```r
library(RcmdrMisc)
```

```
## Loading required package: car
```

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

```
## Loading required package: sandwich
```

```r
# Load the gclus package and position it in the 16th position in the search list
library(gclus, pos = 16)
```

```
## Loading required package: cluster
```

```r
# Load the body dataset from the gclus package
data(body, package = "gclus")

# Display the first few rows of the body dataset
head(body)
```

```
##   Biacrom Biiliac Bitro ChestDp ChestD ElbowD WristD KneeD AnkleD ShoulderG
## 1    42.9    26.0  31.5    17.7   28.0   13.1   10.4  18.8   14.1     106.2
## 2    43.7    28.5  33.5    16.9   30.8   14.0   11.8  20.6   15.1     110.5
## 3    40.1    28.2  33.3    20.9   31.7   13.9   10.9  19.7   14.1     115.1
## 4    44.3    29.9  34.0    18.4   28.2   13.9   11.2  20.9   15.0     104.5
## 5    42.5    29.9  34.0    21.5   29.4   15.2   11.6  20.7   14.9     107.5
## 6    43.3    27.0  31.5    19.6   31.3   14.0   11.5  18.8   13.9     119.8
##   ChestG WaistG AbdG HipG ThighG BicepG ForearmG KneeG CalfG AnkleG WristG Age
## 1   89.5   71.5 74.5 93.5   51.5   32.5     26.0  34.5  36.5   23.5   16.5  21
## 2   97.0   79.0 86.5 94.8   51.5   34.4     28.0  36.5  37.5   24.5   17.0  23
## 3   97.5   83.2 82.9 95.0   57.3   33.4     28.8  37.0  37.3   21.9   16.9  28
## 4   97.0   77.8 78.8 94.0   53.0   31.0     26.2  37.0  34.8   23.0   16.6  23
## 5   97.5   80.0 82.5 98.5   55.4   32.0     28.4  37.7  38.6   24.4   18.0  22
## 6   99.9   82.5 80.1 95.3   57.5   33.0     28.0  36.6  36.1   23.5   16.9  21
##   Weight Height Gender
## 1   65.6  174.0      1
## 2   71.8  175.3      1
## 3   80.7  193.5      1
## 4   72.6  186.5      1
## 5   78.8  187.2      1
## 6   74.8  181.5      1
```

```r
# Check the number of columns in the body dataset
ncol(body)
```

```
## [1] 25
```

```r
# Fit a linear model of Age with all anthropometric variables except Weight, Height, and
Gender
Linmodel_Age_OnAnthropoVars <- lm(Age ~ . - Weight - Height - Gender, data = body)

# Display the linear model summary
summary(Linmodel_Age_OnAnthropoVars)
```

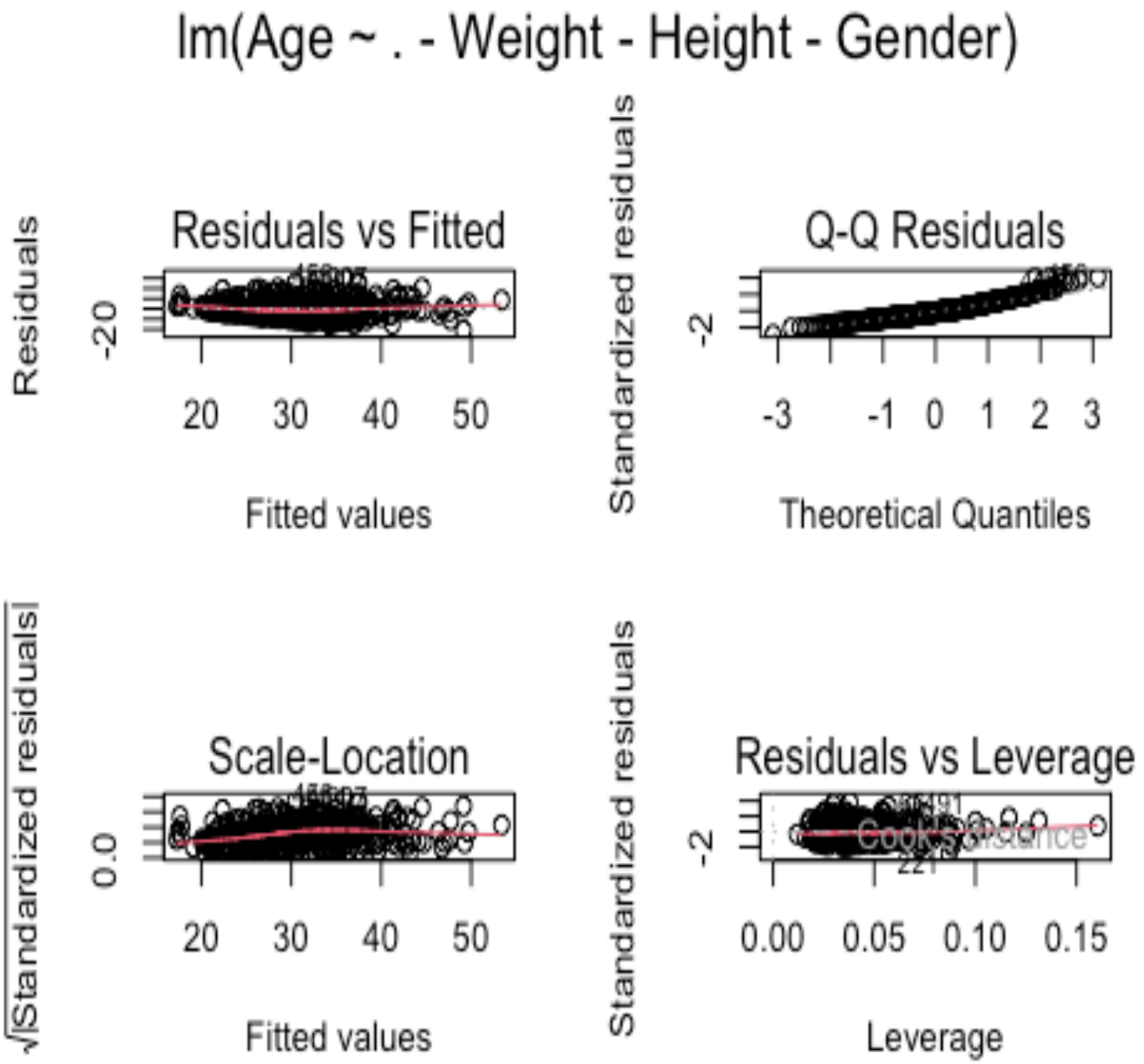
```
##
## Call:
## lm(formula = Age ~ . - Weight - Height - Gender, data = body)
##
## Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -21.149  -5.089  -1.023   4.091  31.197
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 29.37083    8.07218   3.639 0.000304 ***
## Biacrom     -0.92906    0.23076  -4.026 6.58e-05 ***
## Biiliac     -0.09085    0.23432  -0.388 0.698400
## Bitro        1.00419    0.33370   3.009 0.002755 **
## ChestDp      0.56359    0.25426   2.217 0.027114 *
## ChestD       0.18517    0.30154   0.614 0.539449
## ElbowD      -0.27030    0.67367  -0.401 0.688428
## WristD       0.67897    0.82510   0.823 0.410972
## KneeD        0.73449    0.50481   1.455 0.146323
## AnkleD       0.44601    0.56586   0.788 0.430965
## ShoulderG   -0.03756    0.11402  -0.329 0.741983
## ChestG      -0.15293    0.14048  -1.089 0.276832
## WaistG       0.28350    0.09059   3.130 0.001856 **
## AbdG         0.48129    0.08622   5.582 3.95e-08 ***
## HipG        -0.07793    0.17461  -0.446 0.655564
## ThighG      -0.93562    0.18760  -4.987 8.54e-07 ***
## BicepG       0.13576    0.30411   0.446 0.655482
## ForearmG    -0.89111    0.49900  -1.786 0.074761 .
## KneeG       -0.40460    0.28278  -1.431 0.153134
## CalfG        0.27382    0.24944   1.098 0.272855
## AnkleG      -0.58446    0.36856  -1.586 0.113440
## WristG       1.26427    0.76574   1.651 0.099379 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.752 on 485 degrees of freedom
## Multiple R-squared:  0.3761, Adjusted R-squared:  0.3491
## F-statistic: 13.92 on 21 and 485 DF,  p-value: < 2.2e-16
```

