628
## PC23  0.0050939739 -0.0030249929
## PC24 -0.0043941787  0.0026094282
## PC25 -0.0131576035  0.0078134789
## PC26  0.0014805547 -0.0008792090
## PC27  0.0066814986 -0.0039677247
## PC28  0.0032151208 -0.0019092594
## PC29  0.0005756496 -0.0003418423
## PC30  0.0016567480 -0.0009838392
```

```
colnames(tabfmeans) <- t(as.vector(tabmeansPC[1]))
tabfmeans
```

```
##                 M            B
## PC1  -3.7118786952  2.2042528946
## PC2   0.5786764540 -0.3436397990
## PC3  -0.3638271826  0.2160542373
## PC4  -0.2331394896  0.1384469798
## PC5   0.1650447018 -0.0980097389
## PC6  -0.0073641886  0.0043731316
## PC7  -0.0284892608  0.0169179924
## PC8  -0.0826110415  0.0490575373
## PC9  -0.0568689505  0.0337709174
## PC10  0.0168851623 -0.0100270432
## PC11  0.0013284090 -0.0007888591
## PC12 -0.0101334459  0.0060176205
## PC13 -0.0055659702  0.0033052820
## PC14  0.0629207582 -0.0373647080
## PC15  0.0413101623 -0.0245315249
## PC16  0.0423802589 -0.0251669885
## PC17 -0.0001874111  0.0001112917
## PC18 -0.0102785304  0.0061037771
## PC19  0.0220210837 -0.0130769461
## PC20  0.0163915046 -0.0097338907
## PC21  0.0140775772 -0.0083597937
## PC22  0.0104827709 -0.0062250628
## PC23  0.0050939739 -0.0030249929
## PC24 -0.0043941787  0.0026094282
## PC25 -0.0131576035  0.0078134789
## PC26  0.0014805547 -0.0008792090
## PC27  0.0066814986 -0.0039677247
## PC28  0.0032151208 -0.0019092594
## PC29  0.0005756496 -0.0003418423
## PC30  0.0016567480 -0.0009838392
```

```
# Standard deviations of scores for all the PC's classified by diagnosis status
tabsdsPC <- aggregate(diag_pca[,2:31],by=list(breast_cancer$diagnosis),sd)
tabfsds <- t(tabsdsPC[,-1])
colnames(tabfsds) <- t(as.vector(tabsdsPC[1]))
tabfsds
```

```
##                B          M
## PC1  1.63956487 3.02839244
## PC2  2.08691418 2.72966952
## PC3  1.36038677 2.07323861
## PC4  1.39613539 1.39927526
## PC5  1.39777817 1.04807636
## PC6  0.95340249 1.33789147
## PC7  0.95140466 1.05116532
## PC8  0.64932787 1.04212370
## PC9  0.65881989 0.70917409
## PC10 0.57998076 0.71917808
## PC11 0.60269891 0.57186757
## PC12 0.54006502 0.54668527
## PC13 0.51222488 0.51016086
## PC14 0.37926601 0.63294179
## PC15 0.38070917 0.41867516
## PC16 0.26760334 0.36012377
## PC17 0.26627925 0.30856638
## PC18 0.17881651 0.32377631
## PC19 0.17193548 0.30152802
## PC20 0.17202337 0.28613872
## PC21 0.15015083 0.21280261
## PC22 0.15982321 0.19320204
## PC23 0.14579937 0.19476702
## PC24 0.12247334 0.19984615
## PC25 0.11050781 0.16637188
## PC26 0.09806381 0.15950557
## PC27 0.07202620 0.11477556
## PC28 0.06617618 0.10565982
## PC29 0.02588741 0.05609976
## PC30 0.01834069 0.03798219
```

```
t.test(PC1~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC1 by breast_cancer$diagnosis
## t = 26.251, df = 285.72, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  5.472542 6.359721
## sample estimates:
## mean in group B mean in group M
##        2.204253       -3.711879
```

```
t.test(PC2~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC2 by breast_cancer$diagnosis
## t = -4.2387, df = 357.38, p-value = 2.865e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.3502373 -0.4943952
## sample estimates:
## mean in group B mean in group M
##      -0.3436398       0.5786765
```

```
t.test(PC3~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC3 by breast_cancer$diagnosis
## t = 3.6343, df = 320.28, p-value = 0.0003246
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.2659658 0.8937970
## sample estimates:
## mean in group B mean in group M
##       0.2160542      -0.3638272
```

```
t.test(PC4~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC4 by breast_cancer$diagnosis
## t = 3.0652, df = 442.55, p-value = 0.002308
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.1333371 0.6098358
## sample estimates:
## mean in group B mean in group M
##       0.1384470      -0.2331395
```

```
t.test(PC5~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC5 by breast_cancer$diagnosis
## t = -2.5485, df = 537.03, p-value = 0.0111
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.46581747 -0.06029141
## sample estimates:
## mean in group B mean in group M
##     -0.09800974      0.16504470
```

```
t.test(PC6~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC6 by breast_cancer$diagnosis
## t = 0.11197, df = 339.17, p-value = 0.9109
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.1944615  0.2179362
## sample estimates:
## mean in group B mean in group M
##     0.004373132    -0.007364189
```

```
t.test(PC7~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC7 by breast_cancer$diagnosis
## t = 0.51587, df = 408.87, p-value = 0.6062
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.1276209  0.2184354
## sample estimates:
## mean in group B mean in group M
##      0.01691799     -0.02848926
```

```
t.test(PC8~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC8 by breast_cancer$diagnosis
## t = 1.6584, df = 309.75, p-value = 0.09825
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.02455572  0.28789287
## sample estimates:
## mean in group B mean in group M
##      0.04905754     -0.08261104
```

```
t.test(PC9~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC9 by breast_cancer$diagnosis
## t = 1.5132, df = 417.67, p-value = 0.131
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.0271048  0.2083845
## sample estimates:
## mean in group B mean in group M
##      0.03377092     -0.05686895
```

```
t.test(PC10~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC10 by breast_cancer$diagnosis
## t = -0.46277, df = 372.52, p-value = 0.6438
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.14126432  0.08743991
## sample estimates:
## mean in group B mean in group M
##     -0.01002704      0.01688516
```

