Regression Final

2024-04-01

```
rm(list = ls())
library(knitr)
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.4
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.4.4     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.0
## v purrr     1.0.2
## -- Conflicts ---------------------------------------- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(WVPlots)
```

```
## Loading required package: wrapr
##
## Attaching package: 'wrapr'
##
## The following object is masked from 'package:dplyr':
##
##     coalesce
##
## The following objects are masked from 'package:tidyr':
##
##     pack, unpack
##
## The following object is masked from 'package:tibble':
##
##     view
```

```
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```
library(questionr)
library(scales)
```

```
##
```

```
## Attaching package: 'scales'
##
## The following object is masked from 'package:purrr':
##
##     discard
##
## The following object is masked from 'package:readr':
##
##     col_factor
```

```
#Question A.1
dcorp = read.table('/Users/markus/Downloads/Densité corporelle.txt',header=TRUE)
str(dcorp)#nombre d'observations
```

```
## 'data.frame':    238 obs. of  14 variables:
##  $ Denscorp: num  1.07 1.09 1.04 1.08 1.03 ...
##  $ Age     : chr  "<40" "<40" "<40" "<40" ...
##  $ Poids   : num  70 78.6 69.9 83.8 83.6 95.4 82.1 79.8 86.6 89.9 ...
##  $ Taille  : num  172 184 168 184 181 ...
##  $ Cou     : num  36.2 38.5 34 37.4 34.4 39 36.4 37.8 38.1 42.1 ...
##  $ Thorax  : num  93.1 93.6 95.8 101.8 97.3 ...
##  $ Abdomen : num  85.2 83 87.9 86.4 100 94.4 90.7 88.5 82.5 88.6 ...
##  $ Hanche  : num  94.5 98.7 99.2 101.2 101.9 ...
##  $ Cuisse  : num  59 58.7 59.6 60.1 63.2 66 58.4 60 62.9 63.1 ...
##  $ Genou   : num  37.3 37.3 38.9 37.3 42.2 42 38.3 39.4 38.3 41.7 ...
##  $ Cheville: num  21.9 23.4 24 22.8 24 25.6 22.9 23.2 23.8 25 ...
##  $ Biceps  : num  32 30.5 28.8 32.4 32.2 35.7 31.9 30.5 35.9 35.6 ...
##  $ Bras    : num  27.4 28.9 25.2 29.4 27.7 30.6 27.8 29 31.1 30 ...
##  $ Poignet : num  17.1 18.2 16.6 18.2 17.7 18.8 17.7 18.8 18.2 19.2 ...
```

```
#A.2
dcorp$IMC = dcorp$Poids/((dcorp$Taille/100)^2) #variable IMC
head(dcorp)
```

```
##   Denscorp Age Poids Taille  Cou Thorax Abdomen Hanche Cuisse Genou Cheville
## 1   1.0708 <40  70.0  172.1 36.2   93.1    85.2   94.5   59.0  37.3     21.9
## 2   1.0853 <40  78.6  183.5 38.5   93.6    83.0   98.7   58.7  37.3     23.4
## 3   1.0414 <40  69.9  168.3 34.0   95.8    87.9   99.2   59.6  38.9     24.0
## 4   1.0751 <40  83.8  183.5 37.4  101.8    86.4  101.2   60.1  37.3     22.8
## 5   1.0340 <40  83.6  181.0 34.4   97.3   100.0  101.9   63.2  42.2     24.0
## 6   1.0502 <40  95.4  189.9 39.0  104.5    94.4  107.8   66.0  42.0     25.6
##   Biceps Bras Poignet      IMC
## 1   32.0 27.4    17.1 23.63395
## 2   30.5 28.9    18.2 23.34266
## 3   28.8 25.2    16.6 24.67794
## 4   32.4 29.4    18.2 24.88696
## 5   32.2 27.7    17.7 25.51815
## 6   35.7 30.6    18.8 26.45443
```

```
#A.3
str(dcorp)#type des variables
```

```
## 'data.frame':    238 obs. of  15 variables:
##  $ Denscorp: num  1.07 1.09 1.04 1.08 1.03 ...
##  $ Age     : chr  "<40" "<40" "<40" "<40" ...
##  $ Poids   : num  70 78.6 69.9 83.8 83.6 95.4 82.1 79.8 86.6 89.9 ...
##  $ Taille  : num  172 184 168 184 181 ...
##  $ Cou     : num  36.2 38.5 34 37.4 34.4 39 36.4 37.8 38.1 42.1 ...
##  $ Thorax  : num  93.1 93.6 95.8 101.8 97.3 ...
##  $ Abdomen : num  85.2 83 87.9 86.4 100 94.4 90.7 88.5 82.5 88.6 ...
##  $ Hanche  : num  94.5 98.7 99.2 101.2 101.9 ...
##  $ Cuisse  : num  59 58.7 59.6 60.1 63.2 66 58.4 60 62.9 63.1 ...
##  $ Genou   : num  37.3 37.3 38.9 37.3 42.2 42 38.3 39.4 38.3 41.7 ...
##  $ Cheville: num  21.9 23.4 24 22.8 24 25.6 22.9 23.2 23.8 25 ...
##  $ Biceps  : num  32 30.5 28.8 32.4 32.2 35.7 31.9 30.5 35.9 35.6 ...
##  $ Bras    : num  27.4 28.9 25.2 29.4 27.7 30.6 27.8 29 31.1 30 ...
##  $ Poignet : num  17.1 18.2 16.6 18.2 17.7 18.8 17.7 18.8 18.2 19.2 ...
##  $ IMC     : num  23.6 23.3 24.7 24.9 25.5 ...
```

```
#TABLEAU 1
table(dcorp$Age)#répartition uniforme de la variable qualitative
```

```
##
##   <40  >=50 40-49
##    70    80    88
```

```
#A.3
dcorp$Age = as.factor(dcorp$Age)
summary(dcorp)
```

```
##     Denscorp        Age         Poids            Taille           Cou
##  Min.   :1.014   <40  :70   Min.   : 53.80   Min.   :162.6   Min.   :32.80
##  1st Qu.:1.042   >=50 :80   1st Qu.: 71.90   1st Qu.:173.6   1st Qu.:36.40
##  Median :1.055   40-49:88   Median : 79.70   Median :178.4   Median :37.90
##  Mean   :1.056              Mean   : 80.36   Mean   :178.7   Mean   :37.92
##  3rd Qu.:1.070              3rd Qu.: 88.45   3rd Qu.:183.5   3rd Qu.:39.38
##  Max.   :1.100              Max.   :112.20   Max.   :196.8   Max.   :43.90
##      Thorax          Abdomen           Hanche           Cuisse
##  Min.   : 79.30   Min.   : 69.40   Min.   : 85.00   Min.   :47.20
##  1st Qu.: 94.45   1st Qu.: 84.53   1st Qu.: 95.50   1st Qu.:56.02
##  Median : 99.60   Median : 90.80   Median : 99.20   Median :58.90
##  Mean   :100.32   Mean   : 91.86   Mean   : 99.36   Mean   :59.12
##  3rd Qu.:104.78   3rd Qu.: 98.75   3rd Qu.:102.67   3rd Qu.:62.05
##  Max.   :121.60   Max.   :118.00   Max.   :116.10   Max.   :72.90
##      Genou          Cheville         Biceps           Bras
##  Min.   :33.40   Min.   :19.10   Min.   :24.80   Min.   :24.60
##  1st Qu.:37.02   1st Qu.:22.00   1st Qu.:30.20   1st Qu.:27.30
##  Median :38.40   Median :22.75   Median :31.95   Median :28.70
##  Mean   :38.53   Mean   :23.06   Mean   :32.21   Mean   :28.69
##  3rd Qu.:39.80   3rd Qu.:23.90   3rd Qu.:34.08   3rd Qu.:30.00
##  Max.   :46.00   Max.   :33.90   Max.   :39.10   Max.   :33.80
##     Poignet           IMC
##  Min.   :16.30   Min.   :18.04
##  1st Qu.:17.60   1st Qu.:23.05
##  Median :18.25   Median :24.90
```

```
##  Mean   :18.21   Mean   :25.12
##  3rd Qu.:18.80   3rd Qu.:27.11
##  Max.   :20.90   Max.   :33.86
```

```
#Tableau 2
summary(data.frame(dcorp$Denscorp,dcorp$Poids,dcorp$Taille,dcorp$IMC))
```

```
##  dcorp.Denscorp   dcorp.Poids      dcorp.Taille     dcorp.IMC
##  Min.   :1.014   Min.   : 53.80   Min.   :162.6   Min.   :18.04
##  1st Qu.:1.042   1st Qu.: 71.90   1st Qu.:173.6   1st Qu.:23.05
##  Median :1.055   Median : 79.70   Median :178.4   Median :24.90
##  Mean   :1.056   Mean   : 80.36   Mean   :178.7   Mean   :25.12
##  3rd Qu.:1.070   3rd Qu.: 88.45   3rd Qu.:183.5   3rd Qu.:27.11
##  Max.   :1.100   Max.   :112.20   Max.   :196.8   Max.   :33.86
```

```
# variance et écart-type observés de Denscorp
var(dcorp$Denscorp)*(nrow(dcorp)-1)/nrow(dcorp); sd(dcorp$Denscorp)*sqrt((nrow(dcorp)-1)/nrow(dcorp))
```

```
## [1] 0.0003177921
```

```
## [1] 0.01782672
```

```
# variance et écart-type observés de Poids
var(dcorp$Poids)*(nrow(dcorp)-1)/nrow(dcorp); sd(dcorp$Poids)*sqrt((nrow(dcorp)-1)/nrow(dcorp))
```

```
## [1] 132.6617
```

```
## [1] 11.51789
```

```
# variance et écart-type observés de Taille
var(dcorp$Taille)*(nrow(dcorp)-1)/nrow(dcorp); sd(dcorp$Taille)*sqrt((nrow(dcorp)-1)/nrow(dcorp))
```

```
## [1] 41.86438
```

```
## [1] 6.470269
```

```
# variance et écart-type observés de IMC
var(dcorp$IMC)*(nrow(dcorp)-1)/nrow(dcorp); sd(dcorp$IMC)*sqrt((nrow(dcorp)-1)/nrow(dcorp))
```

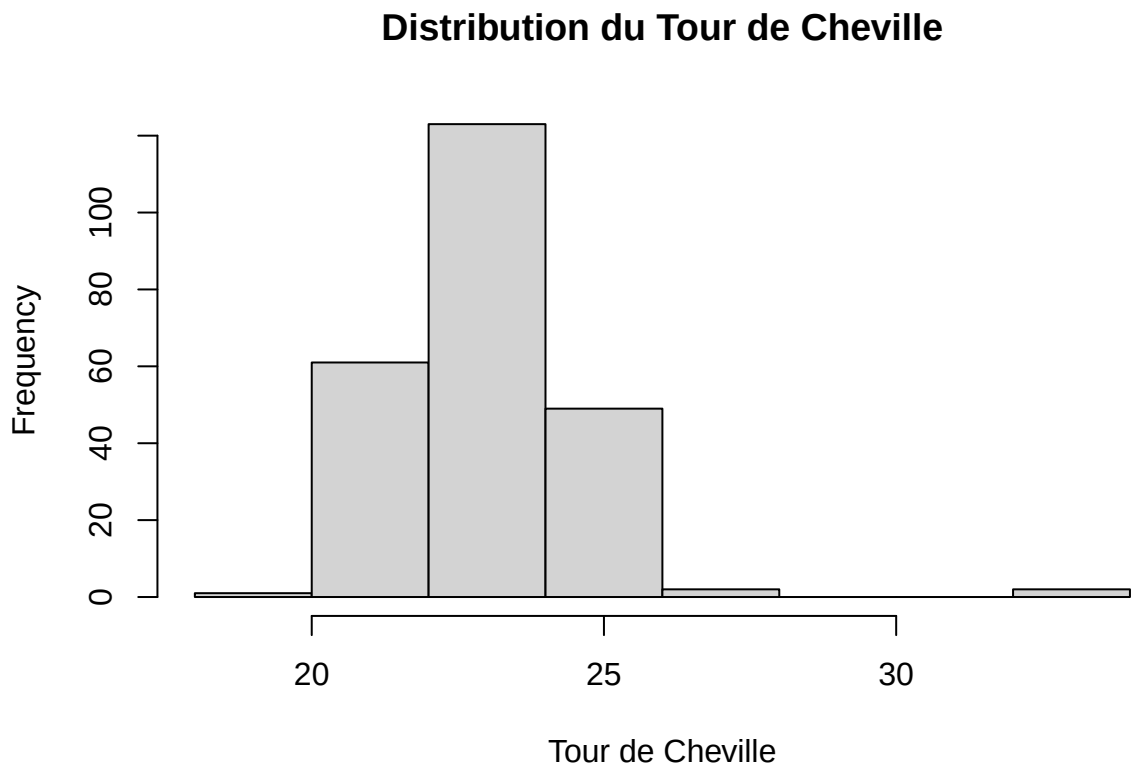
```
## [1] 8.995868
```

```
## [1] 2.999311
```

```
#B.1
#Graphique 1
summary(dcorp$Cheville)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   19.10   22.00   22.75   23.06   23.90   33.90
```

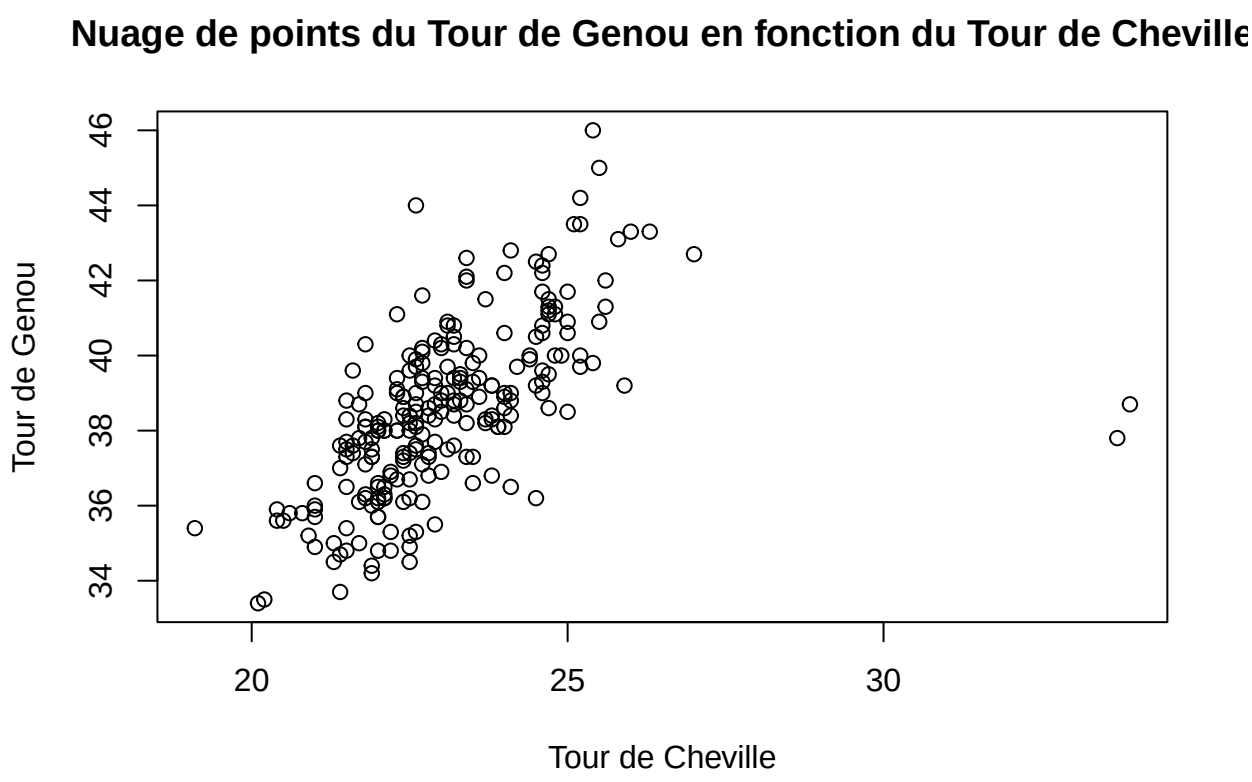
```r
hist(x=dcorp$Cheville,xlab="Tour de Cheville", main="Distribution du Tour de Cheville")
```