```
# Perform evaluations such as multicollinearity, assumptions (independence, normality,
mean=0, constant variance)
# Load additional required packages
library(abind, pos = 18)
library(e1071, pos = 19)

# Numerical summaries of just the response variable (Age) to compare against root Mean
Squared Error (MSE)
numSummary(body[, "Age", drop = FALSE], statistics = c("mean", "sd", "IQR", "quantiles"),
quantiles = c(0, .25, .5, .75, 1))
```

```
##      mean       sd IQR 0% 25% 50% 75% 100%   n
##  30.18146 9.608472  13 18  23  27  36   67 507
```

```
# Set up plotting parameters for diagnostic plots
oldpar <- par(oma = c(0, 0, 3, 0), mfrow = c(2, 2))

# Create diagnostic plots for the linear model
plot(Linmodel_Age_OnAnthropoVars)
```




```r
# Reset plotting parameters
par(oldpar)

# Add residuals from the linear model to the body dataset
body <- within(body, {
  residuals.Linmodel_Age_OnAnthropoVars <- residuals(Linmodel_Age_OnAnthropoVars)
})

# Display the first few rows of the modified body dataset with residuals
head(body)
```

```
##   Biacrom Biiliac Bitro ChestDp ChestD ElbowD WristD KneeD AnkleD ShoulderG
## 1    42.9    26.0  31.5    17.7   28.0   13.1   10.4  18.8   14.1     106.2
## 2    43.7    28.5  33.5    16.9   30.8   14.0   11.8  20.6   15.1     110.5
## 3    40.1    28.2  33.3    20.9   31.7   13.9   10.9  19.7   14.1     115.1
## 4    44.3    29.9  34.0    18.4   28.2   13.9   11.2  20.9   15.0     104.5
## 5    42.5    29.9  34.0    21.5   29.4   15.2   11.6  20.7   14.9     107.5
## 6    43.3    27.0  31.5    19.6   31.3   14.0   11.5  18.8   13.9     119.8
##   ChestG WaistG AbdG HipG ThighG BicepG ForearmG KneeG CalfG AnkleG WristG Age
## 1   89.5   71.5 74.5 93.5   51.5   32.5     26.0  34.5  36.5   23.5   16.5  21
## 2   97.0   79.0 86.5 94.8   51.5   34.4     28.0  36.5  37.5   24.5   17.0  23
## 3   97.5   83.2 82.9 95.0   57.3   33.4     28.8  37.0  37.3   21.9   16.9  28
## 4   97.0   77.8 78.8 94.0   53.0   31.0     26.2  37.0  34.8   23.0   16.6  23
## 5   97.5   80.0 82.5 98.5   55.4   32.0     28.4  37.7  38.6   24.4   18.0  22
## 6   99.9   82.5 80.1 95.3   57.5   33.0     28.0  36.6  36.1   23.5   16.9  21
##   Weight Height Gender residuals.Linmodel_Age_OnAnthropoVars
## 1   65.6  174.0      1                            -3.946440
## 2   71.8  175.3      1                           -10.007450
## 3   80.7  193.5      1                            -2.962480
## 4   72.6  186.5      1                            -5.394106
## 5   78.8  187.2      1                            -9.267999
## 6   74.8  181.5      1                            -1.370881
```

```
# Test for normality of residuals using Shapiro-Wilk test
normalityTest(~ residuals.Linmodel_Age_OnAnthropoVars, test = "shapiro.test", data =
body)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  residuals.Linmodel_Age_OnAnthropoVars
## W = 0.96419, p-value = 8.92e-10
```

```
# Conduct power transformation on the response variable (Age) using Box-Cox method
summary(powerTransform(Age ~ 1, data = body, family = "bcPower"))
```

```
## bcPower Transformation to Normality
##    Est Power Rounded Pwr Wald Lwr Bnd Wald Upr Bnd
## Y1   -0.9558          -1      -1.2683      -0.6433
##
## Likelihood ratio test that transformation parameter is equal to 0
##  (log transformation)
##                            LRT df       pval
## LR test, lambda = (0) 37.90491  1 7.4278e-10
##
## Likelihood ratio test that no transformation is needed
##                            LRT df       pval
## LR test, lambda = (1) 166.6028  1 < 2.22e-16
```

