

# Catchup Growth Models

```
knitr::opts_chunk$set(echo = TRUE)

library(tidyverse) # great collection of packages for data carpentry, modelling, and visualization

## -- Attaching packages ----- tidyverse 1.3.0 --

## v ggplot2 3.3.3      v purrr 0.3.4
## v tibble 3.0.6       v dplyr 1.0.4
## v tidyr 1.1.2        v stringr 1.4.0
## v readr 1.4.0        v forcats 0.5.1

## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()

library(readr)
library(haven) # package for loading Stata's .dta files.
library(sjlabelled) # good for renaming, changing classes, etc. in the piped dplyr mode

##
## Attaching package: 'sjlabelled'

## The following objects are masked from 'package:haven':
##
##   as_factor, read_sas, read_spss, read_stata, write_sas, zap_labels
##
## The following object is masked from 'package:forcats':
##
##   as_factor
##
## The following object is masked from 'package:dplyr':
##
##   as_label

library(zscorer)
library(lubridate)

##
## Attaching package: 'lubridate'

## The following objects are masked from 'package:base':
##
##   date, intersect, setdiff, union

library(anthro)
library(childsds)
library(sjlabelled)
library(sjPlot)
# library(VIF) # another VIF package we won't use.
library(car)

## Loading required package: carData
```

```
## Registered S3 methods overwritten by 'car':
##   method                      from
##   influence.merMod             lme4
##   cooks.distance.influence.merMod lme4
##   dfbeta.influence.merMod      lme4
##   dfbetas.influence.merMod     lme4
##
## Attaching package: 'car'
## The following object is masked from 'package:dplyr':
##
##   recode
## The following object is masked from 'package:purrr':
##
##   some
# install.packages("interactions")
library(interactions)

growth_clocks_data <- read_csv(here::here ("Data/growth_clocks_data.csv"))

## Warning: Missing column names filled in: 'X1' [1]
##
## -- Column specification -----
## cols(
##   .default = col_double(),
##   basebrgy_basewman = col_character(),
##   birthdate = col_date(format = ""),
##   intwdate_birth = col_date(format = ""),
##   date_inf_meas = col_date(format = ""),
##   intwdate91 = col_date(format = ""),
##   intw_date02 = col_date(format = ""),
##   reprostat = col_character(),
##   was_preg_no_na = col_character(),
##   trimester = col_character(),
##   SampleID = col_character(),
##   Comment = col_character(),
##   predictedGender = col_character(),
##   predictedTissue = col_character(),
##   Tissue = col_character()
## )
## i Use `spec()` for the full column specifications.
growth_clocks_data

## # A tibble: 3,023 x 158
##       X1 uncchdid basebrgy_basewman sexchild sex outcome birthdate
##   <dbl>   <dbl> <chr>                <dbl> <dbl>   <dbl> <date>
## 1     1     20001 1_12                  1     NA     1 1983-06-03
## 2     2     20002 1_14                  2     NA     1 1983-05-23
## 3     3     20003 1_21                  2     NA     1 1983-05-13
## 4     4     20004 1_23                  1     1     1 1983-05-19
## 5     5     20006 1_26                  2     NA     1 1983-06-20
## 6     6     20007 1_27                  2     2     1 1983-05-16
## 7     7     20008 1_30                  1     1     1 1983-05-03
```

```
## 8      8      20009 1_32                2      NA      1 1983-05-20
## 9      9      20010 1_33                2      2      1 1983-05-07
## 10    10      20011 1_34                2      NA      1 1983-05-31
## # ... with 3,013 more rows, and 151 more variables: intwdate_birth <date>,
## #   age_days_birthweigh <dbl>, weightak_birth_kg <dbl>, heightcm_birth <dbl>,
## #   date_inf_meas <date>, age_days_infweigh <dbl>, hght_12 <dbl>,
## #   wght_12 <dbl>, intwdate91 <date>, age91_days <dbl>, age_mo_91 <dbl>,
## #   age91_years <dbl>, hightndx_91 <dbl>, weghtndx_91 <dbl>,
## #   intw_date02 <date>, age_days_02 <dbl>, age_years_02 <dbl>,
## #   age_cutoff_02 <dbl>, age_cutoff_02_days <dbl>, height_02 <dbl>,
## #   weight_02 <dbl>, age_05 <dbl>, height_05 <dbl>, height_m_05 <dbl>,
## #   weight_05 <dbl>, bmi_05 <dbl>, hfaz_birth <dbl>, hfaz_inf_12 <dbl>,
## #   hfaz_91 <dbl>, hfaz_02 <dbl>, hfa_diff_birth_inf12 <dbl>,
## #   hfa_diff_inf12_91 <dbl>, hfa_diff_91_02 <dbl>, wfaz_birth <dbl>,
## #   wfaz_inf_12 <dbl>, wfaz_91 <dbl>, wfa_diff_birth_inf12 <dbl>,
## #   wfa_diff_inf12_91 <dbl>, reprostat <chr>, was_preg_no_na <chr>,
## #   trimester <chr>, SampleID <chr>, DNAmAge <dbl>, Comment <chr>,
## #   noMissingPerSample <dbl>, meanMethBySample <dbl>, minMethBySample <dbl>,
## #   maxMethBySample <dbl>, corSampleVSGoldstandard <dbl>,
## #   meanAbsDifferenceSampleVSGoldstandard <dbl>, predictedGender <chr>,
## #   meanXchromosome <dbl>, predictedTissue <chr>,
## #   ProbabilityFrom.X.Vasc.Endoth.Umbilical. <dbl>,
## #   ProbabilityFrom.Ape.WB <dbl>, ProbabilityFrom.Blood.CD4.Tcells <dbl>,
## #   ProbabilityFrom.Blood.CD4.CD14 <dbl>,
## #   ProbabilityFrom.Blood.Cell.Types <dbl>, ProbabilityFrom.Blood.Cord <dbl>,
## #   ProbabilityFrom.Blood.PBMC <dbl>, ProbabilityFrom.Blood.WB <dbl>,
## #   ProbabilityFrom.Bone <dbl>, ProbabilityFrom.Brain.Cerebellar <dbl>,
## #   ProbabilityFrom.Brain.CRBLM <dbl>, ProbabilityFrom.Brain.FCTX <dbl>,
## #   ProbabilityFrom.Brain.Occipital.Cortex <dbl>,
## #   ProbabilityFrom.Brain.PONS <dbl>, ProbabilityFrom.Brain.Prefr.CTX <dbl>,
## #   ProbabilityFrom.Brain.TCTX <dbl>, ProbabilityFrom.Breast <dbl>,
## #   ProbabilityFrom.Breast.NL <dbl>, ProbabilityFrom.Buccal <dbl>,
## #   ProbabilityFrom.Cartilage.Knee <dbl>, ProbabilityFrom.Colon <dbl>,
## #   ProbabilityFrom.Dermal.fibroblast <dbl>, ProbabilityFrom.Epidermis <dbl>,
## #   ProbabilityFrom.Fat.Adip <dbl>, ProbabilityFrom.Gastric <dbl>,
## #   ProbabilityFrom.GlialCell <dbl>, ProbabilityFrom.Head.Neck <dbl>,
## #   ProbabilityFrom.Heart <dbl>, ProbabilityFrom.Kidney <dbl>,
## #   ProbabilityFrom.Liver <dbl>, ProbabilityFrom.Liver. <dbl>,
## #   ProbabilityFrom.Lung <dbl>, ProbabilityFrom.MSC <dbl>,
## #   ProbabilityFrom.Muscle <dbl>, ProbabilityFrom.Neuron <dbl>,
## #   ProbabilityFrom.Placenta <dbl>, ProbabilityFrom.Prostate.NL <dbl>,
## #   ProbabilityFrom.Saliva <dbl>, ProbabilityFrom.Sperm <dbl>,
## #   ProbabilityFrom.Stomach <dbl>, ProbabilityFrom.Thyroid <dbl>,
## #   ProbabilityFrom.Uterine.Cervix <dbl>,
## #   ProbabilityFrom.Uterine.Endomet <dbl>, AgeAccelerationDiff <dbl>,
## #   AgeAccelerationResidual <dbl>, Female <dbl>, Age <dbl>, ...
```

## Birth to 2 years old

```
grim_height_b_2_f<-lm(AgeAccelGrim ~ hfa_diff_birth_inf12 +
                      was_preg_no_na, subset(growth_clocks_data, sex == "2"))
```

```

grim_height_b_2_m<-lm(AgeAccelGrim ~ hfa_diff_birth_inf12, subset(growth_clocks_data, sex == "1"))

pheno_height_b_2_f <-update(grim_height_b_2_f, AgeAccelPheno ~ .)

pheno_height_b_2_m <-update(grim_height_b_2_m, AgeAccelPheno ~ .-was_preg_no_na)

han_height_b_2_f <-update(grim_height_b_2_f, EEAA ~ .)

han_height_b_2_m <-update(grim_height_b_2_m, EEAA ~ . -was_preg_no_na)

horv_height_b_2_f <-update(grim_height_b_2_f, IEAA ~ .)

horv_height_b_2_m <-update(grim_height_b_2_m, IEAA ~ . -was_preg_no_na)

sjPlot::tab_model(grim_height_b_2_f, grim_height_b_2_m,
                  pheno_height_b_2_f, pheno_height_b_2_m,
                  han_height_b_2_f, han_height_b_2_m,
                  horv_height_b_2_f, horv_height_b_2_m)

```

Age Accel Grim

Age Accel Grim

Age Accel Pheno

Age Accel Pheno

EEAA

EEAA

IEAA

IEAA

Predictors

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

p
Estimates
CI
p
Estimates
CI
p
Estimates
CI
p
Estimates
CI
p
(Intercept)
-0.93
-1.39 – -0.48
<0.001
1.80
0.76 – 2.84
0.001
-0.34
-1.29 – 0.61
0.478
-2.19
-4.02 – -0.37
0.019
-0.39
-1.39 – 0.61
0.442
0.33
-1.49 – 2.16
0.719
0.09
-0.50 – 0.68
0.757
1.15

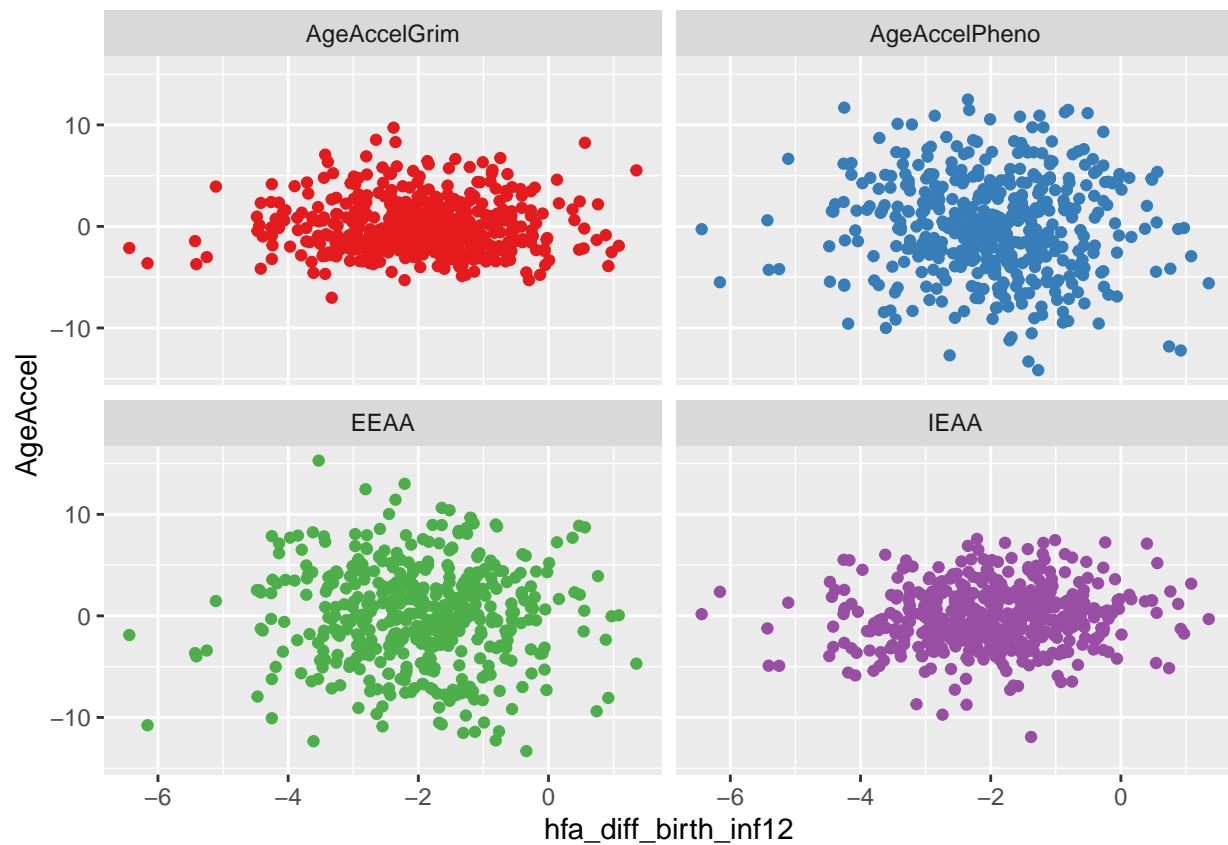
-0.16 – 2.47  
 0.085  
 hfa\_diff\_birth\_inf12  
 -0.04  
 -0.23 – 0.16  
 0.717  
 0.16  
 -0.30 – 0.63  
 0.483  
 -0.04  
 -0.43 – 0.36  
 0.859  
 -0.51  
 -1.33 – 0.30  
 0.214  
 0.01  
 -0.41 – 0.43  
 0.962  
 -0.35  
 -1.17 – 0.47  
 0.397  
 0.09  
 -0.16 – 0.34  
 0.473  
 0.54  
 -0.04 – 1.13  
 0.070  
 was\_preg\_no\_na [Yes]  
 2.79  
 2.20 – 3.39  
 <0.001  
 3.47  
 2.23 – 4.71  
 <0.001  
 0.96  
 -0.34 – 2.26

0.146  
 -0.00  
 -0.77 – 0.77  
 0.995  
 Observations  
 372  
 100  
 372  
 100  
 372  
 100  
 372  
 100  
 R2 / R2 adjusted  
 0.189 / 0.185  
 0.005 / -0.005  
 0.076 / 0.071  
 0.016 / 0.006  
 0.006 / 0.000  
 0.007 / -0.003  
 0.001 / -0.004  
 0.033 / 0.023

```

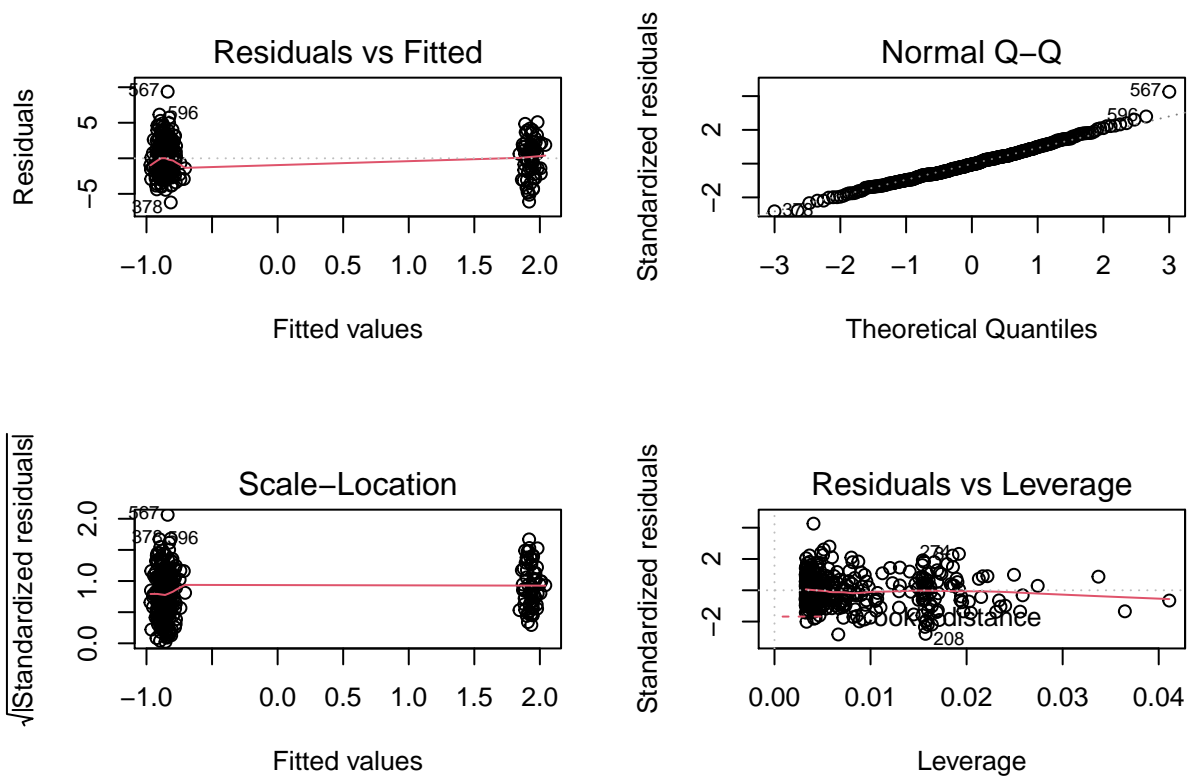
growth_clocks_data %>%
  select(uncchdid, hfa_diff_birth_inf12, AgeAccelGrim, AgeAccelPheno, EEAA, IEAA) %>%
  gather(key = clock_type, value = AgeAccel, -c(1,2)) %>%
  na.omit() %>%
  ggplot(., aes(x = hfa_diff_birth_inf12, y = AgeAccel, col = clock_type))+
  geom_point()+
  scale_color_brewer(type = "qual", palette = 6)+
  facet_wrap(~clock_type)+
  theme(legend.position = "none")

```

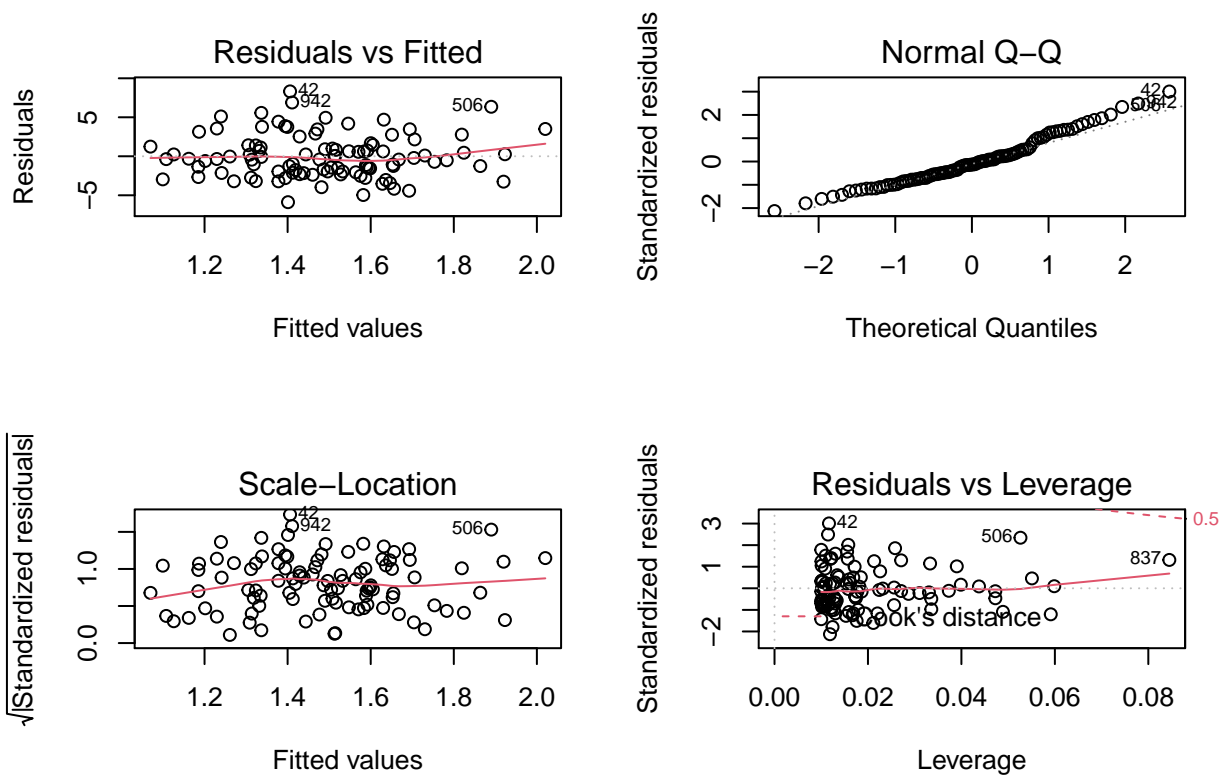


```
#birth-2 yrs old visualization
par(mfrow=c(2,2))
plot(grim_height_b_2_f)
```