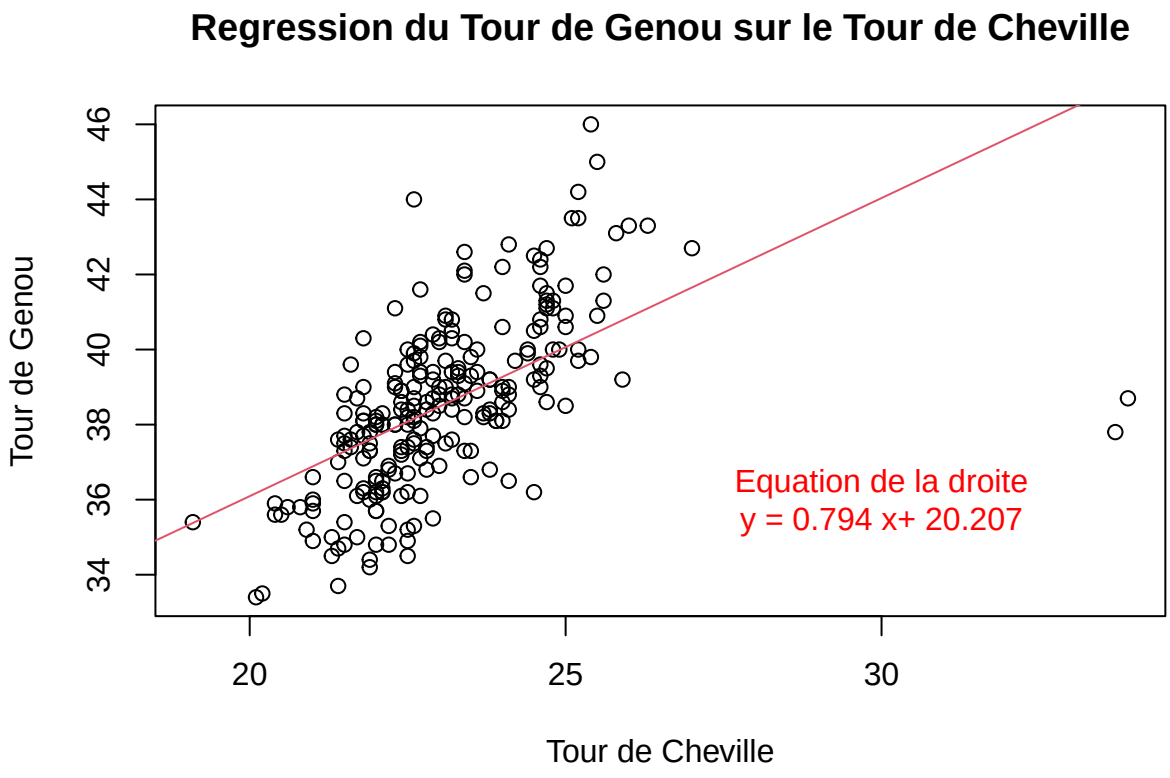

```r
#B.2
cor(dcorp$Cheville,dcorp$Genou)
```

```
## [1] 0.5747724
```

```r
#Graphique 2
plot(x=dcorp$Cheville,y=dcorp$Genou,xlab="Tour de Cheville",
     ylab="Tour de Genou",
     main="Nuage de points du Tour de Genou en fonction du Tour de Cheville")#nuage de points du tour d
```



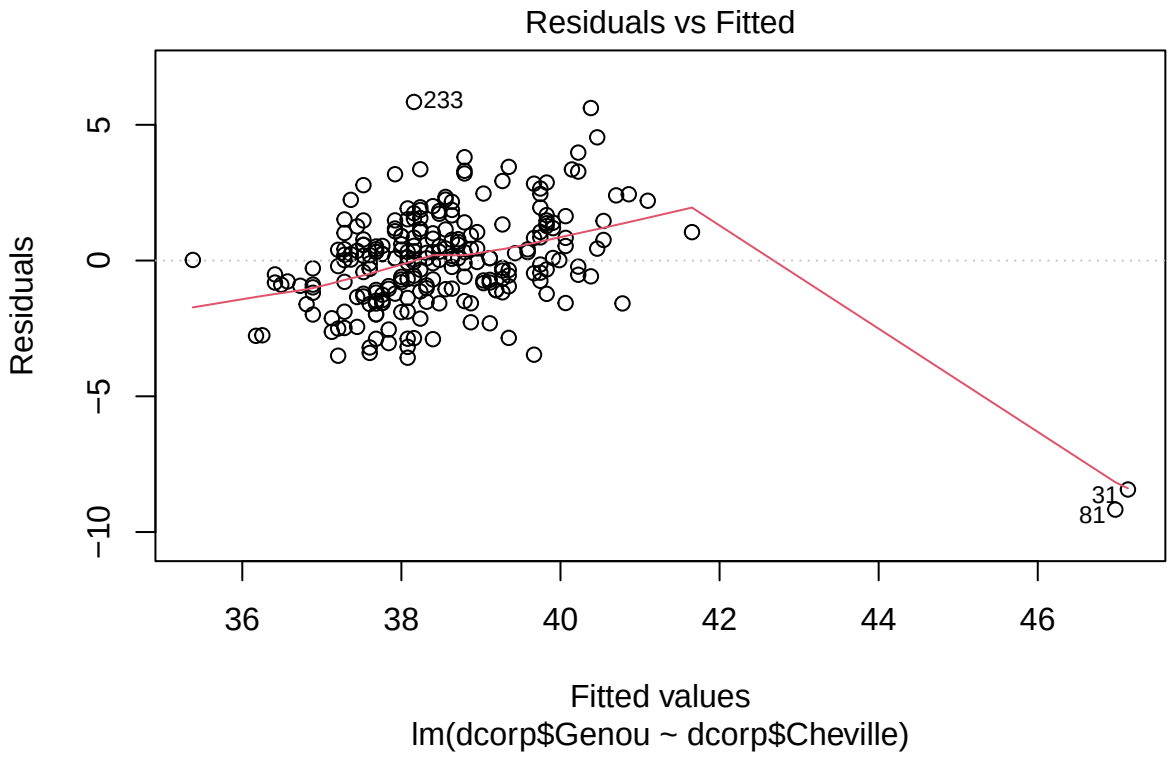

```
#B.3

mod1 = lm(dcorp$Genou~dcorp$Cheville)

#Graphique 3
plot(dcorp$Cheville,dcorp$Genou,type="p",xlab="Tour de Cheville",
     ylab="Tour de Genou",
     main="Regression du Tour de Genou sur le Tour de Cheville")
abline(mod1,col=2)#droite de regression du modèle
text(30,36,paste("Equation de la droite\ny =",
                 round(mod1$coefficients[2],3),"x+",
                 round(mod1$coefficients[1],3)),col="red")
```



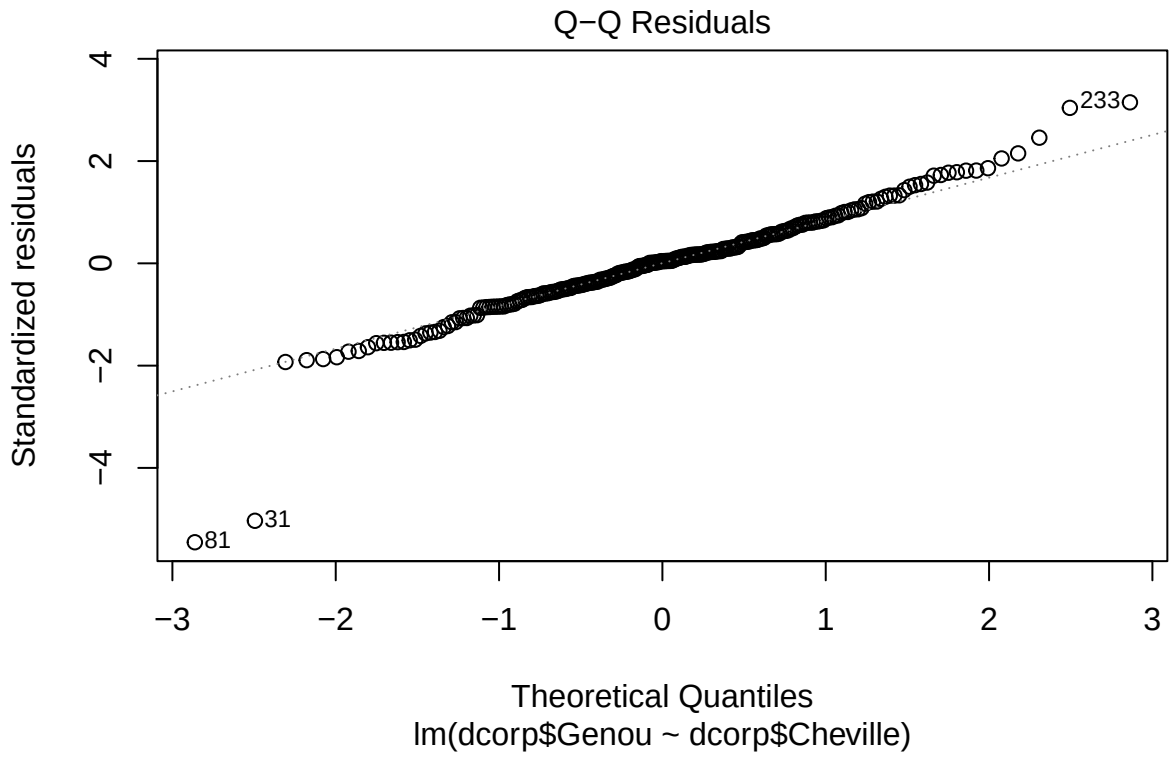

```
summary(mod1)
```

```
##
## Call:
## lm(formula = dcorp$Genou ~ dcorp$Cheville)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -9.175 -1.039  0.080  1.047  5.842
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)    20.20743    1.70197   11.87   <2e-16 ***
## dcorp$Cheville  0.79429    0.07361   10.79   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.859 on 236 degrees of freedom
## Multiple R-squared:  0.3304, Adjusted R-squared:  0.3275
## F-statistic: 116.4 on 1 and 236 DF,  p-value: < 2.2e-16
```

```
#Valider le modèle

#Graphique 4 Hypothèse de linéarité du modele
plot(mod1, which = 1)
```



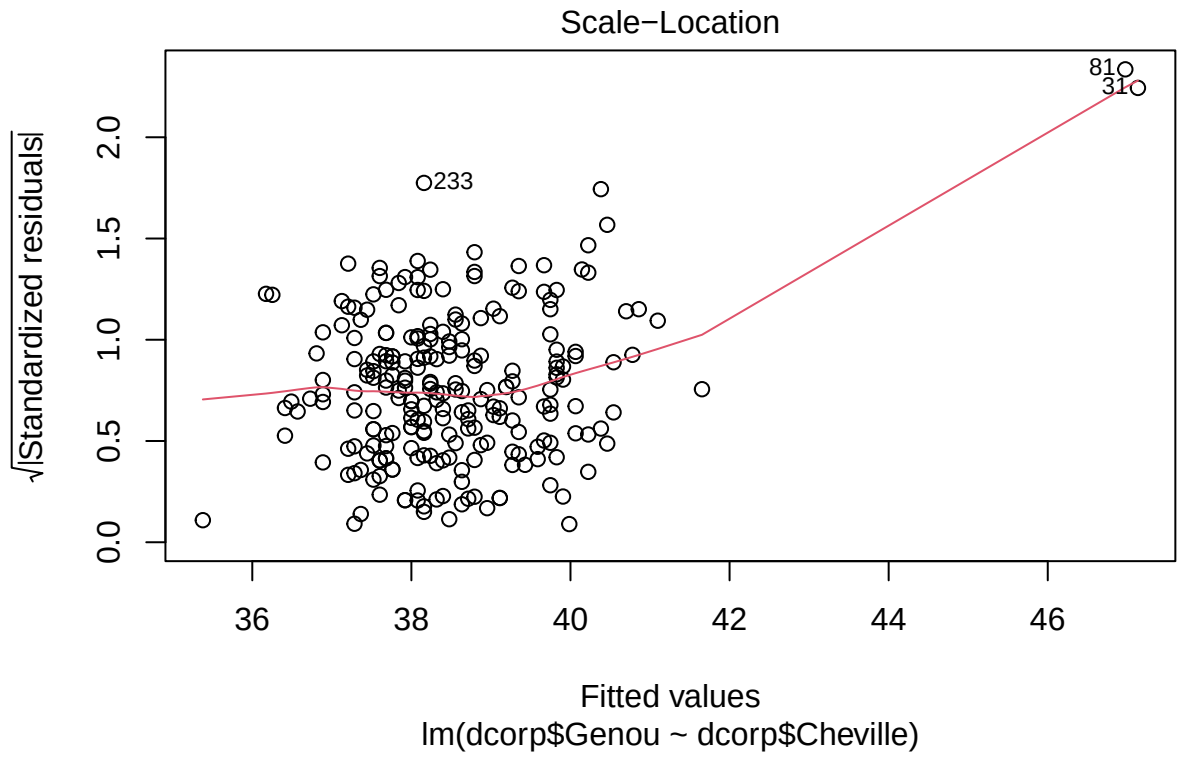

```
#Graphique 5 Hypothèse de normalité de distribution des résidus
plot(mod1, which = 2)
```



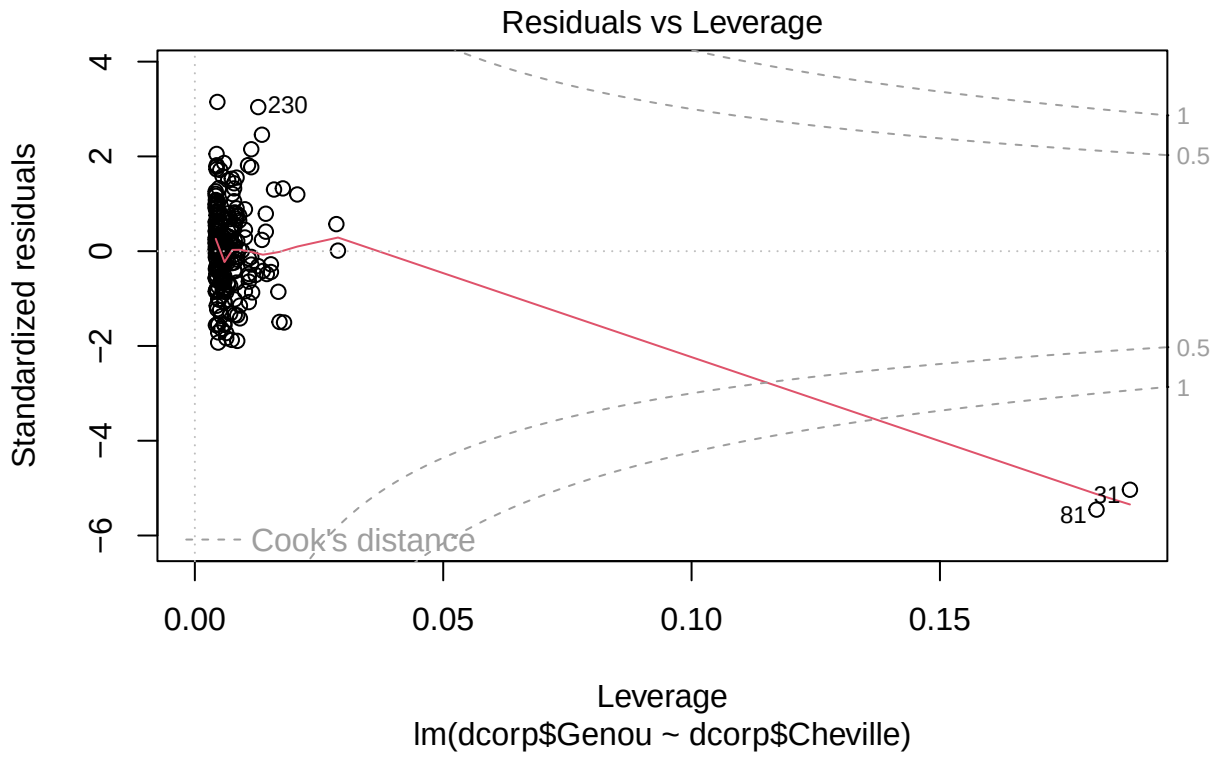

```
shapiro.test(mod1$residuals)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  mod1$residuals
## W = 0.95486, p-value = 8.774e-07
```

```
#Graphique 6 Hypothèse d'homogénéité de la dispersion des résidus
plot(mod1, which = 3)
```




```
#Graphique 7
plot(mod1, which = 5)
```




```
which(abs(rstandard(mod1))>2)# résidus extrêmes
```

```
##  31  34  81 181 214 230 233
##  31  34  81 181 214 230 233
```

```
#hypothèse d'indépendance des résidus
Box.test(mod1$residuals,type='Ljung')
```

