ASM Practice

GAMs for hirsutism data

Maria Gkotsopoulou & Ricard Monge Calvo & Amalia Vradi

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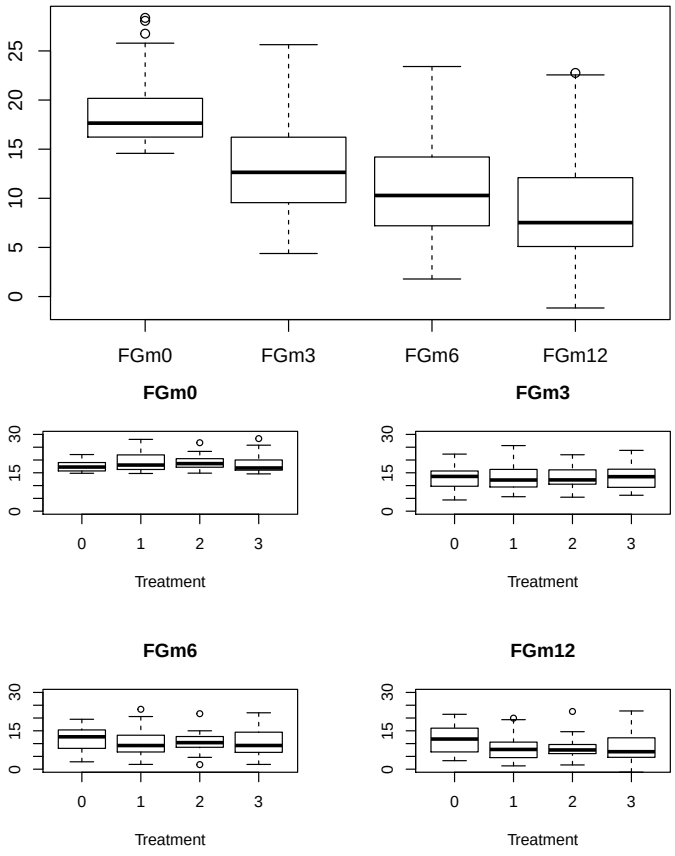
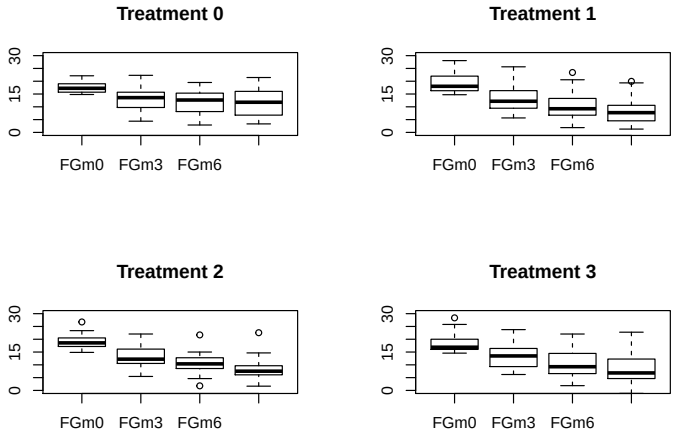
A clinical trial was conducted to evaluate the effectiveness of an antiandrogen combined with an oral contraceptive in reducing hirsutism for 12 consecutive months. The data set `hirsutism.dat` contains artificial values of measures corresponding to some patients in this study. The variables are the following:

- `Treatment`, with values 0, 1, 2 or 3.
- `FGm0`, it indicates the baseline hirsutism level at the randomization moment (the beginning of the clinical trial). Only women with baseline FG values grater than 15 where recruited.
- `FGm3`, FG value at 3 months.
- `FGm6`, FG value at 6 months.
- `FGm12`, FG value at 12 months, the end of the trial.
- `SysPres`, baseline systolic blood pressure.
- `DiaPres`, baseline diastolic blood pressure.
- `weight`, baseline weight.
- `height`, baseline height.





Our objective is to fit several *GAM* models (including semiparametric models) explaining `FGm12` as a function of the variables that were measured at the beginning of the clinical trial (including `FGm0`) and `Treatment` (treated as factor).

Additive Models

We use function `gam` from package `mgcv` to fit the following additive models:

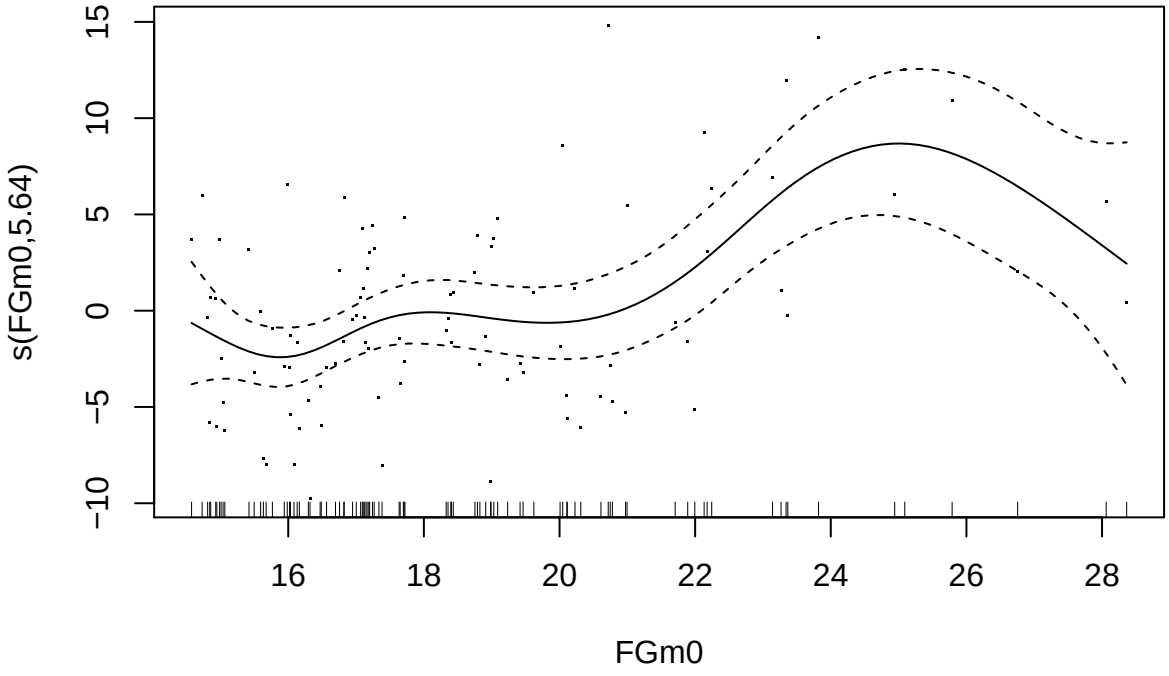
- `FGm12 ~ FGm0 + Treatment`
- `FGm12 ~ s(FGm0) + Treatment`
- `FGm12 ~ s(FGm0, by= Treatment)`