```
# Check for multicollinearity using Variance Inflation Factor (VIF)
vif(Linmodel_Age_OnAnthropoVars)
```

```
##   Biacrom   Biiliac     Bitro   ChestDp    ChestD    ElbowD    WristD     KneeD
##  4.196325  2.250610  3.867610  3.445660  5.755259  6.994841  5.112549  3.896978
##    AnkleD ShoulderG    ChestG    WaistG      AbdG      HipG    ThighG    BicepG
##  4.195169 11.783301 16.708822  8.380293  5.559052 11.457894  5.894473 14.045921
##  ForearmG     KneeG     CalfG    AnkleG    WristG
## 16.799853  4.613627  4.248719  3.967183  9.415825
```

```r
# Calculate correlations of parameter estimates
round(cov2cor(vcov(Linmodel_Age_OnAnthropoVars)), 3)
```

```
##             (Intercept) Biacrom Biiliac  Bitro ChestDp ChestD ElbowD WristD
## (Intercept)       1.000  -0.227  -0.133 -0.101   0.000  0.069  0.139 -0.079
## Biacrom          -0.227   1.000  -0.154 -0.174  -0.044 -0.217 -0.108  0.006
## Biiliac          -0.133  -0.154   1.000 -0.385  -0.017  0.013  0.058  0.002
## Bitro            -0.101  -0.174  -0.385  1.000  -0.026 -0.138 -0.172  0.031
## ChestDp           0.000  -0.044  -0.017 -0.026   1.000  0.168 -0.088  0.088
## ChestD            0.069  -0.217   0.013 -0.138   0.168  1.000  0.017 -0.040
## ElbowD            0.139  -0.108   0.058 -0.172  -0.088  0.017  1.000 -0.224
## WristD           -0.079   0.006   0.002  0.031   0.088 -0.040 -0.224  1.000
## KneeD            -0.030  -0.047  -0.068 -0.058   0.032 -0.059 -0.070 -0.071
## AnkleD           -0.095   0.038  -0.123 -0.006  -0.024 -0.012 -0.339 -0.163
## ShoulderG        -0.142  -0.290   0.101  0.088   0.014 -0.193 -0.089  0.011
## ChestG           -0.161   0.093   0.003  0.126  -0.265 -0.356 -0.051 -0.048
## WaistG            0.346  -0.080   0.002  0.039  -0.254 -0.116  0.166 -0.057
## AbdG             -0.018   0.161  -0.275  0.075  -0.068  0.060 -0.067  0.077
## HipG             -0.102   0.086   0.074 -0.448   0.074  0.054  0.002 -0.072
## ThighG           -0.172   0.039  -0.010  0.154  -0.067 -0.053  0.131  0.089
## BicepG            0.287   0.084   0.023 -0.077   0.045  0.127  0.004  0.004
## ForearmG          0.000  -0.024  -0.048  0.096   0.010 -0.045 -0.228  0.028
## KneeG             0.002   0.020  -0.084  0.042  -0.005  0.007 -0.051 -0.029
## CalfG             0.033   0.055  -0.034 -0.081  -0.038 -0.034  0.013 -0.052
## AnkleG            0.035  -0.073   0.109 -0.020   0.013  0.002  0.061  0.085
## WristG           -0.192  -0.151   0.108 -0.026  -0.070  0.082  0.026 -0.349
##               KneeD AnkleD ShoulderG ChestG WaistG   AbdG   HipG ThighG BicepG
## (Intercept) -0.030 -0.095    -0.142 -0.161  0.346 -0.018 -0.102 -0.172  0.287
## Biacrom     -0.047  0.038    -0.290  0.093 -0.080  0.161  0.086  0.039  0.084
## Biiliac     -0.068 -0.123     0.101  0.003  0.002 -0.275  0.074 -0.010  0.023
## Bitro       -0.058 -0.006     0.088  0.126  0.039  0.075 -0.448  0.154 -0.077
## ChestDp      0.032 -0.024     0.014 -0.265 -0.254 -0.068  0.074 -0.067  0.045
## ChestD      -0.059 -0.012    -0.193 -0.356 -0.116  0.060  0.054 -0.053  0.127
## ElbowD      -0.070 -0.339    -0.089 -0.051  0.166 -0.067  0.002  0.131  0.004
## WristD      -0.071 -0.163     0.011 -0.048 -0.057  0.077 -0.072  0.089  0.004
## KneeD        1.000 -0.292    -0.033  0.095  0.029  0.083 -0.064 -0.032 -0.066
## AnkleD      -0.292  1.000     0.087 -0.079 -0.023 -0.066  0.097 -0.008  0.051
## ShoulderG   -0.033  0.087     1.000 -0.352 -0.046  0.116 -0.129  0.099 -0.199
## ChestG       0.095 -0.079    -0.352  1.000 -0.239 -0.126 -0.014 -0.030 -0.233
## WaistG       0.029 -0.023    -0.046 -0.239  1.000 -0.320 -0.208  0.282 -0.043
## AbdG         0.083 -0.066     0.116 -0.126 -0.320  1.000 -0.429  0.105 -0.134
## HipG        -0.064  0.097    -0.129 -0.014 -0.208 -0.429  1.000 -0.662  0.158
## ThighG      -0.032 -0.008     0.099 -0.030  0.282  0.105 -0.662  1.000 -0.280
## BicepG      -0.066  0.051    -0.199 -0.233 -0.043 -0.134  0.158 -0.280  1.000
## ForearmG     0.029  0.000    -0.024 -0.029 -0.042  0.150 -0.008  0.004 -0.595
## KneeG       -0.290  0.144    -0.063  0.068 -0.070 -0.072 -0.049 -0.177  0.175
## CalfG       -0.090  0.053    -0.046  0.085 -0.121  0.110  0.076 -0.306  0.066
## AnkleG       0.146 -0.280    -0.019  0.007  0.041 -0.085 -0.043  0.064  0.016
## WristG      -0.103 -0.014     0.025 -0.045  0.052  0.012 -0.053  0.180 -0.059
##             ForearmG  KneeG  CalfG AnkleG WristG
## (Intercept)    0.000  0.002  0.033  0.035 -0.192
## Biacrom       -0.024  0.020  0.055 -0.073 -0.151
## Biiliac       -0.048 -0.084 -0.034  0.109  0.108
## Bitro          0.096  0.042 -0.081 -0.020 -0.026
## ChestDp        0.010 -0.005 -0.038  0.013 -0.070
## ChestD        -0.045  0.007 -0.034  0.002  0.082
```

```
## ElbowD        -0.228 -0.051  0.013  0.061  0.026
## WristD         0.028 -0.029 -0.052  0.085 -0.349
## KneeD          0.029 -0.290 -0.090  0.146 -0.103
## AnkleD         0.000  0.144  0.053 -0.280 -0.014
## ShoulderG     -0.024 -0.063 -0.046 -0.019  0.025
## ChestG        -0.029  0.068  0.085  0.007 -0.045
## WaistG        -0.042 -0.070 -0.121  0.041  0.052
## AbdG           0.150 -0.072  0.110 -0.085  0.012
## HipG          -0.008 -0.049  0.076 -0.043 -0.053
## ThighG         0.004 -0.177 -0.306  0.064  0.180
## BicepG        -0.595  0.175  0.066  0.016 -0.059
## ForearmG       1.000 -0.129 -0.102  0.025 -0.318
## KneeG         -0.129  1.000 -0.204 -0.243 -0.047
## CalfG         -0.102 -0.204  1.000 -0.349 -0.026
## AnkleG         0.025 -0.243 -0.349  1.000 -0.257
## WristG        -0.318 -0.047 -0.026 -0.257  1.000
```

```
# Create a new variable Age_reciprocal as the reciprocal of Age
body$Age_reciprocal <- with(body, 1/Age)

# Fit a linear model with Age_reciprocal as the response variable and other variables as
predictors
LinModel_OneoverAge <- lm(Age_reciprocal ~ . - Age - Weight - Height - Gender -
residuals.Linmodel_Age_OnAnthropoVars, data = body)

# Display the summary of the new linear model
summary(LinModel_OneoverAge)
```

```
##
## Call:
## lm(formula = Age_reciprocal ~ . - Age - Weight - Height - Gender -
##     residuals.Linmodel_Age_OnAnthropoVars, data = body)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0201230 -0.0056585  0.0000539  0.0055523  0.0221682
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  4.031e-02  8.325e-03   4.842 1.73e-06 ***
## Biacrom      8.692e-04  2.380e-04   3.652 0.000288 ***
## Biiliac     -2.725e-05  2.417e-04  -0.113 0.910261
## Bitro       -6.936e-04  3.442e-04  -2.015 0.044433 *
## ChestDp     -4.994e-04  2.622e-04  -1.905 0.057424 .
## ChestD      -3.741e-04  3.110e-04  -1.203 0.229600
## ElbowD       6.624e-04  6.948e-04   0.953 0.340911
## WristD      -7.176e-04  8.510e-04  -0.843 0.399489
## KneeD       -9.767e-04  5.206e-04  -1.876 0.061248 .
## AnkleD      -8.945e-04  5.836e-04  -1.533 0.126014
## ShoulderG   -5.691e-05  1.176e-04  -0.484 0.628642
## ChestG       2.238e-04  1.449e-04   1.545 0.123092
## WaistG      -2.252e-04  9.343e-05  -2.411 0.016300 *
## AbdG        -5.505e-04  8.892e-05  -6.191 1.27e-09 ***
## HipG         1.253e-04  1.801e-04   0.696 0.486827
## ThighG       8.744e-04  1.935e-04   4.519 7.81e-06 ***
## BicepG      -2.894e-04  3.136e-04  -0.923 0.356576
```