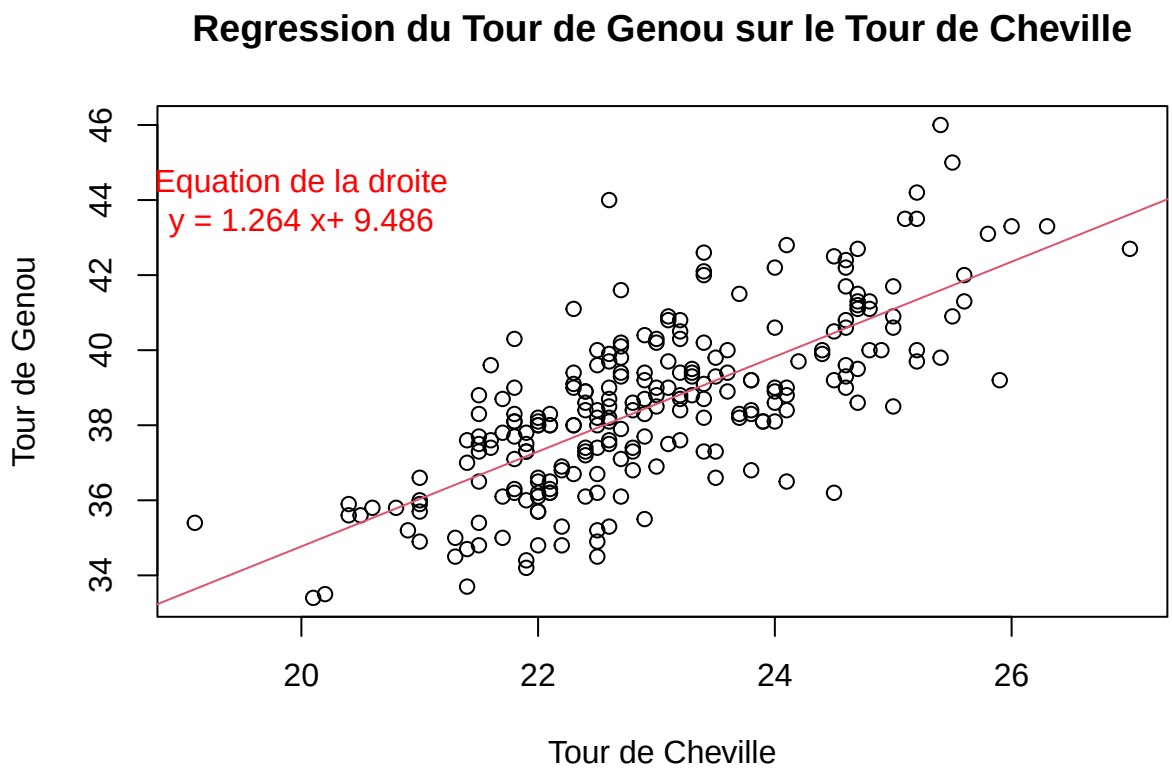
```
##
##  Box-Ljung test
##
## data:  mod1$residuals
## X-squared = 2.3084, df = 1, p-value = 0.1287
```

```
#Retire les observations 31 et 81
dcorp2 = dcorp[-c(31,81),]
nrow(dcorp2)
```

```
## [1] 236
```

```
mod2 = lm(dcorp2$Genou~dcorp2$Cheville)

plot(dcorp2$Cheville,dcorp2$Genou,type="p",xlab="Tour de Cheville"
```

```
     ,ylab="Tour de Genou",
     main="Regression du Tour de Genou sur le Tour de Cheville")
abline(mod2,col=2)
text(20,44,paste("Equation de la droite\ny =",
                 round(mod2$coefficients[2],3),"x+",
                 round(mod2$coefficients[1],3)),col="red")
```

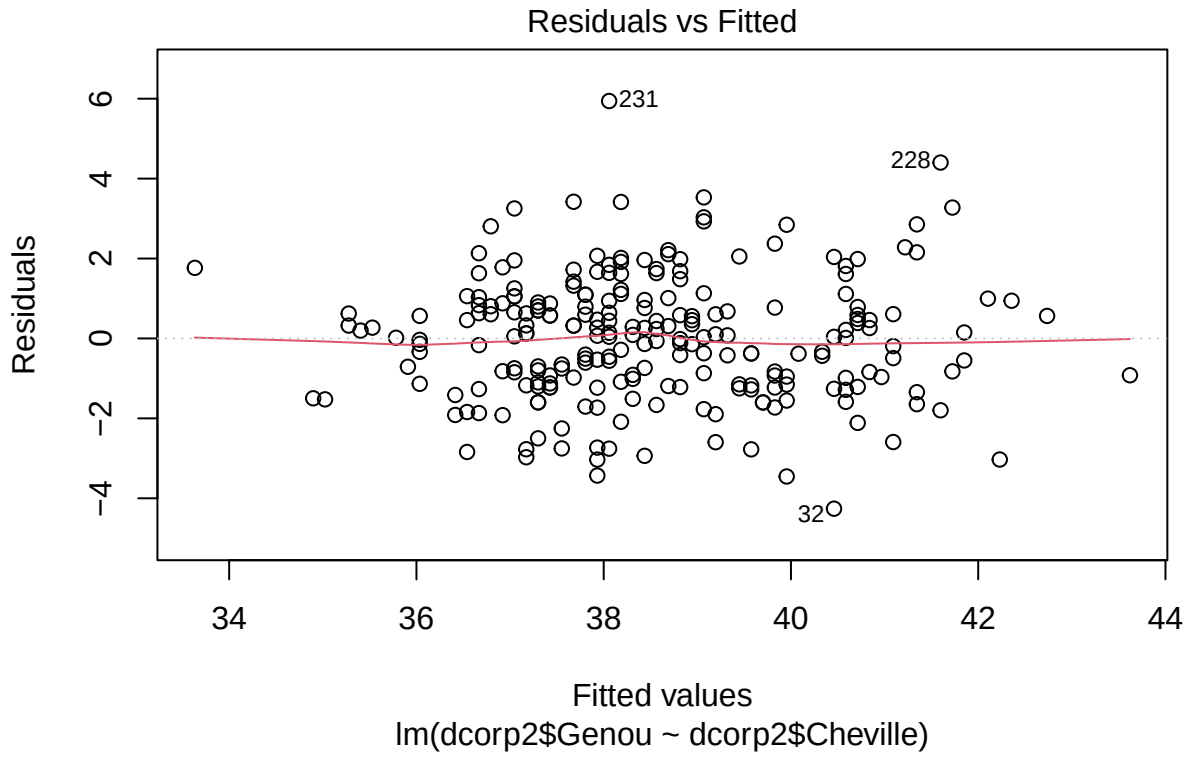



```
summary(mod2)
```

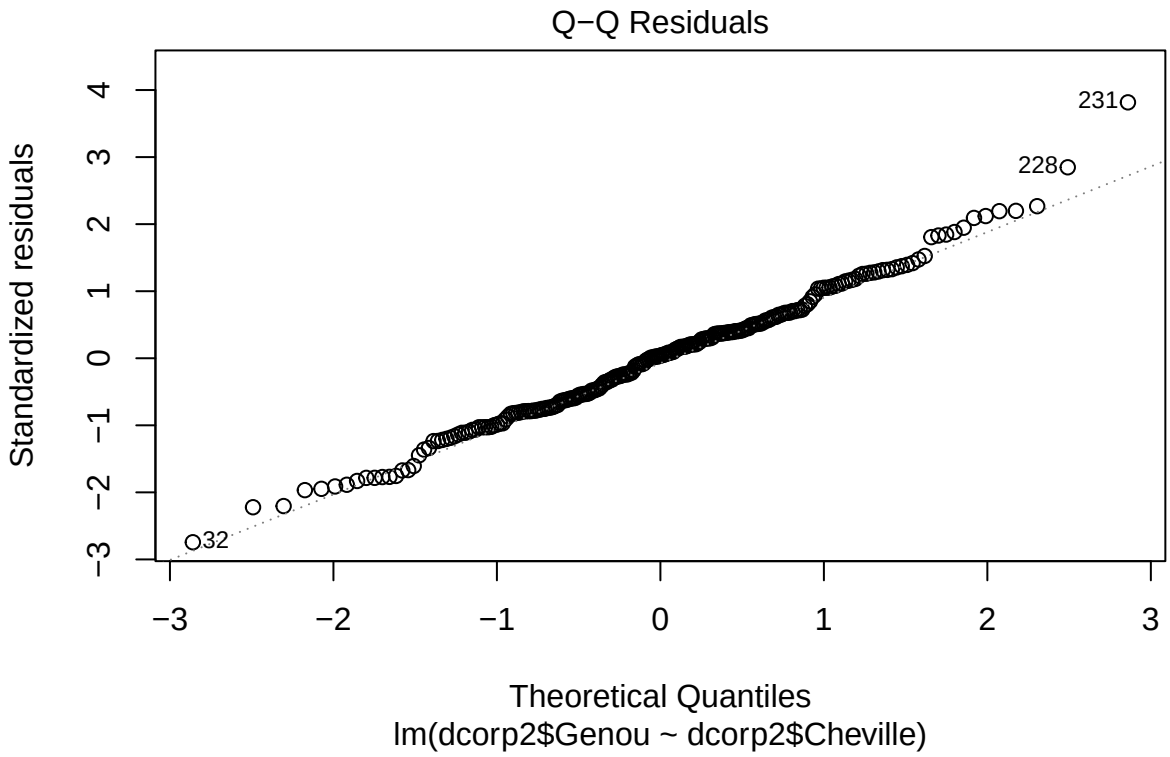
```
##
## Call:
## lm(formula = dcorp2$Genou ~ dcorp2$Cheville)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.2601 -1.1386  0.0609  0.9109  5.9419
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      9.48634    1.78293   5.321 2.42e-07 ***
## dcorp2$Cheville  1.26424    0.07749  16.315  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.56 on 234 degrees of freedom
```

```
## Multiple R-squared:  0.5322, Adjusted R-squared:  0.5302
## F-statistic: 266.2 on 1 and 234 DF,  p-value: < 2.2e-16
```

```r
#Valider le modèle

#Graphique 8 Hypothèse de linéarité du modele
plot(mod2, which = 1)
```



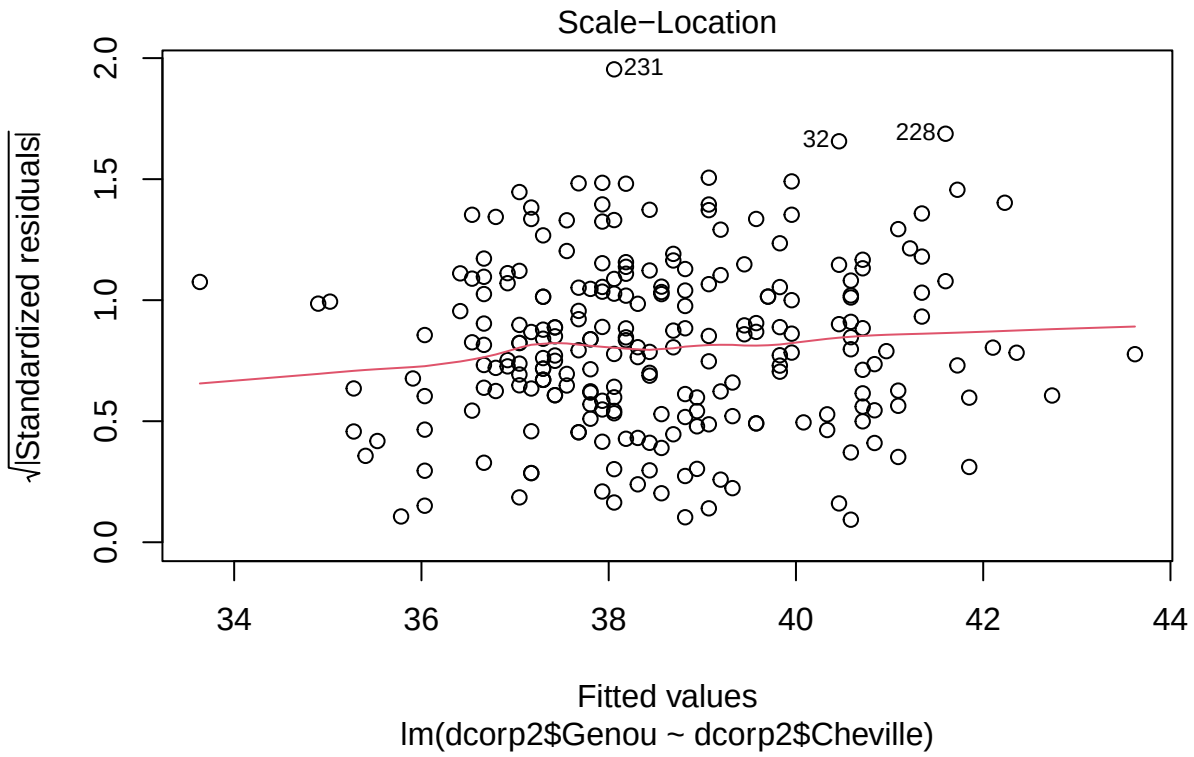

```r
#Graphique 9 Hypothèse de normalité de distribution des résidus
plot(mod2, which = 2)
```



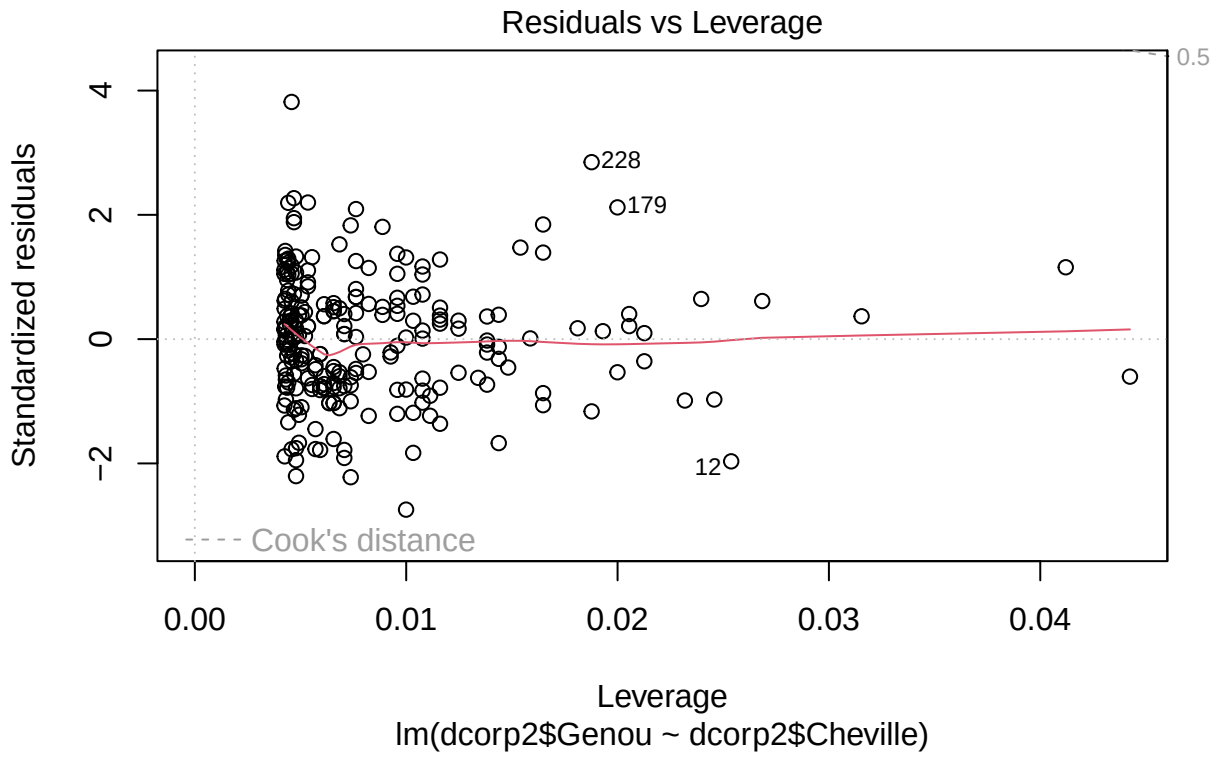

```
shapiro.test(mod2$residuals)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  mod2$residuals
## W = 0.99175, p-value = 0.2066
```

```
#Graphique 10 Hypothèse d'homogénéité de la dispersion des résidus
plot(mod2, which = 3)
```




```
#Graphique 11
plot(mod2, which = 5)
```




```
which(abs(rstandard(mod2))>2)# résidus extrêmes
```

```
##  32  41  78 179 192 212 222 228 231 235
##  32  41  78 179 192 212 222 228 231 235
```

```
#hypothèse d'indépendance des résidus
Box.test(mod2$residuals,type='Ljung')
```

```
##
##  Box-Ljung test
##
## data:  mod2$residuals
## X-squared = 0.31115, df = 1, p-value = 0.577
```

```
dcorp[c(31,81),]
```