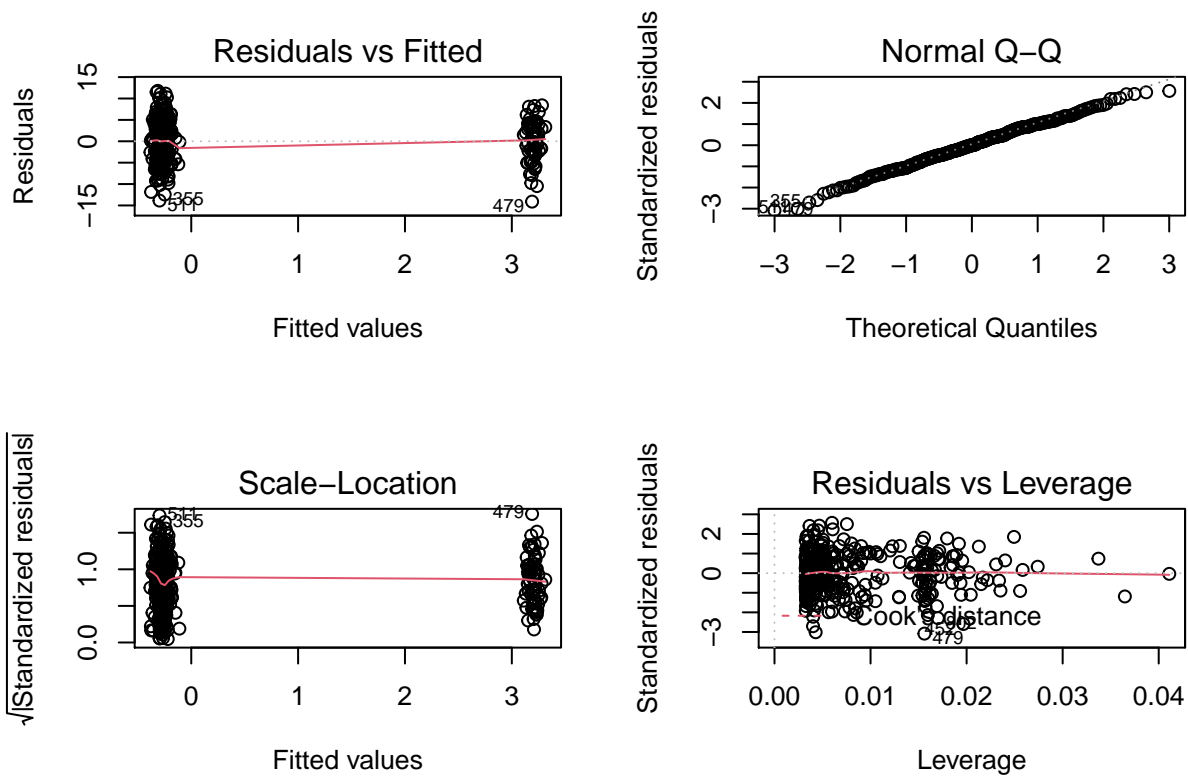




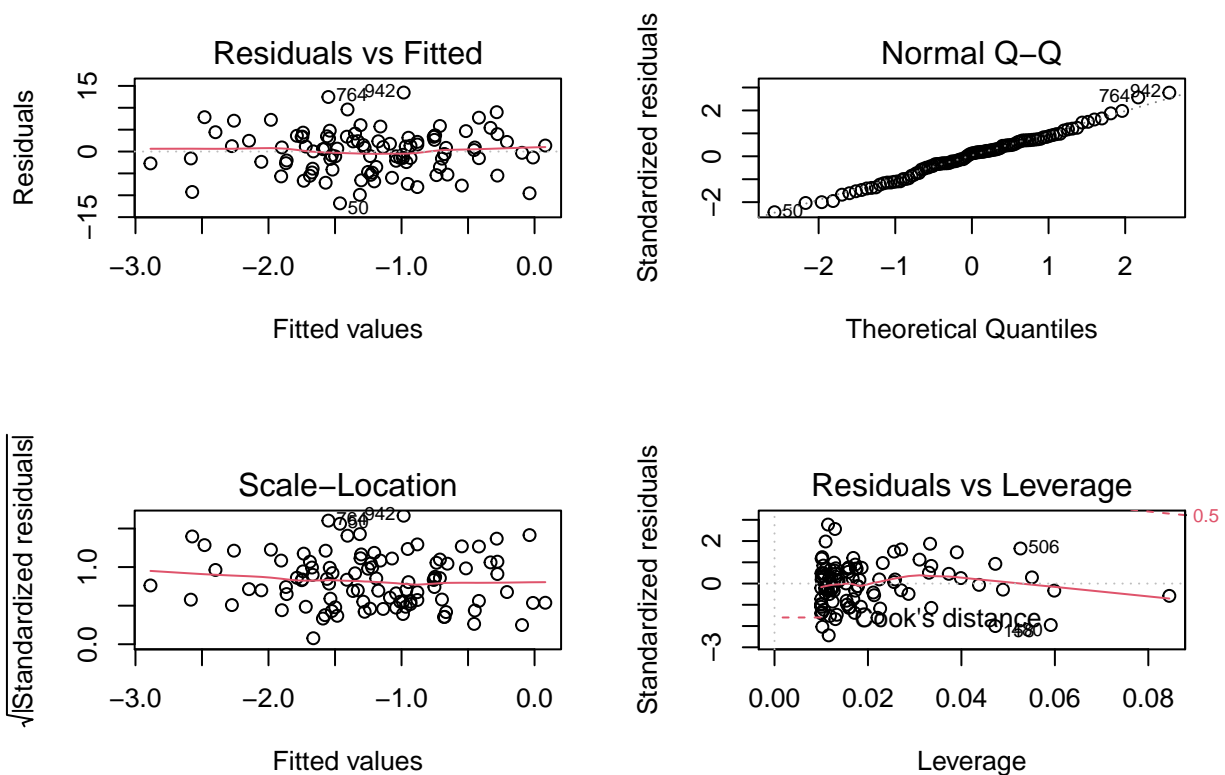
```
par(mfrow=c(2,2))
plot(grim_height_b_2_m)
```



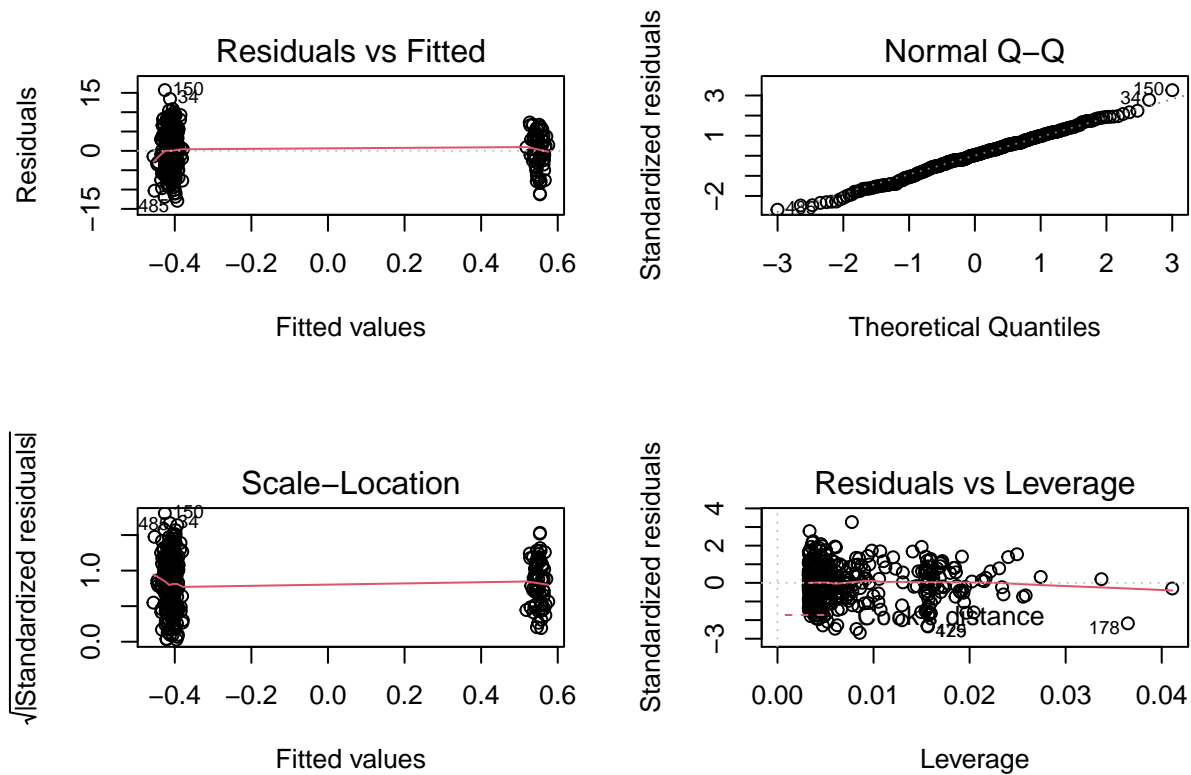
```
par(mfrow=c(2,2))
plot(pheno_height_b_2_f)
```



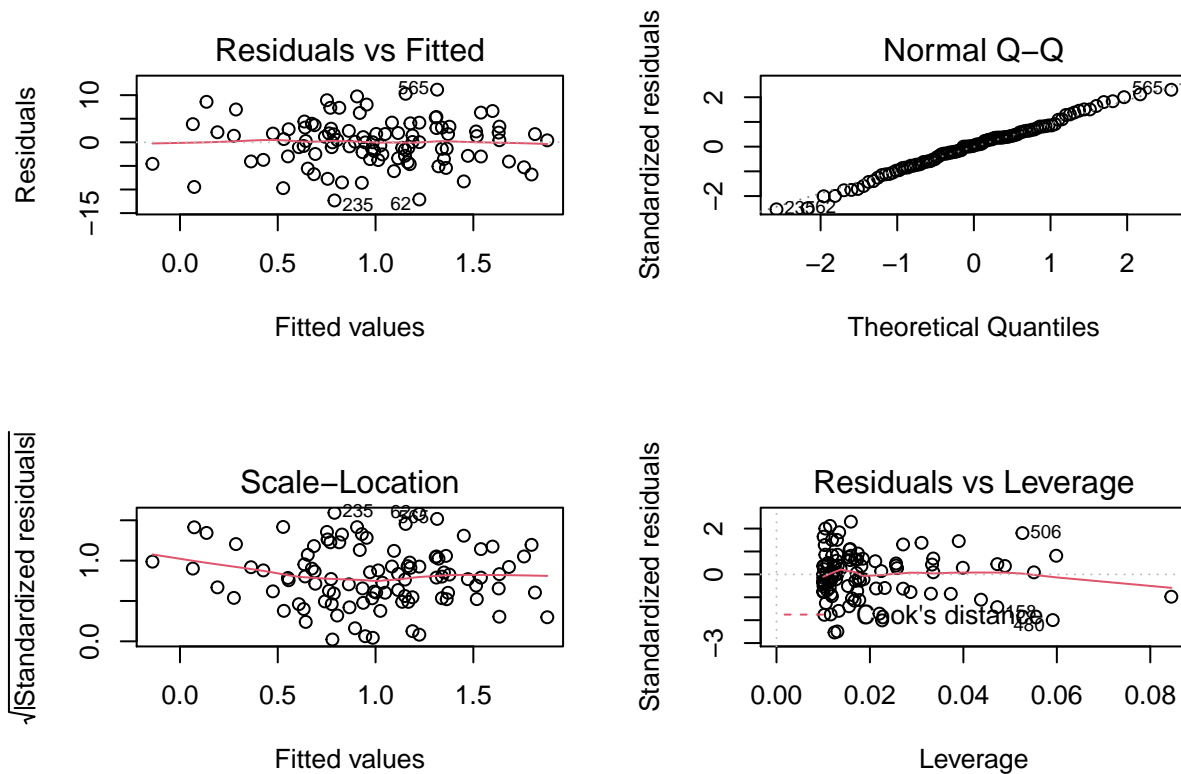
```
par(mfrow=c(2,2))
plot(pheno_height_b_2_m)
```



```
par(mfrow=c(2,2))
plot(han_height_b_2_f)
```



```
par(mfrow=c(2,2))
plot(han_height_b_2_m)
```



```
#hfaz 2years old model
grim_height_83_91_f <-lm(AgeAccelGrim ~ hfa_diff_inf12_91 +
                        hfa_diff_birth_inf12 +
                        was_preg_no_na, subset(growth_clocks_data, sex == "2"))

grim_height_83_91_m<-lm(AgeAccelGrim ~ hfa_diff_inf12_91 +
                        hfa_diff_birth_inf12, subset(growth_clocks_data, sex == "1"))

pheno_height_83_91_f <-update(grim_height_83_91_f, AgeAccelPheno ~ .)

pheno_height_83_91_m <-update(grim_height_83_91_m, AgeAccelPheno ~ .-was_preg_no_na)

han_height_83_91_f <-update(grim_height_83_91_f, EEAA ~ .)

han_height_83_91_m <-update(grim_height_83_91_m, EEAA ~ .-was_preg_no_na)

horv_height_83_91_f <-update(grim_height_83_91_f, IEAA ~ .)

horv_height_83_91_m <-update(grim_height_83_91_m, IEAA ~ .-was_preg_no_na)

sjPlot::tab_model(grim_height_83_91_f, grim_height_83_91_m,
                  pheno_height_83_91_f, pheno_height_83_91_m,
                  han_height_83_91_f, han_height_83_91_m,
                  horv_height_83_91_f, horv_height_83_91_m)
```



-0.89  
 -1.35 – -0.43  
 <0.001  
 1.96  
 0.93 – 2.98  
 <0.001  
 -0.24  
 -1.20 – 0.71  
 0.617  
 -1.86  
 -3.64 – -0.09  
 0.040  
 -0.21  
 -1.21 – 0.78  
 0.672  
 0.71  
 -1.05 – 2.46  
 0.426  
 0.07  
 -0.53 – 0.66  
 0.820  
 1.28  
 -0.04 – 2.60  
 0.056  
 hfa\_diff\_inf12\_91  
 0.16  
 -0.12 – 0.43  
 0.268  
 0.92  
 0.16 – 1.68  
 0.018  
 0.18  
 -0.40 – 0.76  
 0.542  
 1.93  
 0.61 – 3.24

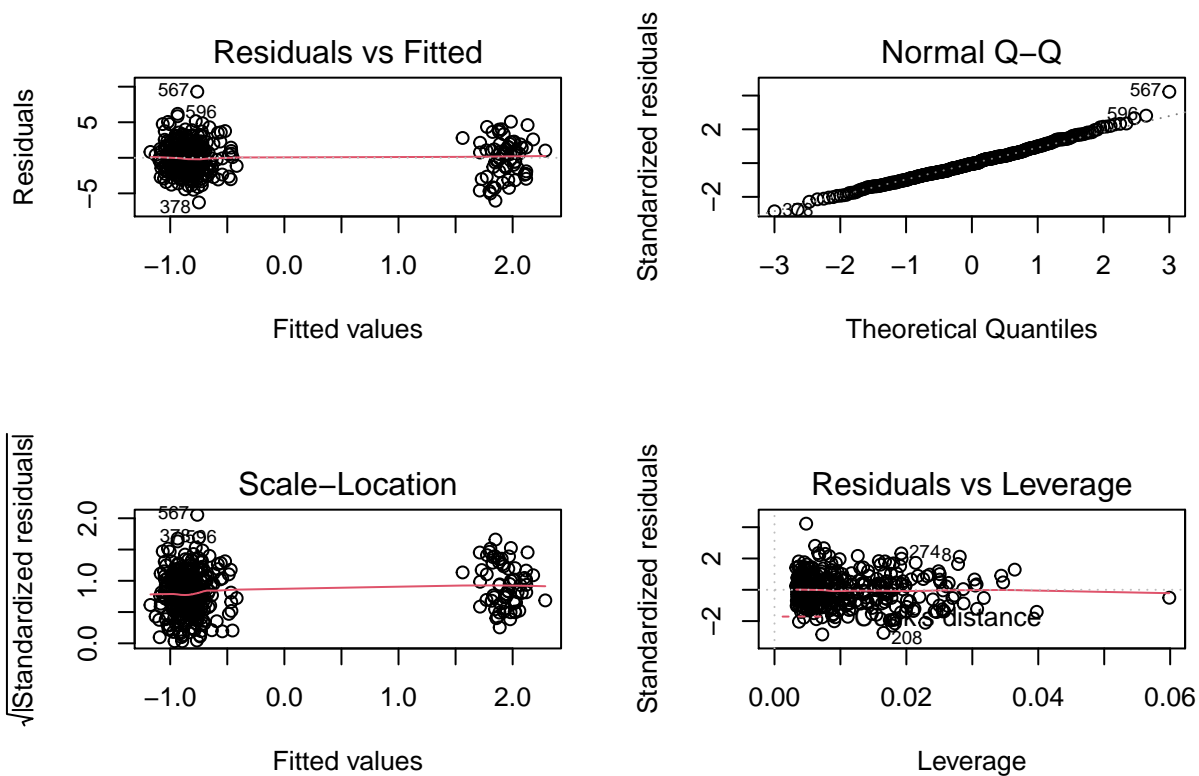
0.004  
 0.52  
 $-0.09 - 1.12$   
 0.093  
 2.19  
 $0.89 - 3.48$   
 0.001  
 $-0.31$   
 $-0.67 - 0.05$   
 0.094  
 0.75  
 $-0.23 - 1.73$   
 0.131  
 hfa\_diff\_birth\_inf12  
 0.01  
 $-0.19 - 0.22$   
 0.898  
 0.41  
 $-0.08 - 0.91$   
 0.103  
 0.03  
 $-0.40 - 0.47$   
 0.876  
 0.01  
 $-0.86 - 0.87$   
 0.989  
 0.18  
 $-0.27 - 0.63$   
 0.433  
 0.24  
 $-0.61 - 1.09$   
 0.576  
 0.01  
 $-0.26 - 0.28$   
 0.953  
 0.75

```

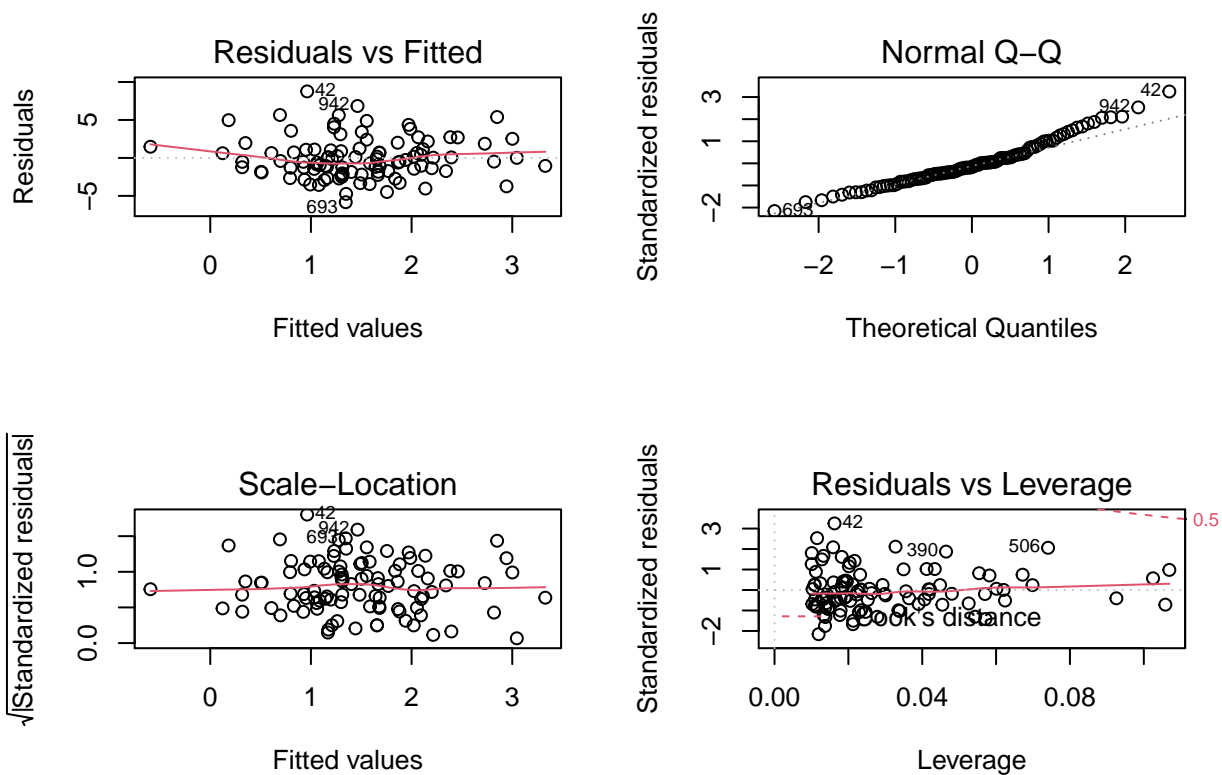
0.11 – 1.39
0.023
was_preg_no_na [Yes]
2.76
2.17 – 3.36
<0.001
3.42
2.18 – 4.66
<0.001
0.85
-0.44 – 2.14
0.196
0.02
-0.75 – 0.79
0.957
Observations
370
100
370
100
370
100
370
100
R2 / R2 adjusted
0.191 / 0.185
0.061 / 0.042
0.076 / 0.069
0.095 / 0.076
0.013 / 0.005
0.110 / 0.092
0.009 / 0.001
0.056 / 0.036
#83-91 visualization
par(mfrow=c(2,2))
plot(grim_height_83_91_f)

```

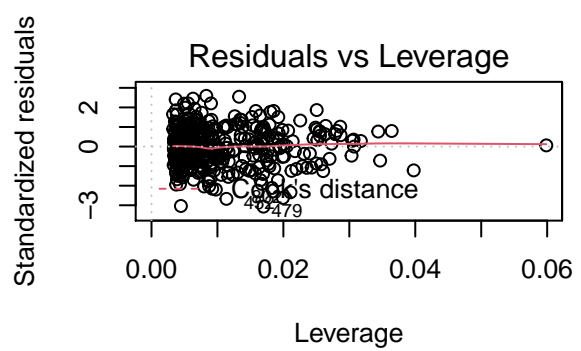
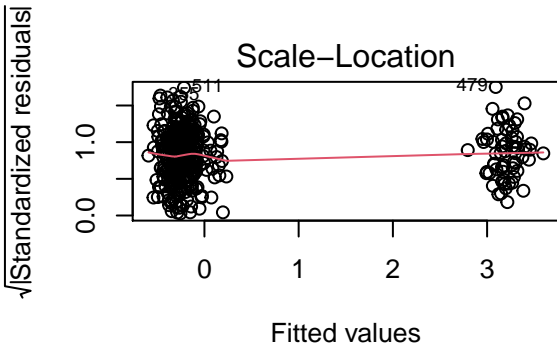
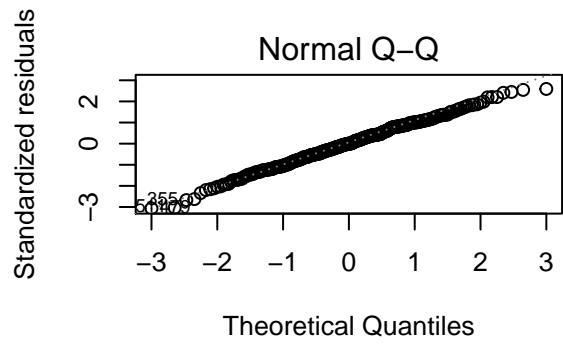
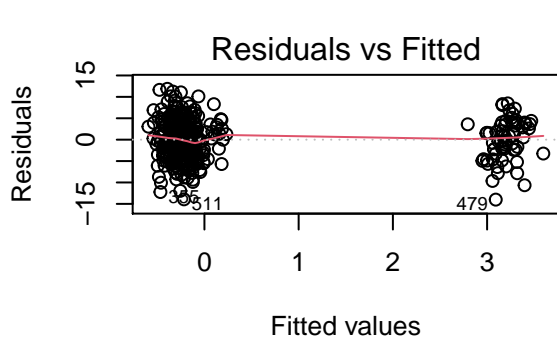




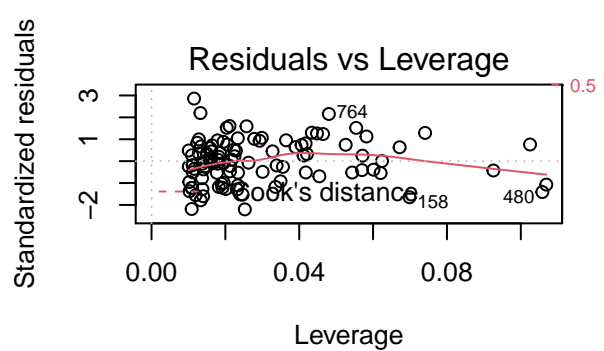
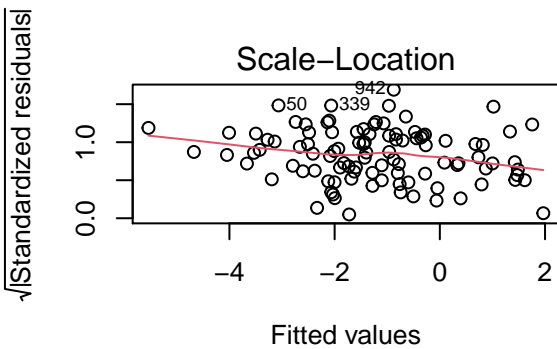
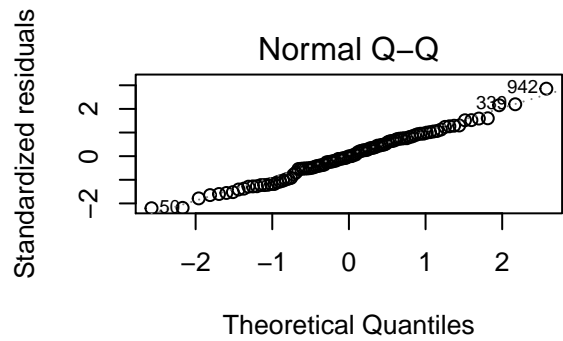
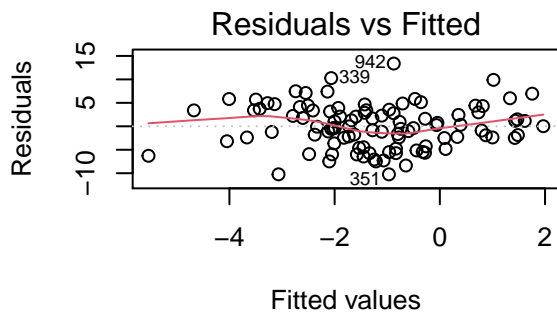
```
par(mfrow=c(2,2))
plot(grim_height_83_91_m)
```