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ FGm0 + Treatment
## Total model degrees of freedom 5
##
## GCV score: 23.51506
```

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ FGm0 + Treatment
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -0.7319     2.9348  -0.249  0.80361
## FGm0          0.6893     0.1567   4.399 2.86e-05 ***
## Treatment1   -4.3420     1.3712  -3.167  0.00208 **
## Treatment2   -4.3736     1.3997  -3.125  0.00237 **
## Treatment3   -3.6456     1.3568  -2.687  0.00853 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## R-sq.(adj) =  0.196   Deviance explained = 22.9%
```

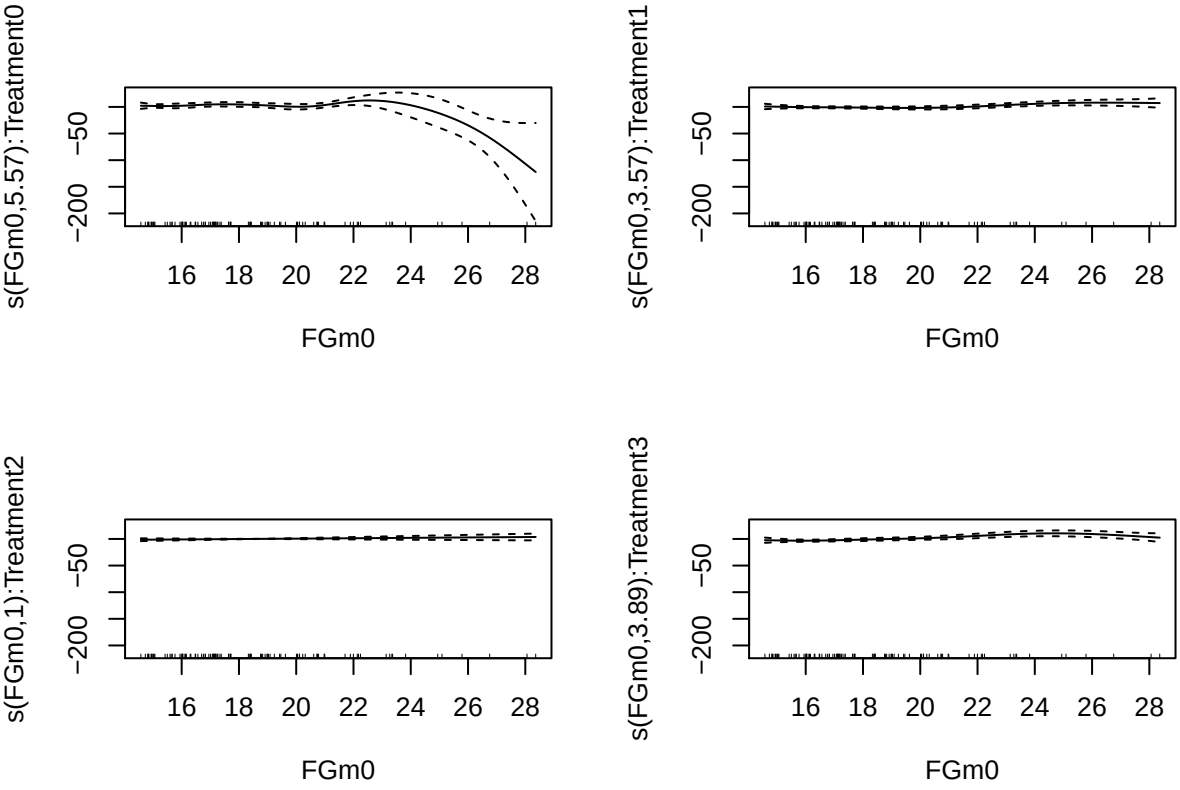
```
## GCV = 23.515  Scale est. = 22.327    n = 99
```

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  12.1951     0.9572  12.740  < 2e-16 ***
## Treatment1   -4.7935     1.3260  -3.615 0.000496 ***
## Treatment2   -4.4464     1.3491  -3.296 0.001408 **
## Treatment3   -3.6073     1.3135  -2.746 0.007286 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##          edf Ref.df     F  p-value
## s(FGm0) 5.64  6.766 4.879 0.000111 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.277   Deviance explained = 34.1%
## GCV = 22.248  Scale est. = 20.081    n = 99
```




```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0, by = Treatment)
##
```