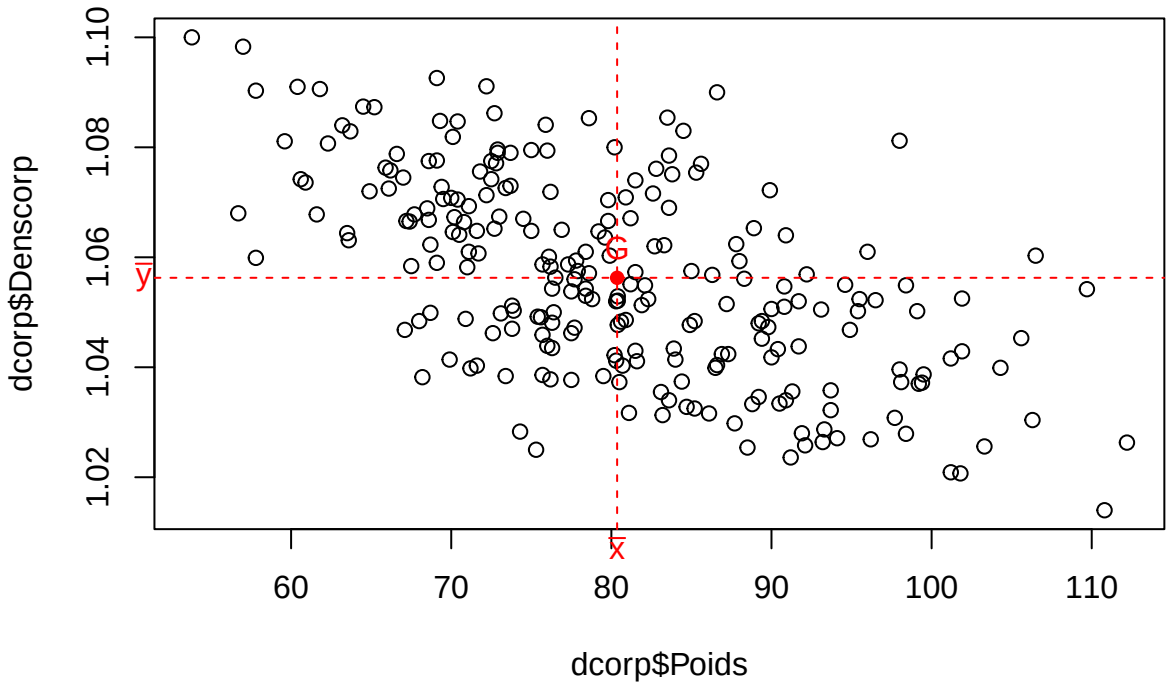
```
##    Denscorp  Age Poids Taille  Cou Thorax Abdomen Hanche Cuisse Genou Cheville
## 31   1.0716  <40  82.6  187.3 38.7  100.5    88.7   99.8   57.5  38.7     33.9
## 81   1.0386 >=50  75.7  171.4 36.5   98.9    89.7   96.2   54.7  37.8     33.7
##    Biceps Bras Poignet      IMC
## 31   32.5 27.7    18.4 23.54531
## 81   32.4 27.7    18.2 25.76762
```

```r
summary(dcorp)
```

```
##     Denscorp        Age         Poids            Taille           Cou
##  Min.   :1.014   <40  :70   Min.   : 53.80   Min.   :162.6   Min.   :32.80
##  1st Qu.:1.042   >=50 :80   1st Qu.: 71.90   1st Qu.:173.6   1st Qu.:36.40
##  Median :1.055   40-49:88   Median : 79.70   Median :178.4   Median :37.90
##  Mean   :1.056              Mean   : 80.36   Mean   :178.7   Mean   :37.92
##  3rd Qu.:1.070              3rd Qu.: 88.45   3rd Qu.:183.5   3rd Qu.:39.38
##  Max.   :1.100              Max.   :112.20   Max.   :196.8   Max.   :43.90
##      Thorax          Abdomen           Hanche           Cuisse
##  Min.   : 79.30   Min.   : 69.40   Min.   : 85.00   Min.   :47.20
##  1st Qu.: 94.45   1st Qu.: 84.53   1st Qu.: 95.50   1st Qu.:56.02
##  Median : 99.60   Median : 90.80   Median : 99.20   Median :58.90
##  Mean   :100.32   Mean   : 91.86   Mean   : 99.36   Mean   :59.12
##  3rd Qu.:104.78   3rd Qu.: 98.75   3rd Qu.:102.67   3rd Qu.:62.05
##  Max.   :121.60   Max.   :118.00   Max.   :116.10   Max.   :72.90
##      Genou          Cheville         Biceps           Bras
##  Min.   :33.40   Min.   :19.10   Min.   :24.80   Min.   :24.60
##  1st Qu.:37.02   1st Qu.:22.00   1st Qu.:30.20   1st Qu.:27.30
##  Median :38.40   Median :22.75   Median :31.95   Median :28.70
##  Mean   :38.53   Mean   :23.06   Mean   :32.21   Mean   :28.69
##  3rd Qu.:39.80   3rd Qu.:23.90   3rd Qu.:34.08   3rd Qu.:30.00
##  Max.   :46.00   Max.   :33.90   Max.   :39.10   Max.   :33.80
##     Poignet           IMC
##  Min.   :16.30   Min.   :18.04
##  1st Qu.:17.60   1st Qu.:23.05
##  Median :18.25   Median :24.90
##  Mean   :18.21   Mean   :25.12
##  3rd Qu.:18.80   3rd Qu.:27.11
##  Max.   :20.90   Max.   :33.86
```

```r
#En conclusion modèle valide et de meilleur qualité mais les observations influentes ne sont pas inhabi
```

```r
#C.1

#Graphique 12
plot(x=dcorp$Poids,y=dcorp$Denscorp)#nuage de points de la densité corporelle en fonction du poids
points(mean(dcorp$Poids),mean(dcorp$Denscorp),col="red",pch=16)# son centre de gravité
abline(v=mean(dcorp$Poids), h=mean(dcorp$Denscorp), col='red', lty=2)
text(mean(dcorp$Poids), mean(dcorp$Denscorp), "G", col='red', pos=3)
text(mean(dcorp$Poids), max(dcorp$Denscorp)-0.093, expression(bar(x)), col='red', xpd=TRUE)
text(min(dcorp$Poids)-3, mean(dcorp$Denscorp), expression(bar(y)), col='red', xpd=TRUE)
```




```
mean(dcorp$Poids);mean(dcorp$Denscorp)
```

```
## [1] 80.36008
```

```
## [1] 1.056272
```

```
cor(dcorp$Poids,dcorp$Denscorp)#cœfficient de corrélation linéaire observé entre les deux variables
```

```
## [1] -0.6006492
```

```
modele_1 = lm(dcorp$Denscorp~dcorp$Poids)# modèle de régression linéaire simple de la densité corporell
modele_1
```

```
##
## Call:
## lm(formula = dcorp$Denscorp ~ dcorp$Poids)
##
## Coefficients:
## (Intercept)  dcorp$Poids
##   1.1309786   -0.0009297
```

```r
summary(modele_1)
```

```
##
## Call:
## lm(formula = dcorp$Denscorp ~ dcorp$Poids)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.035976 -0.011531 -0.000398  0.010272  0.041327
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.131e+00  6.539e-03  172.95   <2e-16 ***
## dcorp$Poids -9.296e-04  8.055e-05  -11.54   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01431 on 236 degrees of freedom
## Multiple R-squared:  0.3608, Adjusted R-squared:  0.3581
## F-statistic: 133.2 on 1 and 236 DF,  p-value: < 2.2e-16
```

```r
sigma(modele_1)^2 # variance estimée des erreurs du modèle
```

```
## [1] 0.0002048608
```

```r
X = model.matrix(modele_1)#forme matricielle
head(X)
```

```
##   (Intercept) dcorp$Poids
## 1           1        70.0
## 2           1        78.6
## 3           1        69.9
## 4           1        83.8
## 5           1        83.6
## 6           1        95.4
```

```r
#Sortie anova(modele_1)
modele_1$coefficients
```

```
##   (Intercept)   dcorp$Poids
##  1.1309786307 -0.0009296504
```

```r
cat(" \n")
```

```r
anova(modele_1)
```

```
## Analysis of Variance Table
##
## Response: dcorp$Denscorp
##              Df   Sum Sq   Mean Sq F value    Pr(>F)
```

```
## dcorp$Poids   1 0.027287 0.0272874   133.2 < 2.2e-16 ***
## Residuals   236 0.048347 0.0002049
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#anova(droite)# table d'analyse de la variance
# Response: y
#           Df    Sum Sq    Mean Sq       F value     Pr(>F)
# x         Df1   SSR       MS1=SSR/Df1   MS1/MS2     pvalue prob(F(alpha,Df1,Df2)>F)
# Residuals Df2   SSE       MS2=SSE/Df2
# H0 "pente nulle" est rejetee si pvalue<risque_alpha

# SSR=sum square regression (variance expliquee par le modele)
# SSE= sum square error (variance non expliquee par le modele)
# SST=SSE+SSR (variance totale)
# Multiple R-squared: SSR/SST,
```

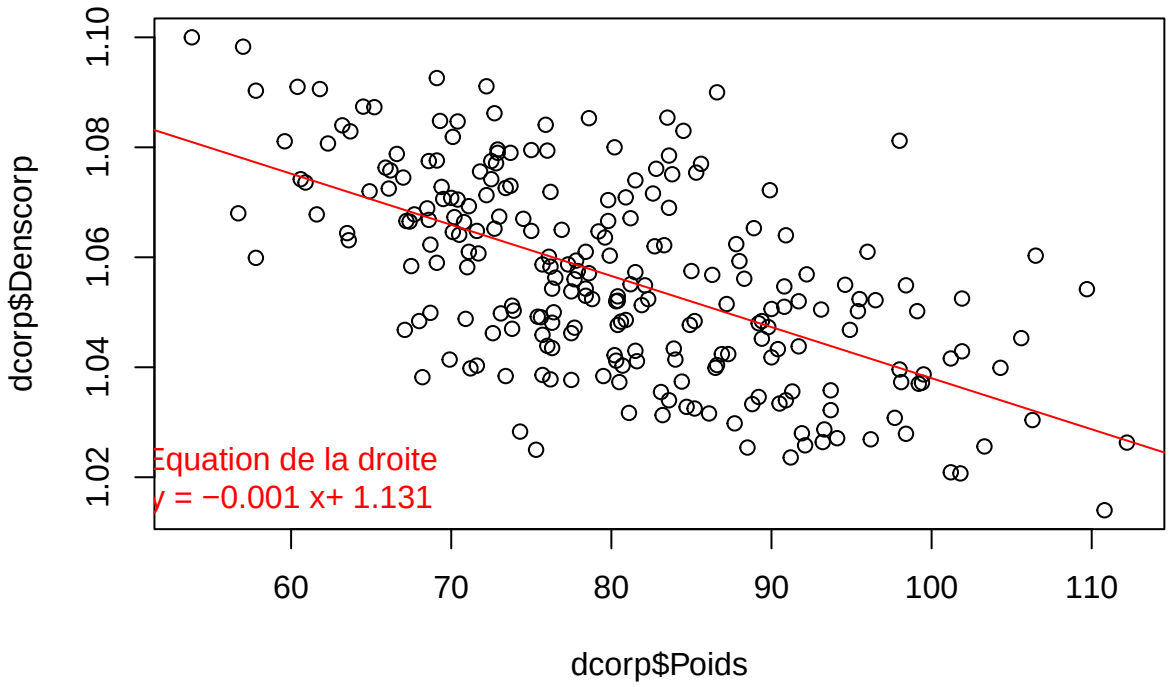
```
#C.2c
modele_1$coefficients
```

```
##   (Intercept)   dcorp$Poids
##  1.1309786307 -0.0009296504
```

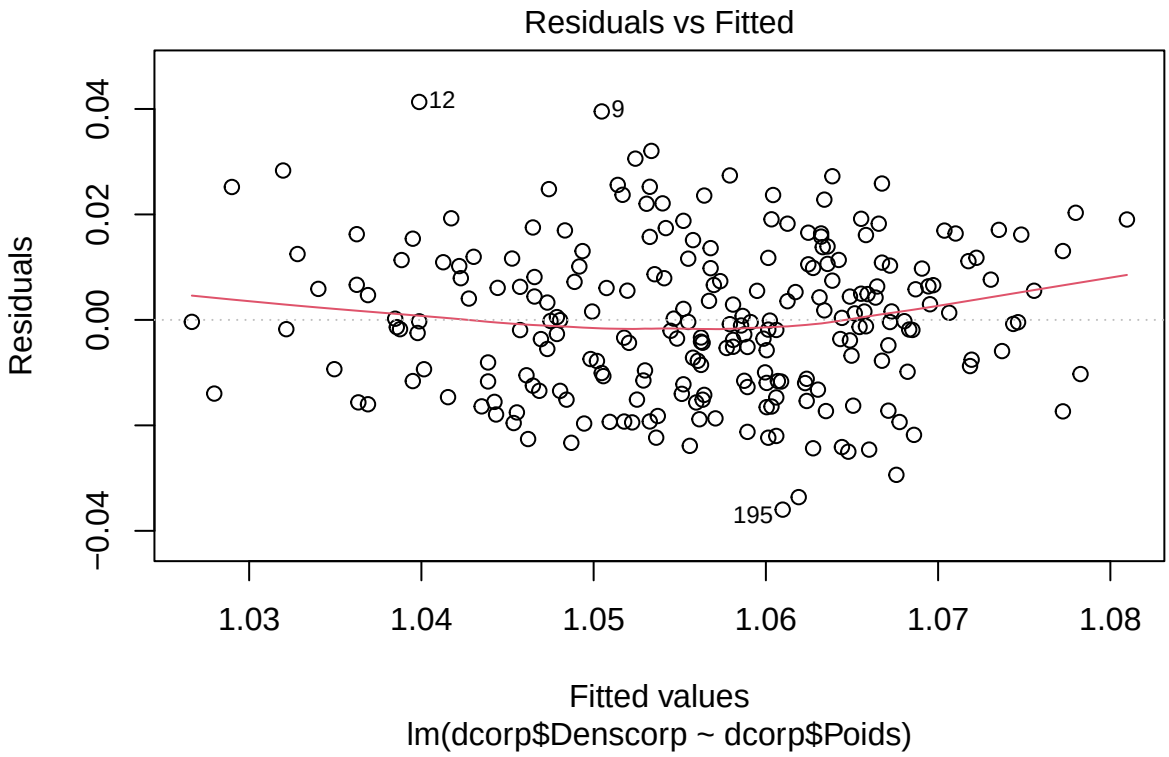
```
summary(modele_1)
```

```
##
## Call:
## lm(formula = dcorp$Denscorp ~ dcorp$Poids)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.035976 -0.011531 -0.000398  0.010272  0.041327
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.131e+00  6.539e-03  172.95   <2e-16 ***
## dcorp$Poids -9.296e-04  8.055e-05  -11.54   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01431 on 236 degrees of freedom
## Multiple R-squared:  0.3608, Adjusted R-squared:  0.3581
## F-statistic: 133.2 on 1 and 236 DF,  p-value: < 2.2e-16
```

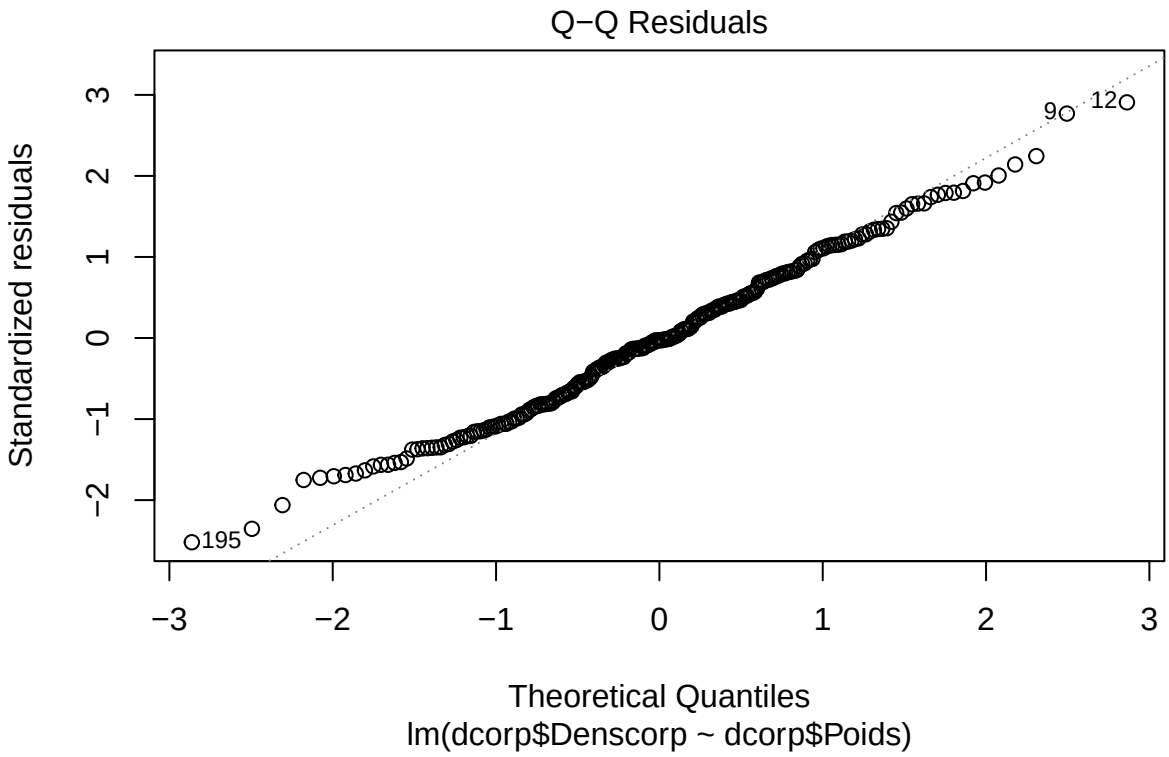
```
#Graphique 13
plot(x=dcorp$Poids,y=dcorp$Denscorp)
abline(modele_1,col='red')#droite de régression
text(60,1.02,paste("Equation de la droite\ny =",
                   round(modele_1$coefficients[2],3),"x+",
                   round(modele_1$coefficients[1],3)),col="red") # Afficher l'équation de la droite
```




```
#Valider le modèle

#Graphique 14 Hypothèse de linéarité du modele
plot(modele_1, which = 1)
```