```
t.test(PC11~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC11 by breast_cancer$diagnosis
## t = -0.041845, df = 462.01, p-value = 0.9666
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.10154692  0.09731238
## sample estimates:
## mean in group B mean in group M
##   -0.0007888591    0.0013284090
```

```
t.test(PC12~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC12 by breast_cancer$diagnosis
## t = 0.34227, df = 439.04, p-value = 0.7323
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.07659212  0.10889425
## sample estimates:
## mean in group B mean in group M
##     0.006017621    -0.010133446
```

```
t.test(PC13~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC13 by breast_cancer$diagnosis
## t = 0.20025, df = 444.77, p-value = 0.8414
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.07819457  0.09593708
## sample estimates:
## mean in group B mean in group M
##     0.003305282    -0.005565970
```

```
t.test(PC14~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC14 by breast_cancer$diagnosis
## t = -2.0945, df = 302.42, p-value = 0.03705
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.194508096 -0.006062836
## sample estimates:
## mean in group B mean in group M
##     -0.03736471      0.06292076
```

```
t.test(PC15~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC15 by breast_cancer$diagnosis
## t = -1.8752, df = 410.43, p-value = 0.06147
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.134862771  0.003179396
## sample estimates:
## mean in group B mean in group M
##     -0.02453152      0.04131016
```

```
t.test(PC16~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC16 by breast_cancer$diagnosis
## t = -2.37, df = 349.77, p-value = 0.01833
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.12360307 -0.01149143
## sample estimates:
## mean in group B mean in group M
##     -0.02516699      0.04238026
```

```
t.test(PC17~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC17 by breast_cancer$diagnosis
## t = 0.011737, df = 393.3, p-value = 0.9906
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.04973747  0.05033487
## sample estimates:
## mean in group B mean in group M
##    0.0001112917   -0.0001874111
```

```
t.test(PC18~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC18 by breast_cancer$diagnosis
## t = 0.67787, df = 288.75, p-value = 0.4984
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.03118389  0.06394850
## sample estimates:
## mean in group B mean in group M
##     0.006103777    -0.010278530
```

```
t.test(PC19~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC19 by breast_cancer$diagnosis
## t = -1.5516, df = 293.85, p-value = 0.1218
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.079616015  0.009419955
## sample estimates:
## mean in group B mean in group M
##     -0.01307695      0.02202108
```

```
t.test(PC20~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC20 by breast_cancer$diagnosis
## t = -1.2062, df = 303.02, p-value = 0.2287
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.06874572  0.01649493
## sample estimates:
## mean in group B mean in group M
##    -0.009733891     0.016391505
```

```
t.test(PC21~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC21 by breast_cancer$diagnosis
## t = -1.3487, df = 336.76, p-value = 0.1783
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.05516116  0.01028642
## sample estimates:
## mean in group B mean in group M
##    -0.008359794     0.014077577
```

```
t.test(PC22~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC22 by breast_cancer$diagnosis
## t = -1.0618, df = 380.13, p-value = 0.289
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.04764831  0.01423264
## sample estimates:
## mean in group B mean in group M
##    -0.006225063     0.010482771
```

```
t.test(PC23~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC23 by breast_cancer$diagnosis
## t = -0.52575, df = 351.71, p-value = 0.5994
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.03849078  0.02225285
## sample estimates:
## mean in group B mean in group M
##    -0.003024993     0.005093974
```

```
t.test(PC24~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC24 by breast_cancer$diagnosis
## t = 0.4614, df = 306.57, p-value = 0.6448
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.02286480  0.03687201
## sample estimates:
## mean in group B mean in group M
##     0.002609428    -0.004394179
```

```
t.test(PC25~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC25 by breast_cancer$diagnosis
## t = 1.6337, df = 322.91, p-value = 0.1033
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.004282315  0.046224480
## sample estimates:
## mean in group B mean in group M
##     0.007813479    -0.013157604
```

```
t.test(PC26~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC26 by breast_cancer$diagnosis
## t = -0.19467, df = 307.18, p-value = 0.8458
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.02621273  0.02149320
## sample estimates:
## mean in group B mean in group M
##    -0.000879209     0.001480555
```

```
t.test(PC27~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC27 by breast_cancer$diagnosis
## t = -1.2162, df = 311.14, p-value = 0.2248
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.027878004  0.006579557
## sample estimates:
## mean in group B mean in group M
##    -0.003967725     0.006681499
```

```
t.test(PC28~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC28 by breast_cancer$diagnosis
## t = -0.63596, df = 310.76, p-value = 0.5253
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.02097902  0.01073026
## sample estimates:
## mean in group B mean in group M
##    -0.001909259     0.003215121
```

```
t.test(PC29~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC29 by breast_cancer$diagnosis
## t = -0.22436, df = 265.22, p-value = 0.8226
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.008969119  0.007134135
## sample estimates:
## mean in group B mean in group M
##   -0.0003418423    0.0005756496
```

```
t.test(PC30~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC30 by breast_cancer$diagnosis
## t = -0.9487, df = 270.4, p-value = 0.3436
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.008120430  0.002839256
## sample estimates:
## mean in group B mean in group M
##   -0.0009838392    0.0016567480
```

```
t.test(PC31~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC31 by breast_cancer$diagnosis
## t = -0.54256, df = 278.74, p-value = 0.5879
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.002917016  0.001656473
## sample estimates:
## mean in group B mean in group M
##   -0.0002348289    0.0003954429
```

```
# F ratio tests
var.test(PC1~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC1 by breast_cancer$diagnosis
## F = 0.29311, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.2293890 0.3717204
## sample estimates:
## ratio of variances
##          0.2931115
```

```
var.test(PC2~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC2 by breast_cancer$diagnosis
## F = 0.58451, num df = 356, denom df = 211, p-value = 8.474e-06
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.4574343 0.7412633
## sample estimates:
## ratio of variances
##          0.5845061
```

```
var.test(PC3~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC3 by breast_cancer$diagnosis
## F = 0.43055, num df = 356, denom df = 211, p-value = 2.327e-12
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.3369504 0.5460214
## sample estimates:
## ratio of variances
##          0.4305526
```

```
var.test(PC4~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC4 by breast_cancer$diagnosis
## F = 0.99552, num df = 356, denom df = 211, p-value = 0.9625
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.7790915 1.2625024
## sample estimates:
## ratio of variances
##          0.9955172
```