```
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   8.0749     0.5157   15.66   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##                       edf Ref.df     F p-value
## s(FGm0):Treatment0 5.567  6.300 2.648 0.01909 *
## s(FGm0):Treatment1 3.568  4.385 2.811 0.02382 *
## s(FGm0):Treatment2 1.000  1.000 1.305 0.25661
## s(FGm0):Treatment3 3.888  4.779 4.555 0.00137 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.312   Deviance explained = 41.1%
## GCV =  22.52  Scale est. = 19.103    n = 99
```



ANOVA type tests

We use function `anova` to compare the fitted models two by two.

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ FGm0 + Treatment
## Model 2: FGm12 ~ s(FGm0) + Treatment
##   Resid. Df Resid. Dev     Df Deviance      F  Pr(>F)
## 1    94.000     2098.8
## 2    88.234     1794.5 5.7657   304.32 2.6283 0.02313 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

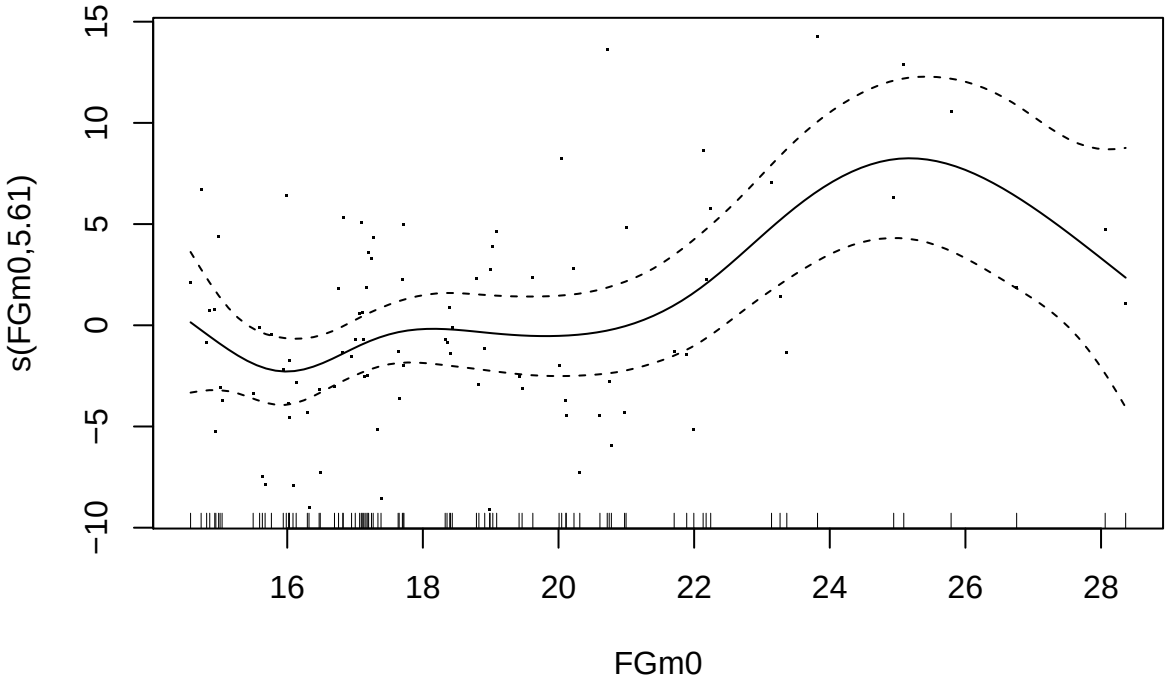
```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ FGm0 + Treatment
## Model 2: FGm12 ~ s(FGm0, by = Treatment)
##   Resid. Df Resid. Dev     Df Deviance      F  Pr(>F)
## 1    94.000     2098.8
## 2    81.537     1604.2 12.463   494.59 2.0774 0.02587 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment
## Model 2: FGm12 ~ s(FGm0, by = Treatment)
##   Resid. Df Resid. Dev     Df Deviance      F Pr(>F)
## 1    88.234     1794.5
## 2    81.537     1604.2 6.6978   190.28 1.4872 0.1862
```

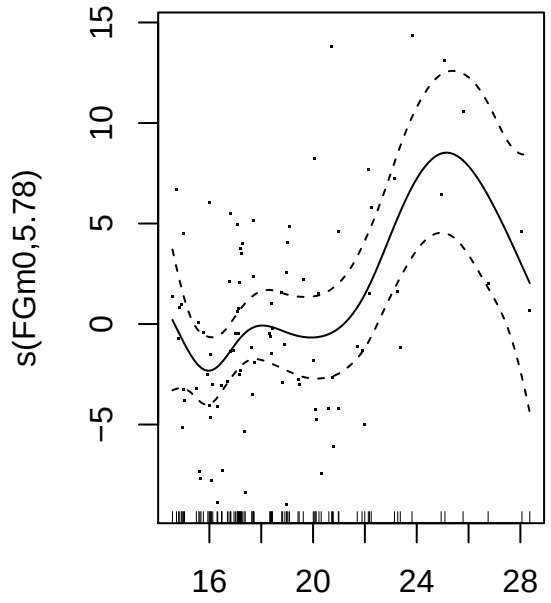
Explaining FGm12 by SysPres and DiaPres

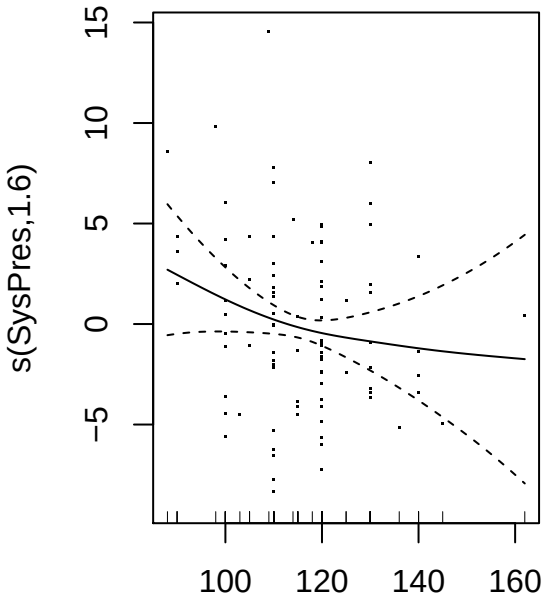
- FGm12 ~ s(FGm0) + Treatment + SysPres + DiaPres
- FGm12 ~ s(FGm0) + Treatment + s(SysPres) + DiaPres
- FGm12 ~ s(FGm0) + Treatment + SysPres + s(DiaPres)
- FGm12 ~ s(FGm0) + Treatment + s(SysPres) + s(DiaPres)
- FGm12 ~ s(FGm0) + Treatment + s(SysPres, DiaPres)

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + SysPres + DiaPres
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 16.05977    4.62838   3.470 0.000845 ***
## Treatment1  -4.98077    1.42745  -3.489 0.000793 ***
## Treatment2  -4.45373    1.43156  -3.111 0.002590 **
## Treatment3  -3.63666    1.35309  -2.688 0.008763 **
## SysPres     -0.06766    0.04840  -1.398 0.166010
## DiaPres      0.05871    0.06628   0.886 0.378352
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##           edf Ref.df     F p-value
## s(FGm0) 5.613  6.736 3.818 0.00159 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.257   Deviance explained = 34.4%
## GCV = 23.262  Scale est. = 20.293    n = 91
```