```
## ForearmG     9.220e-04  5.146e-04   1.791 0.073850 .
## KneeG        4.545e-04  2.917e-04   1.558 0.119836
## CalfG       -2.750e-04  2.573e-04  -1.069 0.285594
## AnkleG       5.789e-04  3.801e-04   1.523 0.128428
## WristG      -7.329e-04  7.897e-04  -0.928 0.353845
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.007995 on 485 degrees of freedom
## Multiple R-squared:  0.3613, Adjusted R-squared:  0.3337
## F-statistic: 13.07 on 21 and 485 DF,  p-value: < 2.2e-16
```

```
# Test for normality of the new response variable (Age_reciprocal)
normalityTest(~ Age_reciprocal, test = "shapiro.test", data = body)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  Age_reciprocal
## W = 0.97256, p-value = 3.8e-08
```

```
# Convert Gender variable to factor
body <- within(body, {
  Gender <- as.factor(Gender)
})

# Fit a logistic regression model predicting Gender using all variables except residuals
and transformed Age
glm_AgeBased <- glm(Gender ~ . - residuals.Linmodel_Age_OnAnthropoVars - Height - Weight
- Age_reciprocal - Age, family = binomial(logit), data = body)
```

```
## Warning: glm.fit: algorithm did not converge
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
# Display summary of logistic regression model
summary(glm_AgeBased)
```

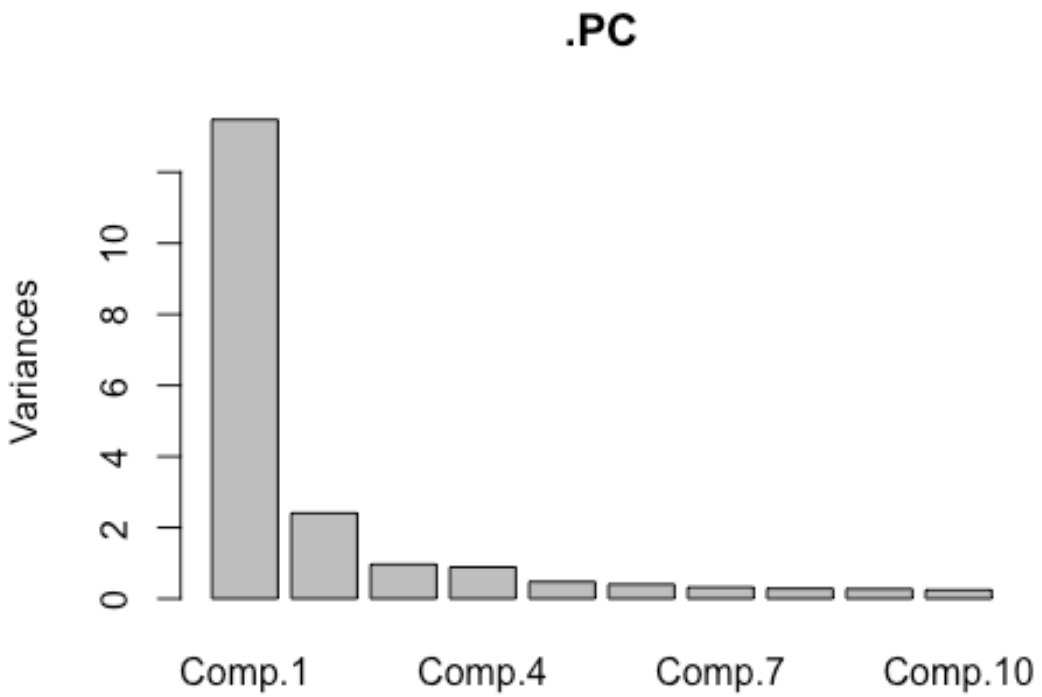
```
##
## Call:
## glm(formula = Gender ~ . - residuals.Linmodel_Age_OnAnthropoVars -
##     Height - Weight - Age_reciprocal - Age, family = binomial(logit),
##     data = body)
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -722.331 378590.643  -0.002    0.998
## Biacrom          7.505   8092.499   0.001    0.999
## Biiliac          3.241   9094.546   0.000    1.000
## Bitro            2.607  11813.337   0.000    1.000
## ChestDp          7.672  13247.263   0.001    1.000
## ChestD           5.965  13801.039   0.000    1.000
## ElbowD          24.222  24697.409   0.001    0.999
## WristD          -5.175  84470.596   0.000    1.000
## KneeD          -13.060  82782.677   0.000    1.000
## AnkleD          29.934  25012.022   0.001    0.999
## ShoulderG        2.143   7121.897   0.000    1.000
```

```
## ChestG          -3.028   8770.376   0.000    1.000
## WaistG           4.240   5385.916   0.001    0.999
## AbdG            -5.058   8089.631  -0.001    1.000
## HipG            -4.578  12609.952   0.000    1.000
## ThighG          -5.016  18367.437   0.000    1.000
## BicepG          10.392  36651.098   0.000    1.000
## ForearmG        12.694  45633.852   0.000    1.000
## KneeG           -1.235  43655.135   0.000    1.000
## CalfG           -6.682   7903.488  -0.001    0.999
## AnkleG          18.381  13171.235   0.001    0.999
## WristG         -22.857  27060.622  -0.001    0.999
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 7.0252e+02  on 506  degrees of freedom
## Residual deviance: 6.6697e-08  on 485  degrees of freedom
## AIC: 44
##
## Number of Fisher Scoring iterations: 25

# Display exponentiated coefficients ("odds ratios") of the logistic regression model
exp(coef(glm_AgeBased))

##   (Intercept)       Biacrom       Biiliac         Bitro       ChestDp
## 1.974899e-314  1.816975e+03  2.556842e+01  1.355231e+01  2.148023e+03
##        ChestD        ElbowD        WristD         KneeD        AnkleD
##  3.896946e+02  3.306423e+10  5.658857e-03  2.128076e-06  1.000690e+13
##     ShoulderG        ChestG        WaistG          AbdG          HipG
##  8.527435e+00  4.838840e-02  6.940955e+01  6.358494e-03  1.027972e-02
##        ThighG        BicepG     ForearmG         KneeG         CalfG
##  6.633628e-03  3.260132e+04  3.258086e+05  2.907258e-01  1.253245e-03
##        AnkleG        WristG
##  9.606312e+07  1.184532e-10

# Perform Principal Component Analysis (PCA)
local({
  .PC <- princomp(~ AbdG + AnkleD + AnkleG + Biacrom + BicepG + Biiliac + Bitro + CalfG +
ChestD + ChestDp + ChestG + ElbowD + ForearmG + HipG + KneeD + KneeG + ShoulderG + ThighG
+ WaistG + WristD + WristG, cor = TRUE, data = body)

  cat("\nComponent loadings:\n")
  print(unclass(loadings(.PC)))

  cat("\nComponent variances:\n")
  print(.PC$sd^2)

  cat("\n")
  print(summary(.PC))

  screeplot(.PC)

  body <<- within(body, {
    PC4 <- .PC$scores[, 4]