```
var.test(PC5~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC5 by breast_cancer$diagnosis
## F = 1.7787, num df = 356, denom df = 211, p-value = 5.82e-06
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  1.391972 2.255662
## sample estimates:
## ratio of variances
##           1.778651
```

```
var.test(PC6~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC6 by breast_cancer$diagnosis
## F = 0.50782, num df = 356, denom df = 211, p-value = 1.795e-08
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.3974207 0.6440124
## sample estimates:
## ratio of variances
##          0.5078212
```

```
var.test(PC7~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC7 by breast_cancer$diagnosis
## F = 0.8192, num df = 356, denom df = 211, p-value = 0.1
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.6411036 1.0388957
## sample estimates:
## ratio of variances
##          0.8191973
```

```
var.test(PC8~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC8 by breast_cancer$diagnosis
## F = 0.38823, num df = 356, denom df = 211, p-value = 3.319e-15
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.3038290 0.4923489
## sample estimates:
## ratio of variances
##          0.3882304
```

```
var.test(PC9~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC9 by breast_cancer$diagnosis
## F = 0.86303, num df = 356, denom df = 211, p-value = 0.2243
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.6754099 1.0944883
## sample estimates:
## ratio of variances
##          0.8630336
```

```
var.test(PC10~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC10 by breast_cancer$diagnosis
## F = 0.65036, num df = 356, denom df = 211, p-value = 0.0003698
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.5089722 0.8247793
## sample estimates:
## ratio of variances
##          0.6503607
```

```
var.test(PC11~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC11 by breast_cancer$diagnosis
## F = 1.1107, num df = 356, denom df = 211, p-value = 0.4012
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.8692598 1.4086183
## sample estimates:
## ratio of variances
##           1.110734
```

```
var.test(PC12~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC12 by breast_cancer$diagnosis
## F = 0.97593, num df = 356, denom df = 211, p-value = 0.8346
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.7637603 1.2376584
## sample estimates:
## ratio of variances
##           0.975927
```

```
var.test(PC13~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC13 by breast_cancer$diagnosis
## F = 1.0081, num df = 356, denom df = 211, p-value = 0.956
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.7889451 1.2784699
## sample estimates:
## ratio of variances
##           1.008108
```

```
var.test(PC14~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC14 by breast_cancer$diagnosis
## F = 0.35905, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.2809959 0.4553483
## sample estimates:
## ratio of variances
##          0.3590544
```

```
var.test(PC15~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC15 by breast_cancer$diagnosis
## F = 0.82686, num df = 356, denom df = 211, p-value = 0.1169
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.6471009 1.0486142
## sample estimates:
## ratio of variances
##          0.8268605
```

```
var.test(PC16~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC16 by breast_cancer$diagnosis
## F = 0.55218, num df = 356, denom df = 211, p-value = 8.26e-07
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.4321348 0.7002658
## sample estimates:
## ratio of variances
##          0.5521785
```

```
var.test(PC17~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC17 by breast_cancer$diagnosis
## F = 0.74469, num df = 356, denom df = 211, p-value = 0.01494
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.5827968 0.9444106
## sample estimates:
## ratio of variances
##          0.7446933
```

```
var.test(PC18~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC18 by breast_cancer$diagnosis
## F = 0.30502, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.2387068 0.3868197
## sample estimates:
## ratio of variances
##          0.3050177
```

```
var.test(PC19~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC19 by breast_cancer$diagnosis
## F = 0.32514, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.2544576 0.4123434
## sample estimates:
## ratio of variances
##          0.3251439
```

```
var.test(PC20~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC20 by breast_cancer$diagnosis
## F = 0.36143, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.2828534 0.4583583
## sample estimates:
## ratio of variances
##          0.3614279
```

```
var.test(PC21~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC21 by breast_cancer$diagnosis
## F = 0.49785, num df = 356, denom df = 211, p-value = 6.758e-09
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.3896201 0.6313716
## sample estimates:
## ratio of variances
##          0.4978535
```

```
var.test(PC22~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC22 by breast_cancer$diagnosis
## F = 0.68432, num df = 356, denom df = 211, p-value = 0.001709
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.5355451 0.8678402
## sample estimates:
## ratio of variances
##          0.6843154
```

```
var.test(PC23~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC23 by breast_cancer$diagnosis
## F = 0.56038, num df = 356, denom df = 211, p-value = 1.542e-06
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.4385511 0.7106634
## sample estimates:
## ratio of variances
##          0.5603772
```

```
var.test(PC24~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC24 by breast_cancer$diagnosis
## F = 0.37557, num df = 356, denom df = 211, p-value = 3.495e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.2939215 0.4762939
## sample estimates:
## ratio of variances
##          0.3755706
```

```
var.test(PC25~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC25 by breast_cancer$diagnosis
## F = 0.44119, num df = 356, denom df = 211, p-value = 9.824e-12
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.3452756 0.5595122
## sample estimates:
## ratio of variances
##          0.4411905
```

```
var.test(PC26~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC26 by breast_cancer$diagnosis
## F = 0.37798, num df = 356, denom df = 211, p-value = 5.423e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.2958050 0.4793461
## sample estimates:
## ratio of variances
##          0.3779774
```

```
var.test(PC27~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC27 by breast_cancer$diagnosis
## F = 0.39381, num df = 356, denom df = 211, p-value = 8.544e-15
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.3081924 0.4994196
## sample estimates:
## ratio of variances
##          0.3938058
```

```
var.test(PC28~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC28 by breast_cancer$diagnosis
## F = 0.39227, num df = 356, denom df = 211, p-value = 6.601e-15
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.3069894 0.4974701
## sample estimates:
## ratio of variances
##          0.3922686
```

```
var.test(PC29~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC29 by breast_cancer$diagnosis
## F = 0.21294, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.1666460 0.2700465
## sample estimates:
## ratio of variances
##          0.2129389
```

```
var.test(PC30~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC30 by breast_cancer$diagnosis
## F = 0.23317, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.1824782 0.2957024
## sample estimates:
## ratio of variances
##          0.2331693
```

```
var.test(PC31~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC31 by breast_cancer$diagnosis
## F = 0.26577, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.2079951 0.3370519
## sample estimates:
## ratio of variances
##          0.2657746
```

```
# Levene's tests (one-sided)
library(car)
(LTPC1 <- leveneTest(PC1~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group   1  62.132 1.654e-14 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(p_PC1_1sided <- LTPC1[[3]][1]/2)
```