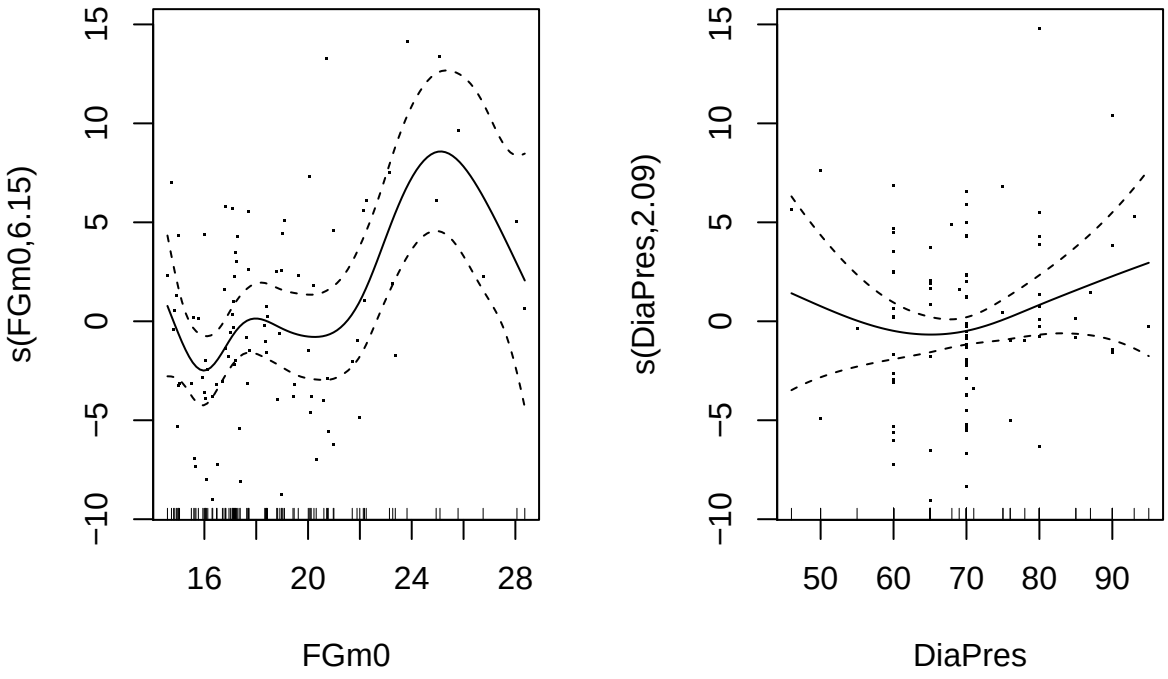



```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + s(SysPres) + DiaPres
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  8.55419    4.63202   1.847 0.068547 .
## Treatment1  -5.03120    1.41931  -3.545 0.000665 ***
## Treatment2  -4.44333    1.42469  -3.119 0.002538 **
## Treatment3  -3.63016    1.34530  -2.698 0.008524 **
## DiaPres      0.05406    0.06614   0.817 0.416201
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##              edf Ref.df     F p-value
## s(FGm0)    5.783  6.909 3.849  0.0013 **
## s(SysPres) 1.602  2.011 1.370  0.2656
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.267   Deviance explained =   36%
## GCV = 23.159  Scale est. = 20.007    n = 91
```