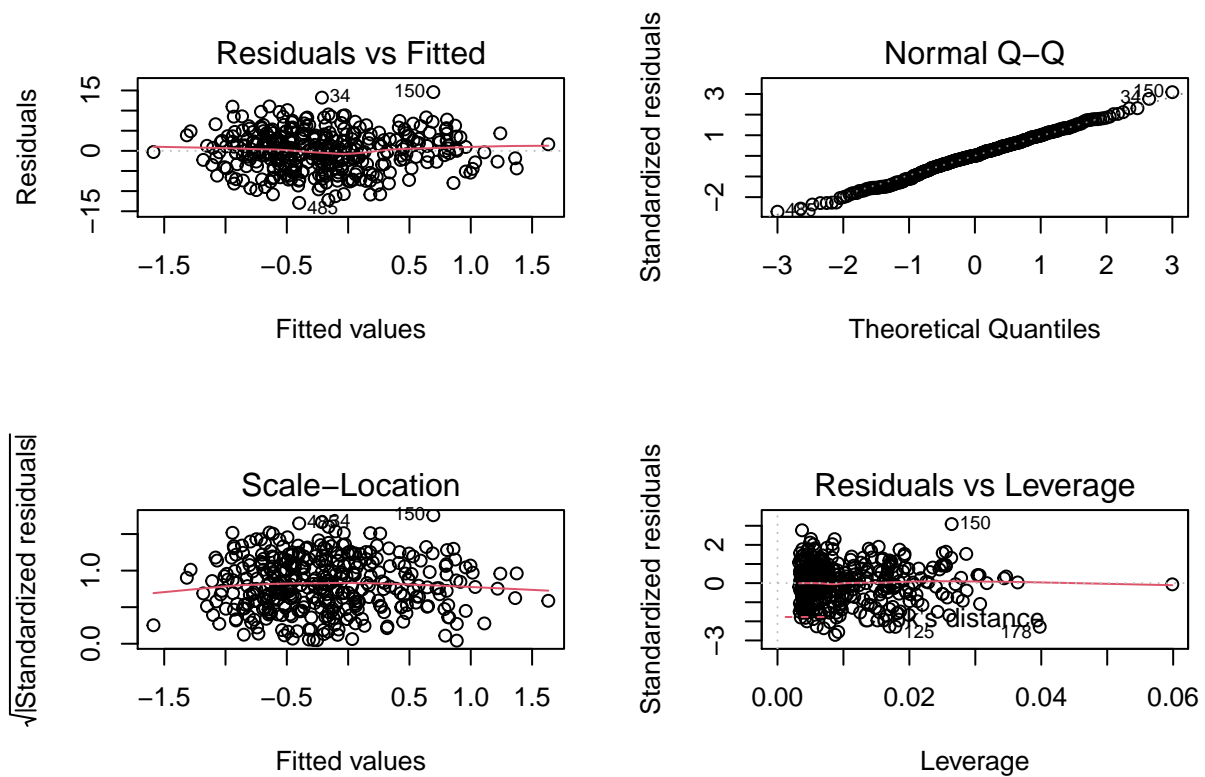
```
par(mfrow=c(2,2))
plot(pheno_height_83_91_f)
```



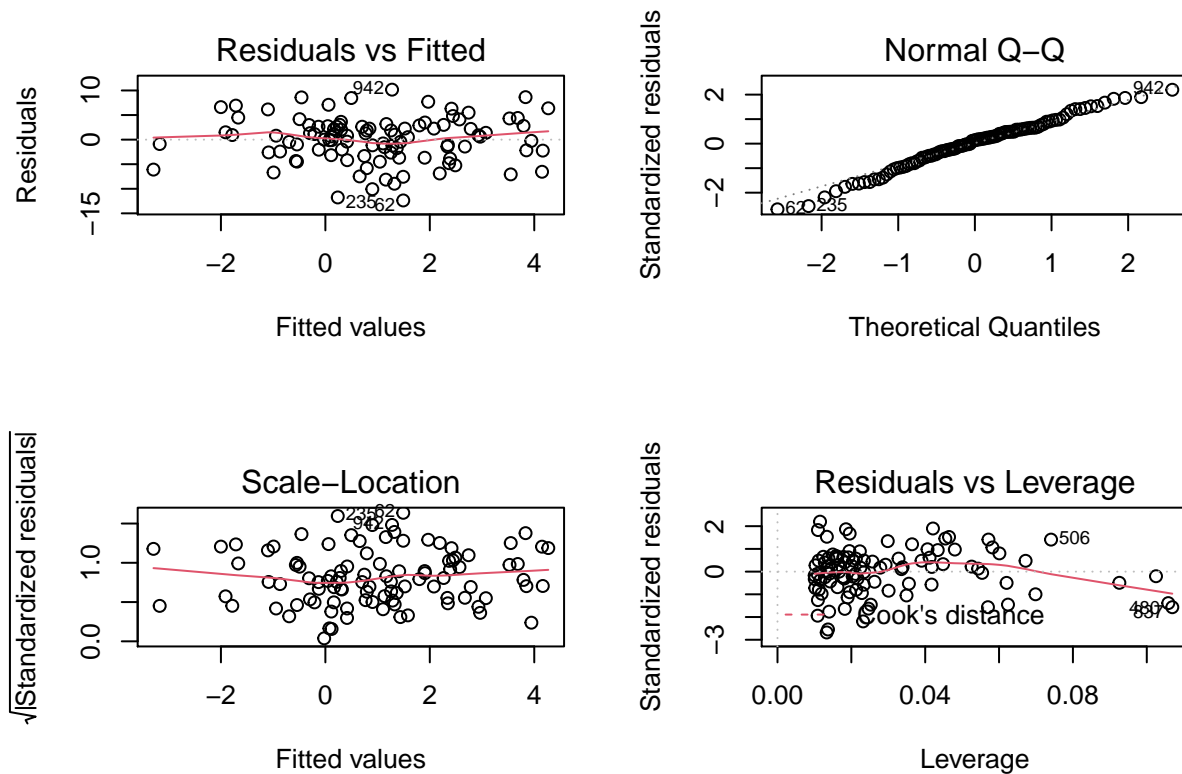
```
par(mfrow=c(2,2))
plot(pheno_height_83_91_m)
```



```
par(mfrow=c(2,2))
plot(han_height_83_91_f)
```



```
par(mfrow=c(2,2))
plot(han_height_83_91_m)
```



8 to 19 years old

```
#hfaz_91 minimal models

grim_height_91_02_f<-lm(AgeAccelGrim ~ hfa_diff_91_02 +
  hfa_diff_birth_inf12 +
  was_preg_no_na, subset(growth_clocks_data, sex == "2"))

grim_height_91_02_m<-lm(AgeAccelGrim ~ hfa_diff_91_02 +
  hfa_diff_birth_inf12, subset(growth_clocks_data, sex == "1"))

pheno_height_91_02_f <-update(grim_height_91_02_f, AgeAccelPheno ~ .)

pheno_height_91_02_m <-update(grim_height_91_02_m, AgeAccelPheno ~ .-was_preg_no_na)

han_height_91_02_f <-update(grim_height_91_02_f, EEAA ~ .)

han_height_91_02_m <-update(grim_height_91_02_m, EEAA ~ .-was_preg_no_na)

horv_height_91_02_f <-update(grim_height_91_02_f, IEAA ~ .)

horv_height_91_02_m <-update(grim_height_91_02_m, IEAA ~ .-was_preg_no_na)

sjPlot::tab_model(grim_height_91_02_f, grim_height_91_02_m,
  pheno_height_91_02_f, pheno_height_91_02_m,
  han_height_91_02_f, han_height_91_02_m,
```

horv\_height\_91\_02\_f, horv\_height\_91\_02\_m)

Age Accel Grim

Age Accel Grim

Age Accel Pheno

Age Accel Pheno

EEAA

EEAA

IEAA

IEAA

Predictors

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

(Intercept)

-0.94  
 -1.39 – -0.48  
 <0.001  
 1.90  
 0.86 – 2.93  
 <0.001  
 -0.30  
 -1.26 – 0.66  
 0.538  
 -2.05  
 -3.87 – -0.22  
 0.029  
 -0.35  
 -1.35 – 0.65  
 0.493  
 0.33  
 -1.51 – 2.18  
 0.721  
 0.11  
 -0.47 – 0.70  
 0.703  
 1.21  
 -0.11 – 2.54  
 0.073  
 hfa\_diff\_91\_02  
 -0.33  
 -0.68 – 0.03  
 0.069  
 -0.90  
 -1.97 – 0.16  
 0.096  
 -0.38  
 -1.13 – 0.36  
 0.310  
 -1.35  
 -3.22 – 0.53

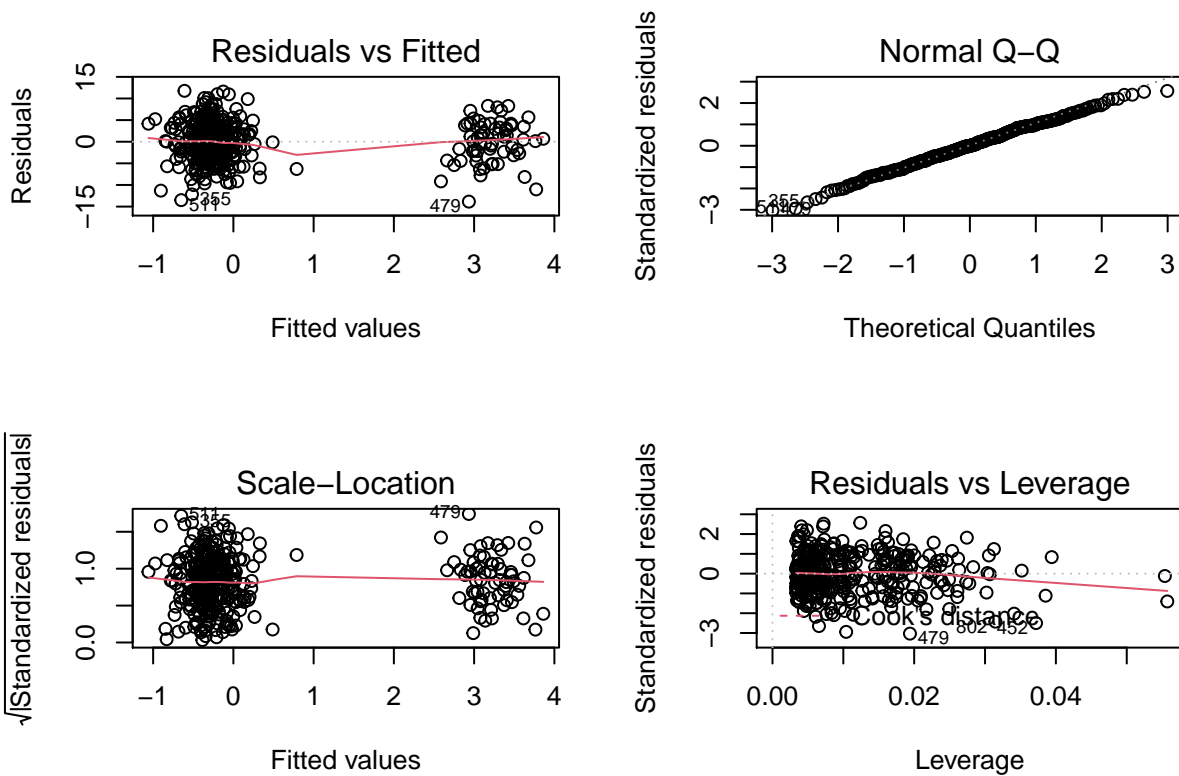
0.158  
 -0.51  
 -1.29 – 0.26  
 0.194  
 -0.02  
 -1.91 – 1.88  
 0.987  
 0.28  
 -0.18 – 0.74  
 0.229  
 -0.54  
 -1.90 – 0.83  
 0.435  
 hfa\_diff\_birth\_inf12  
 -0.07  
 -0.27 – 0.13  
 0.480  
 0.11  
 -0.36 – 0.57  
 0.644  
 -0.05  
 -0.46 – 0.36  
 0.820  
 -0.60  
 -1.42 – 0.22  
 0.151  
 -0.04  
 -0.47 – 0.38  
 0.840  
 -0.35  
 -1.18 – 0.48  
 0.403  
 0.15  
 -0.10 – 0.41  
 0.238  
 0.51

```
-0.08 – 1.11
0.092
was_preg_no_na [Yes]
2.72
2.12 – 3.32
<0.001
3.45
2.20 – 4.70
<0.001
0.87
-0.44 – 2.17
0.192
0.07
-0.70 – 0.84
0.859
Observations
364
100
364
100
364
100
364
100
R2 / R2 adjusted
0.193 / 0.187
0.033 / 0.013
0.080 / 0.073
0.036 / 0.016
0.010 / 0.002
0.007 / -0.013
0.006 / -0.002
0.039 / 0.019
```

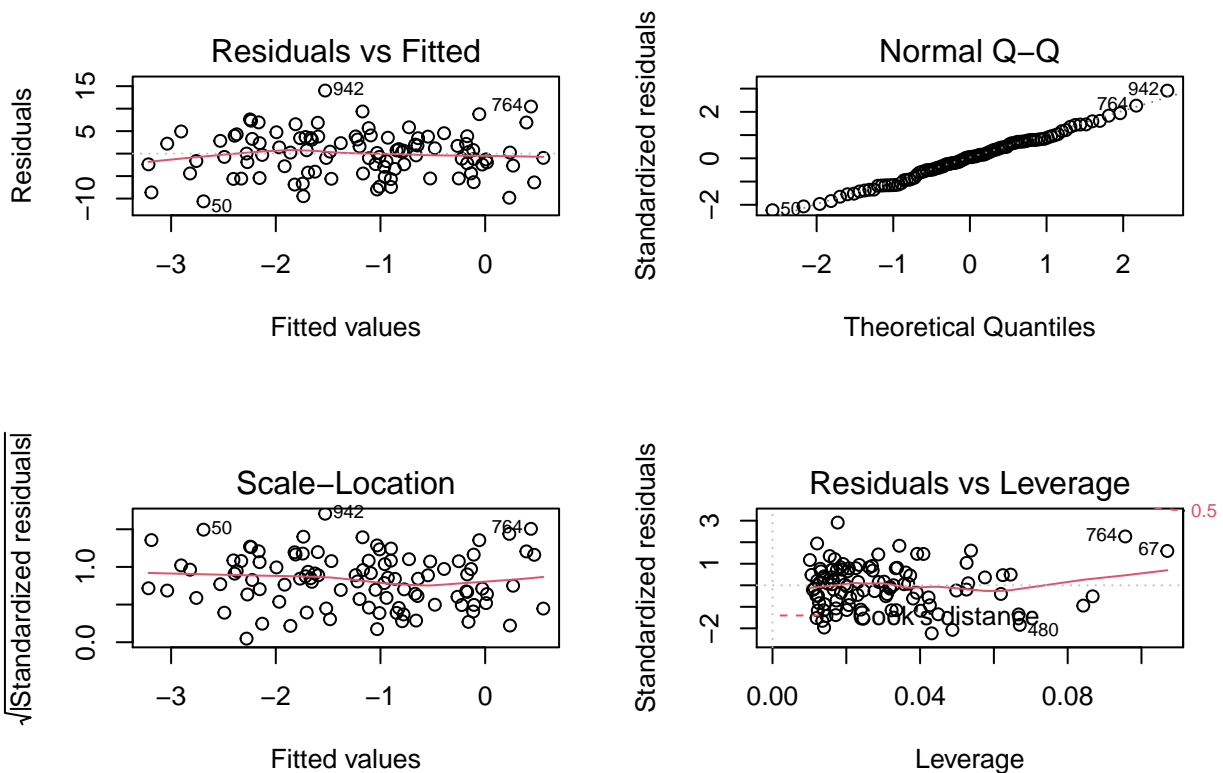
```
#91-02 visualization
par(mfrow=c(2,2))
plot(grim_height_91_02_f)
```



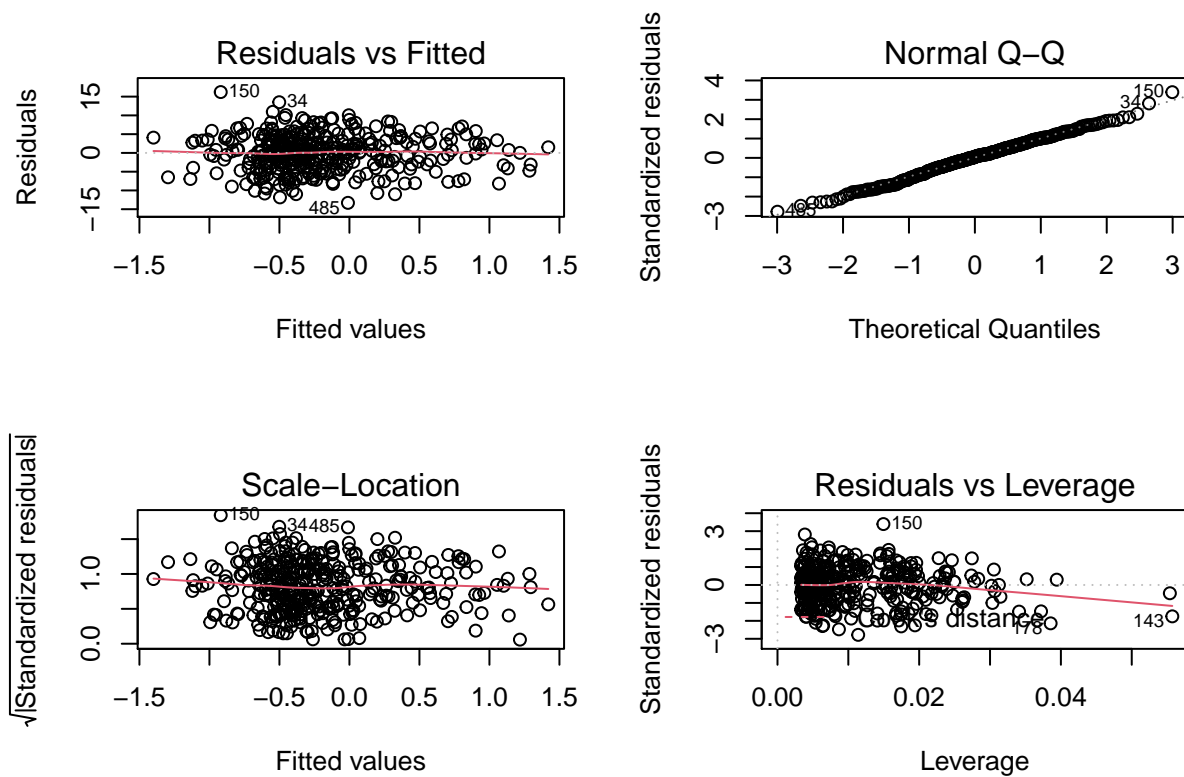




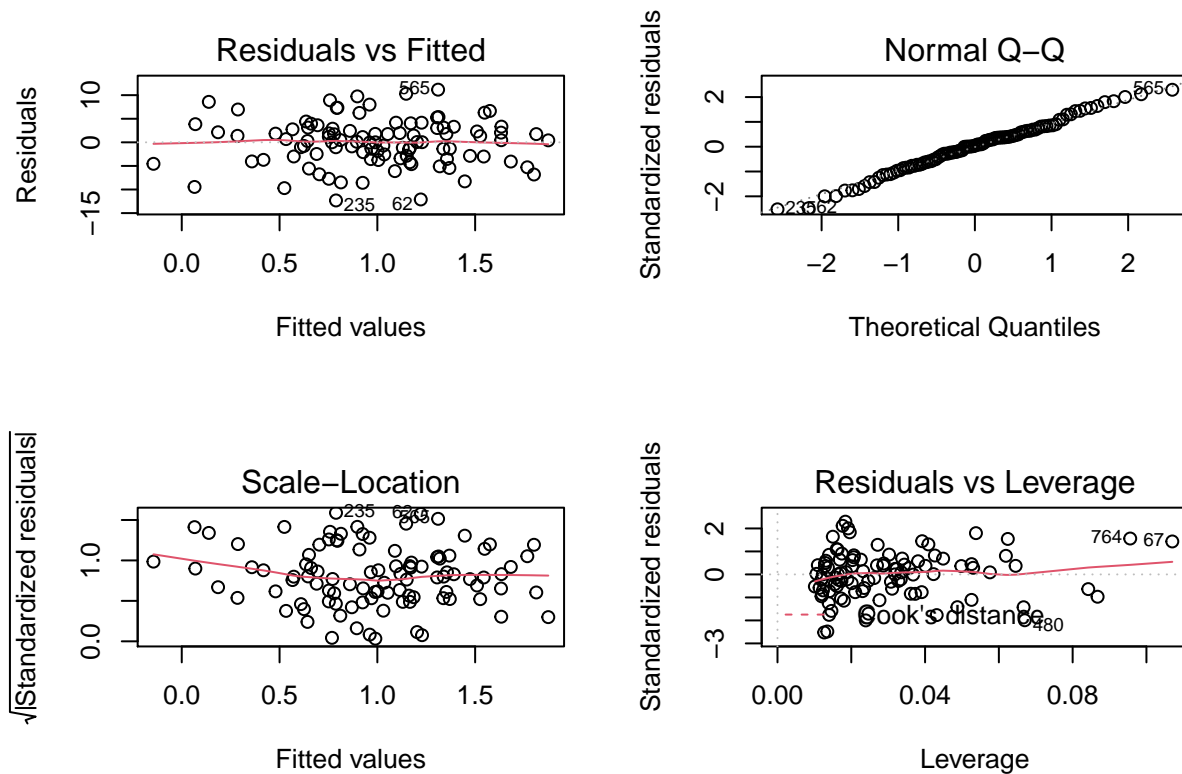
```
par(mfrow=c(2,2))
plot(pheno_height_91_02_m)
```



```
par(mfrow=c(2,2))
plot(han_height_91_02_f)
```



```
par(mfrow=c(2,2))
plot(han_height_91_02_m)
```



modeling wfaz (no interactions)

Birth to 2 years old

```
#wfa birth minimal models
grim_weight_b_2_f<-lm(AgeAccelGrim ~ wfa_diff_birth_inf12 + was_preg_no_na, subset(growth_clocks_data, 
grim_weight_b_2_m<-lm(AgeAccelGrim ~ wfa_diff_birth_inf12, subset(growth_clocks_data, sex == "1"))

pheno_weight_b_2_f <-update(grim_weight_b_2_f, AgeAccelPheno ~ .)
pheno_weight_b_2_m <-update(grim_weight_b_2_m, AgeAccelPheno ~ .)

han_weight_b_2_f <-update(grim_weight_b_2_f, EEAA ~ .)
han_weight_b_2_m <-update(grim_weight_b_2_m, EEAA ~ .)

horv_weight_b_2_f <-update(grim_weight_b_2_f, IEAA ~ .)
horv_weight_b_2_m <-update(grim_weight_b_2_m, IEAA ~ .)

sjPlot::tab_model(grim_weight_b_2_f, grim_weight_b_2_m,
                  pheno_weight_b_2_f, pheno_weight_b_2_m,
                  han_weight_b_2_f, han_weight_b_2_m,
                  horv_weight_b_2_f, horv_weight_b_2_m)
```

[illegible]

-1.46 – -0.07  
 0.031  
 1.10  
 -0.84 – 3.04  
 0.262  
 0.29  
 -1.17 – 1.74  
 0.698  
 0.32  
 -3.09 – 3.73  
 0.851  
 0.76  
 -0.76 – 2.28  
 0.327  
 1.90  
 -1.51 – 5.31  
 0.271  
 0.30  
 -0.61 – 1.20  
 0.521  
 -0.37  
 -2.86 – 2.12  
 0.771  
 wfa\_diff\_birth\_inf12  
 -0.04  
 -0.30 – 0.22  
 0.770  
 0.14  
 -0.53 – 0.81  
 0.683  
 -0.22  
 -0.76 – 0.32  
 0.420  
 -0.56  
 -1.73 – 0.62  
 0.352