```
## [1] 8.268824e-15
```

```
(LTPC2 <- leveneTest(PC2~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value   Pr(>F)
## group   1  18.786 1.73e-05 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(p_PC2_1sided=LTPC2[[3]][1]/2)
```

```
## [1] 8.651441e-06
```

```
(LTPC3 <- leveneTest(PC3~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group   1   27.65 2.063e-07 ***
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(p_PC3_1sided <- LTPC3[[3]][1]/2)
```

```
## [1] 1.031266e-07
```

```
(LTPC4 <- leveneTest(PC4~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value Pr(>F)
## group   1   2e-04  0.989
##       567
```

```
(p_PC4_1sided <- LTPC4[[3]][1]/2)
```

```
## [1] 0.4944984
```

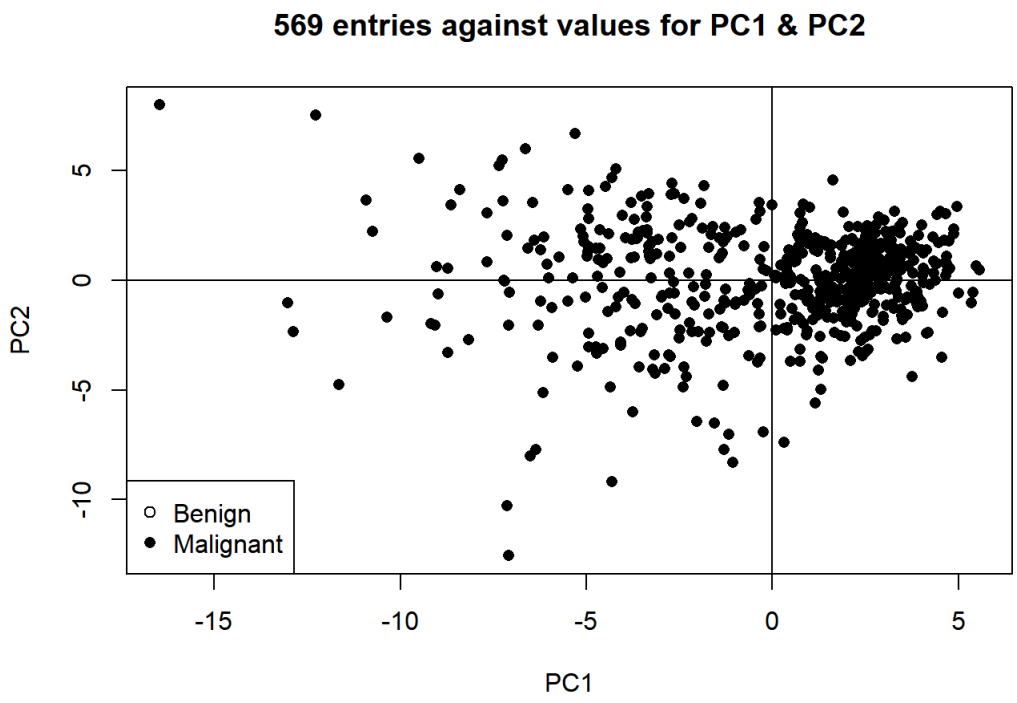
```
(LTPC5 <- leveneTest(PC5~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value   Pr(>F)
## group   1  6.8535 0.009083 **
##       567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

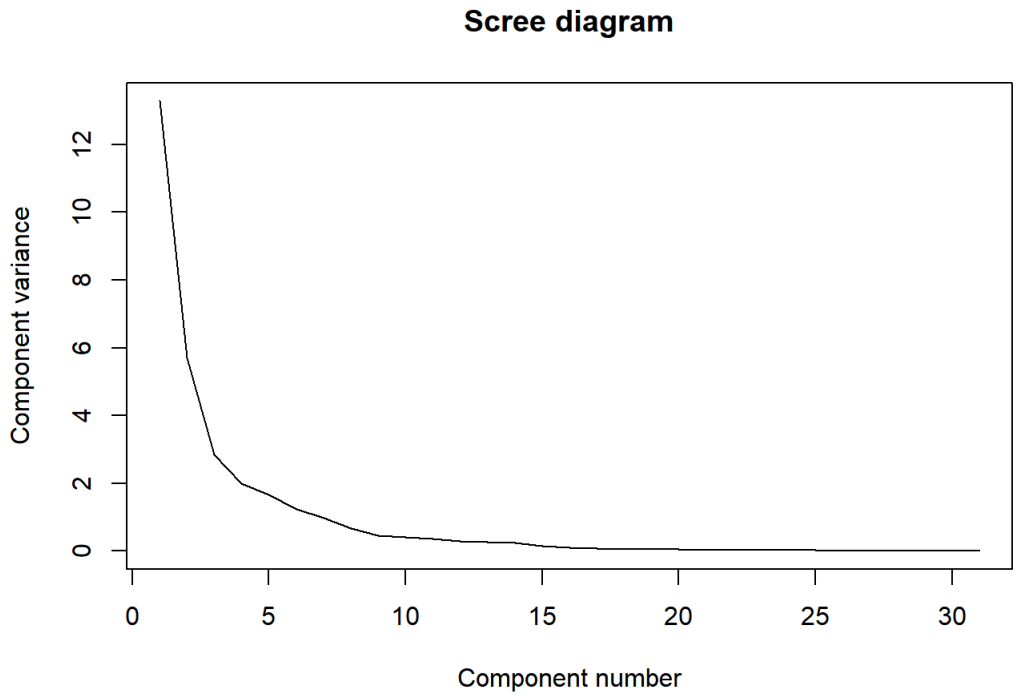
```
(p_PC5_1sided <- LTPC5[[3]][1]/2)
```

```
## [1] 0.004541533
```