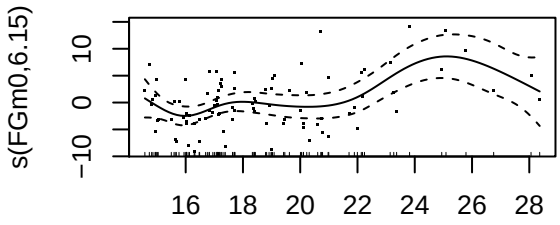


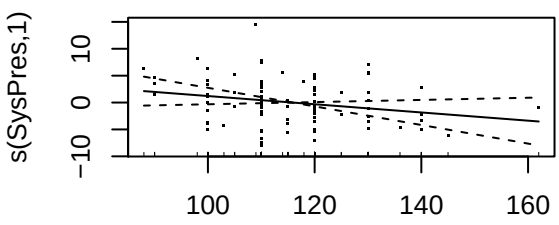


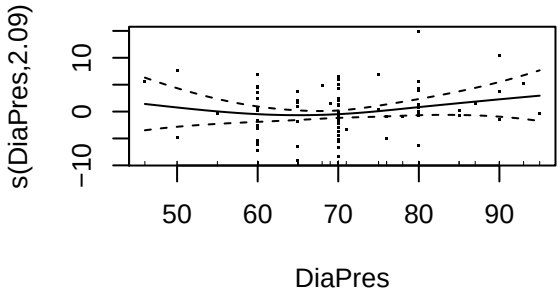

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + SysPres + s(DiaPres)
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 21.15625    5.65436   3.742 0.000348 ***
## Treatment1  -4.93295    1.40402  -3.513 0.000741 ***
## Treatment2  -4.38600    1.40820  -3.115 0.002579 **
## Treatment3  -3.66886    1.33737  -2.743 0.007547 **
## SysPres     -0.07632    0.04827  -1.581 0.117910
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##               edf Ref.df     F p-value
## s(FGm0)    6.153  7.278 3.638 0.00146 **
## s(DiaPres) 2.092  2.636 0.986 0.30170
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.288   Deviance explained = 38.5%
## GCV = 22.745  Scale est. = 19.435    n = 91
```



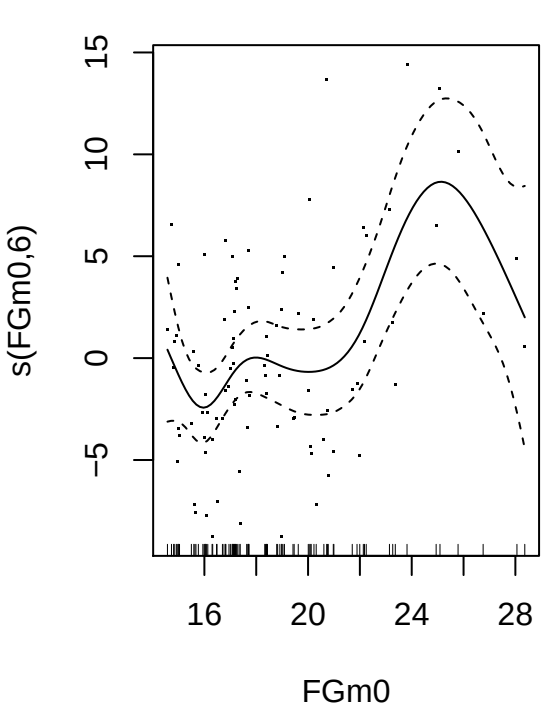

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + s(SysPres) + s(DiaPres)
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  12.3138     0.9787  12.582  < 2e-16 ***
## Treatment1   -4.9329     1.4040  -3.513 0.000741 ***
## Treatment2   -4.3860     1.4082  -3.115 0.002579 **
## Treatment3   -3.6689     1.3374  -2.743 0.007547 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##              edf Ref.df     F p-value
## s(FGm0)    6.153  7.278 3.638 0.00146 **
## s(SysPres) 1.000  1.000 2.500 0.11785
## s(DiaPres) 2.092  2.636 0.986 0.30170
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.288   Deviance explained = 38.5%
## GCV = 22.745  Scale est. = 19.435    n = 91
```

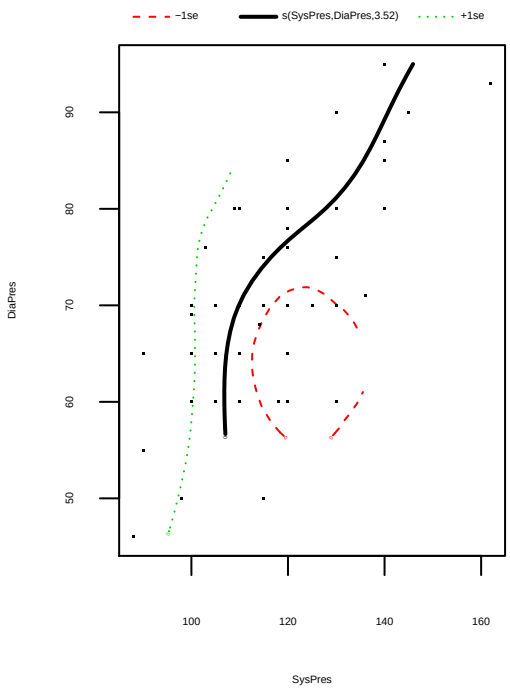







```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + s(SysPres, DiaPres)
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   12.322      0.981  12.561  < 2e-16 ***
## Treatment1    -5.012      1.410  -3.555 0.000647 ***
## Treatment2    -4.373      1.414  -3.092 0.002760 **
## Treatment3    -3.641      1.339  -2.720 0.008059 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##                       edf Ref.df     F p-value
## s(FGm0)             6.005  7.120 3.813 0.00132 **
## s(SysPres,DiaPres) 3.522  4.648 0.861 0.50854
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.284   Deviance explained = 38.3%
## GCV = 22.967  Scale est. = 19.553    n = 91
```





ANOVA type tests

We use function **anova** to compare the fitted models two by two.

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + SysPres + DiaPres
## Model 2: FGm12 ~ s(FGm0) + Treatment + s(SysPres) + DiaPres
##   Resid. Df Resid. Dev     Df Deviance      F Pr(>F)
## 1    78.264     1611.0
## 2    77.081     1572.8 1.1826    38.16 1.6128 0.2098
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + SysPres + DiaPres
## Model 2: FGm12 ~ s(FGm0) + Treatment + SysPres + s(DiaPres)
##   Resid. Df Resid. Dev     Df Deviance     F  Pr(>F)
## 1    78.264     1611.0
## 2    76.086     1511.2 2.1773   99.819 2.359 0.09682 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + SysPres + DiaPres
## Model 2: FGm12 ~ s(FGm0) + Treatment + s(SysPres) + s(DiaPres)
##   Resid. Df Resid. Dev     Df Deviance     F  Pr(>F)
## 1    78.264     1611.0
## 2    76.086     1511.2 2.1773   99.819 2.359 0.09682 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Analysis of Deviance Table
##
```

```
## Model 1: FGm12 ~ s(FGm0) + Treatment + SysPres + DiaPres
## Model 2: FGm12 ~ s(FGm0) + Treatment + s(SysPres, DiaPres)
##   Resid. Df Resid. Dev     Df Deviance      F Pr(>F)
## 1    78.264     1611.0
## 2    75.232     1514.9 3.0319   96.114 1.6213 0.1911
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + s(SysPres) + DiaPres
## Model 2: FGm12 ~ s(FGm0) + Treatment + SysPres + s(DiaPres)
##   Resid. Df Resid. Dev      Df Deviance      F  Pr(>F)
## 1    77.081     1572.8
## 2    76.086     1511.2 0.99463   61.659 3.1897 0.07829 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