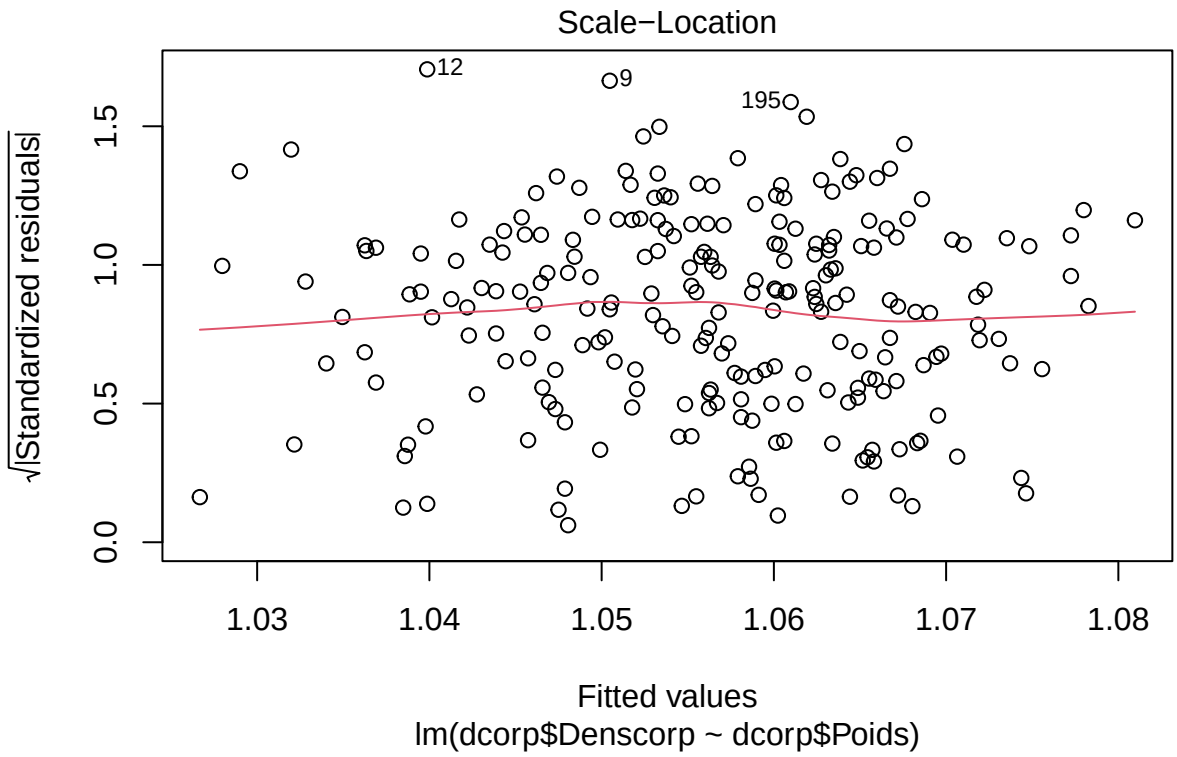

```
#Graphique 15 Hypothèse de normalité de distribution des résidus
plot(modele_1, which = 2)
```



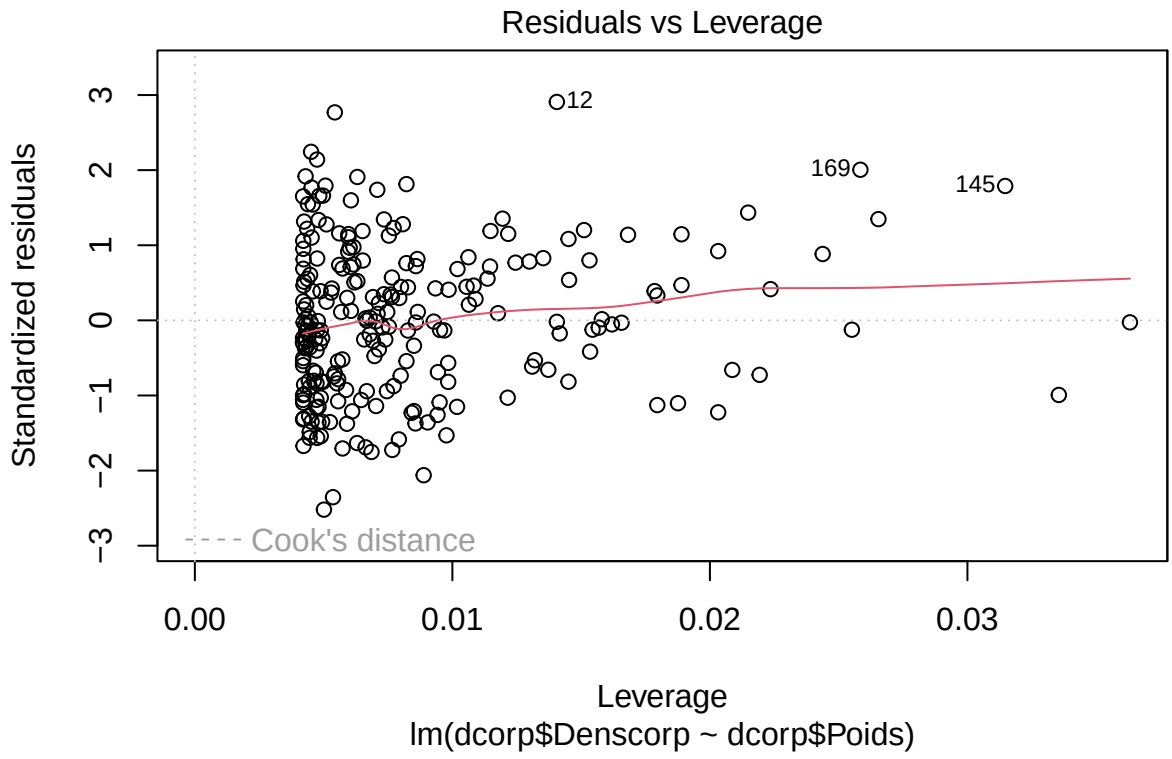

```
shapiro.test(modele_1$residuals)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  modele_1$residuals
## W = 0.99255, p-value = 0.275
```

```
#Graphique 16 Hypothèse d'homogénéité de la dispersion des résidus
plot(modele_1, which = 3)
```




```
#Graphique 17
plot(modele_1, which = 5)
```




```
which(abs(rstandard(modele_1))>2)# résidus extrêmes
```

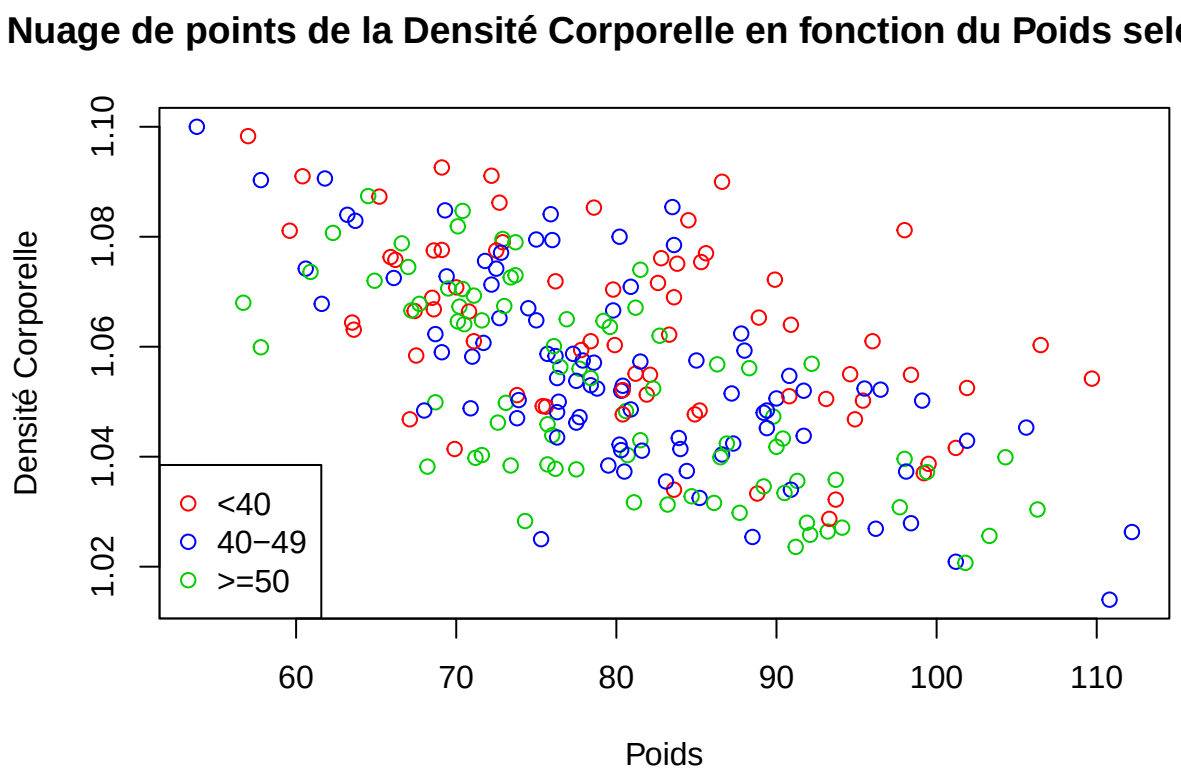
```
##   9  11  12  76  77 169 193 195
##   9  11  12  76  77 169 193 195
```

```
#hypothèse d'indépendance des résidus
Box.test(modele_1$residuals,type='Ljung')
```

```
##
##  Box-Ljung test
##
## data:  modele_1$residuals
## X-squared = 18.505, df = 1, p-value = 1.695e-05
```

```
#D.
dcorp$Age = factor(dcorp$Age, levels = c("<40", "40-49", ">=50"))

# Graphique 18

couleurAGE = c('red','blue','green3')
coulAGE = ifelse(dcorp$Age==levels(dcorp$Age)[1], couleurAGE[1],
ifelse(dcorp$Age==levels(dcorp$Age)[2], couleurAGE[2], couleurAGE[3]))
plot(x=dcorp$Poids,y=dcorp$Denscorp, col=coulAGE,xlab="Poids",
     ylab="Densité Corporelle",
```

```
    main="Nuage de points de la Densité Corporelle en fonction du Poids selon l'Age")
legend('bottomleft', legend=c(levels(dcorp$Age)[1],levels(dcorp$Age)[2],levels(dcorp$Age)[3]),col=coule
```



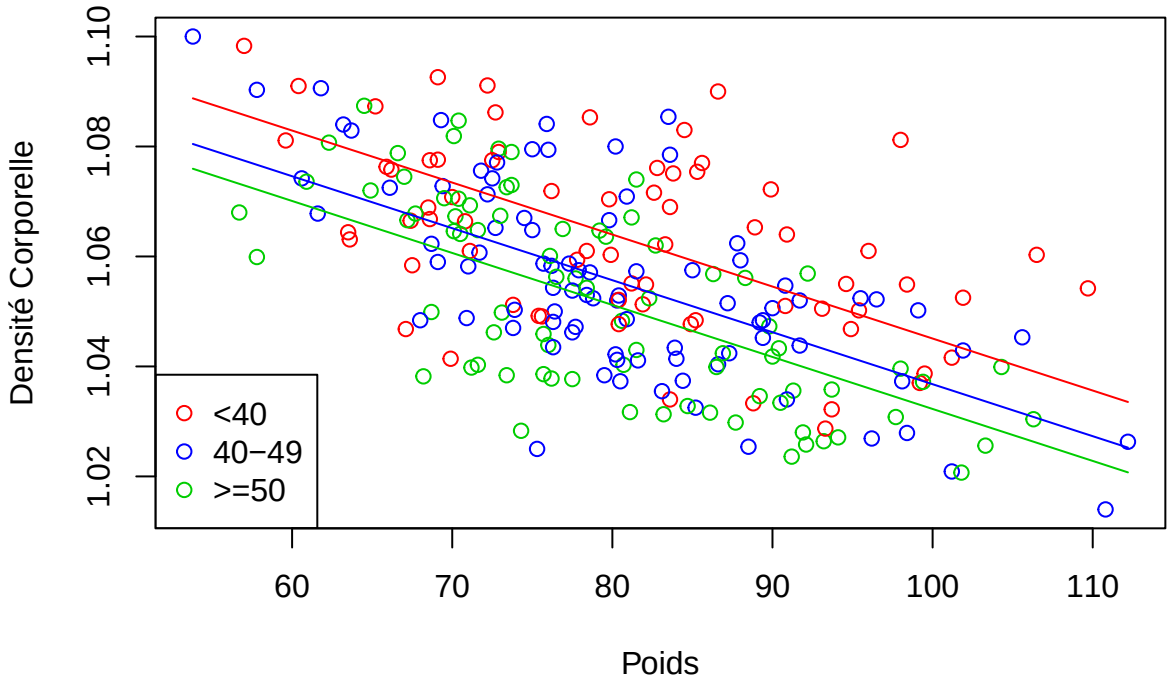

```
#D.2

mod2a <- lm(dcorp$Denscorp ~ dcorp$Poids+dcorp$Age) # modèle (2.a) additif
mod2b <- lm(dcorp$Denscorp ~ dcorp$Poids*dcorp$Age) # modèle (2.b) multiplicatif
mod2c <- lm(dcorp$Denscorp ~ dcorp$Poids*dcorp$Age-dcorp$Age) # modèle (2.c)
```

```
#Coeffs modele 2a

data.frame(mod2a$coef)
```

```
##                     mod2a.coef
## (Intercept)      1.1396326776
## dcorp$Poids     -0.0009455735
## dcorp$Age40-49 -0.0083040635
## dcorp$Age>=50  -0.0128045610
```

```
#Graphique 19
plot(x=dcorp$Poids,y=dcorp$Denscorp, col=coulAGE,xlab="Poids",ylab="Densité Corporelle")
legend('bottomleft', legend=c(levels(dcorp$Age)[1],
                              levels(dcorp$Age)[2],
                              levels(dcorp$Age)[3]),
```

```
       col=couleurAGE, pch=1)

#droites estimées modèle (2a)
curve(mod2a$coef[1]+mod2a$coef[2]*x, col=couleurAGE[1], add=T) # Age niveau 1 "<40"
curve(sum(mod2a$coef[c(1,3)])+mod2a$coef[2]*x, col=couleurAGE[2], add=T) # Age niveau 2, "40-49"
curve(sum(mod2a$coef[c(1,4)])+mod2a$coef[2]*x, col=couleurAGE[3], add=T) # Age niveau 3, ">=50"
```



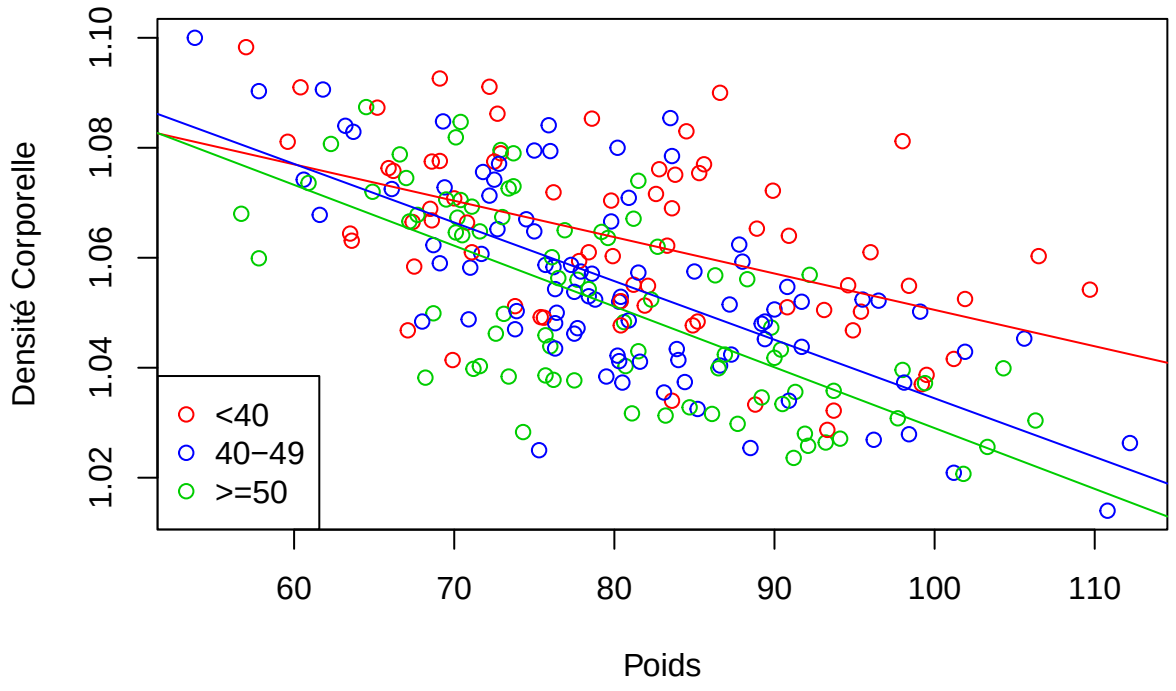

```
sigma(mod2a)^2
```

```
## [1] 0.0001799719
```

```
#Coefficientss modele 2b

data.frame(mod2b$coef)
```

```
##                                 mod2b.coef
## (Intercept)                  1.1166786487
## dcorp$Poids                 -0.0006615593
## dcorp$Age40-49               0.0243370561
## dcorp$Age>=50                0.0229118246
## dcorp$Poids:dcorp$Age40-49 -0.0004042184
## dcorp$Poids:dcorp$Age>=50  -0.0004441316
```

```r
#Graphique 20

plot(x=dcorp$Poids,y=dcorp$Denscorp, col=coulAGE,
     xlab="Poids",
     ylab="Densité Corporelle")
legend('bottomleft', legend=c(levels(dcorp$Age)[1],
                              levels(dcorp$Age)[2],
                              levels(dcorp$Age)[3]),
       col=couleurAGE, pch=1)

#droites estimées modèle (2b)
for(i in 1:nlevels(dcorp$Age)) {
  abline(lm(dcorp$Denscorp[dcorp$Age==levels(dcorp$Age)[i]] ~
  dcorp$Poids[dcorp$Age==levels(dcorp$Age)[i]])$coef, col=couleurAGE[i], lty=1)
}
```




```r
sigma(mod2b)^2
```