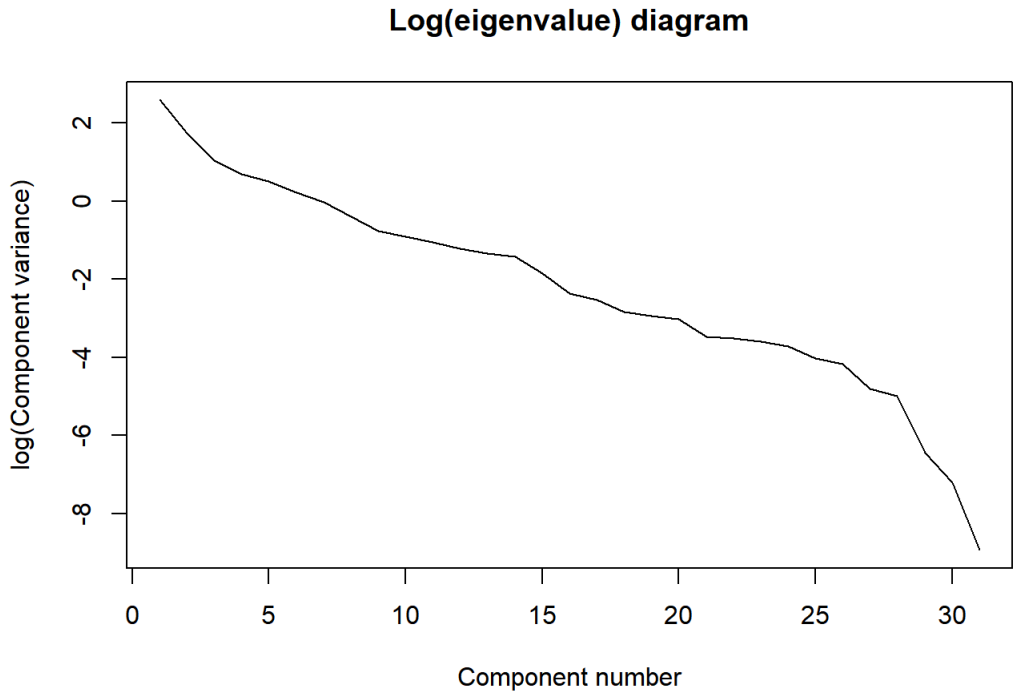
```
# Plotting the scores for the first and second components
plot(diag_pca$PC1, diag_pca$PC2,pch=ifelse(diag_pca$diagnosis == "S",1,16),xlab="PC1", ylab="PC2", main="569 entries against values for PC1 & PC2")
abline(h=0)
abline(v=0)
legend("bottomleft", legend=c("Benign","Malignant"), pch=c(1,16))
```




```
plot(eigen_breast_cancer, xlab = "Component number", ylab = "Component variance", type = "l", main = "Scree diagram")
```




```
plot(log(eigen_breast_cancer), xlab = "Component number",ylab = "log(Component variance)", type="l",main = "
Log(eigenvalue) diagram")
```




```
print(summary(breast_cancer_pca))
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6
## Standard deviation     3.6453 2.3868 1.68386 1.40761 1.28406 1.11116
## Proportion of Variance 0.4286 0.1838 0.09146 0.06391 0.05319 0.03983
## Cumulative Proportion  0.4286 0.6124 0.70388 0.76779 0.82098 0.86081
##                           PC7     PC8     PC9   PC10    PC11    PC12
## Standard deviation     0.98908 0.81961 0.67882 0.6349 0.59089 0.54212
## Proportion of Variance 0.03156 0.02167 0.01486 0.0130 0.01126 0.00948
## Cumulative Proportion  0.89237 0.91404 0.92890 0.9419 0.95317 0.96265
##                           PC13    PC14    PC15    PC16    PC17   PC18
## Standard deviation     0.51103 0.49125 0.39620 0.30680 0.28251 0.2430
## Proportion of Variance 0.00842 0.00778 0.00506 0.00304 0.00257 0.0019
## Cumulative Proportion  0.97107 0.97886 0.98392 0.98696 0.98953 0.9914
##                           PC19    PC20   PC21    PC22    PC23    PC24
## Standard deviation     0.2293 0.22163 0.1763 0.17304 0.16562 0.15572
## Proportion of Variance 0.0017 0.00158 0.0010 0.00097 0.00088 0.00078
## Cumulative Proportion  0.9931 0.99472 0.9957 0.99669 0.99757 0.99835
##                           PC25   PC26    PC27    PC28    PC29    PC30
## Standard deviation     0.13431 0.1244 0.09040 0.08305 0.03987 0.02736
## Proportion of Variance 0.00058 0.0005 0.00026 0.00022 0.00005 0.00002
## Cumulative Proportion  0.99893 0.9994 0.99970 0.99992 0.99997 1.00000
##                           PC31
## Standard deviation     0.01153
## Proportion of Variance 0.00000
## Cumulative Proportion  1.00000
```

```
#View(breast_cancer_pca)
diag(cov(breast_cancer_pca$x))
```

```
##          PC1          PC2          PC3          PC4          PC5
## 1.328806e+01 5.696805e+00 2.835395e+00 1.981357e+00 1.648815e+00
##          PC6          PC7          PC8          PC9         PC10
## 1.234673e+00 9.782732e-01 6.717530e-01 4.607924e-01 4.031331e-01
##         PC11         PC12         PC13         PC14         PC15
## 3.491550e-01 2.938904e-01 2.611469e-01 2.413302e-01 1.569736e-01
##         PC16         PC17         PC18         PC19         PC20
## 9.412853e-02 7.980995e-02 5.904627e-02 5.259119e-02 4.912193e-02
##         PC21         PC22         PC23         PC24         PC25
## 3.107078e-02 2.994121e-02 2.743052e-02 2.424902e-02 1.803936e-02
##         PC26         PC27         PC28         PC29         PC30
## 1.547973e-02 8.171699e-03 6.898103e-03 1.589338e-03 7.483761e-04
##         PC31
## 1.330402e-04
```