-0.46  
 -1.03 – 0.10  
 0.106  
 -0.33  
 -1.50 – 0.85  
 0.584  
 -0.15  
 -0.49 – 0.18  
 0.373  
 0.18  
 -0.68 – 1.04  
 0.684  
 was\_preg\_no\_na [Yes]  
 2.80  
 2.21 – 3.40  
 <0.001  
 3.52  
 2.28 – 4.76  
 <0.001  
 1.05  
 -0.25 – 2.35  
 0.112  
 0.03  
 -0.75 – 0.80  
 0.948  
 Observations  
 372  
 100  
 372  
 100  
 372  
 100  
 372  
 100  
 R2 / R2 adjusted  
 0.189 / 0.185

0.002 / -0.008

0.078 / 0.073

0.009 / -0.001

0.013 / 0.007

0.003 / -0.007

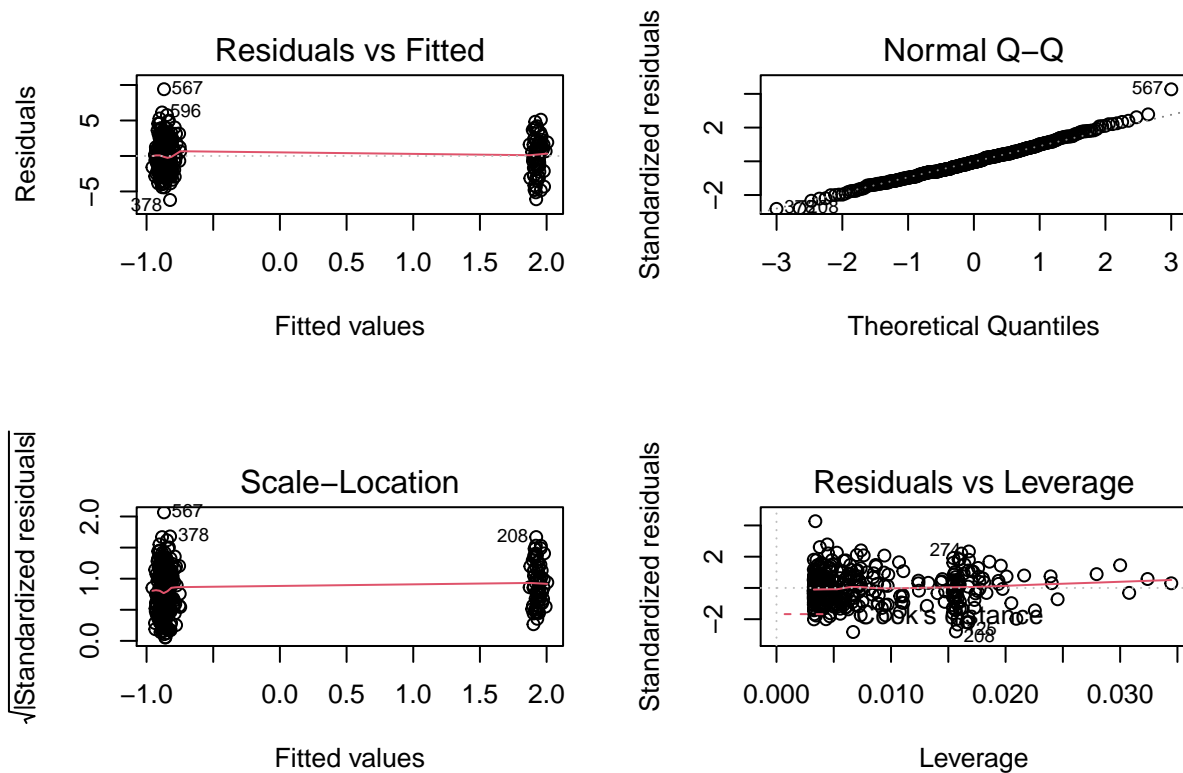
0.002 / -0.003

0.002 / -0.008

```
#weight birth-2 yrs old
```

```
par(mfrow=c(2,2))
```

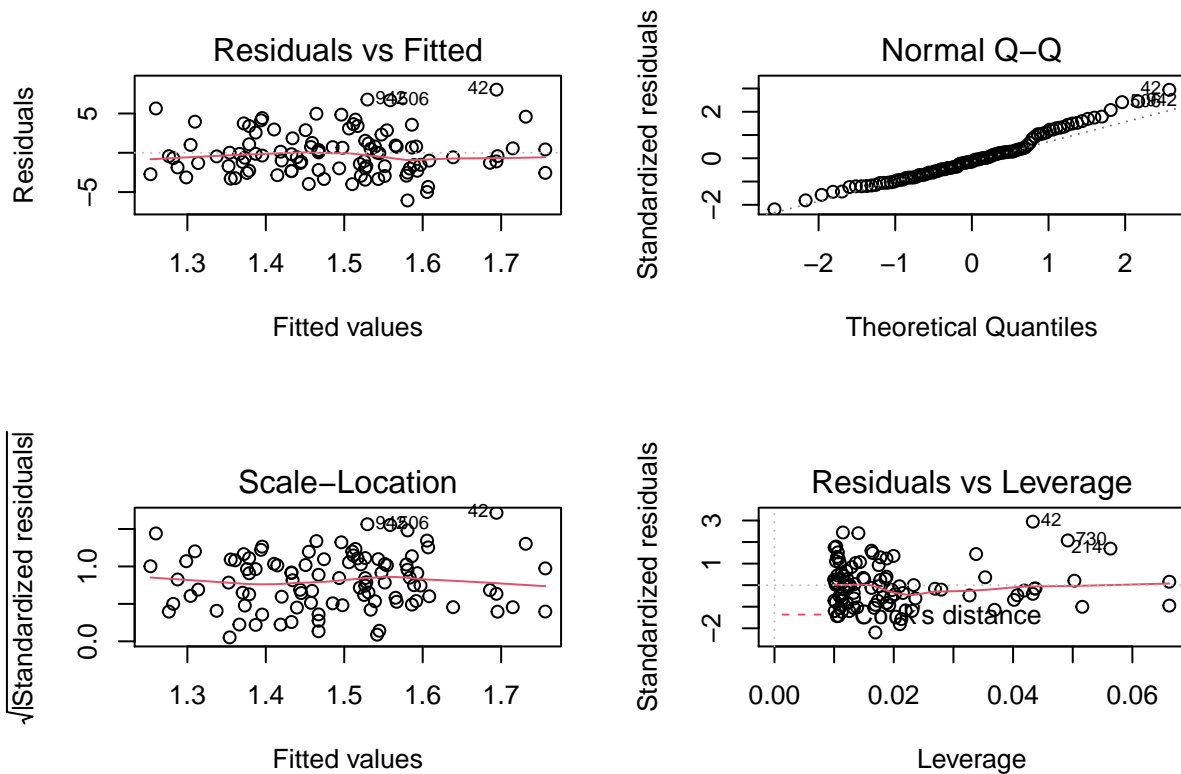
```
plot(grim_weight_b_2_f)
```



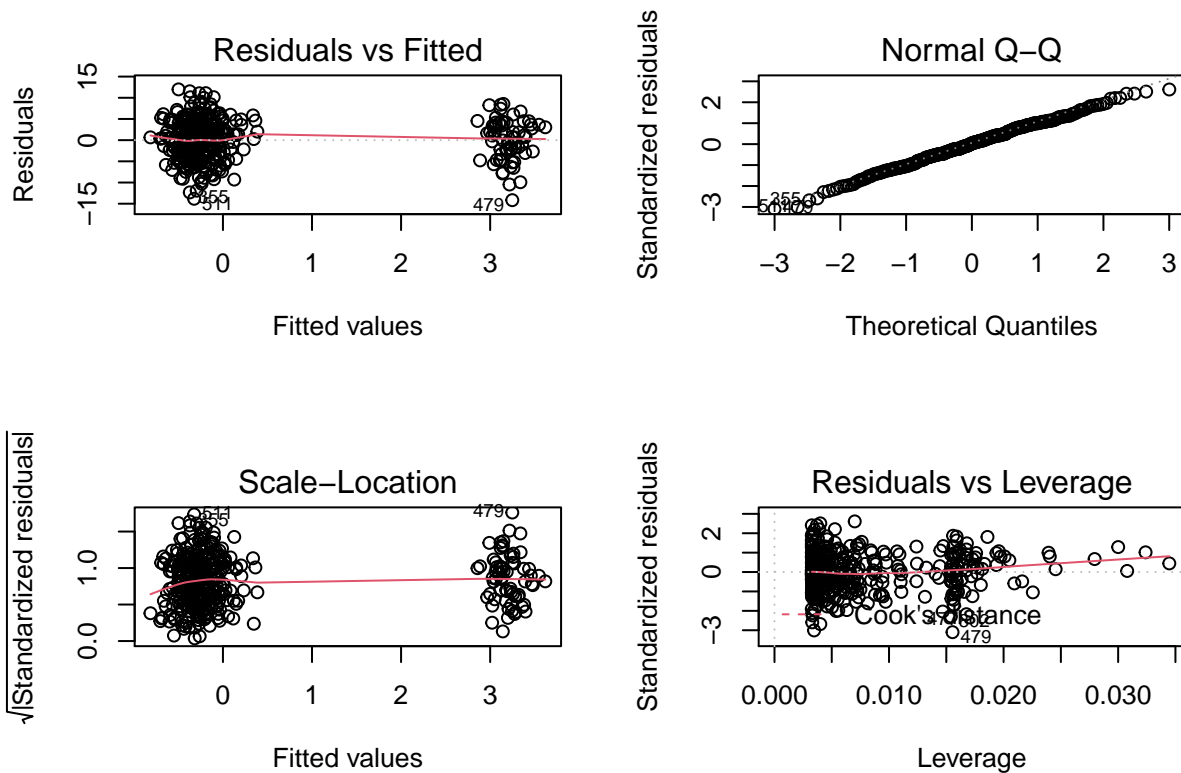
```
par(mfrow=c(2,2))
```

```
plot(grim_weight_b_2_m)
```

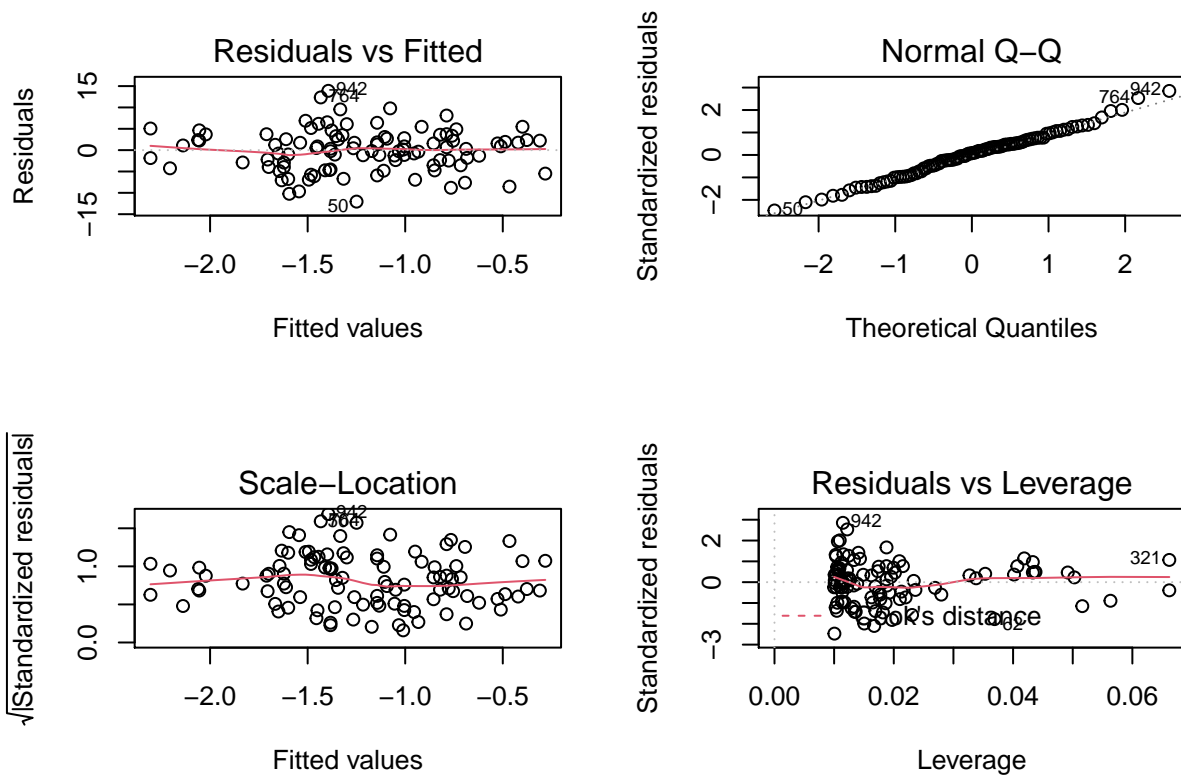




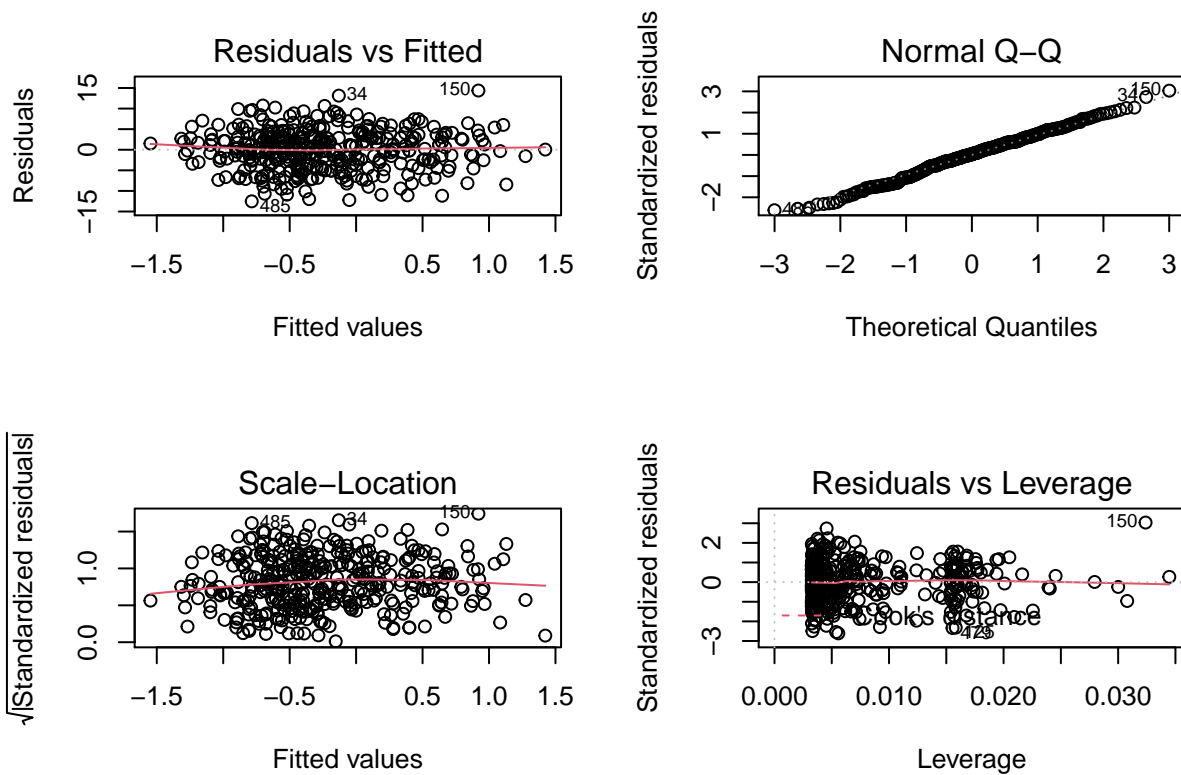
```
par(mfrow=c(2,2))
plot(pheno_weight_b_2_f)
```



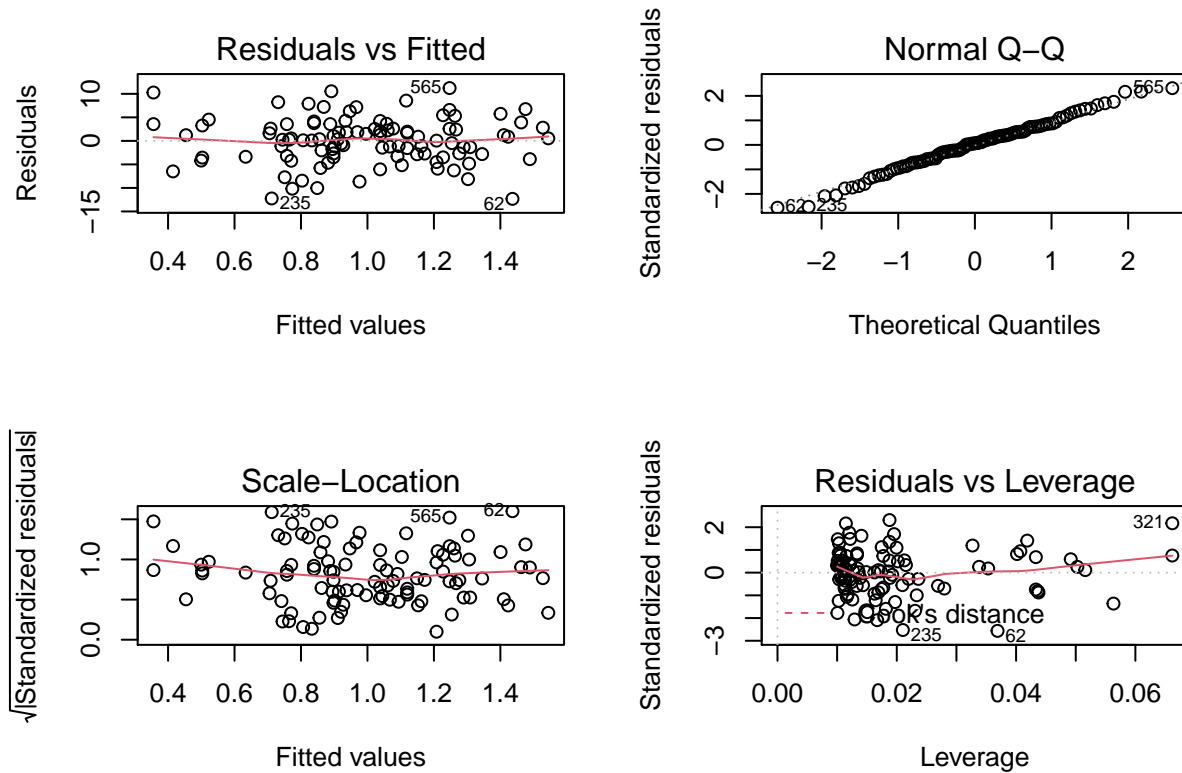
```
par(mfrow=c(2,2))
plot(pheno_weight_b_2_m)
```



```
par(mfrow=c(2,2))
plot(han_weight_b_2_f)
```



```
par(mfrow=c(2,2))
plot(han_weight_b_2_m)
```



## 2 to 8 years old

```
#wfaz inf12 minimal models
grim_weight_83_91_f<-lm(AgeAccelGrim ~ wfa_diff_inf12_91 +
  wfa_diff_birth_inf12+
  was_preg_no_na, subset(growth_clocks_data, sex == "2"))

grim_weight_83_91_m<-lm(AgeAccelGrim ~ wfa_diff_inf12_91+
  wfa_diff_birth_inf12,
  subset(growth_clocks_data, sex == "1"))

pheno_weight_83_91_f <-update(grim_weight_83_91_f, AgeAccelPheno ~ .)
pheno_weight_83_91_m <-update(grim_weight_83_91_m, AgeAccelPheno ~ .)

han_weight_83_91_f <-update(grim_weight_83_91_f, EEAA ~ .)
han_weight_83_91_m <-update(grim_weight_83_91_m, EEAA ~ .)

horv_weight_83_91_f <-update(grim_weight_83_91_f, IEAA ~ .)
horv_weight_83_91_m <-update(grim_weight_83_91_m, IEAA ~ .)
```

```
sjPlot::tab_model(grim_weight_83_91_f, grim_weight_83_91_m,
                  pheno_weight_83_91_f, pheno_weight_83_91_m,
                  han_weight_83_91_f, han_weight_83_91_m,
                  horv_weight_83_91_f, horv_weight_83_91_m)
```

Age Accel Grim

Age Accel Grim

Age Accel Pheno

Age Accel Pheno

EEAA

EEAA

IEAA

IEAA

Predictors

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

CI

p

Estimates

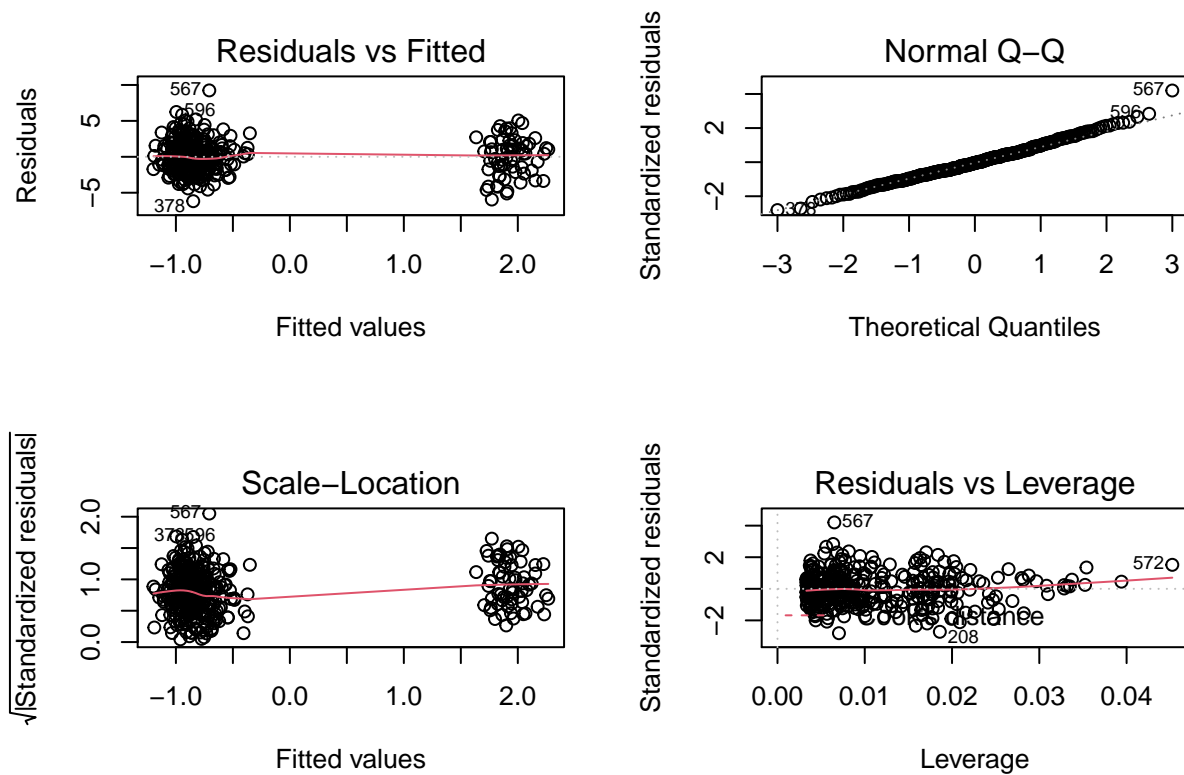
CI

p  
 (Intercept)  
 -0.92  
 -1.68 – -0.16  
 0.018  
 1.02  
 -0.91 – 2.96  
 0.296  
 0.13  
 -1.46 – 1.71  
 0.875  
 0.37  
 -3.05 – 3.80  
 0.829  
 0.53  
 -1.12 – 2.18  
 0.532  
 1.83  
 -1.59 – 5.26  
 0.290  
 0.46  
 -0.53 – 1.45  
 0.361  
 -0.41  
 -2.91 – 2.10  
 0.748  
 wfa\_diff\_inf12\_91  
 0.20  
 -0.12 – 0.52  
 0.219  
 0.58  
 -0.26 – 1.42  
 0.175  
 0.28  
 -0.39 – 0.95  
 0.412