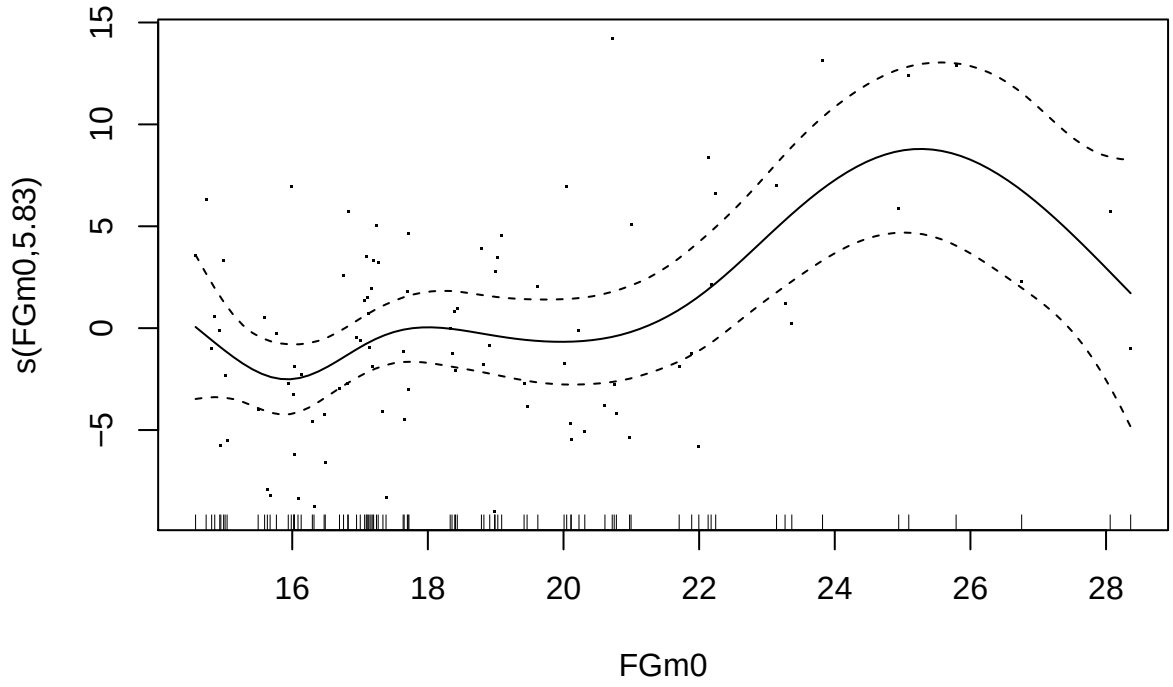
```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + s(SysPres) + s(DiaPres)
## Model 2: FGm12 ~ s(FGm0) + Treatment + s(SysPres, DiaPres)
##   Resid. Df Resid. Dev      Df Deviance F Pr(>F)
## 1    76.086     1511.2
## 2    75.232     1514.9 0.85463  -3.7052
```

Explaining `FGm12` by `weight` and `height`

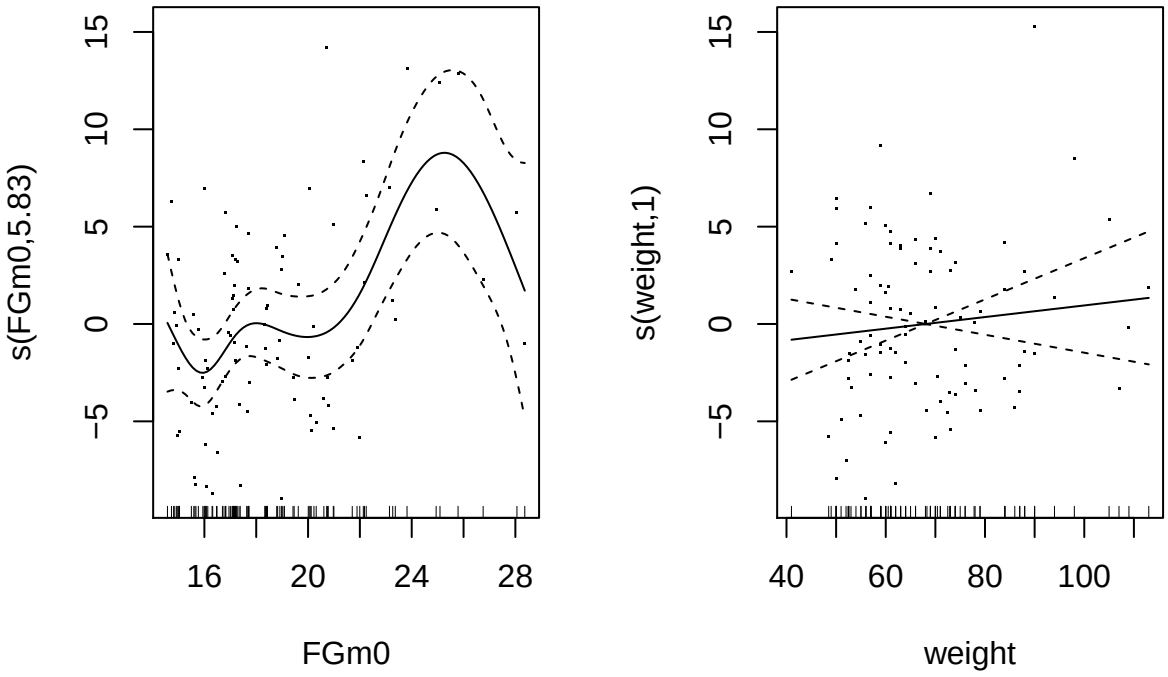
- `FGm12 ~ s(FGm0) + Treatment + weight + height`
- `FGm12 ~ s(FGm0) + Treatment + s(weight) + height`
- `FGm12 ~ s(FGm0) + Treatment + weight + s(height)`
- `FGm12 ~ s(FGm0) + Treatment + s(weight) + s(height)`
- `FGm12 ~ s(FGm0) + Treatment + s(weight, height)`