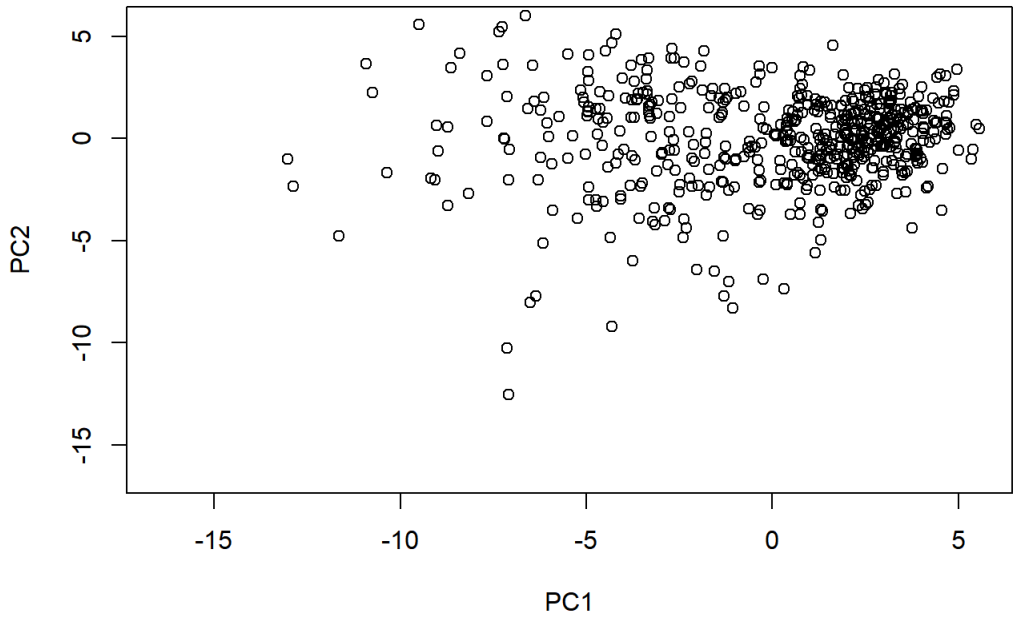
```
xlim <- range(breast_cancer_pca$x[,1])
head(breast_cancer_pca$x[,1])
```

```
## [1] 2.501946 1.467439 2.929028 1.995342 2.500252 2.018308
```

```
head(breast_cancer_pca$x)
```

```
##            PC1         PC2        PC3        PC4          PC5        PC6
## [1,] 2.501946 -0.09694805 -0.4489597  2.3341176  0.69771548 -0.2430058
## [2,] 1.467439 -1.68630059  1.1542039  0.3362109  0.45962538  1.2308248
## [3,] 2.929028 -0.38319924 -0.8955891 -0.1164828  0.98441377 -0.2587872
## [4,] 1.995342 -1.33046592  1.1172876  2.0502761  0.25303846 -1.5539634
## [5,] 2.500252  2.01035097 -0.7584035  1.9862169 -1.13537096  0.5940361
## [6,] 2.018308 -0.78242095  0.1125197 -0.6532280  0.01841577  0.6914453
##             PC7         PC8        PC9        PC10       PC11        PC12
## [1,]  0.5092015 -1.11423307  0.2840243  0.32463197 -0.3245353  0.04981306
## [2,]  0.2937434  0.10000461 -0.0668399  0.42612180  0.4564029  1.19357566
## [3,] -0.3303385  0.03599041  0.8734350  0.02222192  0.4208602 -0.06687286
## [4,] -0.9692185 -1.31852134  0.6254396  0.05666470 -0.0691646  0.97082409
## [5,]  0.1198201 -0.48279704 -0.2727816 -0.29439485 -0.3577533  0.03266208
## [6,]  0.1454026  0.06214539  0.2342454  0.73681239 -0.3671239 -0.77029743
##             PC13       PC14         PC15        PC16        PC17
## [1,] -0.19760220  0.1134403 -0.059302558  0.16637723 -0.04286656
## [2,]  0.01807424 -0.2824292 -0.204858888 -0.07067959  0.03088787
## [3,]  0.37435458  0.2585457 -0.330274216 -0.13000189 -0.24616091
## [4,] -0.90968379  0.2179117 -0.665825669  0.10213387 -0.10289446
## [5,] -0.35547138 -0.1480140 -0.005540503 -0.06495881  0.22273309
## [6,] -0.49542291 -0.2992431  0.049952835 -0.20161083  0.14920422
##              PC18        PC19        PC20        PC21        PC22
## [1,] -0.104542766 -0.03484189 -0.09691187 -0.02846306 -0.00673628
## [2,] -0.405534243 -0.02886103 -0.05262226 -0.05987170  0.05868642
## [3,]  0.327711259  0.15937793 -0.13804895 -0.13489743  0.10080029
## [4,]  0.197085181  0.36251771 -0.40018239 -0.10302093 -0.28821708
## [5,] -0.129129156 -0.35877054  0.08515543 -0.08500541 -0.06332008
## [6,] -0.002229379 -0.08178568  0.18970936 -0.06872875  0.09669594
##              PC23         PC24         PC25        PC26         PC27
## [1,] -0.038971937  0.062212075  0.088438866  0.04872948 -0.007000724
## [2,]  0.070978613 -0.030822339 -0.016741580  0.04173030 -0.059332996
## [3,]  0.053909008  0.085484364  0.038277664 -0.04151896 -0.035546410
## [4,]  0.182045907  0.222848059 -0.115720065 -0.03676948 -0.148171674
## [5,]  0.043591030  0.008165322  0.002738052  0.05983731  0.046167735
## [6,] -0.001458054 -0.031338348  0.042784223 -0.08646068 -0.030944690
##             PC28         PC29         PC30         PC31
## [1,]  0.05356131  0.015184882  0.015985406  0.001396101
## [2,] -0.18696553  0.027011311 -0.000803330  0.008096490
## [3,] -0.07653067 -0.014640388  0.010307894  0.009074601
## [4,] -0.01711665 -0.047828494  0.023862995  0.000265075
## [5,]  0.03835364  0.032450800 -0.002312178 -0.002563269
## [6,]  0.00955434 -0.004403431  0.003869919 -0.002931194
```

```
plot(breast_cancer_pca$x,xlim=xlim,ylim=xlim)
```




```
#Factor Analysis
library(psych)
```

```
## Warning: package 'psych' was built under R version 3.5.2
```

```
##
## Attaching package: 'psych'
```

```
## The following object is masked from 'package:car':
##
##     logit
```

```
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

```
#install.packages("psych", lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")
library(psych)
fit.pc <- principal(breast_cancer[-2], nfactors=4, rotate="varimax")
fit.pc
```