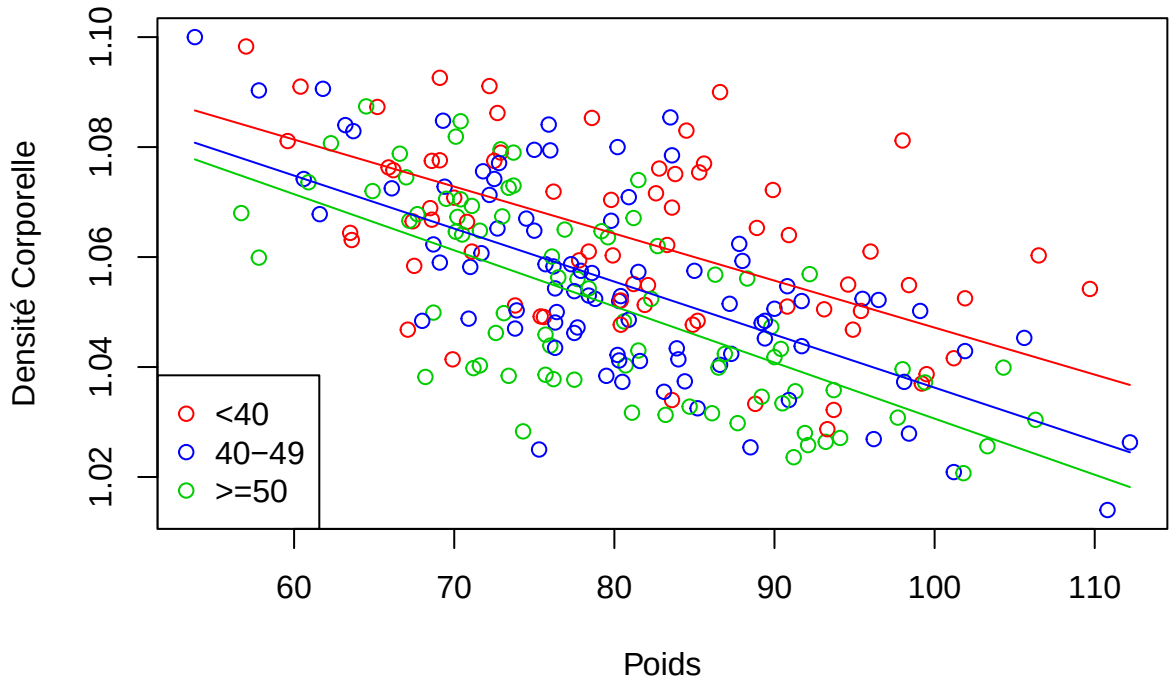
```
## [1] 0.0001761201
```

```r
#Coefficients modele 2c

data.frame(mod2c$coef)
```

```
##                                mod2c.coef
```

```
## (Intercept)                  1.1326571960
## dcorp$Poids                 -0.0008548835
## dcorp$Poids:dcorp$Age40-49 -0.0001091600
## dcorp$Poids:dcorp$Age>=50  -0.0001655025
```

```r
#Graphique 21

plot(x=dcorp$Poids,y=dcorp$Denscorp, col=coulAGE,
     xlab="Poids",
     ylab="Densité Corporelle")
legend('bottomleft', legend=c(levels(dcorp$Age)[1],
                              levels(dcorp$Age)[2],
                              levels(dcorp$Age)[3]),
       col=couleurAGE, pch=1)

#droites estimées modèle (2c)
curve(mod2c$coef[1]+mod2c$coef[2]*x, col=couleurAGE[1], add=T) # Age niveau 1 "<40"
curve(mod2c$coef[1]+sum(mod2c$coef[c(2,3)])*x, col=couleurAGE[2], add=T) # Age niveau 2, "40-49"
curve(mod2c$coef[1]+sum(mod2c$coef[c(2,4)])*x, col=couleurAGE[3], add=T) # Age niveau 3, ">=50"
```




```r
sigma(mod2c)^2
```

```
## [1] 0.0001771274
```

```r
#Comparaison 2A vs 2B
anova(mod2b)
```

```
## Analysis of Variance Table
##
## Response: dcorp$Denscorp
##                         Df   Sum Sq   Mean Sq  F value    Pr(>F)
## dcorp$Poids              1 0.027287 0.0272874 154.9362 < 2.2e-16 ***
## dcorp$Age                2 0.006234 0.0031169  17.6973 7.029e-08 ***
## dcorp$Poids:dcorp$Age    2 0.001254 0.0006268   3.5588   0.03004 *
## Residuals              232 0.040860 0.0001761
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
anova(mod2a, mod2b)
```

```
## Analysis of Variance Table
##
## Model 1: dcorp$Denscorp ~ dcorp$Poids + dcorp$Age
## Model 2: dcorp$Denscorp ~ dcorp$Poids * dcorp$Age
##   Res.Df      RSS Df Sum of Sq      F  Pr(>F)
## 1    234 0.042113
## 2    232 0.040860  2 0.0012536 3.5588 0.03004 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#comparaison 2C vs 2B
anova(mod2c, mod2b)
```

```
## Analysis of Variance Table
##
## Model 1: dcorp$Denscorp ~ dcorp$Poids * dcorp$Age - dcorp$Age
## Model 2: dcorp$Denscorp ~ dcorp$Poids * dcorp$Age
##   Res.Df      RSS Df  Sum of Sq      F Pr(>F)
## 1    234 0.041448
## 2    232 0.040860  2 0.00058794 1.6692 0.1907
```

```r
#Comparaison 2A vs 2C
summary(mod2a)$r.squared; summary(mod2c)$r.squared
```

```
## [1] 0.4431983
```

```
## [1] 0.4519988
```

```r
#R^2 des trois modèles
summary(mod2a)$r.squared; summary(mod2b)$r.squared; summary(mod2c)$r.squared
```

```
## [1] 0.4431983
```

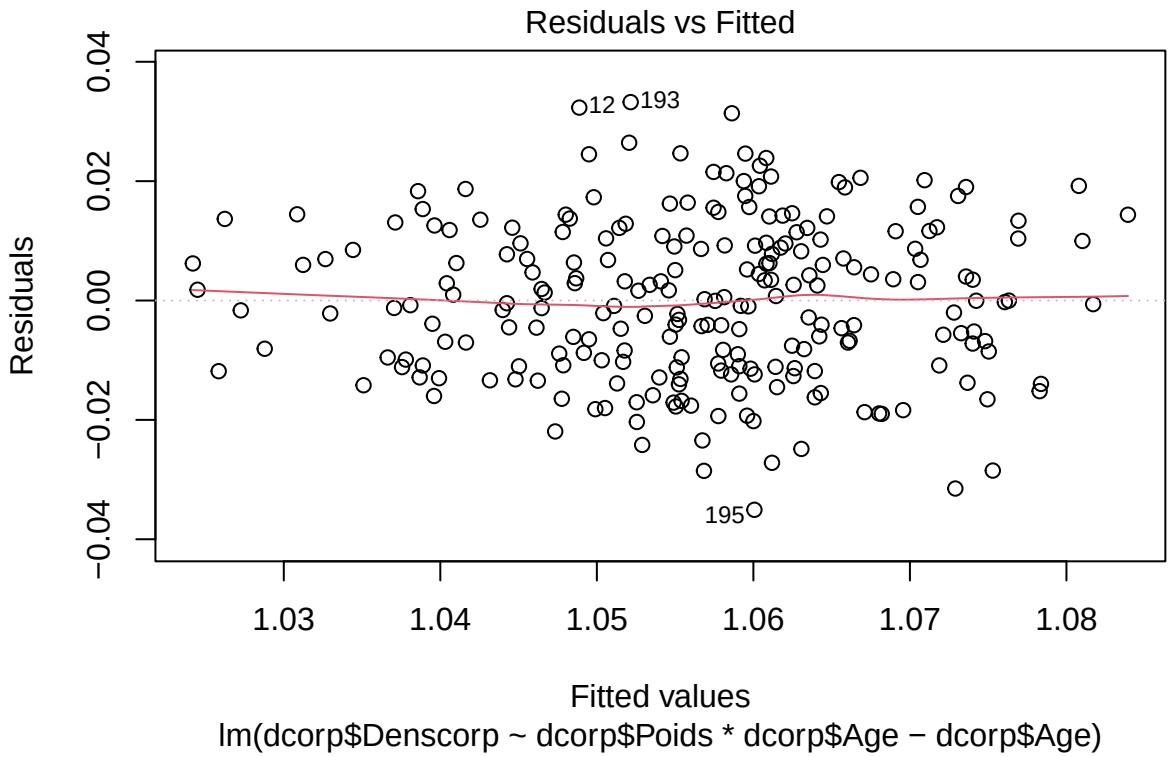
```
## [1] 0.4597723
```

```
## [1] 0.4519988
```

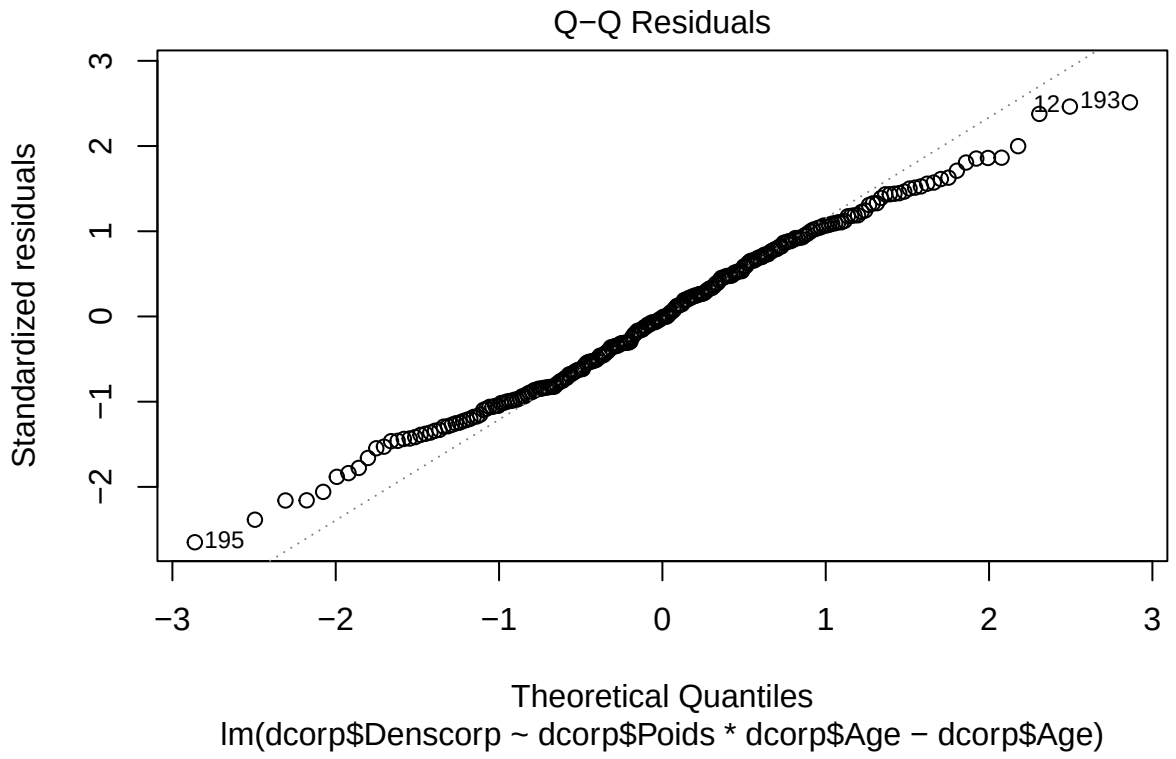
```
#D.6
#Comparaison modele 1 et modele 2
anova(modele_1, mod2c)
```

```
## Analysis of Variance Table
##
## Model 1: dcorp$Denscorp ~ dcorp$Poids
## Model 2: dcorp$Denscorp ~ dcorp$Poids * dcorp$Age - dcorp$Age
##   Res.Df      RSS Df Sum of Sq      F    Pr(>F)
## 1    236 0.048347
## 2    234 0.041448  2 0.0068993 19.476 1.501e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#Vérifier le modèle

#Graphique 22 Hypothèse de linéarité du modele
plot(mod2c, which = 1)
```



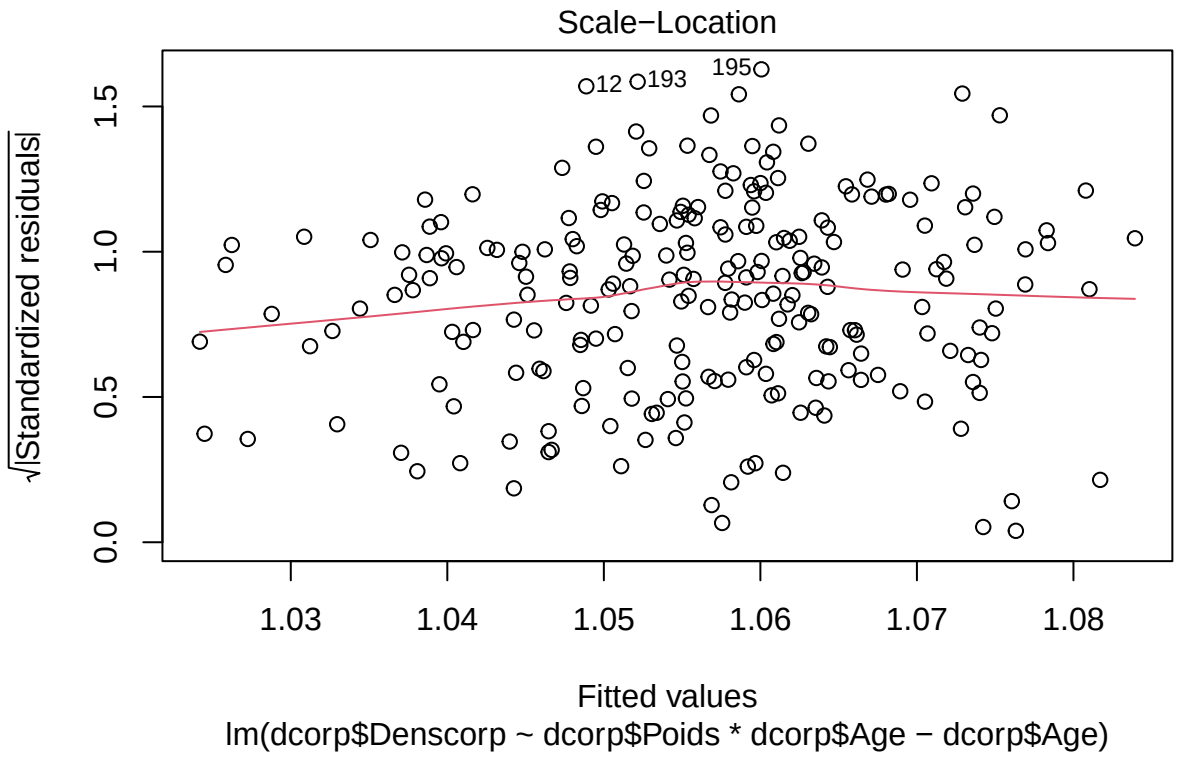

```
#Graphique 23 Hypothèse de normalité de distribution des résidus
plot(mod2c, which = 2)
```