-0.38  
 -1.88 – 1.11  
 0.612  
 0.41  
 -0.29 – 1.11  
 0.247  
 0.49  
 -1.00 – 1.98  
 0.520  
 -0.13  
 -0.55 – 0.29  
 0.537  
 0.29  
 -0.80 – 1.38  
 0.594  
 wfa\_diff\_birth\_inf12  
 0.04  
 -0.26 – 0.33  
 0.803  
 0.24  
 -0.44 – 0.93  
 0.480  
 -0.13  
 -0.74 – 0.48  
 0.671  
 -0.63  
 -1.84 – 0.59  
 0.309  
 -0.33  
 -0.97 – 0.30  
 0.303  
 -0.24  
 -1.45 – 0.98  
 0.699  
 -0.22  
 -0.60 – 0.16

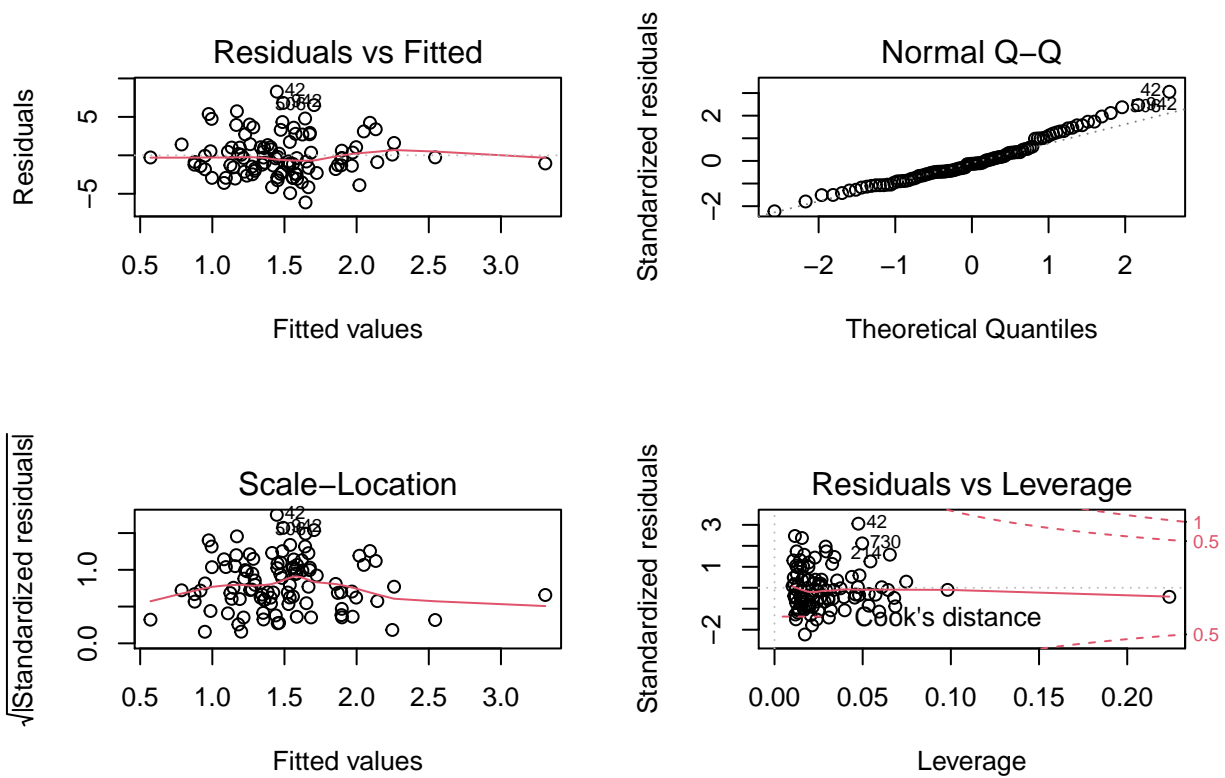
0.258
0.23
-0.66 – 1.12
0.607
was_preg_no_na [Yes]
2.78
2.18 – 3.37
<0.001
3.47
2.23 – 4.71
<0.001
0.98
-0.31 – 2.27
0.136
0.02
-0.75 – 0.80
0.954
Observations
370
100
370
100
370
100
370
100
R2 / R2 adjusted
0.192 / 0.185
0.021 / 0.000
0.079 / 0.072
0.011 / -0.009
0.017 / 0.009
0.007 / -0.013
0.004 / -0.005
0.005 / -0.016

```
#weight 83-91 yrs old
par(mfrow=c(2,2))
plot(grim_weight_83_91_f)
```

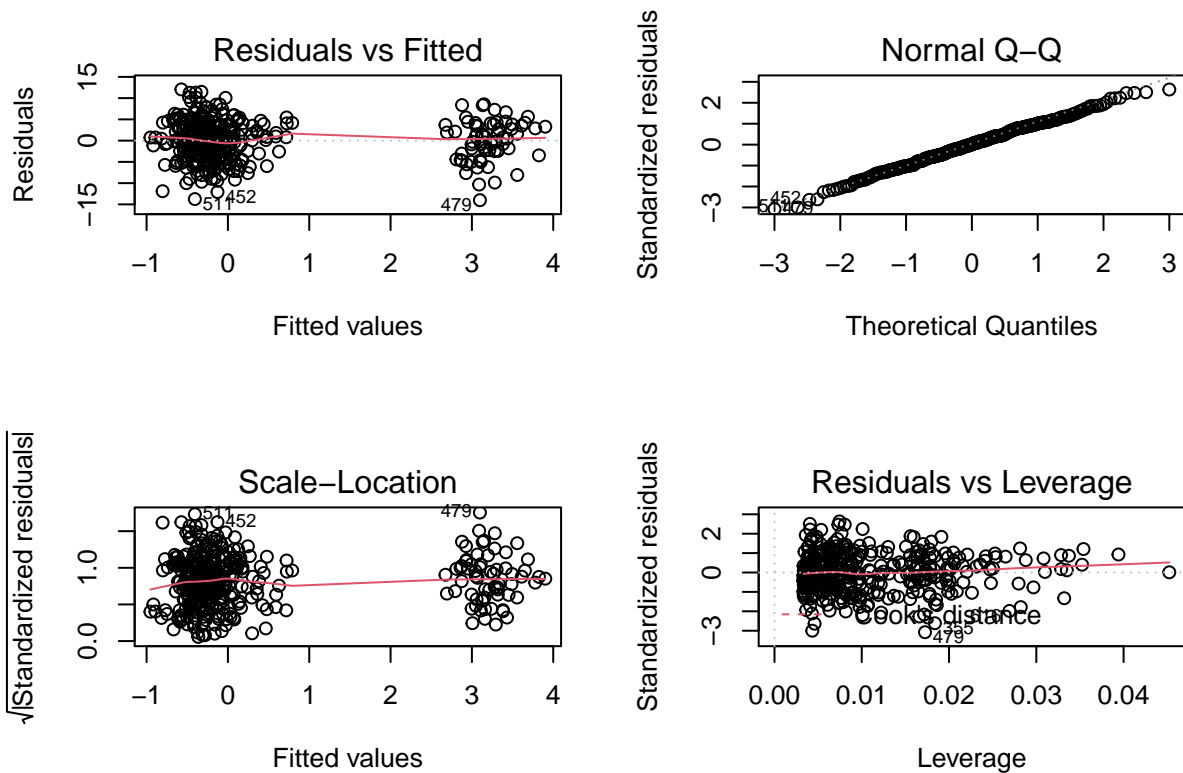


```
par(mfrow=c(2,2))
plot(grim_weight_83_91_m)
```

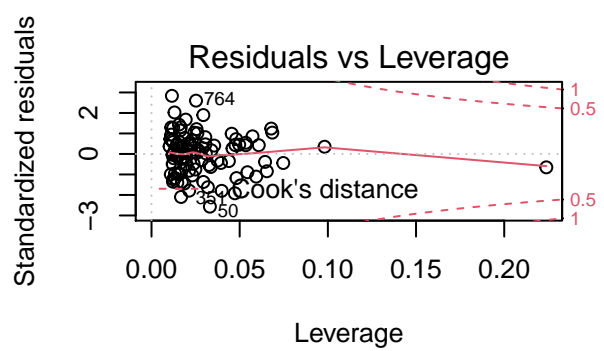
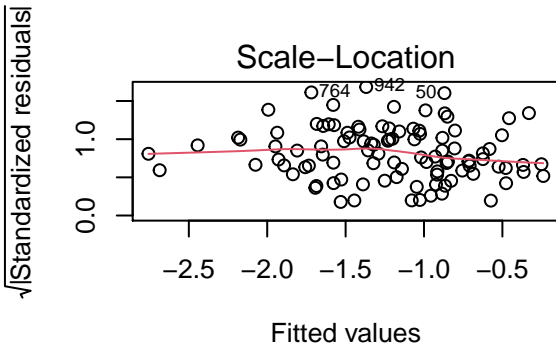
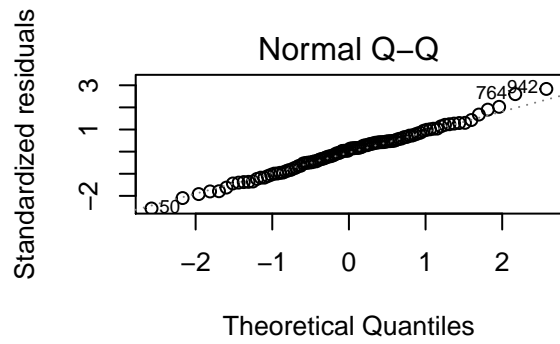
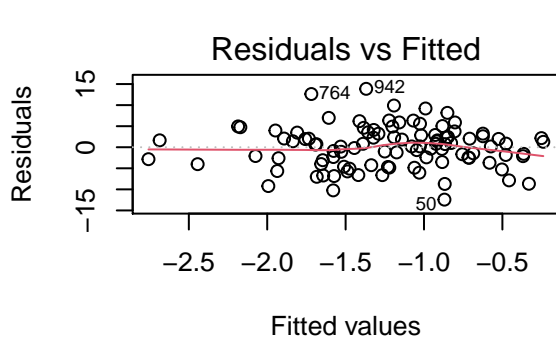




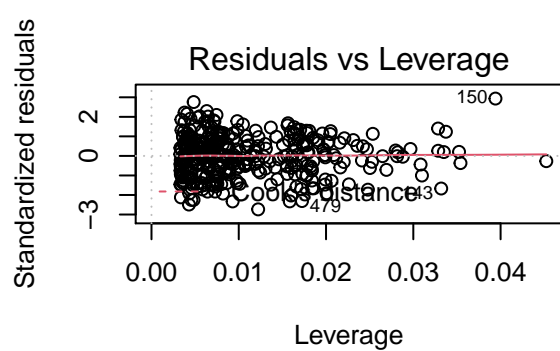
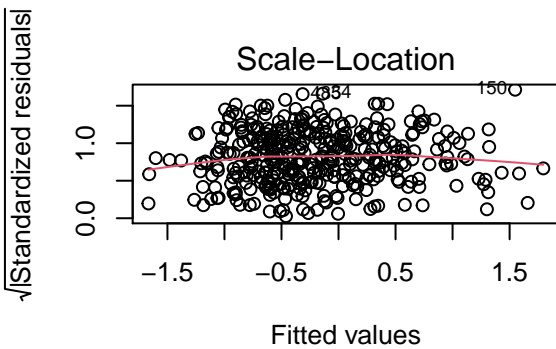
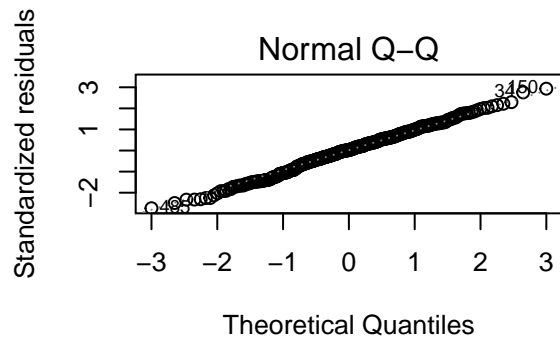
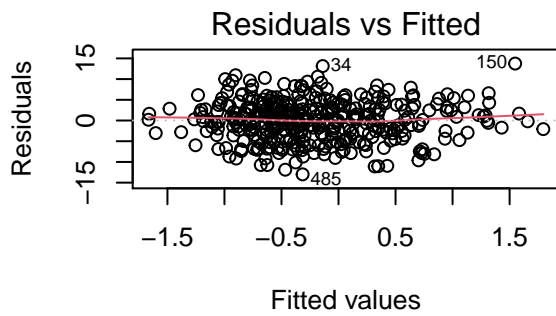
```
par(mfrow=c(2,2))
plot(pheno_weight_83_91_f)
```



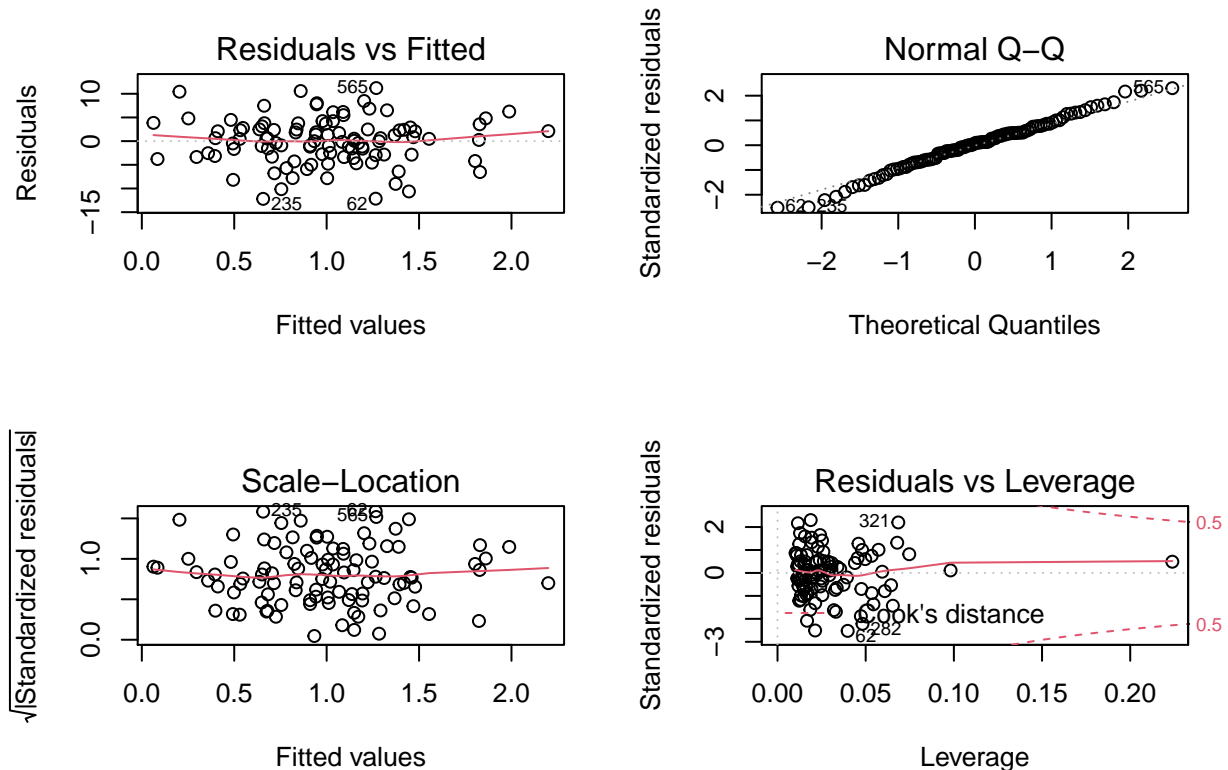
```
par(mfrow=c(2,2))
plot(pheno_weight_83_91_m)
```



```
par(mfrow=c(2,2))
plot(han_weight_83_91_f)
```



```
par(mfrow=c(2,2))
plot(han_weight_83_91_m)
```



## modeling hfaz (interactions)

### 2 to 8 years old

```
#hfaz 2years old model
grim_height_83_91_intxn_f<-lm(AgeAccelGrim ~ hfa_diff_inf12_91 *
                             hfa_diff_birth_inf12 +
                             was_preg_no_na, subset(growth_clocks_data, sex == "2"))

grim_height_83_91_intxn_m<-lm(AgeAccelGrim ~ hfa_diff_inf12_91 *
                             hfa_diff_birth_inf12, subset(growth_clocks_data, sex == "1"))

pheno_height_83_91_intxn_f <-update(grim_height_83_91_intxn_f, AgeAccelPheno ~ .)

pheno_height_83_91_intxn_m <-update(grim_height_83_91_intxn_m, AgeAccelPheno ~ .-was_preg_no_na)

han_height_83_91_intxn_f <-update(grim_height_83_91_intxn_f, EEAA ~ .)

han_height_83_91_intxn_m <-update(grim_height_83_91_intxn_m, EEAA ~ .-was_preg_no_na)

horv_height_83_91_intxn_f <-update(grim_height_83_91_intxn_f, IEAA ~ .)

horv_height_83_91_intxn_m <-update(grim_height_83_91_intxn_m, IEAA ~ .-was_preg_no_na)
```

```

sjPlot::tab_model(grim_height_83_91_intxn_f, grim_height_83_91_intxn_m,
                  pheno_height_83_91_intxn_f, pheno_height_83_91_intxn_m,
                  han_height_83_91_intxn_f, han_height_83_91_intxn_m,
                  horv_height_83_91_intxn_f, horv_height_83_91_intxn_m)

```

Age Accel Grim

Age Accel Grim

Age Accel Pheno

Age Accel Pheno

EEAA

EEAA

IEAA

IEAA

Predictors

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI
P
(Intercept)
-0.92
-1.41 – -0.43
<0.001
1.75
0.71 – 2.80
0.001
-0.18
-1.20 – 0.84
0.730
-1.81
-3.65 – 0.02
0.052
-0.11
-1.17 – 0.96
0.844
0.60
-1.21 – 2.41
0.512
-0.04
-0.67 – 0.60
0.904
1.03
-0.31 – 2.38
0.131
hfa_diff_inf12_91
0.25
-0.27 – 0.76
0.344
1.72
0.50 – 2.93
0.006
0.02
-1.06 – 1.09

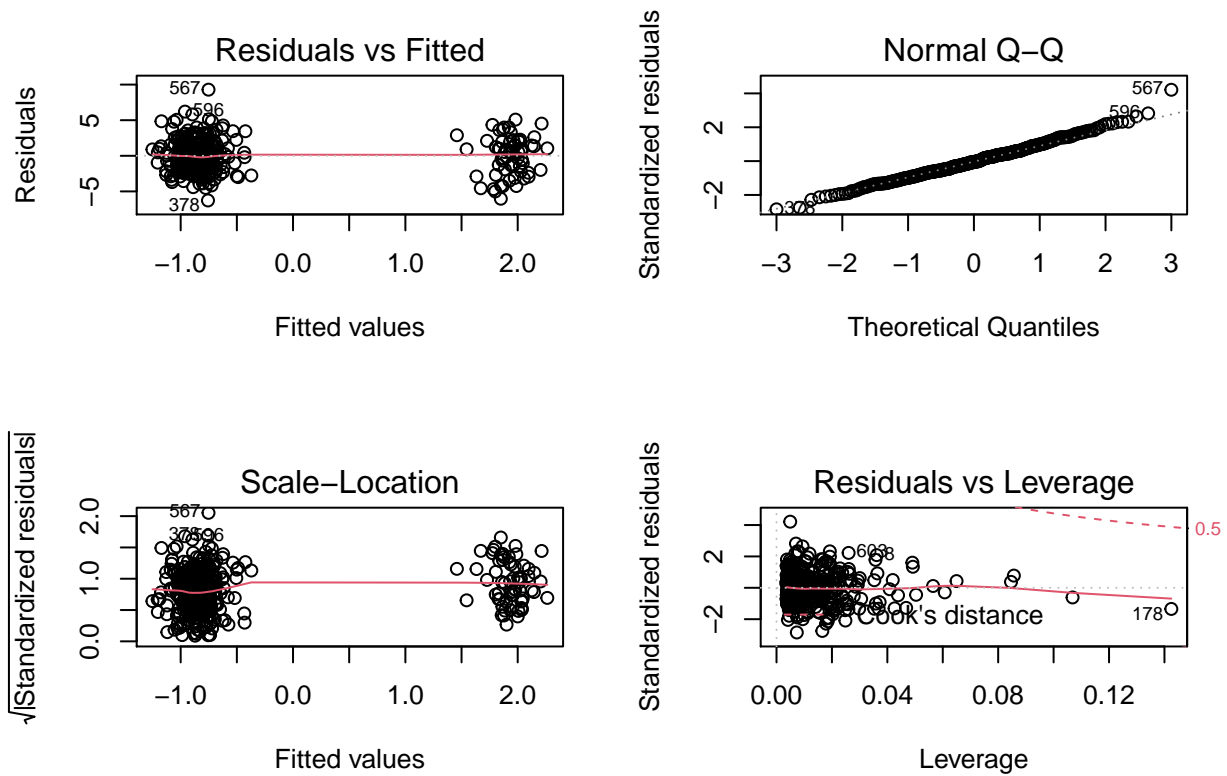
0.975  
 1.73  
 -0.40 – 3.86  
 0.110  
 0.24  
 -0.88 – 1.36  
 0.671  
 2.60  
 0.50 – 4.71  
 0.016  
 -0.03  
 -0.70 – 0.63  
 0.919  
 1.73  
 0.17 – 3.30  
 0.031  
 hfa\_diff\_birth\_inf12  
 -0.01  
 -0.25 – 0.23  
 0.926  
 0.22  
 -0.33 – 0.76  
 0.428  
 0.08  
 -0.42 – 0.58  
 0.756  
 0.05  
 -0.90 – 1.01  
 0.912  
 0.25  
 -0.26 – 0.77  
 0.335  
 0.14  
 -0.81 – 1.08  
 0.771  
 -0.07

-0.38 – 0.24  
 0.673  
 0.51  
 -0.20 – 1.21  
 0.156  
 was\_preg\_no\_na [Yes]  
 2.76  
 2.17 – 3.35  
 <0.001  
 3.42  
 2.18 – 4.66  
 <0.001  
 0.86  
 -0.43 – 2.15  
 0.192  
 0.01  
 -0.76 – 0.78  
 0.974  
 hfa\_diff\_inf12\_91 \*hfa\_diff\_birth\_inf12  
 0.04  
 -0.16 – 0.24  
 0.680  
 0.43  
 -0.08 – 0.94  
 0.100  
 -0.07  
 -0.49 – 0.34  
 0.723  
 -0.10  
 -1.00 – 0.79  
 0.819  
 -0.13  
 -0.55 – 0.30  
 0.566  
 0.22  
 -0.66 – 1.11