```
## Principal Components Analysis
## Call: principal(r = breast_cancer[-2], nfactors = 4, rotate = "varimax")
## Standardized loadings (pattern matrix) based upon correlation matrix
##                       RC1   RC2   RC3   RC4    h2    u2 com
## id                   0.13 -0.10  0.10  0.07 0.042 0.958 3.3
## radius_mean          0.95  0.13 -0.14  0.10 0.951 0.049 1.1
## texture_mean         0.25  0.06  0.05  0.91 0.897 0.103 1.2
## perimeter_mean       0.95  0.17 -0.11  0.10 0.954 0.046 1.1
## area_mean            0.97  0.10 -0.08  0.09 0.960 0.040 1.1
## smoothness_mean      0.16  0.65  0.26 -0.19 0.547 0.453 1.6
## compactness_mean     0.46  0.77  0.32  0.05 0.910 0.090 2.0
## concavity_mean       0.66  0.61  0.31  0.10 0.908 0.092 2.5
## points_mean          0.80  0.51  0.15  0.05 0.921 0.079 1.8
## symmetry_mean        0.14  0.58  0.33 -0.06 0.474 0.526 1.7
## dimension_mean      -0.31  0.66  0.53 -0.10 0.826 0.174 2.4
## radius_se            0.83  0.00  0.40  0.03 0.850 0.150 1.4
## texture_se          -0.05 -0.21  0.60  0.54 0.693 0.307 2.3
## perimeter_se         0.82  0.04  0.42  0.04 0.855 0.145 1.5
## area_se              0.88 -0.02  0.26  0.01 0.836 0.164 1.2
## smoothness_se       -0.14  0.00  0.70 -0.05 0.518 0.482 1.1
## compactness_se       0.20  0.51  0.67  0.11 0.762 0.238 2.2
## concavity_se         0.22  0.41  0.63  0.07 0.622 0.378 2.0
## points_se            0.43  0.33  0.64  0.00 0.697 0.303 2.3
## symmetry_se         -0.04  0.06  0.67 -0.03 0.451 0.549 1.0
## dimension_se        -0.03  0.38  0.75  0.01 0.713 0.287 1.5
## radius_worst         0.94  0.21 -0.16  0.13 0.972 0.028 1.2
## texture_worst        0.20  0.19 -0.08  0.93 0.956 0.044 1.2
## perimeter_worst      0.94  0.25 -0.13  0.13 0.978 0.022 1.2
## area_worst           0.94  0.16 -0.12  0.12 0.947 0.053 1.1
## smoothness_worst     0.06  0.75  0.01 -0.01 0.572 0.428 1.0
## compactness_worst    0.31  0.86  0.06  0.19 0.877 0.123 1.4
## concavity_worst      0.45  0.77  0.10  0.19 0.845 0.155 1.8
## points_worst         0.68  0.67 -0.02  0.11 0.918 0.082 2.1
## symmetry_worst       0.07  0.72 -0.06  0.06 0.526 0.474 1.0
## dimension_worst     -0.09  0.88  0.18  0.10 0.825 0.175 1.1
##
##                        RC1  RC2  RC3  RC4
## SS loadings          10.15 7.04 4.36 2.25
## Proportion Var        0.33 0.23 0.14 0.07
## Cumulative Var        0.33 0.55 0.70 0.77
## Proportion Explained  0.43 0.30 0.18 0.09
## Cumulative Proportion 0.43 0.72 0.91 1.00
##
## Mean item complexity =  1.6
## Test of the hypothesis that 4 components are sufficient.
##
## The root mean square of the residuals (RMSR) is  0.06
##  with the empirical chi square  1923.24  with prob <  3.8e-216
##
## Fit based upon off diagonal values = 0.98
```

```
round(fit.pc$values, 3)
```

```
##  [1] 13.288  5.697  2.835  1.981  1.649  1.235  0.978  0.672  0.461  0.403
## [11]  0.349  0.294  0.261  0.241  0.157  0.094  0.080  0.059  0.053  0.049
## [21]  0.031  0.030  0.027  0.024  0.018  0.015  0.008  0.007  0.002  0.001
## [31]  0.000
```

```
fit.pc$loadings
```

```
##
## Loadings:
##                    RC1    RC2    RC3    RC4
## id                  0.133
## radius_mean         0.951  0.131 -0.139
## texture_mean        0.252                0.909
## perimeter_mean      0.950  0.175 -0.107
## area_mean           0.967  0.101
## smoothness_mean     0.159  0.649  0.255 -0.187
## compactness_mean    0.459  0.771  0.320
## concavity_mean      0.659  0.606  0.311  0.102
## points_mean         0.798  0.508  0.149
## symmetry_mean       0.137  0.585  0.332
## dimension_mean     -0.314  0.660  0.532
## radius_se           0.832         0.395
## texture_se                -0.209  0.597  0.538
## perimeter_se        0.823         0.418
## area_se             0.876         0.262
## smoothness_se      -0.138         0.705
## compactness_se      0.204  0.514  0.667  0.111
## concavity_se        0.218  0.408  0.635
## points_se           0.426  0.328  0.638
## symmetry_se                       0.667
## dimension_se                0.384  0.751
## radius_worst        0.941  0.207 -0.164  0.131
## texture_worst       0.196  0.193         0.935
## perimeter_worst     0.937  0.253 -0.131  0.134
## area_worst          0.944  0.165 -0.118  0.120
## smoothness_worst            0.754
## compactness_worst   0.312  0.861         0.186
## concavity_worst     0.450  0.773  0.100  0.187
## points_worst        0.678  0.668         0.106
## symmetry_worst              0.717
## dimension_worst             0.880  0.181  0.104
##
##                    RC1   RC2   RC3   RC4
## SS loadings     10.151 7.037 4.361 2.252
## Proportion Var   0.327 0.227 0.141 0.073
## Cumulative Var   0.327 0.554 0.695 0.768
```

```
# Loadings with more digits
for (i in c(1,3,2,4)) { print(fit.pc$loadings[[1,i]])}
```