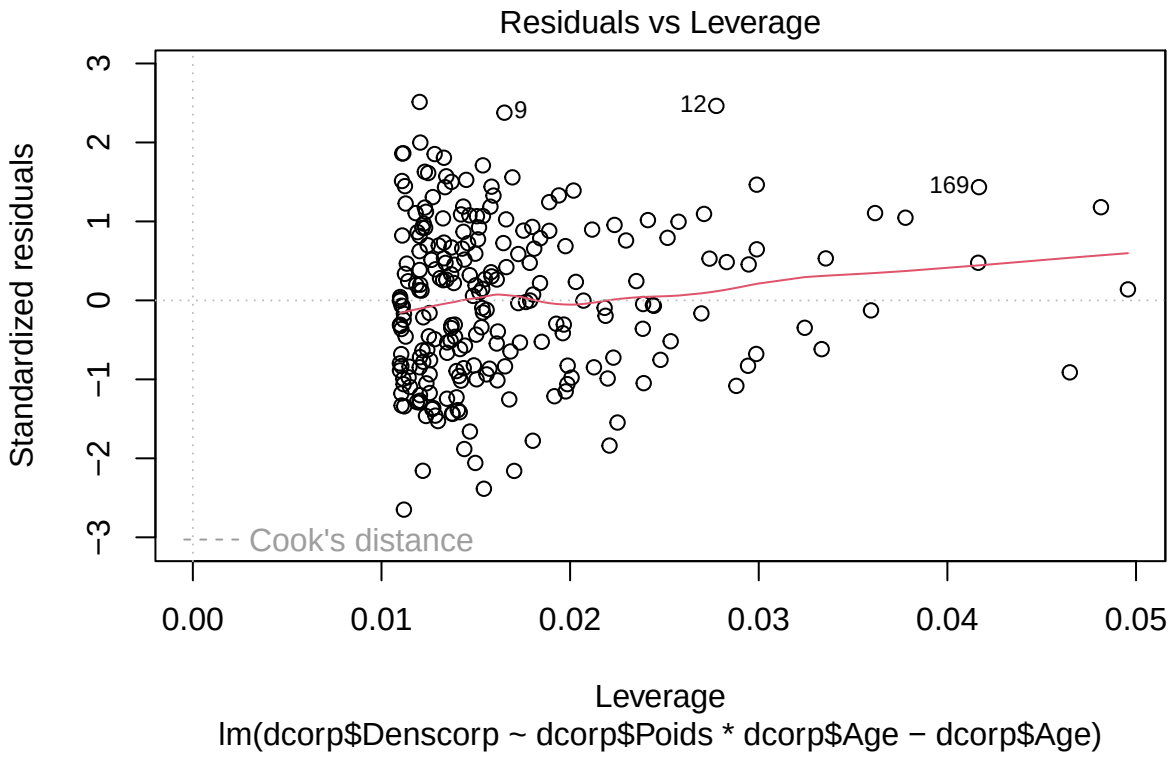

```
shapiro.test(mod2c$residuals)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  mod2c$residuals
## W = 0.99216, p-value = 0.2366
```

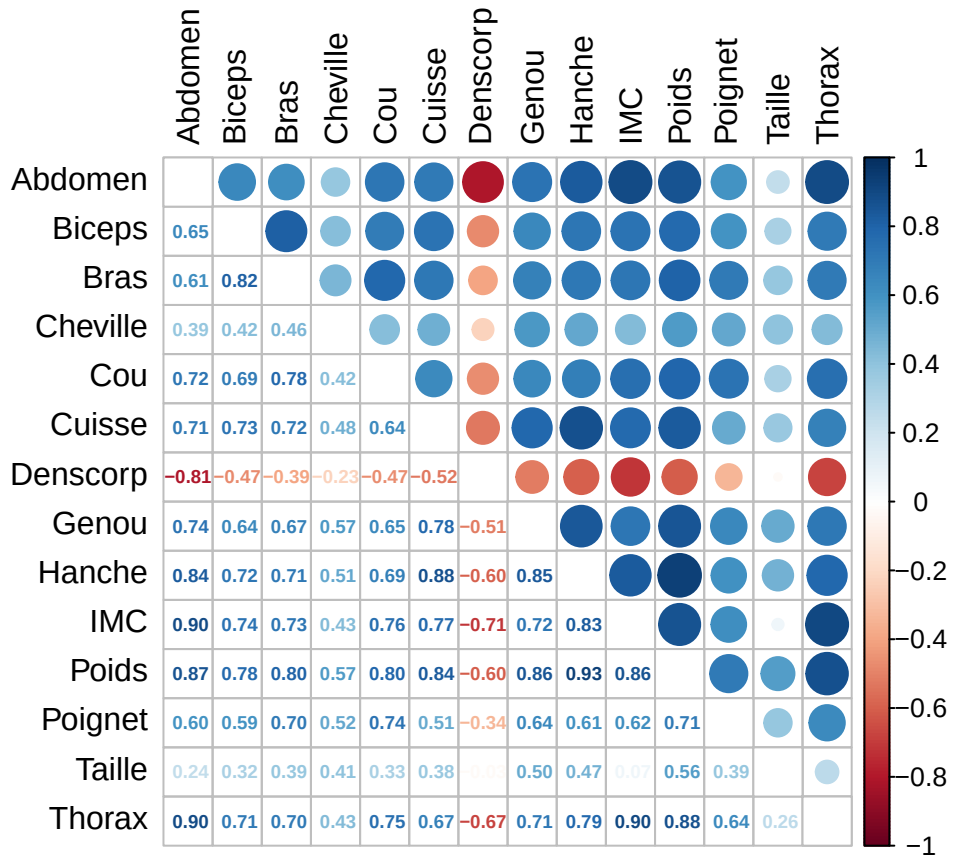
```
#Graphique 24 Hypothèse d'homogénéité de la dispersion des résidus
plot(mod2c, which = 3)
```




```r
#Graphique 25
plot(mod2c, which = 5)
```




```r
#E.
library("corrplot")
corr = cor(dcorp[, unlist(lapply(dcorp,is.numeric))])
corrplot.mixed(corr, tl.col='black', number.cex = .6, tl.pos='lt', tl.cex=1, order="alphabet")
```

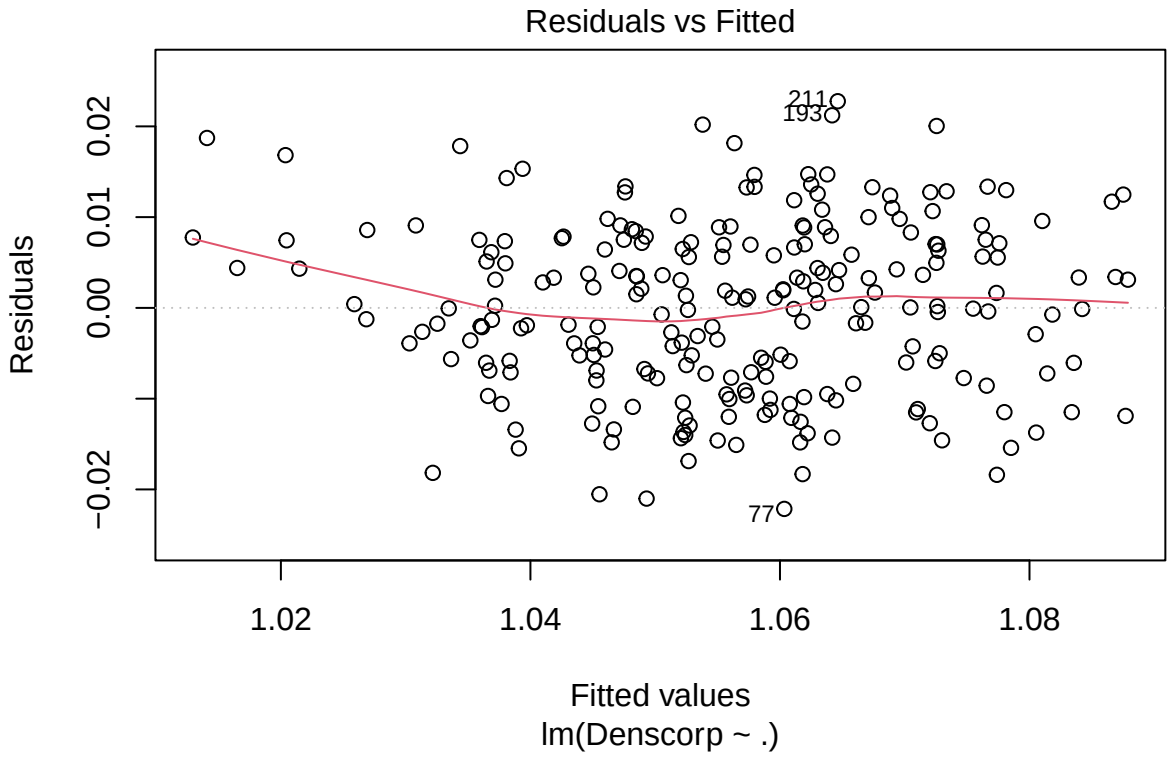


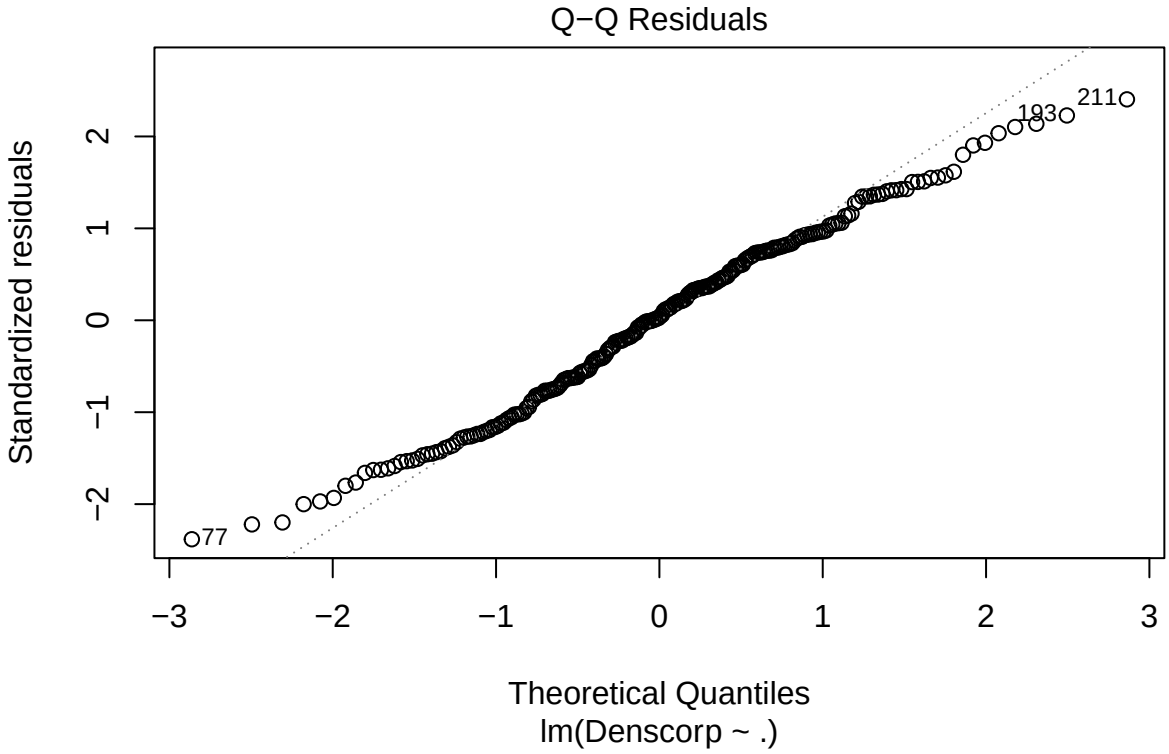

```
#F

#F.1

mod3 = lm(data=dcorp, Denscorp ~ .)

#F.2

summary(mod3)
```

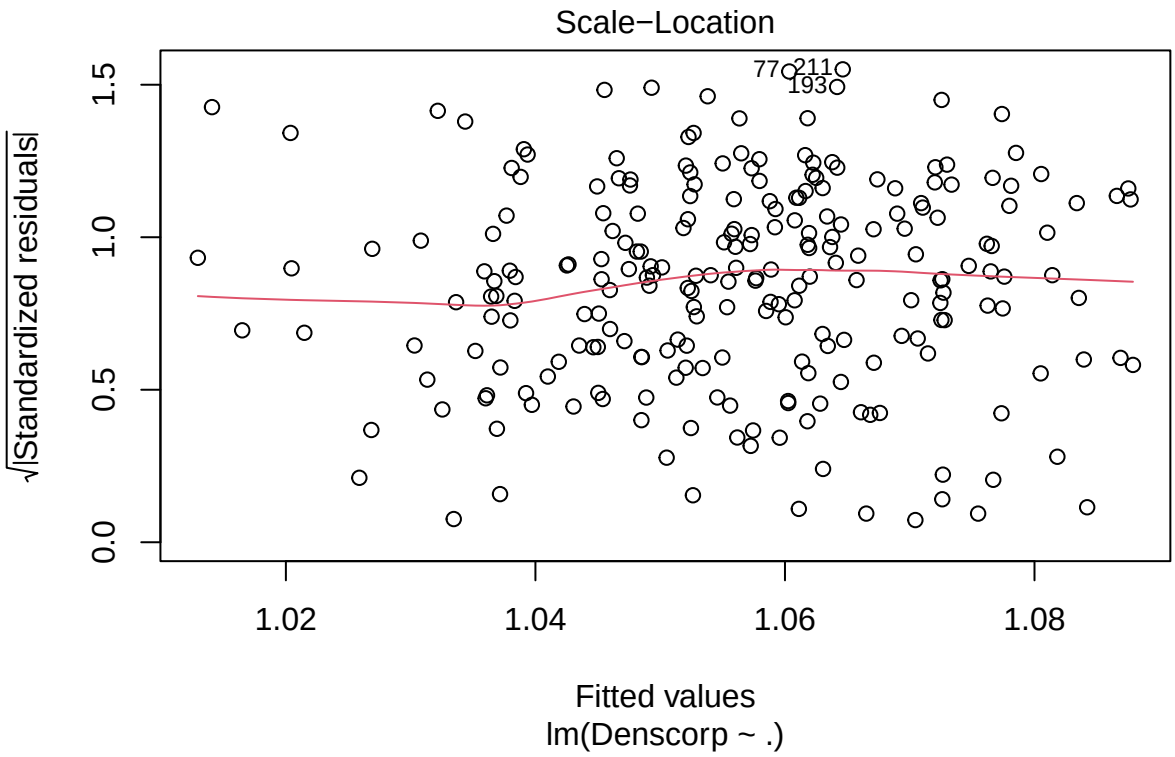
```
##
## Call:
## lm(formula = Denscorp ~ ., data = dcorp)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0221461 -0.0071901  0.0003248  0.0071546  0.0227690
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.361e+00  1.455e-01   9.355   <2e-16 ***
## Age40-49    -3.430e-03  1.690e-03  -2.030   0.0436 *
## Age>=50     -3.537e-03  2.184e-03  -1.619   0.1068
## Poids        1.766e-03  9.060e-04   1.949   0.0526 .
## Taille      -1.386e-03  8.108e-04  -1.710   0.0887 .
## Cou          9.062e-04  6.029e-04   1.503   0.1342
```

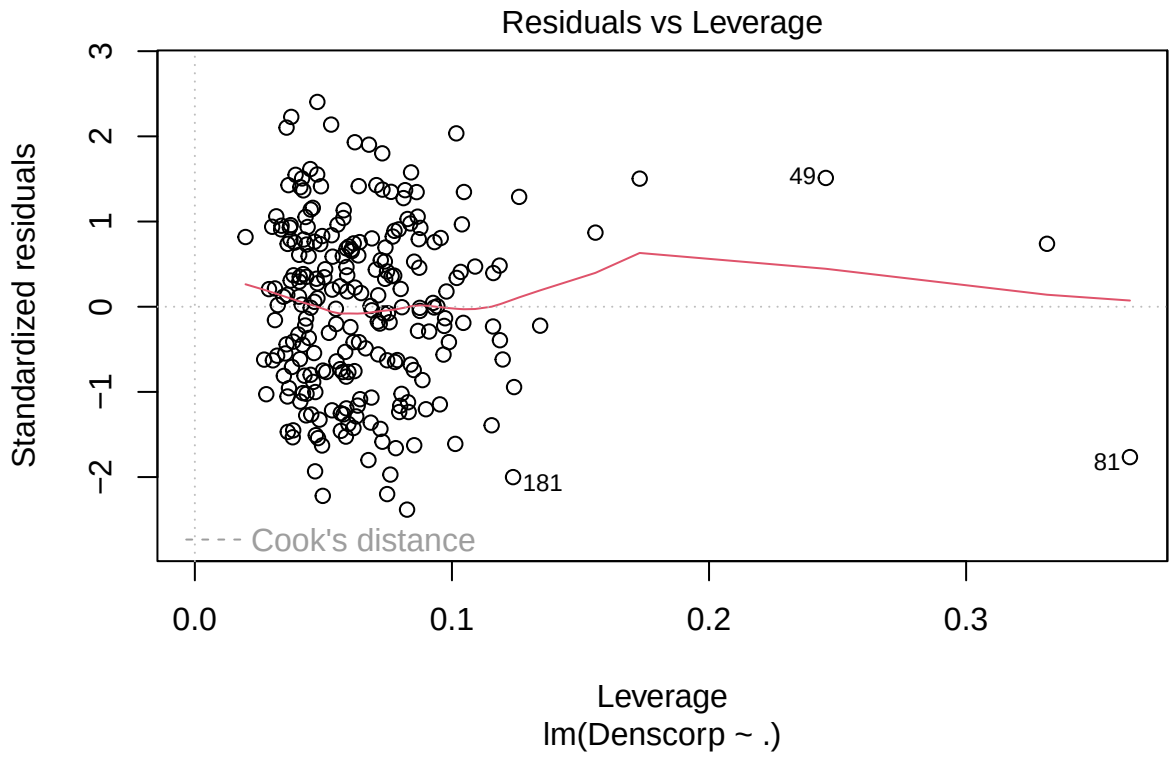
```
## Thorax       3.892e-04  2.639e-04   1.475   0.1417
## Abdomen     -2.041e-03  2.161e-04  -9.445   <2e-16 ***
## Hanche       6.263e-04  3.809e-04   1.644   0.1016
## Cuisse      -3.998e-04  3.457e-04  -1.157   0.2486
## Genou       -6.422e-06  6.094e-04  -0.011   0.9916
## Cheville    -3.012e-04  5.125e-04  -0.588   0.5573
## Biceps      -4.872e-04  4.278e-04  -1.139   0.2560
## Bras        -9.137e-05  8.166e-04  -0.112   0.9110
## Poignet      3.124e-03  1.332e-03   2.346   0.0199 *
## IMC         -6.070e-03  2.963e-03  -2.049   0.0417 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.009706 on 222 degrees of freedom
## Multiple R-squared:  0.7235, Adjusted R-squared:  0.7048
## F-statistic: 38.72 on 15 and 222 DF,  p-value: < 2.2e-16
```

```
plot(mod3)
```