    PC3 <- .PC$scores[, 3]
    PC2 <- .PC$scores[, 2]
    PC1 <- .PC$scores[, 1]
```

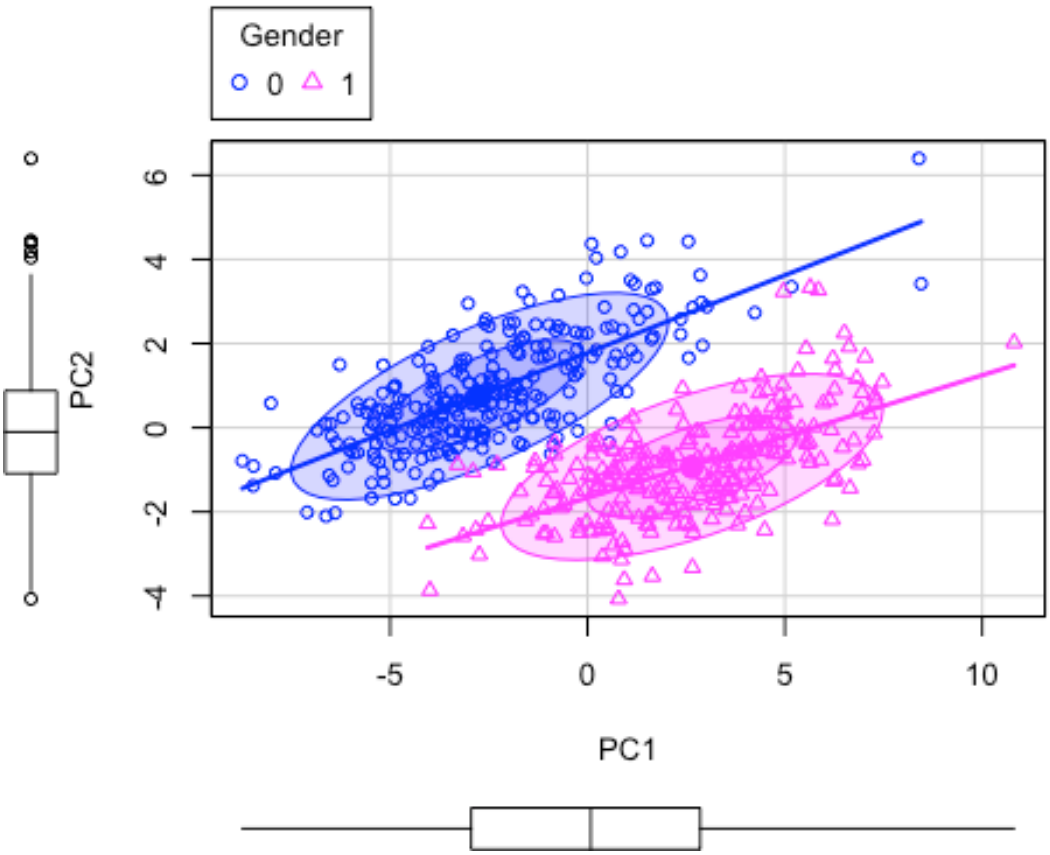
```
  })
})

##
## Component loadings:
##              Comp.1      Comp.2      Comp.3      Comp.4       Comp.5
## AbdG      0.1873934  0.31907080  0.31378559  0.21314833  0.323047395
## AnkleD    0.2169422 -0.15207288 -0.25353234  0.14385798  0.437162237
## AnkleG    0.2209618  0.01963726 -0.18524340 -0.26293554  0.315293754
## Biacrom   0.2113787 -0.22519164 -0.15060290  0.15351378 -0.433610170
## BicepG    0.2449827 -0.11400736  0.20120082 -0.08149489 -0.087948385
## Biiliac   0.1337452  0.32759997 -0.25458159  0.57672523 -0.030102847
## Bitro     0.1875424  0.27970033 -0.26953492  0.29376129 -0.241402542
## CalfG     0.2140944  0.16156283 -0.18520080 -0.37660400 -0.015842441
## ChestD    0.2343297 -0.12199683  0.11346808  0.07084005 -0.374431676
## ChestDp   0.2170502 -0.01973645  0.33821011  0.12272832  0.263875587
## ChestG    0.2489851 -0.11275698  0.29156734  0.04547286 -0.047439985
## ElbowD    0.2355800 -0.19706147 -0.13371279  0.09077774  0.081496749
## ForearmG  0.2487344 -0.16198267  0.06517642 -0.10692456 -0.064449823
## HipG      0.1978512  0.39337399  0.11918937 -0.04487719 -0.055000172
## KneeD     0.2235416  0.01503835 -0.34273364 -0.06812539 -0.007239444
## KneeG     0.2179185  0.20271514 -0.17603399 -0.27296803  0.041144864
## ShoulderG 0.2462324 -0.15866724  0.17634540 -0.02696947 -0.225311259
## ThighG    0.1381498  0.45065822  0.10044138 -0.35254431 -0.206794755
## WaistG    0.2409072  0.02842920  0.31430575  0.13196912  0.078977645
## WristD    0.2269033 -0.20466906 -0.15627857  0.01128800  0.124089295
## WristG    0.2412028 -0.19806459 -0.08102029 -0.09080162  0.084402115
##                Comp.6       Comp.7       Comp.8       Comp.9      Comp.10
## AbdG       0.0276687193  0.208010933  0.168284367  0.233358560  0.149004727
## AnkleD     0.2151167214  0.128854704  0.006252886  0.059834364 -0.573661504
## AnkleG    -0.5144493801  0.228897194  0.250736040 -0.066681920 -0.154392133
## Biacrom   -0.3157308333  0.058838286 -0.152508518  0.040221907 -0.031562349
## BicepG     0.2194435454 -0.172309118  0.237480885 -0.245798379  0.015637874
## Biiliac   -0.1104734346 -0.552553949  0.333842211 -0.033603726 -0.032029593
## Bitro     -0.0214955284  0.464887376 -0.216074717 -0.382864519  0.116269351
## CalfG     -0.2814647012 -0.192895977  0.006784850 -0.121931310 -0.108495568
## ChestD    -0.0947247163  0.142972471  0.082429657  0.360122416 -0.302324604
## ChestDp   -0.2124690022 -0.283886229 -0.665986281 -0.283083116 -0.063824040
## ChestG     0.0286567934 -0.027776863  0.083526083  0.054094879 -0.091583578
## ElbowD     0.2132051814  0.066122536 -0.041005132 -0.168265590 -0.006063478
## ForearmG   0.1323644751 -0.181988678  0.188623997 -0.215858727  0.088973624
## HipG       0.1525237462  0.277911273 -0.024283469 -0.009621322  0.055478020
## KneeD      0.3567938699 -0.164152735 -0.371472430  0.418620538  0.011968416
## KneeG     -0.1387704359 -0.173143923 -0.111953835  0.353325152  0.348104461
## ShoulderG -0.0202154037 -0.014593654  0.064733946  0.073366510 -0.049184723
## ThighG     0.3009522846 -0.081280331  0.007343828 -0.176708778 -0.307585909
## WaistG    -0.1444229928  0.059933870 -0.020190016  0.235301394  0.113276281
## WristD     0.2213480135  0.109859638  0.096563036 -0.029289461  0.398100624
## WristG     0.0006987923 -0.000433445  0.106163800 -0.179539440  0.304566496
##                Comp.11     Comp.12       Comp.13     Comp.14      Comp.15
## AbdG       0.130765027  0.00340299  0.1429975129  0.31153705  0.257413634
## AnkleD    -0.001339158 -0.11937962 -0.0715154182  0.11319382 -0.444092031
## AnkleG     0.267139995  0.07276998  0.0700976418 -0.35034587  0.248995970
## Biacrom    0.369764127 -0.42472167  0.2876072699  0.31150662 -0.063470187
## BicepG     0.175716691  0.25623039  0.0447701789  0.01495293 -0.117331926
## Biiliac   -0.023922326 -0.06978055 -0.0003698682 -0.13580463  0.060187365
```

```