```
## [1] 0.1330256
## [1] 0.0991346
## [1] -0.09752479
## [1] 0.06781887
```

```
# Communalities
fit.pc$communality
```

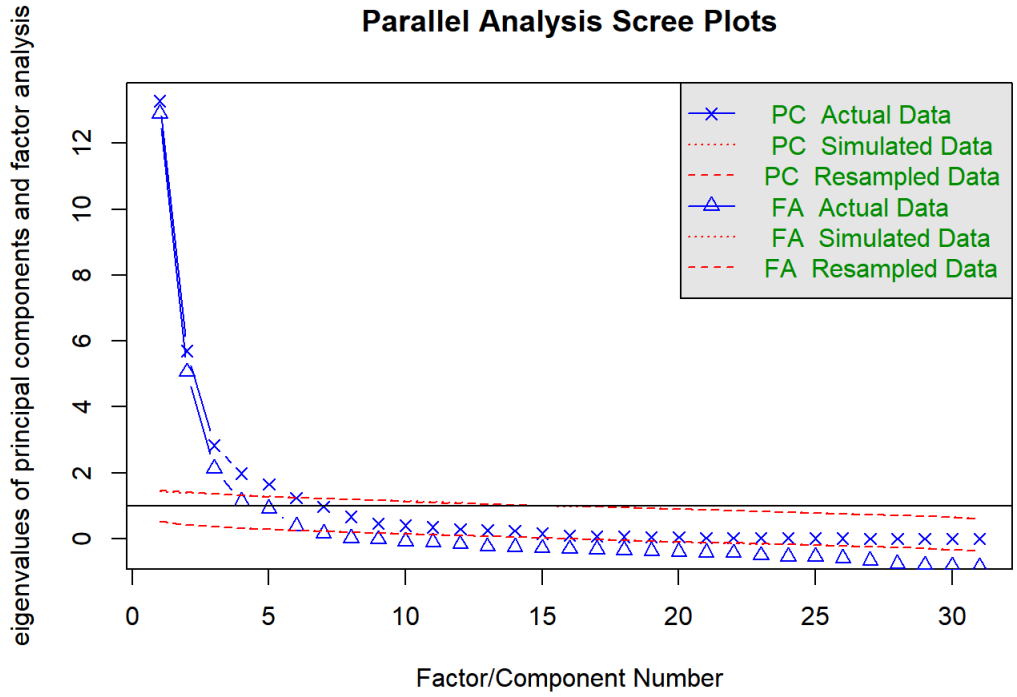
```
##                id       radius_mean      texture_mean    perimeter_mean
##        0.04163396        0.95069170        0.89684853        0.95431848
##         area_mean   smoothness_mean  compactness_mean    concavity_mean
##        0.96014950        0.54720158        0.90971908        0.90807129
##       points_mean     symmetry_mean    dimension_mean         radius_se
##        0.92076209        0.47390203        0.82580280        0.84993832
##        texture_se      perimeter_se           area_se     smoothness_se
##        0.69271471        0.85520824        0.83634402        0.51759585
##    compactness_se      concavity_se         points_se       symmetry_se
##        0.76240129        0.62241576        0.69650774        0.45095156
##      dimension_se      radius_worst     texture_worst   perimeter_worst
##        0.71272740        0.97219376        0.95565236        0.97796884
##        area_worst  smoothness_worst compactness_worst   concavity_worst
##        0.94731995        0.57201913        0.87681767        0.84471615
##      points_worst    symmetry_worst   dimension_worst
##        0.91825491        0.52608733        0.82467896
```

```
# Rotated factor scores, Notice the columns ordering: RC1, RC3, RC2 and RC4
head(fit.pc$scores)
```

```
##             RC1         RC2         RC3         RC4
## [1,] -0.3200066 -0.20898001 -0.25160464 -1.75616620
## [2,] -0.5649931 -0.22081178  0.85830109 -0.28887483
## [3,] -0.8242652 -0.03734588 -0.52158508 -0.09098986
## [4,] -0.3869942 -0.38180634  0.79329588 -1.49911551
## [5,]  0.1145874 -0.61206123 -0.91421184 -1.46638605
## [6,] -0.6900800 -0.15424020  0.07996063  0.35700314
```

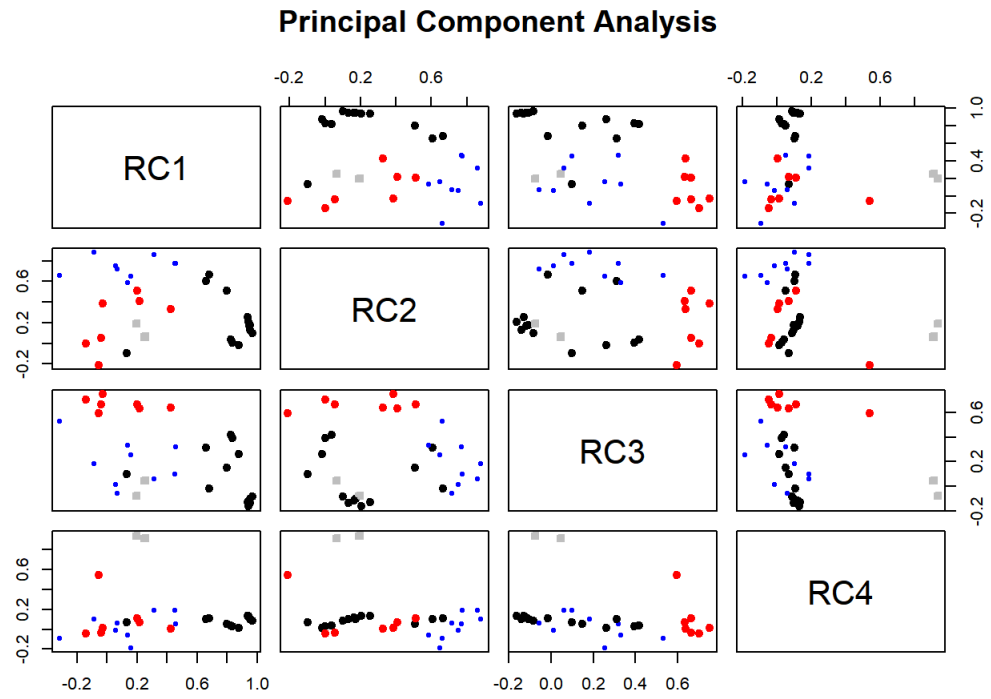
```
# Play with FA utilities

fa.parallel(breast_cancer[-2]) # See factor recommendation
```

```
## Warning in fa.stats(r = r, f = f, phi = phi, n.obs = n.obs, np.obs
## = np.obs, : The estimated weights for the factor scores are probably
## incorrect. Try a different factor extraction method.
```




```
## Parallel analysis suggests that the number of factors =  6  and the number of components =  5
```

```
fa.plot(fit.pc) # See Correlations within Factors
```




```
fa.diagram(fit.pc) # Visualize the relationship
```