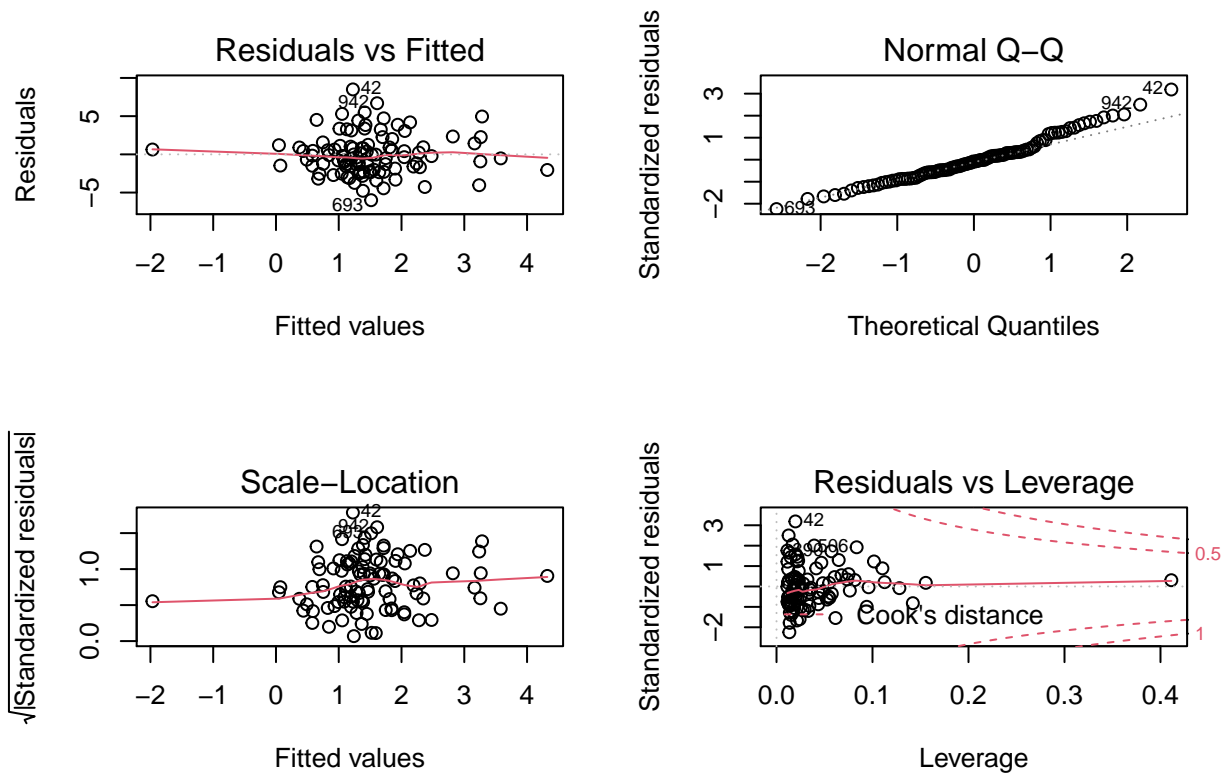
0.618  
0.12  
-0.13 – 0.38  
0.339  
0.52  
-0.13 – 1.18  
0.117  
Observations  
370  
100  
370  
100  
370  
100  
370  
100  
R2 / R2 adjusted  
0.192 / 0.183  
0.087 / 0.059  
0.077 / 0.067  
0.095 / 0.067  
0.014 / 0.003  
0.112 / 0.085  
0.012 / 0.001  
0.080 / 0.051

```
#height 83-91 interaction models  
par(mfrow=c(2,2))  
plot(grim_height_83_91_intxn_f)
```

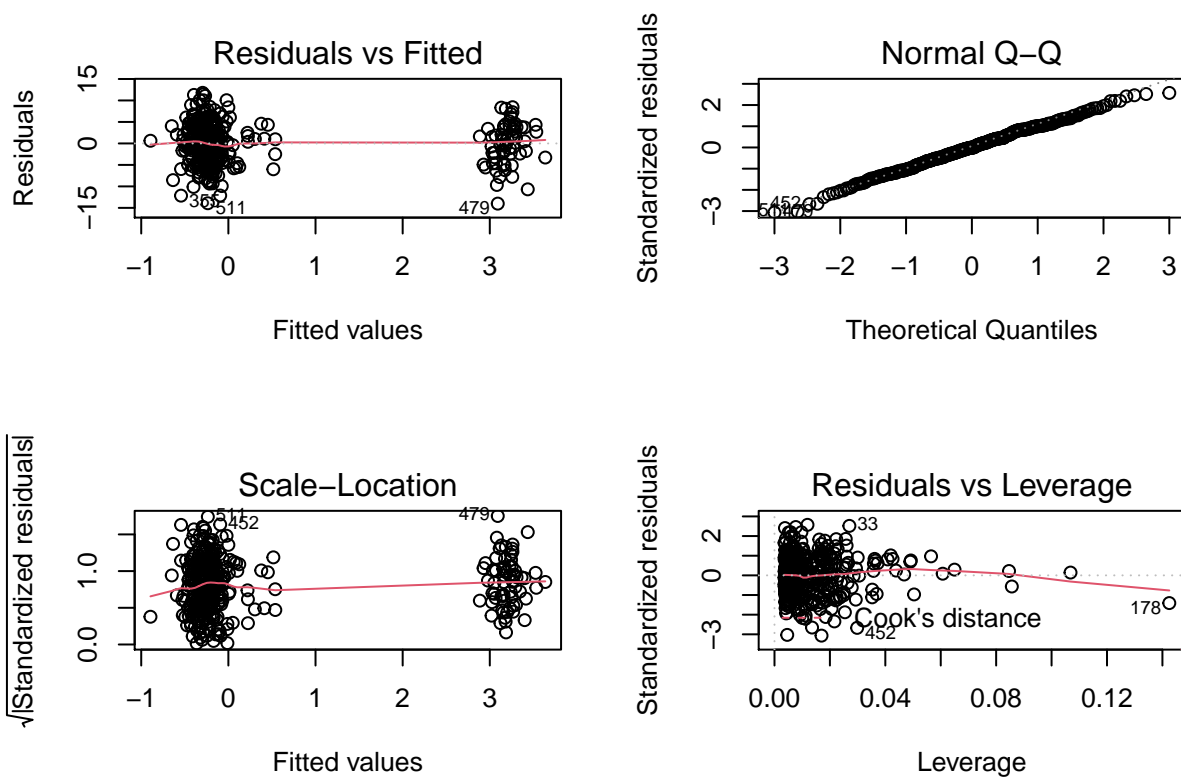




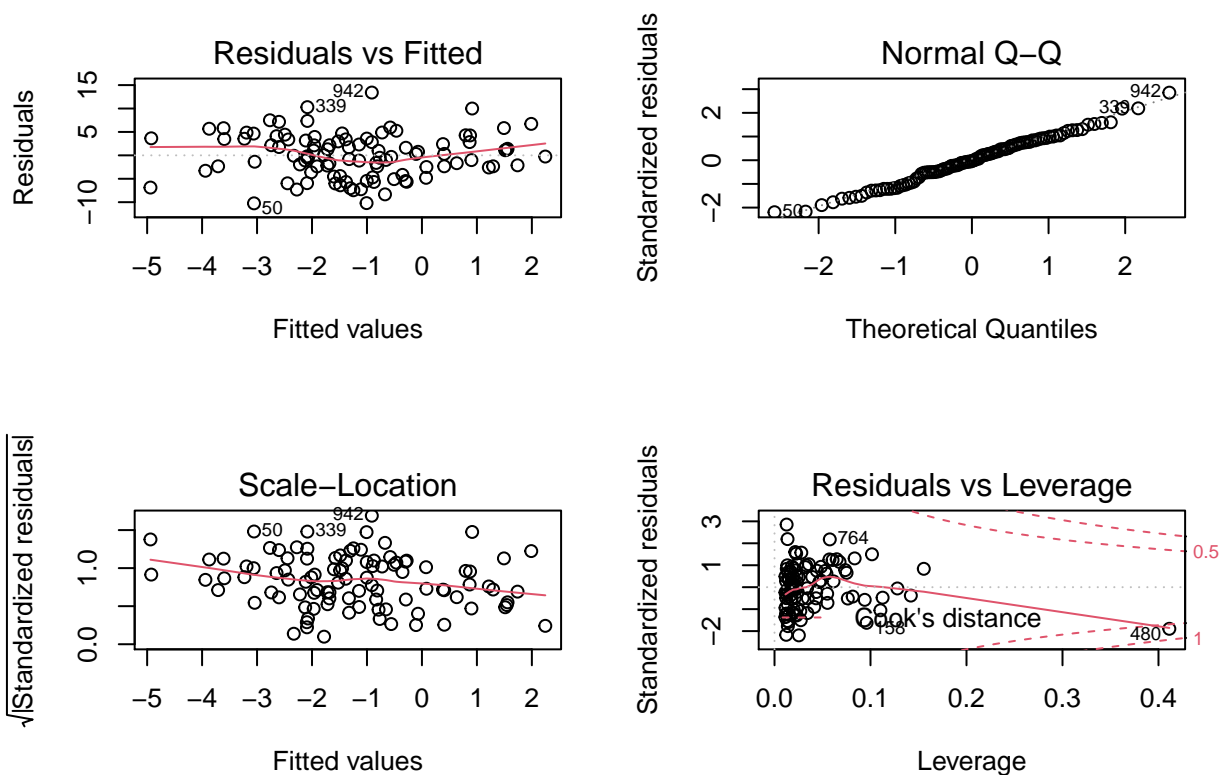
```
par(mfrow=c(2,2))
plot(grim_height_83_91_intxn_m)
```



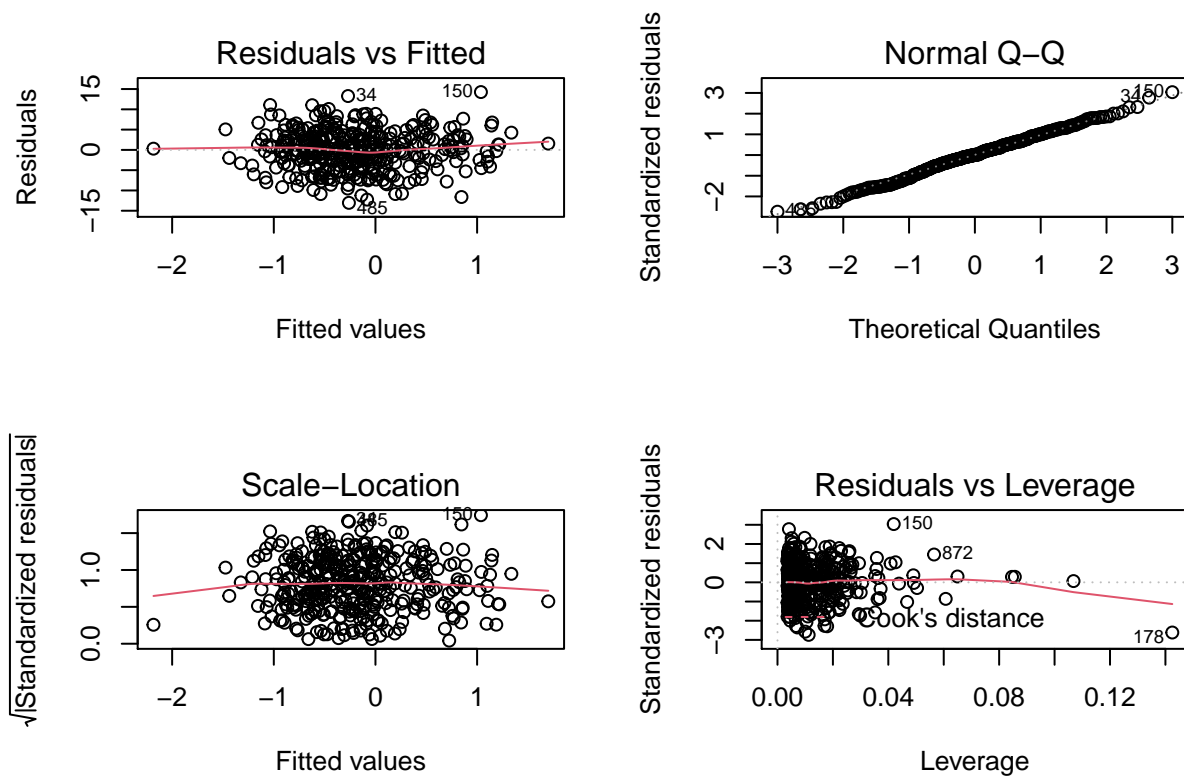
```
par(mfrow=c(2,2))
plot(pheno_height_83_91_intxn_f)
```



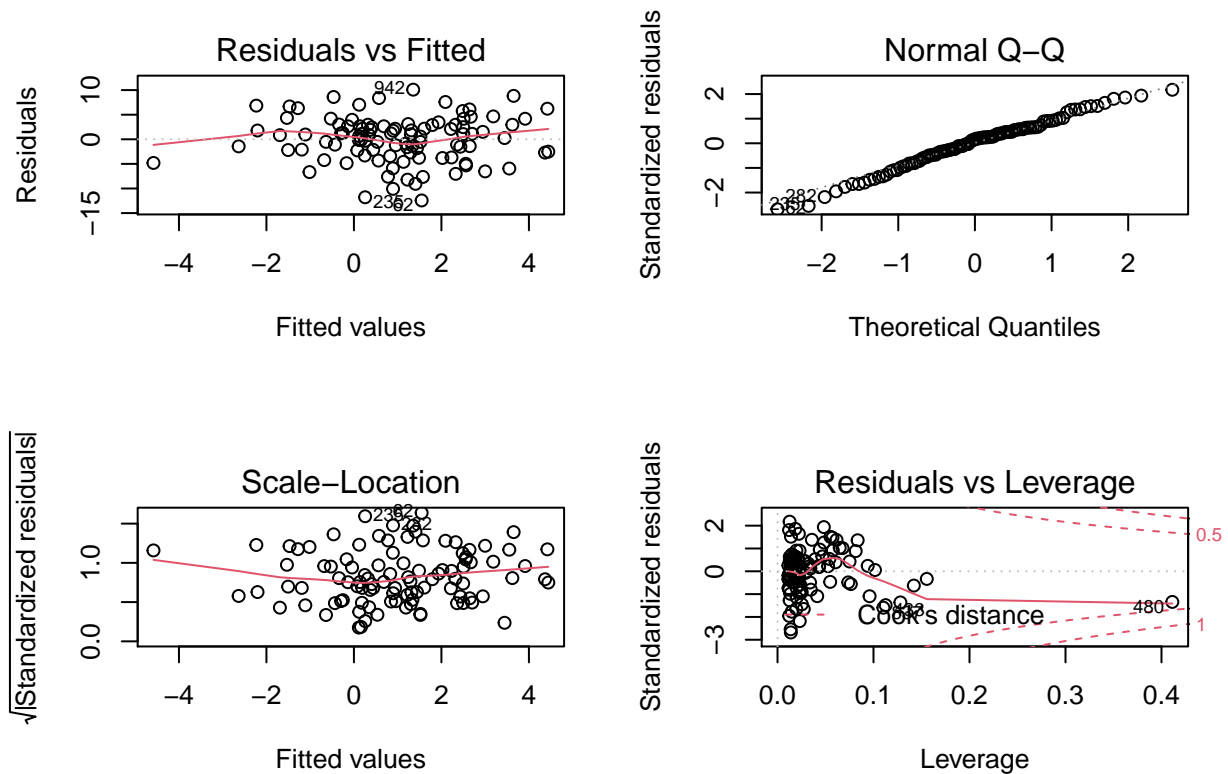
```
par(mfrow=c(2,2))
plot(pheno_height_83_91_intxn_m)
```



```
par(mfrow=c(2,2))
plot(han_height_83_91_intxn_f)
```



```
par(mfrow=c(2,2))
plot(han_height_83_91_intxn_m)
```



8 to 19 years old

```
#hfaz_91 minimal models

grim_height_91_02_intxn_f<-lm(AgeAccelGrim ~ hfa_diff_91_02 *
                             hfa_diff_birth_inf12 +
                             was_preg_no_na, subset(growth_clocks_data, sex == "2"))

grim_height_91_02_intxn_m<-lm(AgeAccelGrim ~ hfa_diff_91_02 *
                             hfa_diff_birth_inf12, subset(growth_clocks_data, sex == "1"))

pheno_height_91_02_intxn_f <-update(grim_height_91_02_intxn_f, AgeAccelPheno ~ .)
pheno_height_91_02_intxn_m <-update(grim_height_91_02_intxn_m, AgeAccelPheno ~ .)

han_height_91_02_intxn_f <-update(grim_height_91_02_intxn_f, EEAA ~ .)
han_height_91_02_intxn_m <-update(grim_height_91_02_intxn_m, EEAA ~ .)

horv_height_91_02_intxn_f <-update(grim_height_91_02_intxn_f, IEAA ~ .)
horv_height_91_02_intxn_m <-update(grim_height_91_02_intxn_m, IEAA ~ .)

sjPlot::tab_model(grim_height_91_02_intxn_f, grim_height_91_02_intxn_m,
                  pheno_height_91_02_intxn_f, pheno_height_91_02_intxn_m,
                  han_height_91_02_intxn_f, han_height_91_02_intxn_m,
                  horv_height_91_02_intxn_f, horv_height_91_02_intxn_m)
```

[illegible]

-1.35 – -0.42  
 <0.001  
 2.08  
 1.00 – 3.16  
 <0.001  
 -0.22  
 -1.20 – 0.76  
 0.659  
 -1.57  
 -3.46 – 0.31  
 0.101  
 -0.39  
 -1.41 – 0.63  
 0.455  
 0.90  
 -1.00 – 2.80  
 0.349  
 0.19  
 -0.41 – 0.79  
 0.538  
 1.67  
 0.31 – 3.02  
 0.017  
 hfa\_diff\_91\_02  
 -0.64  
 -1.34 – 0.06  
 0.071  
 -1.99  
 -4.12 – 0.15  
 0.068  
 -0.89  
 -2.35 – 0.58  
 0.233  
 -4.16  
 -7.90 – -0.43  
 0.029

-0.26  
-1.79 – 1.27  
0.737  
-3.39  
-7.14 – 0.36  
0.076  
-0.19  
-1.09 – 0.71  
0.676  
-3.24  
-5.92 – -0.55  
0.019  
hfa\_diff\_birth\_inf12  
-0.04  
-0.24 – 0.17  
0.740  
0.24  
-0.28 – 0.75  
0.359  
0.01  
-0.43 – 0.44  
0.966  
-0.26  
-1.16 – 0.64  
0.571  
-0.07  
-0.53 – 0.38  
0.754  
0.06  
-0.85 – 0.96  
0.903  
0.21  
-0.06 – 0.47  
0.132  
0.84  
0.19 – 1.48

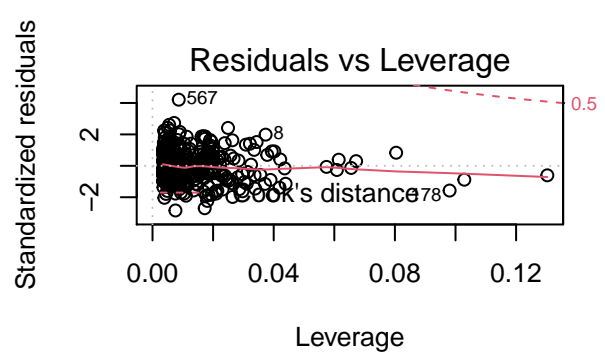
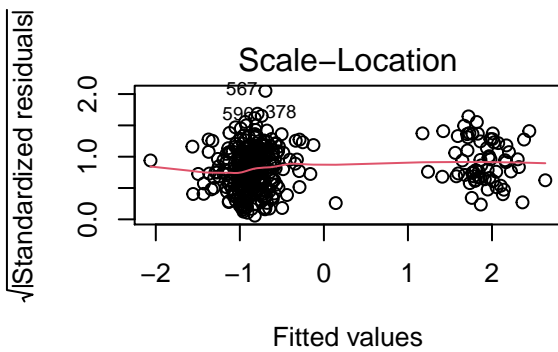
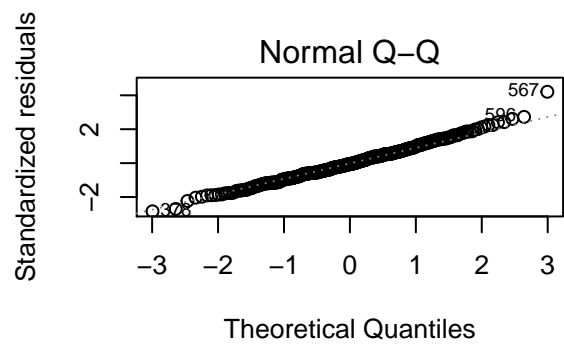
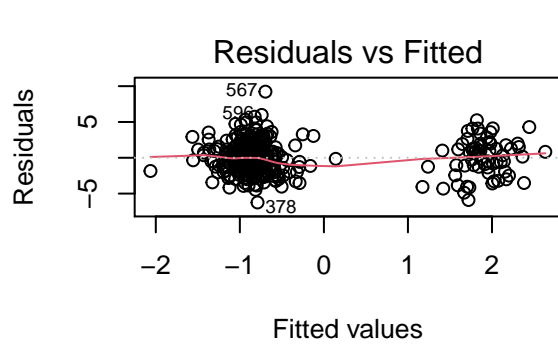
0.012  
 was\_preg\_no\_na [Yes]  
 2.70  
 2.11 – 3.30  
 <0.001  
 3.43  
 2.17 – 4.68  
 <0.001  
 0.88  
 -0.43 – 2.19  
 0.188  
 0.05  
 -0.72 – 0.82  
 0.901  
 hfa\_diff\_91\_02 \*hfa\_diff\_birth\_inf12  
 -0.15  
 -0.44 – 0.14  
 0.304  
 -0.60  
 -1.63 – 0.43  
 0.248  
 -0.24  
 -0.85 – 0.36  
 0.432  
 -1.57  
 -3.37 – 0.23  
 0.087  
 0.12  
 -0.51 – 0.75  
 0.709  
 -1.87  
 -3.68 – -0.07  
 0.042  
 -0.23  
 -0.60 – 0.15  
 0.233



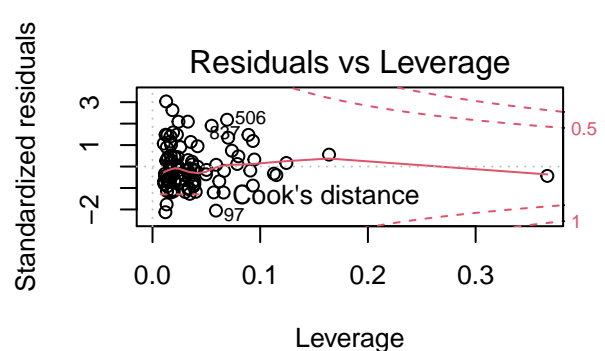
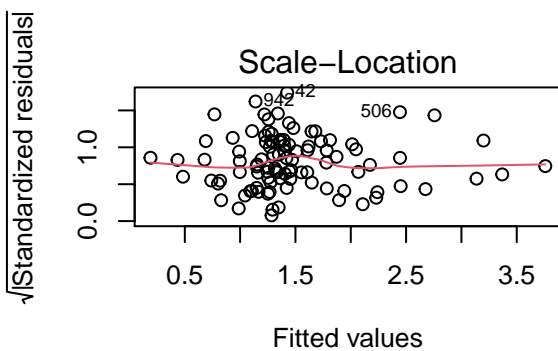
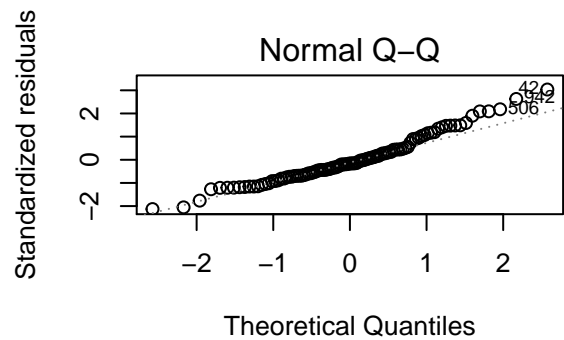
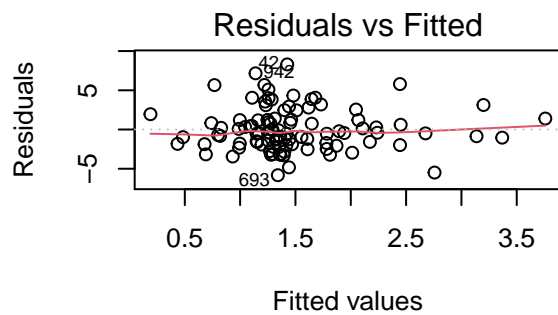
-1.50  
-2.79 – -0.21  
0.024  
Observations  
364  
100  
364  
100  
364  
100  
364  
100  
R2 / R2 adjusted  
0.196 / 0.187  
0.047 / 0.017  
0.082 / 0.072  
0.065 / 0.036  
0.011 / -0.001  
0.049 / 0.020  
0.010 / -0.001  
0.090 / 0.061