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + weight + height
##
## Parametric coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  27.51230   13.91587   1.977 0.051518 .
## Treatment1   -5.07944    1.40425  -3.617 0.000522 ***
## Treatment2   -4.77689    1.42829  -3.344 0.001262 **
## Treatment3   -3.99271    1.39756  -2.857 0.005462 **
## weight        0.02983    0.03801   0.785 0.434880
## height      -10.54435    9.01146  -1.170 0.245469
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##           edf Ref.df     F  p-value
## s(FGm0) 5.834  6.964 4.052 0.000811 ***
## ---
```

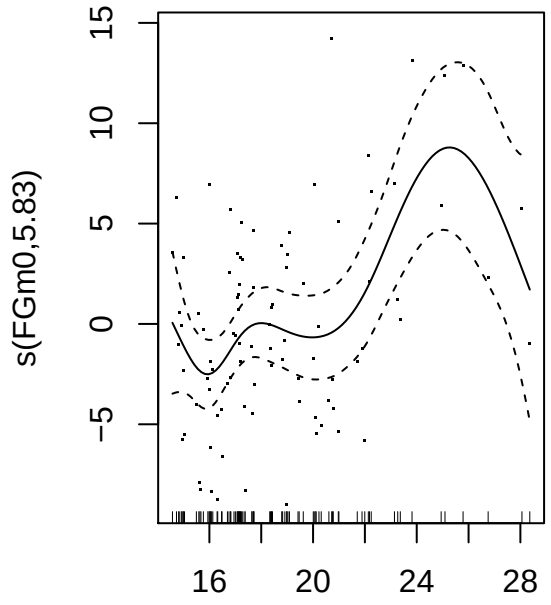
```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.258   Deviance explained = 34.8%
## GCV = 23.278  Scale est. = 20.251    n = 91
```

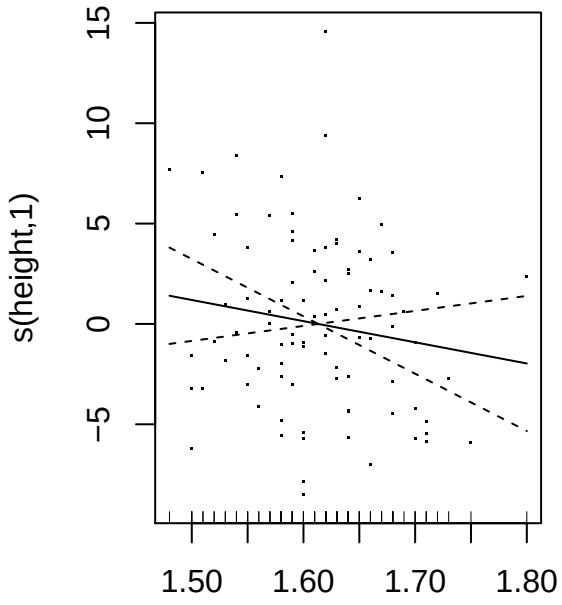



```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + s(weight) + height
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   29.543     14.665   2.015 0.047346 *
## Treatment1    -5.079      1.404  -3.617 0.000522 ***
## Treatment2    -4.777      1.428  -3.344 0.001262 **
## Treatment3    -3.993      1.398  -2.857 0.005462 **
## height       -10.544      9.011  -1.170 0.245469
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##             edf Ref.df     F  p-value
## s(FGm0)   5.834  6.964 4.052 0.000811 ***
## s(weight) 1.000  1.000 0.616 0.434870
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.258   Deviance explained = 34.8%
## GCV = 23.278  Scale est. = 20.251    n = 91
```

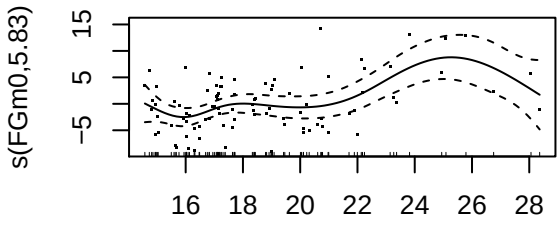


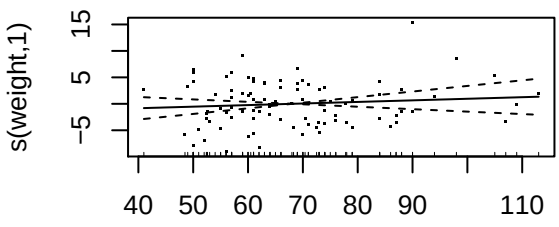

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + weight + s(height)
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 10.50230    2.61592   4.015 0.000134 ***
## Treatment1  -5.07944    1.40425  -3.617 0.000522 ***
## Treatment2  -4.77689    1.42829  -3.344 0.001262 **
## Treatment3  -3.99271    1.39756  -2.857 0.005462 **
## weight       0.02983    0.03801   0.785 0.434880
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##             edf Ref.df     F  p-value
## s(FGm0)   5.834  6.964 4.052 0.000811 ***
## s(height) 1.000  1.000 1.369 0.245433
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.258   Deviance explained = 34.8%
## GCV = 23.278  Scale est. = 20.251    n = 91
```