## Bitro     -0.086415758  0.34446428 -0.1293326111 -0.07372028 -0.173831117
## CalfG     -0.554417609  0.14254771  0.2013241822  0.45574495  0.049470576
## ChestD    -0.320953853  0.04938178 -0.2316005764 -0.30560352  0.177159240
## ChestDp   -0.035741900 -0.10245527 -0.0506239843 -0.20746214  0.101327844
## ChestG    -0.055967636  0.06908688 -0.0634848233 -0.08868881 -0.005592704
## ElbowD     0.044955917 -0.04156664 -0.4153189092  0.39080313  0.532047165
## ForearmG   0.132391198  0.18193260 -0.0578265461  0.05270289 -0.116767463
## HipG       0.055316991 -0.15579956  0.0892175768 -0.03233887  0.013415941
## KneeD      0.139049087  0.34640016  0.3817036656 -0.14073896  0.210331735
## KneeG      0.166542108 -0.09142723 -0.5971222736  0.03761695 -0.277344392
## ShoulderG  0.049069799  0.06082661 -0.0575550130  0.02143403  0.043454595
## ThighG     0.099421513 -0.36844408  0.0354291658 -0.11923646 -0.003601958
## WaistG    -0.164382663  0.10267300  0.1669984492  0.12290637 -0.372601226
## WristD    -0.449260750 -0.48502530  0.1226440246 -0.23795884  0.055135401
## WristG     0.101312741  0.01226849  0.1837574962 -0.17340339 -0.130131105
##                Comp.16      Comp.17      Comp.18      Comp.19      Comp.20
## AbdG       0.35562922  0.312051258  0.090971106  0.081475865  0.118488418
## AnkleD     0.07129860  0.098238640 -0.090840957 -0.068594477  0.025976995
## AnkleG    -0.21960993 -0.033292212  0.153557906 -0.008284208  0.003712655
## Biacrom    0.06962766  0.050226078  0.139169799 -0.032427917 -0.111380824
## BicepG    -0.01381395  0.214591122  0.340080533 -0.106137003 -0.018570255
## Biiliac   -0.07546787 -0.067723061 -0.083237579 -0.008649492  0.004383763
## Bitro     -0.00037373  0.161126005  0.096863017  0.154953371  0.025818170
## CalfG      0.08261554  0.085562908 -0.086237356 -0.038505584 -0.072154318
## ChestD     0.40622919 -0.118766065  0.106951582 -0.131133058  0.117924680
## ChestDp    0.09248589  0.068591387  0.017171850 -0.116206403  0.067418054
## ChestG    -0.12993681  0.135273324 -0.129311811  0.331174133 -0.773378208
## ElbowD    -0.14615180 -0.363852720  0.008092243  0.133149385  0.015859552
## ForearmG   0.13395790 -0.121882335  0.165593053 -0.410390050  0.056745960
## HipG      -0.13228167 -0.231789764 -0.367104491 -0.590987504 -0.239160126
## KneeD     -0.07123253 -0.004614485  0.052760654  0.022264196 -0.029994552
## KneeG      0.04415786  0.118373516  0.037542934  0.008860900 -0.052482405
## ShoulderG -0.41454760  0.389015137 -0.511630936  0.040550046  0.462936705
## ThighG     0.01831552 -0.089323390  0.142811735  0.378449825  0.168964789
## WaistG    -0.34346424 -0.520332786  0.217072248  0.184324297  0.190584553
## WristD    -0.15841160  0.218254432  0.219239927 -0.050066810  0.024046325
## WristG     0.48282728 -0.274987140 -0.478406674  0.304937970  0.077334245
##                Comp.21
## AbdG       0.11015339
## AnkleD    -0.01936796
## AnkleG     0.02030621
## Biacrom   -0.01511976
## BicepG    -0.62545444
## Biiliac   -0.02287062
## Bitro      0.08647384
## CalfG     -0.04371774
## ChestD    -0.09633864
## ChestDp   -0.02629911
## ChestG     0.19118692
## ElbowD    -0.09598163
## ForearmG   0.67013688
## HipG      -0.18339848
## KneeD      0.04086948
## KneeG     -0.07246262
## ShoulderG  0.07949080
```

```
## ThighG     0.12653096
## WaistG    -0.01167878
## WristD     0.03571423
## WristG    -0.12894505
##
## Component variances:
##      Comp.1      Comp.2      Comp.3      Comp.4      Comp.5      Comp.6
## 13.47663972  2.40885069  0.96704479  0.88804364  0.47618947  0.40427520
##      Comp.7      Comp.8      Comp.9     Comp.10     Comp.11     Comp.12
##  0.32323029  0.28569616  0.27562450  0.24790516  0.20648540  0.18782162
##     Comp.13     Comp.14     Comp.15     Comp.16     Comp.17     Comp.18
##  0.16794029  0.15587394  0.12161828  0.10122490  0.08477288  0.08137612
##     Comp.19     Comp.20     Comp.21
##  0.05582931  0.04644515  0.03711250
##
## Importance of components:
##                            Comp.1    Comp.2     Comp.3     Comp.4     Comp.5
## Standard deviation     3.6710543 1.5520473 0.98338435 0.94236067 0.69006483
## Proportion of Variance 0.6417447 0.1147072 0.04604975 0.04228779 0.02267569
## Cumulative Proportion  0.6417447 0.7564519 0.80250168 0.84478947 0.86746516
##                            Comp.6     Comp.7     Comp.8     Comp.9    