Q−Q Residuals
Standardized residuals
Theoretical Quantiles
lm(Denscorp ~ .)
77
193
211
−3
−2
−1
0
1
2
3


Scale−Location
77
211
193
√|Standardized residuals|
0.0
0.5
1.0
1.5
1.02
1.04
1.06
1.08
Fitted values
lm(Denscorp ~ .)




```
head(model.matrix(mod3))
```

```
##   (Intercept) Age40-49 Age>=50 Poids Taille  Cou Thorax Abdomen Hanche Cuisse
## 1           1        0       0  70.0  172.1 36.2   93.1    85.2   94.5   59.0
## 2           1        0       0  78.6  183.5 38.5   93.6    83.0   98.7   58.7
## 3           1        0       0  69.9  168.3 34.0   95.8    87.9   99.2   59.6
## 4           1        0       0  83.8  183.5 37.4  101.8    86.4  101.2   60.1
## 5           1        0       0  83.6  181.0 34.4   97.3   100.0  101.9   63.2
## 6           1        0       0  95.4  189.9 39.0  104.5    94.4  107.8   66.0
##   Genou Cheville Biceps Bras Poignet      IMC
## 1  37.3     21.9   32.0 27.4    17.1 23.63395
## 2  37.3     23.4   30.5 28.9    18.2 23.34266
## 3  38.9     24.0   28.8 25.2    16.6 24.67794
## 4  37.3     22.8   32.4 29.4    18.2 24.88696
## 5  42.2     24.0   32.2 27.7    17.7 25.51815
## 6  42.0     25.6   35.7 30.6    18.8 26.45443
```

```
anova(lm(data=dcorp,Denscorp ~ 1), mod3) # comparaison modèle nul au modèle 3
```

```
## Analysis of Variance Table
##
## Model 1: Denscorp ~ 1
## Model 2: Denscorp ~ Age + Poids + Taille + Cou + Thorax + Abdomen + Hanche +
##     Cuisse + Genou + Cheville + Biceps + Bras + Poignet + IMC
##   Res.Df      RSS Df Sum of Sq      F    Pr(>F)
```

```
## 1    237 0.075635
## 2    222 0.020914 15   0.05472 38.723 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#F.3
drop1(mod3, test='F')
```

```
## Single term deletions
##
## Model:
## Denscorp ~ Age + Poids + Taille + Cou + Thorax + Abdomen + Hanche +
##     Cuisse + Genou + Cheville + Biceps + Bras + Poignet + IMC
##          Df Sum of Sq      RSS     AIC F value  Pr(>F)
## <none>                0.020914 -2190.8
## Age       2 0.0004175 0.021332 -2190.1  2.2159 0.11146
## Poids     1 0.0003577 0.021272 -2188.8  3.7974 0.05259 .
## Taille    1 0.0002754 0.021190 -2189.7  2.9232 0.08871 .
## Cou       1 0.0002129 0.021127 -2190.4  2.2595 0.13422
## Thorax    1 0.0002049 0.021119 -2190.5  2.1753 0.14166
## Abdomen   1 0.0084037 0.029318 -2112.4 89.2028 < 2e-16 ***
## Hanche    1 0.0002546 0.021169 -2189.9  2.7029 0.10158
## Cuisse    1 0.0001261 0.021040 -2191.4  1.3380 0.24862
## Genou     1 0.0000000 0.020914 -2192.8  0.0001 0.99160
## Cheville  1 0.0000325 0.020947 -2192.4  0.3454 0.55733
## Biceps    1 0.0001222 0.021036 -2191.4  1.2968 0.25602
## Bras      1 0.0000012 0.020916 -2192.8  0.0125 0.91102
## Poignet   1 0.0005184 0.021433 -2187.0  5.5029 0.01987 *
## IMC       1 0.0003953 0.021310 -2188.4  4.1965 0.04168 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
modele_1
```

```
##
## Call:
## lm(formula = dcorp$Denscorp ~ dcorp$Poids)
##
## Coefficients:
## (Intercept)  dcorp$Poids
##   1.1309786   -0.0009297
```

```
summary(mod3)
```

```
##
## Call:
## lm(formula = Denscorp ~ ., data = dcorp)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0221461 -0.0071901  0.0003248  0.0071546  0.0227690
##
```

```
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.361e+00  1.455e-01   9.355   <2e-16 ***
## Age40-49    -3.430e-03  1.690e-03  -2.030   0.0436 *
## Age>=50     -3.537e-03  2.184e-03  -1.619   0.1068
## Poids        1.766e-03  9.060e-04   1.949   0.0526 .
## Taille      -1.386e-03  8.108e-04  -1.710   0.0887 .
## Cou          9.062e-04  6.029e-04   1.503   0.1342
## Thorax       3.892e-04  2.639e-04   1.475   0.1417
## Abdomen     -2.041e-03  2.161e-04  -9.445   <2e-16 ***
## Hanche       6.263e-04  3.809e-04   1.644   0.1016
## Cuisse      -3.998e-04  3.457e-04  -1.157   0.2486
## Genou       -6.422e-06  6.094e-04  -0.011   0.9916
## Cheville    -3.012e-04  5.125e-04  -0.588   0.5573
## Biceps      -4.872e-04  4.278e-04  -1.139   0.2560
## Bras        -9.137e-05  8.166e-04  -0.112   0.9110
## Poignet      3.124e-03  1.332e-03   2.346   0.0199 *
## IMC         -6.070e-03  2.963e-03  -2.049   0.0417 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.009706 on 222 degrees of freedom
## Multiple R-squared:  0.7235, Adjusted R-squared:  0.7048
## F-statistic: 38.72 on 15 and 222 DF,  p-value: < 2.2e-16
```

```r
#G.1

#Procédure de recherche pas à pas mixte pour minimiser le critère d'information d'Akaike AIC

stAIC = step(mod3, direction="both", trace=0)
summary(stAIC)
```

```
##
## Call:
## lm(formula = Denscorp ~ Age + Poids + Taille + Thorax + Abdomen +
##     Poignet + IMC, data = dcorp)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0196078 -0.0069774  0.0008089  0.0069788  0.0219543
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.3689221  0.1429174   9.578  < 2e-16 ***
## Age40-49    -0.0036384  0.0016525  -2.202  0.02868 *
## Age>=50     -0.0029962  0.0020432  -1.466  0.14390
## Poids        0.0017505  0.0008870   1.974  0.04963 *
## Taille      -0.0012704  0.0008009  -1.586  0.11406
## Thorax       0.0003515  0.0002360   1.489  0.13777
## Abdomen     -0.0018871  0.0001925  -9.804  < 2e-16 ***
## Poignet      0.0033736  0.0011639   2.899  0.00411 **
## IMC         -0.0058638  0.0028984  -2.023  0.04423 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Residual standard error: 0.009711 on 229 degrees of freedom
## Multiple R-squared:  0.7145, Adjusted R-squared:  0.7045
## F-statistic: 71.63 on 8 and 229 DF,  p-value: < 2.2e-16
```

```
AIC(stAIC)
```

```
## [1] -1519.787
```

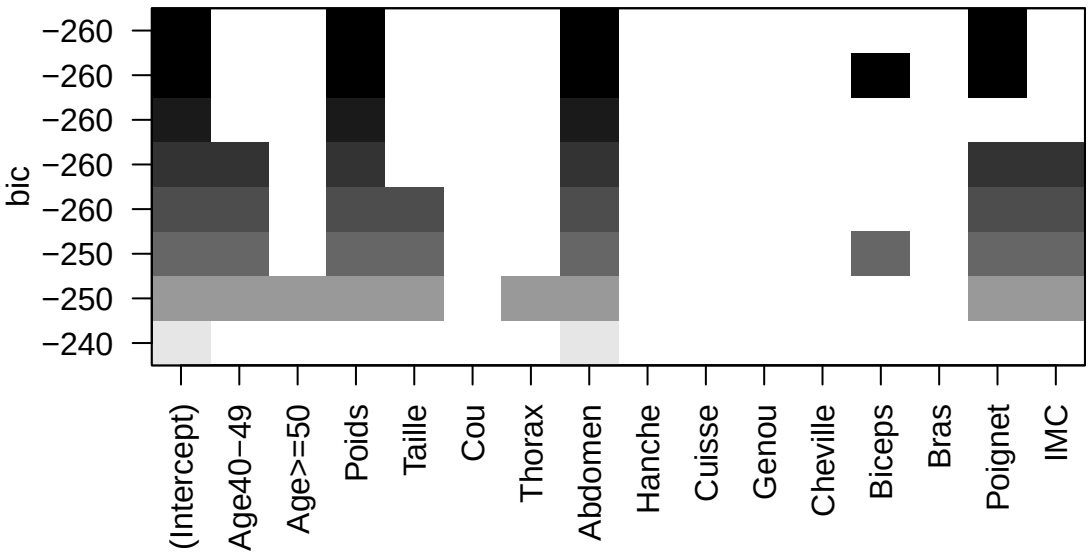
```
#Procédure de recherche pas à pas mixte pour minimiser le critère d'information bayésien

stBIC = step(mod3, direction="both", trace=0, k=log(nrow(dcorp)))
summary(stBIC)
```

```
##
## Call:
## lm(formula = Denscorp ~ Poids + Abdomen + Poignet, data = dcorp)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.021964 -0.007385  0.000700  0.007363  0.022358
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.1629668  0.0162564  71.539  < 2e-16 ***
## Poids        0.0004406  0.0001252   3.519  0.00052 ***
## Abdomen     -0.0021380  0.0001342 -15.927  < 2e-16 ***
## Poignet      0.0029814  0.0010540   2.829  0.00508 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.009841 on 234 degrees of freedom
## Multiple R-squared:  0.7004, Adjusted R-squared:  0.6965
## F-statistic: 182.3 on 3 and 234 DF,  p-value: < 2.2e-16
```

```
BIC(stBIC)
```

```
## [1] -1500.952
```

```
#Procédure de recherche exhaustive pour minimiser le critère d'information bayésien

library(leaps)
selection=regsubsets(Denscorp ~ .,data=dcorp)
plot(selection, main="Critère BIC")
```




```
with(summary(selection),data.frame(outmat,
                                   BIC=round(bic,1),
                                   R2.adj=round(adjr2,4),
                                   Cp=round(cp,1)))
```

```
##          Age40.49 Age..50 Poids Taille Cou Thorax Abdomen Hanche Cuisse Genou
## 1  ( 1 )                                                  *
## 2  ( 1 )                    *                             *
## 3  ( 1 )                    *                             *
## 4  ( 1 )                    *                             *
## 5  ( 1 )        *           *                             *
## 6  ( 1 )        *           *      *                      *
## 7  ( 1 )        *           *      *                      *
## 8  ( 1 )        *       *   *      *          *           *
##          Cheville Biceps Bras Poignet IMC    BIC R2.adj   Cp
## 1  ( 1 )                                  -240.1 0.6502 45.7
## 2  ( 1 )                                  -262.4 0.6875 16.8
## 3  ( 1 )                           *      -265.0 0.6965 10.5
## 4  ( 1 )              *            *      -262.6 0.6992  9.4
## 5  ( 1 )                           *    * -259.4 0.7008  9.1
## 6  ( 1 )                           *    * -256.3 0.7024  8.9
## 7  ( 1 )              *            *    * -252.6 0.7033  9.1
## 8  ( 1 )                           *    * -249.1 0.7045  9.2
```

```r
selBIC = lm(Denscorp ~ Poids + Abdomen + Poignet,data=dcorp)#modele qui minise BIC dans le tableau
BIC(selBIC)
```

```
## [1] -1500.952
```

```r
mod4 = selBIC
summary(mod4)
```

```
##
## Call:
## lm(formula = Denscorp ~ Poids + Abdomen + Poignet, data = dcorp)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.021964 -0.007385  0.000700  0.007363  0.022358
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.1629668  0.0162564  71.539  < 2e-16 ***
## Poids        0.0004406  0.0001252   3.519  0.00052 ***
## Abdomen     -0.0021380  0.0001342 -15.927  < 2e-16 ***
## Poignet      0.0029814  0.0010540   2.829  0.00508 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.009841 on 234 degrees of freedom
## Multiple R-squared:  0.7004, Adjusted R-squared:  0.6965
## F-statistic: 182.3 on 3 and 234 DF,  p-value: < 2.2e-16
```

```r
summary(dcorp)
```

```
##     Denscorp        Age         Poids            Taille           Cou
##  Min.   :1.014   <40  :70   Min.   : 53.80   Min.   :162.6   Min.   :32.80
##  1st Qu.:1.042   40-49:88   1st Qu.: 71.90   1st Qu.:173.6   1st Qu.:36.40
##  Median :1.055   >=50 :80   Median : 79.70   Median :178.4   Median :37.90
##  Mean   :1.056              Mean   : 80.36   Mean   :178.7   Mean   :37.92
##  3rd Qu.:1.070              3rd Qu.: 88.45   3rd Qu.:183.5   3rd Qu.:39.38
##  Max.   :1.100              Max.   :112.20   Max.   :196.8   Max.   :43.90
##      Thorax          Abdomen           Hanche           Cuisse
##  Min.   : 79.30   Min.   : 69.40   Min.   : 85.00   Min.   :47.20
##  1st Qu.: 94.45   1st Qu.: 84.53   1st Qu.: 95.50   1st Qu.:56.02
##  Median : 99.60   Median : 90.80   Median : 99.20   Median :58.90
##  Mean   :100.32   Mean   : 91.86   Mean   : 99.36   Mean   :59.12
##  3rd Qu.:104.78   3rd Qu.: 98.75   3rd Qu.:102.67   3rd Qu.:62.05
##  Max.   :121.60   Max.   :118.00   Max.   :116.10   Max.   :72.90
##      Genou          Cheville         Biceps           Bras
##  Min.   :33.40   Min.   :19.10   Min.   :24.80   Min.   :24.60
##  1st Qu.:37.02   1st Qu.:22.00   1st Qu.:30.20   1st Qu.:27.30
##  Median :38.40   Median :22.75   Median :31.95   Median :28.70
##  Mean   :38.53   Mean   :23.06   Mean   :32.21   Mean   :28.69
##  3rd Qu.:39.80   3rd Qu.:23.90   3rd Qu.:34.08   3rd Qu.:30.00
##  Max.   :46.00   Max.   :33.90   Max.   :39.10   Max.   :33.80
```

```
##     Poignet           IMC
##  Min.   :16.30   Min.   :18.04
##  1st Qu.:17.60   1st Qu.:23.05
##  Median :18.25   Median :24.90
##  Mean   :18.21   Mean   :25.12
##  3rd Qu.:18.80   3rd Qu.:27.11
##  Max.   :20.90   Max.   :33.86
```

```
#Nouvel Individu
pred_frame = data.frame(Age="<40", Poids=65, Taille=173, Cou=32,
Thorax=80, Abdomen=70, Hanche=87, Cuisse=50,
Genou=35, Cheville=20, Biceps=22, Bras=24, Poignet=16,
IMC=21.7)
predict = predict(mod4, pred_frame, interval='prediction')
predict
```

```
##        fit      lwr     upr
## 1 1.089648 1.069706 1.10959
```

```
(predict[3]-predict[2])/2 #précision au niveau 95%
```

```
## [1] 0.01994197
```

```
#Nouvel Individu +10 Abdomen
pred_frame_2 = data.frame(Age="<40", Poids=65, Taille=173, Cou=32,
Thorax=80, Abdomen=80, Hanche=87, Cuisse=50,
Genou=35, Cheville=20, Biceps=22, Bras=24, Poignet=16,
IMC=21.7)
predict = predict(mod4, pred_frame_2, interval='prediction')
predict
```

```
##        fit      lwr      upr
## 1 1.068268 1.048547 1.087988
```

```
(predict[3]-predict[2])/2 #précision au niveau 95%
```

```
## [1] 0.01972038
```