## Diagnostics

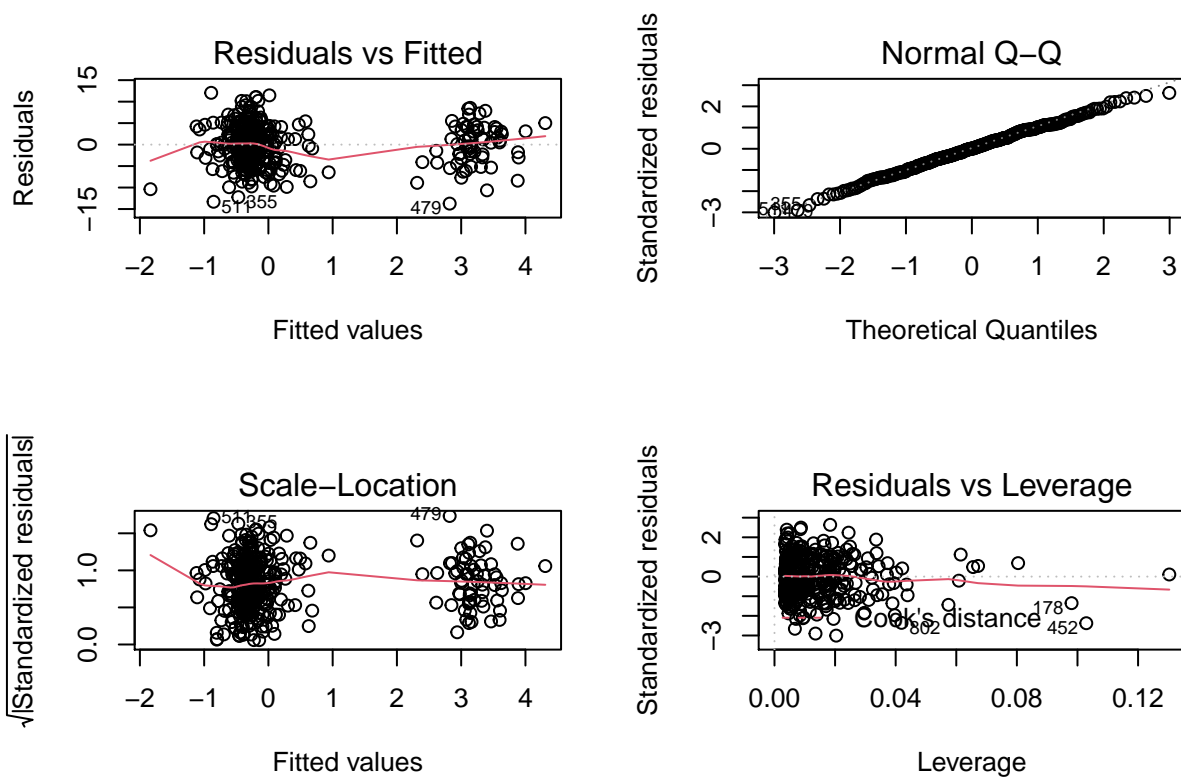
```
#height 91-02 interaction models  
par(mfrow=c(2,2))  
plot(grim_height_91_02_intxn_f)
```



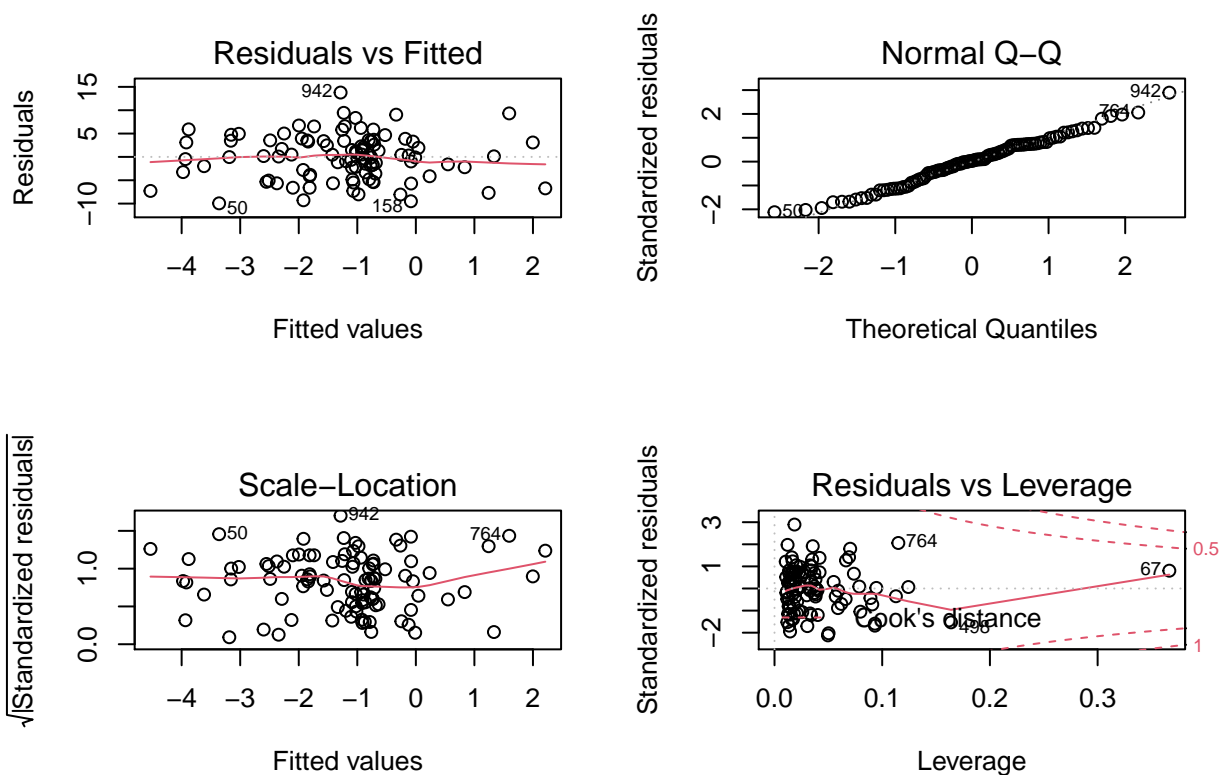
```
par(mfrow=c(2,2))
plot(grim_height_91_02_intxn_m)
```



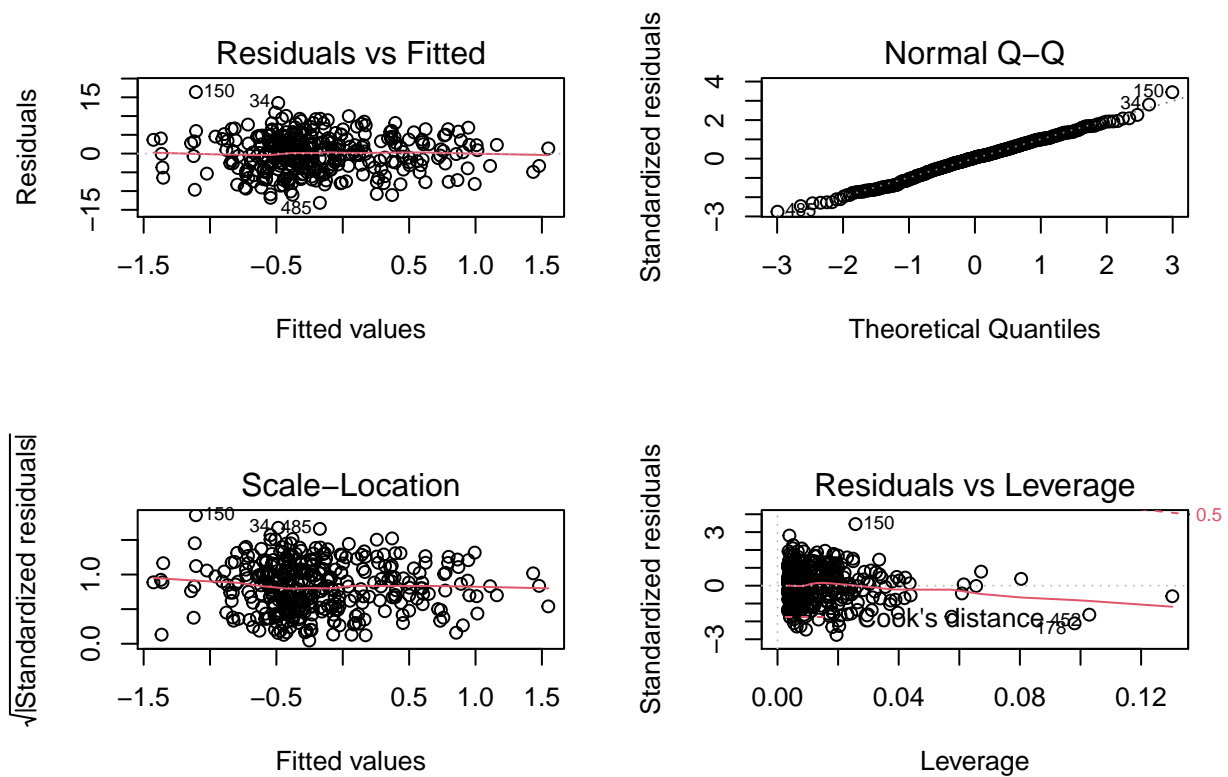
```
par(mfrow=c(2,2))
plot(pheno_height_91_02_intxn_f)
```



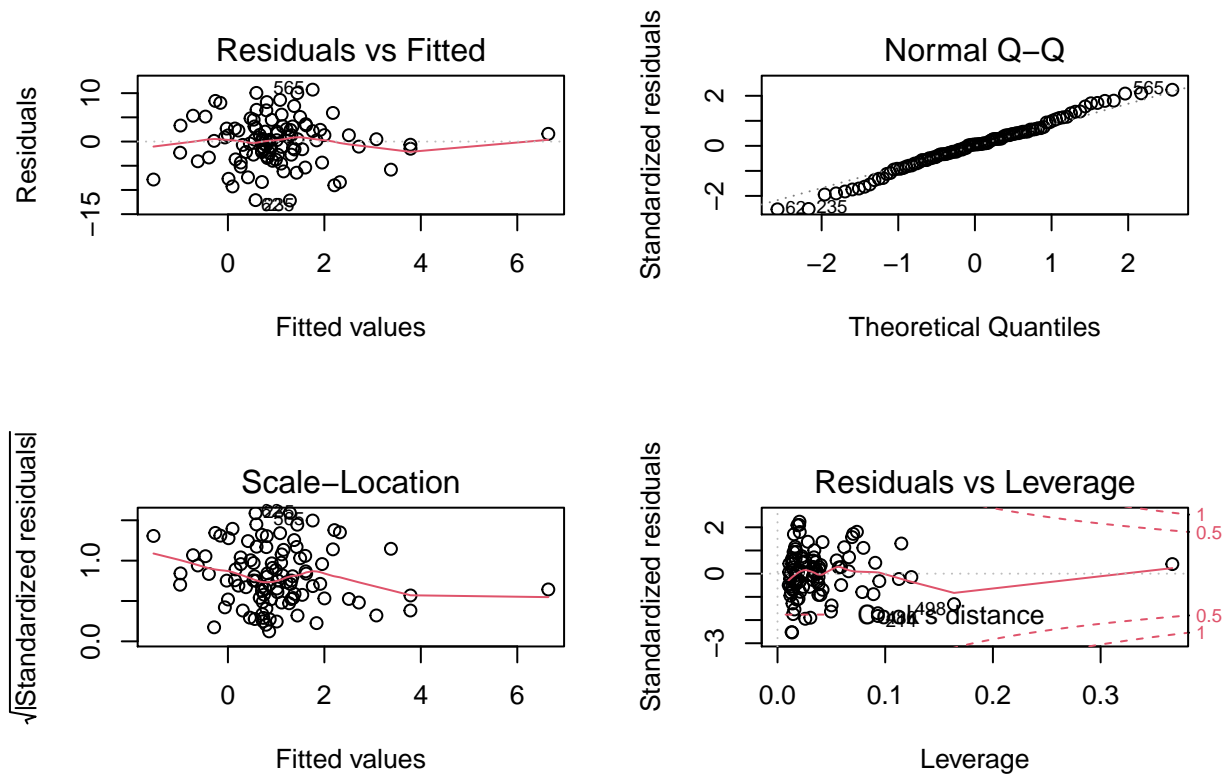
```
par(mfrow=c(2,2))
plot(pheno_height_91_02_intxn_m)
```



```
par(mfrow=c(2,2))
plot(han_height_91_02_intxn_f)
```



```
par(mfrow=c(2,2))
plot(han_height_91_02_intxn_m)
```



## Visualizations

```
# interact_plot(horv_height_91_02_intxn_m, )
#
# han_height_91_02_intxn_m
```

## modeling wfaz (interactions)

### 2 to 8 years old

```
#wfaz inf12 minimal models
grim_weight_83_91_intxn_f<-lm(AgeAccelGrim ~ wfa_diff_inf12_91 * wfa_diff_birth_inf12 + was_preg_no_na,
grim_weight_83_91_intxn_m<-lm(AgeAccelGrim ~ wfa_diff_inf12_91 * wfa_diff_birth_inf12, subset(growth_cl
pheno_weight_83_91_intxn_f <-update(grim_weight_83_91_intxn_f, AgeAccelPheno ~ .)
pheno_weight_83_91_intxn_m <-update(grim_weight_83_91_intxn_m, AgeAccelPheno ~ .)
han_weight_83_91_intxn_f <-update(grim_weight_83_91_intxn_f, EEAA ~ .)
han_weight_83_91_intxn_m <-update(grim_weight_83_91_intxn_m, EEAA ~ .)
horv_weight_83_91_intxn_f <-update(grim_weight_83_91_intxn_f, IEAA ~ .)
```

```

horv_weight_83_91_intxn_m <-update(grim_weight_83_91_intxn_m, IEAA ~ .)

sjPlot::tab_model(grim_weight_83_91_intxn_f, grim_weight_83_91_intxn_m,
                  pheno_weight_83_91_intxn_f, pheno_weight_83_91_intxn_m,
                  han_weight_83_91_intxn_f, han_weight_83_91_intxn_m,
                  horv_weight_83_91_intxn_f, horv_weight_83_91_intxn_m)

```

Age Accel Grim

Age Accel Grim

Age Accel Pheno

Age Accel Pheno

EEAA

EEAA

IEAA

IEAA

Predictors

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates

CI

P

Estimates
CI
p
(Intercept)
-1.07
-1.85 – -0.28
0.008
0.95
-1.12 – 3.03
0.364
-0.26
-1.89 – 1.38
0.757
1.28
-2.36 – 4.93
0.486
0.21
-1.49 – 1.91
0.807
2.63
-1.01 – 6.28
0.155
0.50
-0.52 – 1.53
0.335
-0.60
-3.28 – 2.09
0.660
wfa_diff_inf12_91
0.66
-0.04 – 1.35
0.064
0.31
-2.59 – 3.21
0.834
1.47

0.03 – 2.92  
0.046  
3.09  
-2.01 – 8.18  
0.232  
1.39  
-0.12 – 2.89  
0.072  
3.54  
-1.56 – 8.63  
0.171  
-0.26  
-1.17 – 0.64  
0.568  
-0.44  
-4.19 – 3.32  
0.818  
wfa\_diff\_birth\_inf12  
0.07  
-0.23 – 0.36  
0.650  
0.27  
-0.47 – 1.02  
0.469  
-0.05  
-0.66 – 0.56  
0.872  
-0.98  
-2.29 – 0.33  
0.140  
-0.27  
-0.91 – 0.37  
0.414  
-0.55  
-1.86 – 0.76  
0.407

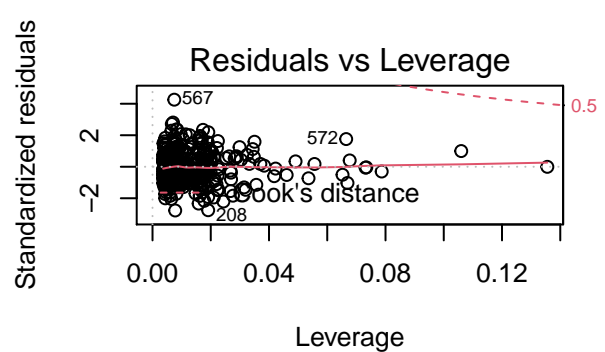
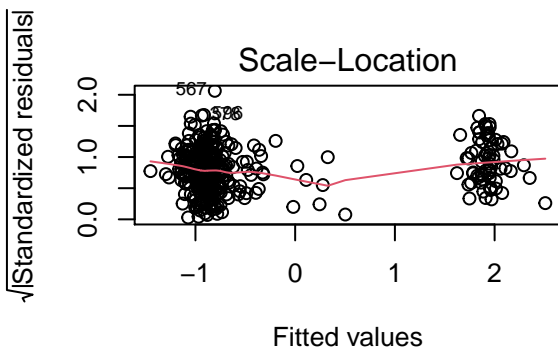
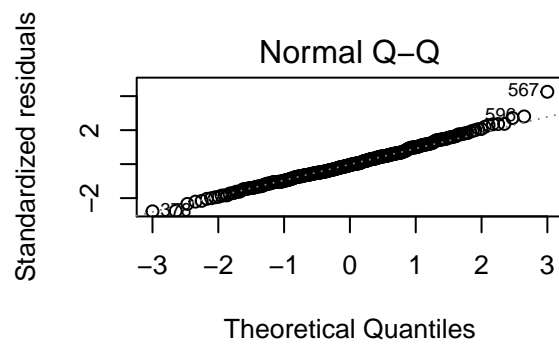
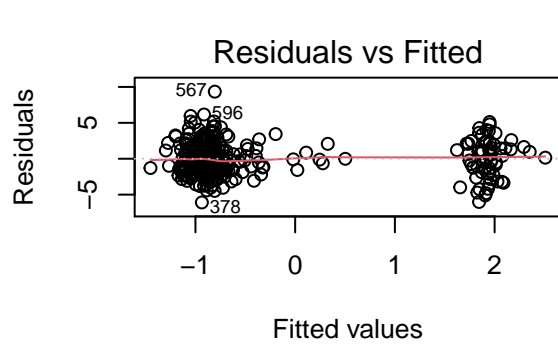


-0.23  
 -0.61 – 0.16  
 0.245  
 0.31  
 -0.66 – 1.27  
 0.531  
 was\_preg\_no\_na [Yes]  
 2.79  
 2.19 – 3.38  
 <0.001  
 3.49  
 2.25 – 4.72  
 <0.001  
 1.00  
 -0.29 – 2.28  
 0.129  
 0.02  
 -0.76 – 0.80  
 0.958  
 wfa\_diff\_inf12\_91 \*wfa\_diff\_birth\_inf12  
 -0.19  
 -0.45 – 0.07  
 0.148  
 0.09  
 -0.85 – 1.04  
 0.846  
 -0.51  
 -1.05 – 0.04  
 0.068  
 -1.18  
 -2.84 – 0.48  
 0.161  
 -0.41  
 -0.98 – 0.15  
 0.153  
 -1.04

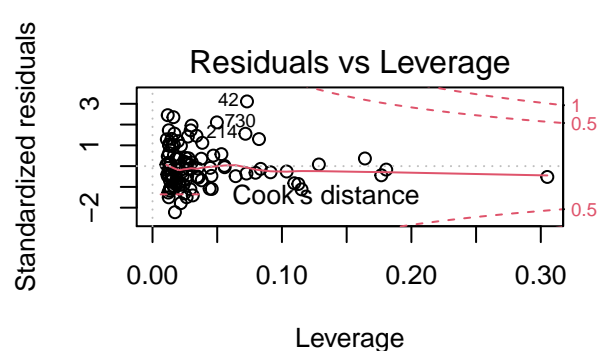
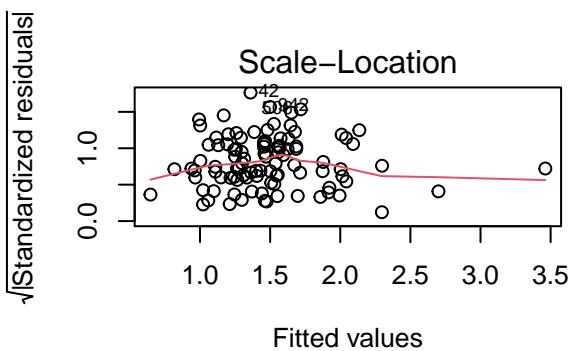
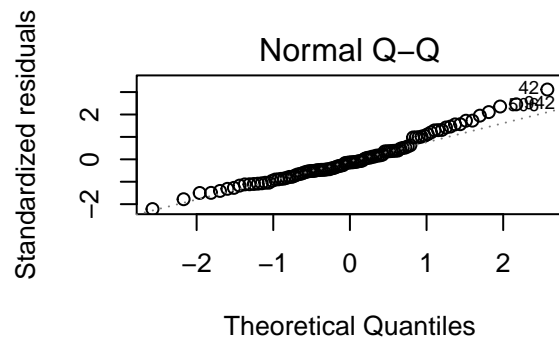
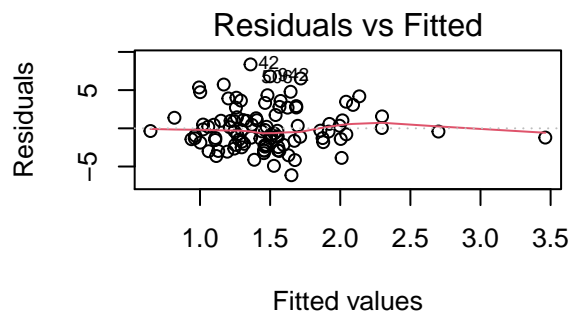
-2.70 – 0.62  
0.217  
0.06  
-0.28 – 0.40  
0.747  
0.25  
-0.97 – 1.47  
0.687  
Observations  
370  
100  
370  
100  
370  
100  
370  
100  
R2 / R2 adjusted  
0.196 / 0.188  
0.021 / -0.010  
0.088 / 0.078  
0.032 / 0.001  
0.023 / 0.012  
0.023 / -0.007  
0.004 / -0.007  
0.006 / -0.025