Comp.10
## Standard deviation     0.6358264 0.56853345 0.53450553 0.52499953 0.49790075
## Proportion of Variance 0.0192512 0.01539192 0.01360458 0.01312498 0.01180501
## Cumulative Proportion  0.8867164 0.90210828 0.91571286 0.92883783 0.94064284
##                           Comp.11     Comp.12     Comp.13     Comp.14
## Standard deviation     0.454406643 0.433383915 0.409805183 0.394808736
## Proportion of Variance 0.009832638 0.008943887 0.007997157 0.007422568
## Cumulative Proportion  0.950475477 0.959419364 0.967416520 0.974839089
##                           Comp.15     Comp.16     Comp.17     Comp.18
## Standard deviation     0.348738125 0.318158608 0.291157824 0.285264992
## Proportion of Variance 0.005791347 0.004820233 0.004036804 0.003875053
## Cumulative Proportion  0.980630435 0.985450669 0.989487473 0.993362526
##                           Comp.19     Comp.20     Comp.21
## Standard deviation     0.236282276 0.215511364 0.192646047
## Proportion of Variance 0.002658539 0.002211674 0.001767262
## Cumulative Proportion  0.996021064 0.998232738 1.000000000
```




```
# Create scatterplot of PC2 against PC1 with grouping by Gender
scatterplot(PC2 ~ PC1 | Gender, regLine = TRUE, smooth = FALSE, boxplots = 'xy', ellipse
= list(levels = c(.5, .9)), by.groups = TRUE, data = body)
```




```r
# Fit logistic regression model predicting Gender using principal components PC1 and PC2
glm_PCA2 <- glm(Gender ~ PC1 + PC2, family = binomial(logit), data = body)

# Display summary of logistic regression model
summary(glm_PCA2)
```

```
##
## Call:
## glm(formula = Gender ~ PC1 + PC2, family = binomial(logit), data = body)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)   0.2324     0.3605   0.645    0.519
## PC1           1.8189     0.2835   6.415 1.40e-10 ***
## PC2          -3.5819     0.5522  -6.487 8.78e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 702.518  on 506  degrees of freedom
## Residual deviance:  58.195  on 504  degrees of freedom
## AIC: 64.195
##
## Number of Fisher Scoring iterations: 9
```

```r
# Display exponentiated coefficients ("odds ratios") of the logistic regression model
exp(coef(glm_PCA2))
```

```
## (Intercept)         PC1         PC2
##  1.26162842  6.16506512  0.02782376
```

```
# Fit logistic regression model predicting Gender using principal components PC1, PC2,
PC3, and PC4
glm_PCA4 <- glm(Gender ~ PC1 + PC2 + PC3 + PC4, family = binomial(logit), data = body)

# Display summary of logistic regression model
summary(glm_PCA4)
```

```
##
## Call:
## glm(formula = Gender ~ PC1 + PC2 + PC3 + PC4, family = binomial(logit),
##     data = body)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.59573    0.46525   1.280  0.20039
## PC1          2.66230    0.57116   4.661 3.14e-06 ***
## PC2         -5.26001    1.14999  -4.574 4.79e-06 ***
## PC3          0.02022    0.46291   0.044  0.96516
## PC4          2.09057    0.63888   3.272  0.00107 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 702.518  on 506  degrees of freedom
## Residual deviance:  37.292  on 502  degrees of freedom
## AIC: 47.292
##
## Number of Fisher Scoring iterations: 10
```

```
# Display exponentiated coefficients ("odds ratios") of the logistic regression model
exp(coef(glm_PCA4))
```

```
##  (Intercept)          PC1          PC2          PC3          PC4
##  1.814353319 14.329141047  0.005195273  1.020422526  8.089516125
```

```
# Add fitted values of glm_PCA4 to the body dataset
body <- within(body, {
  fitted.glm_PCA4 <- fitted(glm_PCA4)
})

# Display the fitted values for inspection
head(body$fitted.glm_PCA4)
```

```
## [1] 0.9995581 0.9999999 0.9999522 0.9999933 0.9999987 0.9999987
```

```
# Create a new variable Gender_Pred based on the fitted values
body$Gender_Pred <- with(body, 1 * (fitted.glm_PCA4 > 0.5))

# Convert Gender_Pred variable to factor
body <- within(body, {
  Gender_Pred <- as.factor(Gender_Pred)
})
```

```r
# Display frequency table of observed vs predicted Gender
local({
  .Table <- xtabs(~ Gender + Gender_Pred, data = body)
  cat("\nFrequency table:\n")
  print(.Table)
})
```

```
##
## Frequency table:
##       Gender_Pred
## Gender   0   1
##      0 257   3
##      1   3 244
```