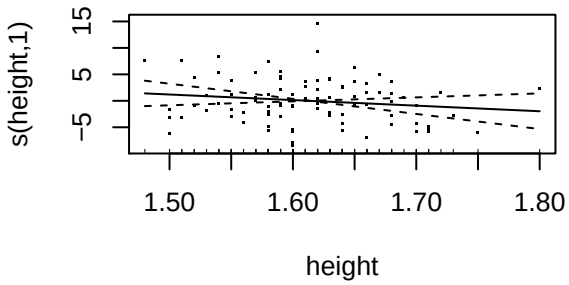




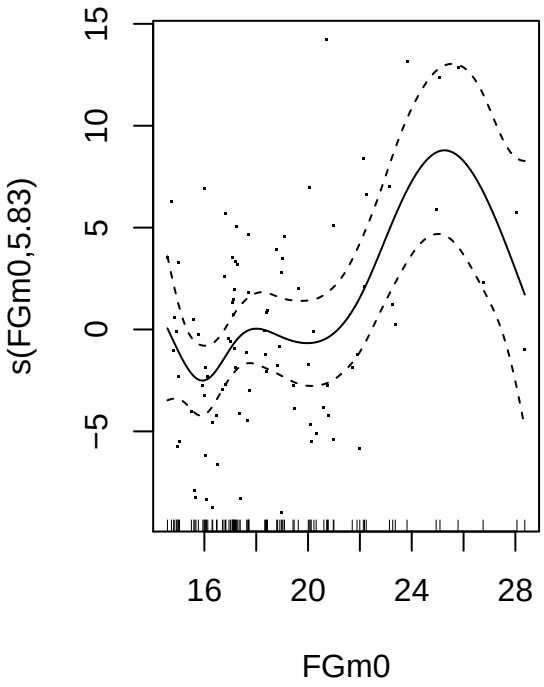

```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + s(weight) + s(height)
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  12.5327     0.9955  12.589  < 2e-16 ***
## Treatment1   -5.0794     1.4043  -3.617 0.000522 ***
## Treatment2   -4.7769     1.4283  -3.344 0.001262 **
## Treatment3   -3.9927     1.3976  -2.857 0.005462 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##             edf Ref.df     F  p-value
## s(FGm0)   5.834  6.964 4.052 0.000811 ***
## s(weight) 1.000  1.000 0.616 0.434870
## s(height) 1.000  1.000 1.369 0.245433
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.258   Deviance explained = 34.8%
## GCV = 23.278  Scale est. = 20.251    n = 91
```

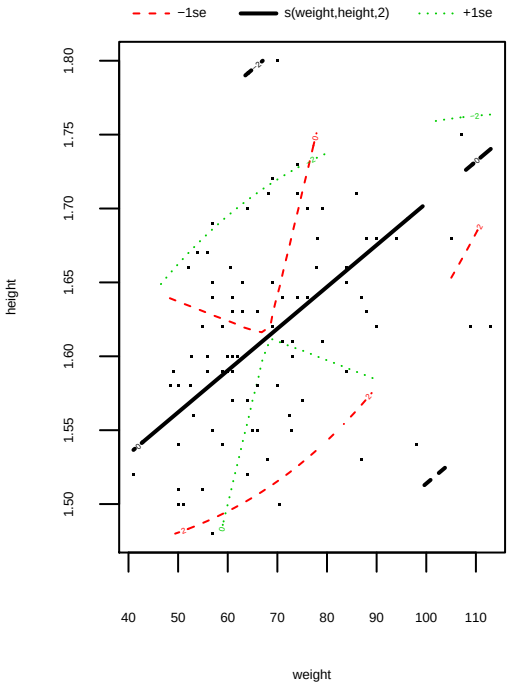







```
##
## Family: gaussian
## Link function: identity
##
## Formula:
## FGm12 ~ s(FGm0) + Treatment + s(weight, height)
##
## Parametric coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  12.5327     0.9955  12.589  < 2e-16 ***
## Treatment1   -5.0794     1.4043  -3.617 0.000522 ***
## Treatment2   -4.7769     1.4283  -3.344 0.001262 **
## Treatment3   -3.9927     1.3976  -2.857 0.005462 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##                     edf Ref.df     F  p-value
## s(FGm0)           5.834  6.964 4.052 0.000811 ***
## s(weight,height) 2.000  2.000 0.760 0.471245
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.258   Deviance explained = 34.8%
## GCV = 23.278  Scale est. = 20.251    n = 91
```





ANOVA type tests

We use function `anova` to compare the fitted models two by two.

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + weight + height
## Model 2: FGm12 ~ s(FGm0) + Treatment + s(weight) + height
##   Resid. Df Resid. Dev         Df   Deviance      F    Pr(>F)
## 1    78.036     1603.2
## 2    78.036     1603.2 2.7569e-08 1.0548e-06 1.8894 2.329e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + weight + height
## Model 2: FGm12 ~ s(FGm0) + Treatment + weight + s(height)
##   Resid. Df Resid. Dev         Df   Deviance      F    Pr(>F)
## 1    78.036     1603.2
## 2    78.036     1603.2 2.8353e-08 1.0713e-06 1.8658 2.394e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + weight + height
## Model 2: FGm12 ~ s(FGm0) + Treatment + s(weight) + s(height)
##   Resid. Df Resid. Dev         Df   Deviance      F    Pr(>F)
## 1    78.036     1603.2
## 2    78.036     1603.2 3.9246e-08 1.1876e-06 1.4943 3.293e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + weight + height
## Model 2: FGm12 ~ s(FGm0) + Treatment + s(weight, height)
##   Resid. Df Resid. Dev        Df   Deviance      F    Pr(>F)
## 1    78.036     1603.2
## 2    78.036     1603.2 2.676e-08 1.0514e-06 1.9402 2.262e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + s(weight) + height
## Model 2: FGm12 ~ s(FGm0) + Treatment + weight + s(height)
##   Resid. Df Resid. Dev         Df   Deviance      F    Pr(>F)
## 1    78.036     1603.2
## 2    78.036     1603.2 7.8381e-10 1.6424e-08 1.0347 8.254e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Analysis of Deviance Table
##
## Model 1: FGm12 ~ s(FGm0) + Treatment + s(weight) + s(height)
## Model 2: FGm12 ~ s(FGm0) + Treatment + s(weight, height)
##   Resid. Df Resid. Dev          Df    Deviance      F    Pr(>F)
## 1    78.036     1603.2
## 2    78.036     1603.2 -1.2486e-08 -1.3623e-07 0.5388 1.183e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```