## Diagnostics

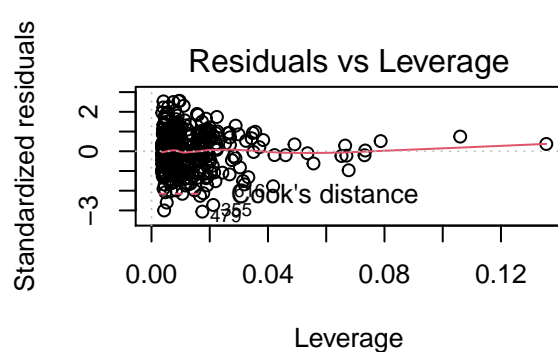
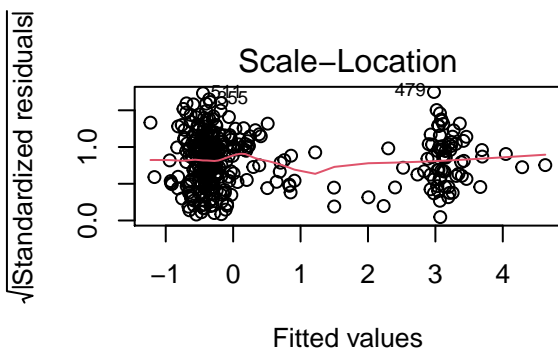
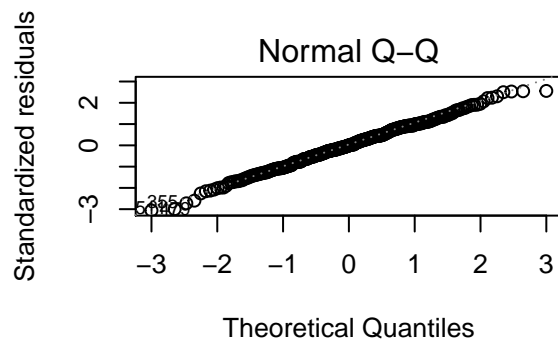
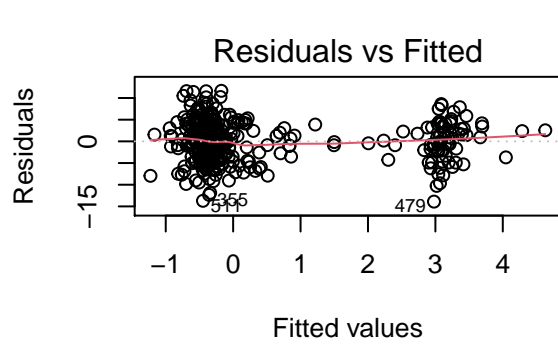
```
#weight 83-91 interaction models  
par(mfrow=c(2,2))  
plot(grim_weight_83_91_intxn_f)
```



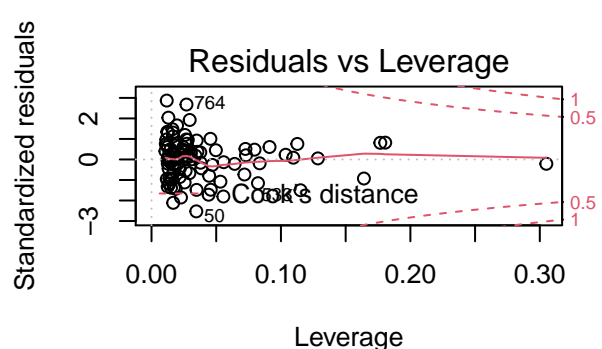
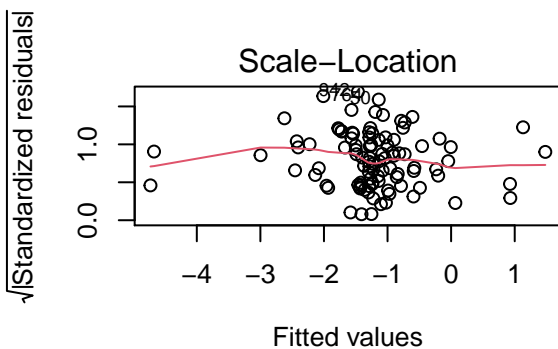
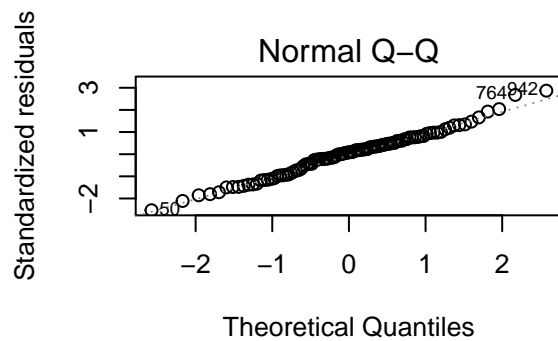
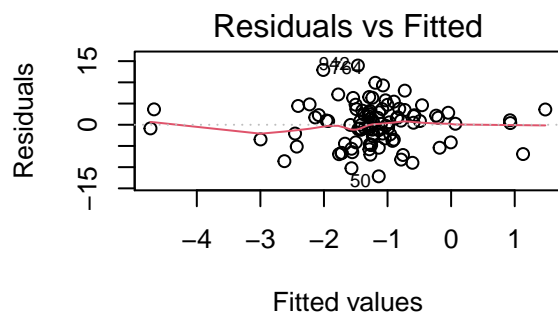
```
par(mfrow=c(2,2))
plot(grim_weight_83_91_intxn_m)
```



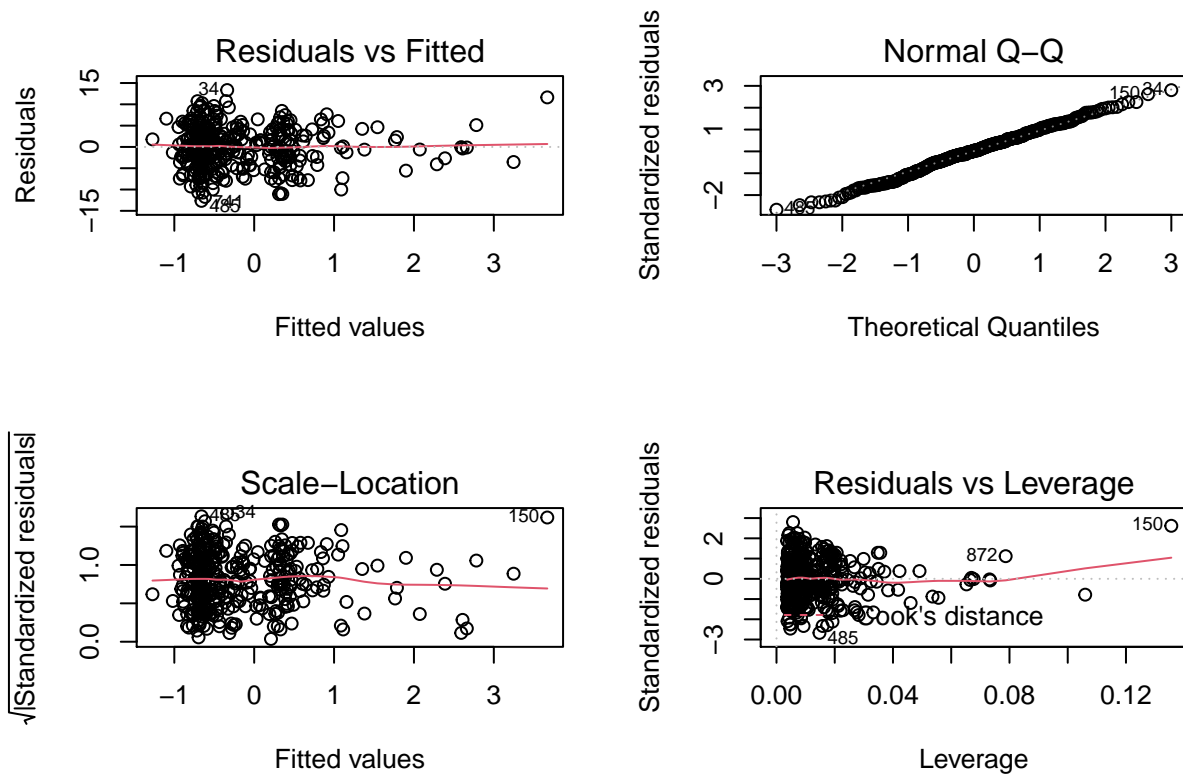
```
par(mfrow=c(2,2))
plot(pheno_weight_83_91_intxn_f)
```



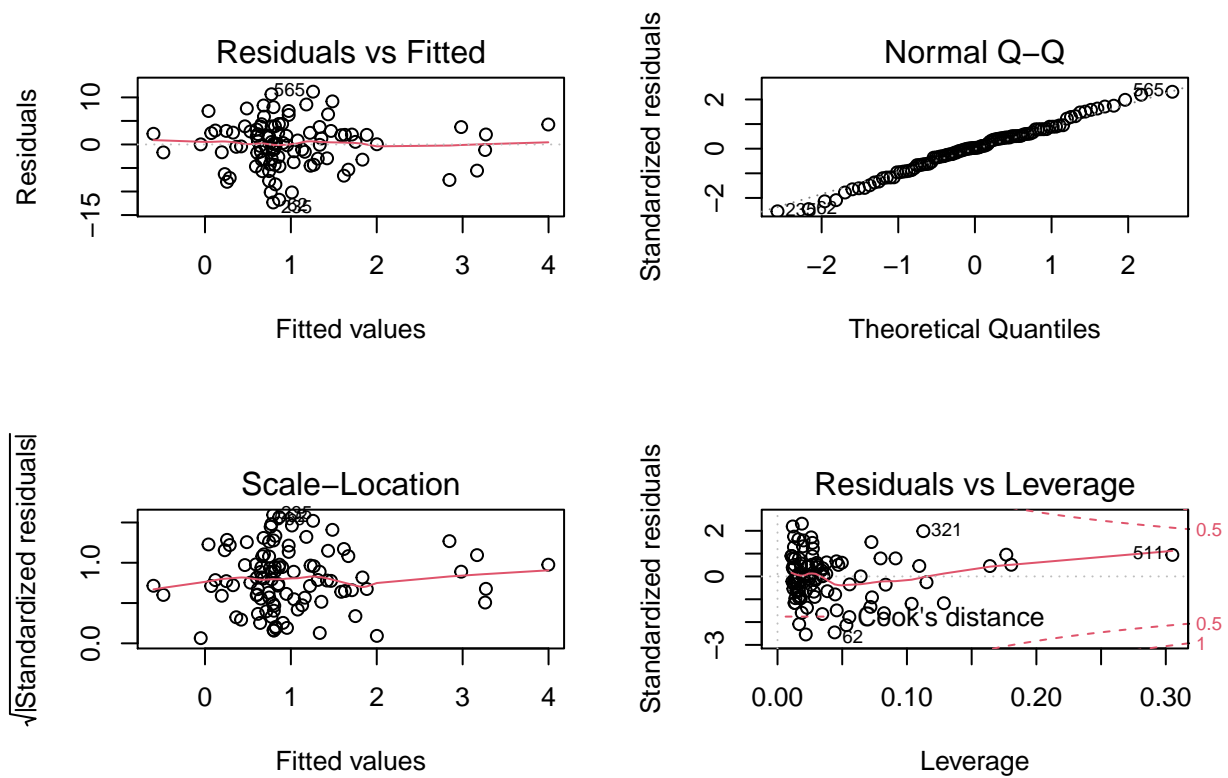
```
par(mfrow=c(2,2))
plot(pheno_weight_83_91_intxn_m)
```



```
par(mfrow=c(2,2))
plot(han_weight_83_91_intxn_f)
```



```
par(mfrow=c(2,2))
plot(han_weight_83_91_intxn_m)
```



Looked at another way (weight and height, females only, 83-91)

```
sjPlot::tab_model(grim_weight_83_91_intxn_f,
  pheno_weight_83_91_intxn_f,
  han_weight_83_91_intxn_f,
  horv_weight_83_91_intxn_f,
  grim_height_83_91_intxn_f,
  pheno_height_83_91_intxn_f,
  han_height_83_91_intxn_f,
  horv_height_83_91_intxn_f)
```

Age Accel Grim

Age Accel Pheno

EEAA

IEAA

Age Accel Grim

Age Accel Pheno

EEAA

IEAA

Predictors

Estimates

CI
p
Estimates
CI
p
Estimates
CI
p
Estimates
CI
p
Estimates
CI
p
Estimates
CI
p
Estimates
CI
p
Estimates
CI
p
(Intercept)
-1.07
-1.85 – -0.28
0.008
-0.26
-1.89 – 1.38
0.757
0.21
-1.49 – 1.91
0.807
0.50
-0.52 – 1.53
0.335

-0.92  
 -1.41 – -0.43  
 <0.001  
 -0.18  
 -1.20 – 0.84  
 0.730  
 -0.11  
 -1.17 – 0.96  
 0.844  
 -0.04  
 -0.67 – 0.60  
 0.904  
 wfa\_diff\_inf12\_91  
 0.66  
 -0.04 – 1.35  
 0.064  
 1.47  
 0.03 – 2.92  
 0.046  
 1.39  
 -0.12 – 2.89  
 0.072  
 -0.26  
 -1.17 – 0.64  
 0.568  
 wfa\_diff\_birth\_inf12  
 0.07  
 -0.23 – 0.36  
 0.650  
 -0.05  
 -0.66 – 0.56  
 0.872  
 -0.27  
 -0.91 – 0.37  
 0.414  
 -0.23



-0.61 – 0.16  
 0.245  
 was\_preg\_no\_na [Yes]  
 2.79  
 2.19 – 3.38  
 <0.001  
 3.49  
 2.25 – 4.72  
 <0.001  
 1.00  
 -0.29 – 2.28  
 0.129  
 0.02  
 -0.76 – 0.80  
 0.958  
 2.76  
 2.17 – 3.35  
 <0.001  
 3.42  
 2.18 – 4.66  
 <0.001  
 0.86  
 -0.43 – 2.15  
 0.192  
 0.01  
 -0.76 – 0.78  
 0.974  
 wfa\_diff\_inf12\_91 \*wfa\_diff\_birth\_inf12  
 -0.19  
 -0.45 – 0.07  
 0.148  
 -0.51  
 -1.05 – 0.04  
 0.068  
 -0.41  
 -0.98 – 0.15

0.153  
 0.06  
 -0.28 – 0.40  
 0.747  
 hfa\_diff\_inf12\_91  
 0.25  
 -0.27 – 0.76  
 0.344  
 0.02  
 -1.06 – 1.09  
 0.975  
 0.24  
 -0.88 – 1.36  
 0.671  
 -0.03  
 -0.70 – 0.63  
 0.919  
 hfa\_diff\_birth\_inf12  
 -0.01  
 -0.25 – 0.23  
 0.926  
 0.08  
 -0.42 – 0.58  
 0.756  
 0.25  
 -0.26 – 0.77  
 0.335  
 -0.07  
 -0.38 – 0.24  
 0.673  
 hfa\_diff\_inf12\_91 \*hfa\_diff\_birth\_inf12  
 0.04  
 -0.16 – 0.24  
 0.680  
 -0.07  
 -0.49 – 0.34

```

0.723
-0.13
-0.55 – 0.30
0.566
0.12
-0.13 – 0.38
0.339
Observations
370
370
370
370
370
370
370
370
370
370
R2 / R2 adjusted
0.196 / 0.188
0.088 / 0.078
0.023 / 0.012
0.004 / -0.007
0.192 / 0.183
0.077 / 0.067
0.014 / 0.003
0.012 / 0.001

```

```
vif(grim_height_83_91_f)
```

```
##      hfa_diff_inf12_91 hfa_diff_birth_inf12      was_preg_no_na
##              1.183167              1.179847              1.003111
```

```
vif(grim_height_83_91_m)
```

```
##      hfa_diff_inf12_91 hfa_diff_birth_inf12
##              1.203573              1.203573
```

```
vif(pheno_height_83_91_f)
```

```
##      hfa_diff_inf12_91 hfa_diff_birth_inf12      was_preg_no_na
##              1.183167              1.179847              1.003111
```

```
vif(pheno_height_83_91_m)
```

```
##      hfa_diff_inf12_91 hfa_diff_birth_inf12
##              1.203573              1.203573
```

```

vif(han_height_83_91_f)

##      hfa_diff_inf12_91 hfa_diff_birth_inf12      was_preg_no_na
##      1.183167          1.179847          1.003111

vif(han_height_83_91_m)

##      hfa_diff_inf12_91 hfa_diff_birth_inf12
##      1.203573          1.203573

vif(grim_height_91_02_f)

##      hfa_diff_91_02 hfa_diff_birth_inf12      was_preg_no_na
##      1.056932          1.051030          1.006030

vif(grim_height_91_02_m)

##      hfa_diff_91_02 hfa_diff_birth_inf12
##      1.020674          1.020674

vif(pheno_height_91_02_f)

##      hfa_diff_91_02 hfa_diff_birth_inf12      was_preg_no_na
##      1.056932          1.051030          1.006030

vif(pheno_height_91_02_m)

##      hfa_diff_91_02 hfa_diff_birth_inf12
##      1.020674          1.020674

vif(han_height_91_02_f)

##      hfa_diff_91_02 hfa_diff_birth_inf12      was_preg_no_na
##      1.056932          1.051030          1.006030

vif(han_height_91_02_m)

##      hfa_diff_91_02 hfa_diff_birth_inf12
##      1.020674          1.020674

vif(grim_weight_83_91_f)

##      wfa_diff_inf12_91 wfa_diff_birth_inf12      was_preg_no_na
##      1.275654          1.284605          1.008342

vif(grim_weight_83_91_m)

##      wfa_diff_inf12_91 wfa_diff_birth_inf12
##      1.053904          1.053904

vif(pheno_weight_83_91_f)

##      wfa_diff_inf12_91 wfa_diff_birth_inf12      was_preg_no_na
##      1.275654          1.284605          1.008342

vif(pheno_weight_83_91_m)

##      wfa_diff_inf12_91 wfa_diff_birth_inf12
##      1.053904          1.053904

vif(han_weight_83_91_f)

```

```

##      wfa_diff_inf12_91 wfa_diff_birth_inf12      was_preg_no_na
##              1.275654              1.284605              1.008342
vif(han_weight_83_91_m)

##      wfa_diff_inf12_91 wfa_diff_birth_inf12
##              1.053904              1.053904
vif(horv_weight_83_91_f)

##      wfa_diff_inf12_91 wfa_diff_birth_inf12      was_preg_no_na
##              1.275654              1.284605              1.008342
vif(horv_weight_83_91_m)

##      wfa_diff_inf12_91 wfa_diff_birth_inf12
##              1.053904              1.053904
vif(grim_height_83_91_intxn_f)

##              hfa_diff_inf12_91              hfa_diff_birth_inf12
##              4.055098              1.561438
##              was_preg_no_na hfa_diff_inf12_91:hfa_diff_birth_inf12
##              1.003588              5.066738
vif(grim_height_83_91_intxn_m)

##              hfa_diff_inf12_91              hfa_diff_birth_inf12
##              3.141898              1.471774
## hfa_diff_inf12_91:hfa_diff_birth_inf12
##              3.799584
vif(pheno_height_83_91_intxn_f)

##              hfa_diff_inf12_91              hfa_diff_birth_inf12
##              4.055098              1.561438
##              was_preg_no_na hfa_diff_inf12_91:hfa_diff_birth_inf12
##              1.003588              5.066738
vif(pheno_height_83_91_intxn_m)

##              hfa_diff_inf12_91              hfa_diff_birth_inf12
##              3.141898              1.471774
## hfa_diff_inf12_91:hfa_diff_birth_inf12
##              3.799584
vif(han_height_83_91_intxn_f)

##              hfa_diff_inf12_91              hfa_diff_birth_inf12
##              4.055098              1.561438
##              was_preg_no_na hfa_diff_inf12_91:hfa_diff_birth_inf12
##              1.003588              5.066738
vif(han_height_83_91_intxn_m)

##              hfa_diff_inf12_91              hfa_diff_birth_inf12
##              3.141898              1.471774
## hfa_diff_inf12_91:hfa_diff_birth_inf12
##              3.799584

```

```

vif(horv_height_83_91_intxn_f)

##                hfa_diff_inf12_91                hfa_diff_birth_inf12
##                4.055098                1.561438
##                was_preg_no_na hfa_diff_inf12_91:hfa_diff_birth_inf12
##                1.003588                5.066738

vif(horv_height_83_91_intxn_m)

##                hfa_diff_inf12_91                hfa_diff_birth_inf12
##                3.141898                1.471774
## hfa_diff_inf12_91:hfa_diff_birth_inf12
##                3.799584

vif(grim_height_91_02_intxn_f)

##                hfa_diff_91_02                hfa_diff_birth_inf12
##                4.111082                1.176695
##                was_preg_no_na hfa_diff_91_02:hfa_diff_birth_inf12
##                1.008046                4.442128

vif(grim_height_91_02_intxn_m)

##                hfa_diff_91_02                hfa_diff_birth_inf12
##                4.117563                1.257104
## hfa_diff_91_02:hfa_diff_birth_inf12
##                4.576882

vif(pheno_height_91_02_intxn_f)

##                hfa_diff_91_02                hfa_diff_birth_inf12
##                4.111082                1.176695
##                was_preg_no_na hfa_diff_91_02:hfa_diff_birth_inf12
##                1.008046                4.442128

vif(pheno_height_91_02_intxn_m)

##                hfa_diff_91_02                hfa_diff_birth_inf12
##                4.117563                1.257104
## hfa_diff_91_02:hfa_diff_birth_inf12
##                4.576882

vif(han_height_91_02_intxn_f)

##                hfa_diff_91_02                hfa_diff_birth_inf12
##                4.111082                1.176695
##                was_preg_no_na hfa_diff_91_02:hfa_diff_birth_inf12
##                1.008046                4.442128

vif(han_height_91_02_intxn_m)

##                hfa_diff_91_02                hfa_diff_birth_inf12
##                4.117563                1.257104
## hfa_diff_91_02:hfa_diff_birth_inf12
##                4.576882

vif(horv_height_91_02_intxn_f)

##                hfa_diff_91_02                hfa_diff_birth_inf12

```

```

##                4.111082                1.176695
##                was_preg_no_na hfa_diff_91_02:hfa_diff_birth_inf12
##                1.008046                4.442128
vif(horv_height_91_02_intxn_m)

##                hfa_diff_91_02                hfa_diff_birth_inf12
##                4.117563                1.257104
## hfa_diff_91_02:hfa_diff_birth_inf12
##                4.576882
vif(grim_weight_83_91_intxn_f)

##                wfa_diff_inf12_91                wfa_diff_birth_inf12
##                5.939198                1.311235
##                was_preg_no_na wfa_diff_inf12_91:wfa_diff_birth_inf12
##                1.008646                5.363499
vif(grim_weight_83_91_intxn_m)

##                wfa_diff_inf12_91                wfa_diff_birth_inf12
##                12.384711                1.233082
## wfa_diff_inf12_91:wfa_diff_birth_inf12
##                13.154471
vif(pheno_weight_83_91_intxn_f)

##                wfa_diff_inf12_91                wfa_diff_birth_inf12
##                5.939198                1.311235
##                was_preg_no_na wfa_diff_inf12_91:wfa_diff_birth_inf12
##                1.008646                5.363499
vif(pheno_weight_83_91_intxn_m)

##                wfa_diff_inf12_91                wfa_diff_birth_inf12
##                12.384711                1.233082
## wfa_diff_inf12_91:wfa_diff_birth_inf12
##                13.154471
vif(han_weight_83_91_intxn_f)

##                wfa_diff_inf12_91                wfa_diff_birth_inf12
##                5.939198                1.311235
##                was_preg_no_na wfa_diff_inf12_91:wfa_diff_birth_inf12
##                1.008646                5.363499
vif(han_weight_83_91_intxn_m)

##                wfa_diff_inf12_91                wfa_diff_birth_inf12
##                12.384711                1.233082
## wfa_diff_inf12_91:wfa_diff_birth_inf12
##                13.154471
vif(horv_weight_83_91_intxn_f)

##                wfa_diff_inf12_91                wfa_diff_birth_inf12
##                5.939198                1.311235
##                was_preg_no_na wfa_diff_inf12_91:wfa_diff_birth_inf12
##                1.008646                5.363499

```

```
vif(horv_weight_83_91_intxn_m)
```

```
##                wfa_diff_inf12_91                wfa_diff_birth_inf12
##                12.384711                1.233082
## wfa_diff_inf12_91:wfa_diff_birth_inf12
##                13.154471
```